academicJournals

Vol. 9(4), pp. 52-59, 28 February, 2014
DOI: 10.5897/SRE2014.5820
ISSN 1992-2248

http://www.academicjournals.org/SRE

Scientific Research and Essays

*Review*

# A review on Oat (*Avena sativa* L.) as a dual-purpose crop

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Received 25 January, 2014; Accepted 20 February, 2014

**The multifunctional uses of oats include forage, fodder, straw for bedding, hay, haylage, silage chaff, human food; most commonly, they are rolled or crushed into oatmeal, or ground into fine oat flour. Oatmeal is chiefly eaten as porridge, but may also be used in a variety of baked goods, such as oatcakes, oatmeal cookies, oat bread and raw material for food, health care and cosmetic products. The major components of oats that contribute to its function include *β*-glucan, protein, oil, and starch. The minor protein of oat is a prolamine, avenin. In addition there are minor components, including tocols and avenanthramides that have antioxidant properties and may contribute to human health and well being. Here we review the progress made in oats and highlight the potential and future prospects.**

**Key words:** Fodder, forage, food, *β*-glucan, protein, tocols, avenanthramides, health.

## INTRODUCTION

Oats rank around sixth in the world cereal production statistics following wheat, maize rice, barley and sorghum. Oat grain has always been an important form of livestock feed. Oats are an annual plant and can be planted either in autumn (for late summer harvest) or in the spring (for early autumn harvest). Known locally as "jau", oats are grown on the foothills of Himalayas, such as in the India State of Himachal Pradesh. They are a good source of protein, fibre, and minerals but world oat grain declined as farm mechanization increased between 1930 to1950. Oats remain an important grain crop for people in marginal ecologies throughout the developing world, and in developed economies for specialist uses. In many parts of the world oats are grown for use as grain as well as for forage and fodder, straw for bedding, hay, haylage, silage and chaff. Livestock grain feed is still the primary use of oat crops, accounting for an average of around 74% of the world's total usage in 1991 to 1992 (Welch, 1995). Oats are better adapted to variable soil types and can perform better on acid soils than other small grain cereals crops. They are mostly grown in cool moist climates and they can be sensitive to hot, dry weather from head emergence through to maturity. For these reasons, world oat production is generally concentrated between latitudes 35 to 65°N, including Finland and Norway, and 20 to 46°S. Most of the world's production comes from spring sown cultivars, but autumn sowing is practiced along the higher altitude regions, including the Himalayan Hindu Kush range and in regions where summers are hot and dry. Where winters are

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**Table 1.** Top ten oats producers in 2013 (Thousand metric tons).

| | |
|---|---|
| European Union | 7,581 |
| Russia | 4,027 |
| Canada | 2,680 |
| Australia | 1,050 |
| United States | 929 |
| Ukraine | 630 |
| Belarus | 600 |
| China | 580 |
| Chile | 560 |
| Argentina | 400 |
| **World Total** | 20,732 |

Source: United States Department of Agriculture (2013).

severe, such as in Scandinavia, northern states of the US, Canada, and higher altitude regions in the tropics, short season to mid maturing oat cultivars are generally sown. In regions with temperate climates, oats are variously spring, winter and/or autumn sown depending on regional climatic conditions, crop rotation requirements, end use and other farming practices. In warmer regions, spring type oats sown in autumn to avoid summer heat and drought.

Russia, countries of the former Soviet Union, the US, Canada, Germany and Poland (Table 1) account for about 75% of the world's supply of grain oats, seed and industrial grade oats. Since the 1960s the proportion of oats used for feed has declined in the US and Canada, remained unchanged in the former Soviet Union countries and Poland, and increased slightly in Germany.

Oats consumed as feed in the US are becoming a specialty feed for race horses, hobby farmers and breeding stock. The leading exporters of oat grain are Canada, Finland, Sweden Australia, and Argentina. The US, Japan, the former Soviet Union, Switzerland and the European Union are the principal importers of oat grains.

A significant proportion of the oat grains and forages produced on smaller more remote farms around the world, including in the Himalayan region, are consumed on the farm and never enter the commercial market place. A case study from Nepal (Stevens et al., 2000) covering oats dating back to the 1950s, shows how people in Pakistan, Afghanistan and China could benefit substantially from access to better performing cultivars to alleviate poverty and improve human and animal nutrition. These examples highlight the need for a co-ordinate international fodder oat network targeting resource-poor environments in the relatively remote communities.

Oats are grown for use as grain as well as forage and fodder, straw for bedding, hay, haylage, silage and chaff. Food uses for oats include oatmeal, oat flour, oat bran and oat flakes for use as breakfast cereals and ingredients in other food stuffs. Oats are one of the most nutritious grain cereals, high in protein and fibre. The protein of rolled (flakes) oats is generally greater than that found in other cereal grains. Many of the vitamins and minerals found in oats are combined in the bran and germ. Most oat food products use the entire groat, making it a nutritious cereal grain. In India, oats have a wider adaptability, particularly in western and north western regions of the country because of its excellent growing habitats, quick re-growth and better nutritional value. Only a few varieties of oats are available for cultivation and their grain yields under good management conditions vary between 15 to 25 q ha$^{-1}$. Development of high yielding varieties of oats, therefore, assumes a greater significance for human consumption (Ahmad and Zaffar, 2014).

## USES OF OAT

### Animal feed

Oats are grown for use as grain as well as forage and fodder, straw for bedding, hay, haylage, silage and chaff. Oat is an important winter fodder, mostly fed as green but surplus is converted into silage or hay to use during fodder deficit periods (Suttie and Reynolds, 2004). Oat as a forage crop has the advantage of being winter hardy and serves as catch crop (Morey, 1961). It is preferred feed of all animals and its straw is soft and grain is also valuable feed for horses, dairy cows, poultry and young breeding animals. The demand of meat, beef, milk, butter and their byproducts is increasing due to rapidly growing human population in India. Oat protein is nearly equivalent in quality to soy protein, which has been shown by the World Health Organization to be equal to meat, milk, and egg protein. In J&K State livestock population is 7.8 million so the fodder production is not sufficient enough to meet the requirements of a burgeoning livestock population (Anonymous, 2009). The farmers face fodder deficiency in winter when they have only dry stalks of summer cereal fodders or dry summer grasses. In order to increase in productivity *per* unit area there is need to develop varieties having higher forage yield potential and quality. Interest in oat hay for the dairy, feedlot and horse industries has grown in recent years. This is mainly due to improvement in oat hay quality brought about by higher quality standards demanded by the export hay market (Lush, 1945). Inadequate supply of quality feed and fodder is the primary cause of lower productivity of milch animals in India (Patel et al., 2011). In Jammu and Kashmir, fodder requirement is about 4.31 against the availability of 3.26 million tones, there by having deficient of 1.05 million tones on dry matter basis (Anonymous, 2008). Kashmir valley experienced a long lean period of winter, resulting in scarcity of green and quality fodder which results in drastic decrease in milk and milk production. Therefore,

**Table 2.** Nutritional value per 100 g.

| | |
|---|---|
| Energy | 1,628 kJ (389 kcal) |
| Carbohydrates | 66.3 g |
| Dietary fibre | 10.6 g |
| Fat | 6.9 g |
| Protein | 16.9 g |
| Pantothenic acid ($B_5$) | 1.3 mg (26%) |
| Folate (vit. $B_9$) | 56 μg (14%) |
| Calcium | 54 mg (5%) |
| Iron | 5 mg (38%) |
| Magnesium | 177 mg (50%) |
| Potassium | 429 mg (9%) |
| *β*-glucan (soluble fibre) | 4 g |

Source: United States Department of Agriculture (2013).

to meet the need of animal products and to maintain good health and potential of livestock in terms of milk, meat and wool, there is a great importance of fodder cultivation to compensate the fodder scarcity during lean period. The present production is not proportionate with the demand. So, oats deserves a deep deliberation for improvement. It should be highly pragmatic by the fact that, sixty corers animals will need 1097 and 1170 million tonnes of green fodder, respectively. Deficiency of green fodder will be about 64.9% and for dry fodders it may go to up to 24.9% in 2025 A.D (Government of India Planning Commission, 2001). It should pave the way for bringing about a kind of plant type, which could enhance its quality and productivity without sacrificing the consumer needs. Cultivation of high yielding fodder oat cultivar Sabzaar developed for temperate climatic conditions of Kashmir valley have helped in enhancing forage productivity but in order to further increase in productivity *per* unit area there is need to develop varieties having higher forage yield potential and quality. Understanding the gene action and combining ability may help in choosing suitable breeding procedure for improvement of forage oat. So, there is an urgent need of exploiting new research technologies to boost forage yield in terms of higher yield of green fodder and dry matter per unit are. The competition for utilization of land for food grains and fodder necessitates intensified efforts towards more efficient forage production. The forage oat varieties having higher productivity, better quality and tolerance to abiotic stress is the need of the hour in bridging the gap between demand and supply of green fodder.

## Human food

The amount of oats used for human consumption has increased progressively, owing its dietary benefits and nutritional value (Table 2). In fact, the health effects of oat rely mainly on the total dietary fibre and *β*-glucan content (Kerckhoffs et al., 2003). Oat protein is nearly equivalent in quality to soy protein, which has been shown by the World Health Organization to be equal to meat, milk, and egg protein. The protein content of the hull-less oat kernel (groat) ranges from 12 to 24%, the highest among cereals (Lasztity, 1999). The popularity of oatmeal and other oat products again increased after a January 1998 decision by the Food and Drug Administration (FDA), when it issued a final rule that allows food companies to make health claims on food labels of foods that contain soluble fibre from whole oats (oat bran, oat flour and rolled oats), noting that 3.0 g of soluble fibre daily from these foods may reduce the risk of heart disease. Oats are a rich source of soluble fiber, well-balanced proteins and several vitamins and minerals essential for the human health (Esposito et al., 2005). Oats contain relatively high amounts of lipids compared with other cereal grains with a substantial level of essential linoleic acid (Mattila et al., 2005). Additionally, oats are a source of several natural antioxidants such as tocopherols, alk(en)ylresorcinols, and phenolic acids and their derivatives, and a unique source of avenanthramides (N-cinnamoylanthranilate alkaloids) and avenalumic acids (ethylenic homologues of cinnamic acids), which are not present in other cereal grains (Mattila et al., 2005). All of these phenolic compounds possess potential health-promoting properties because of their antioxidant activities and/or membrane-modulating effects (alk(en)ylresorcinols). Moreover, *β*-glucans, which also exhibit an antioxidant property are included in the soluble dietary fibre fractions of oats that participates in glucoregulation and causes a decrease in serum cholesterol levels in humans (Esposito et al., 2005). The consumption of oats is therefore an important component of diet for hypercholesterolemic patients (Czerwiński et al., 2004). In addition to their importance in the diet, oats antioxidants may also contribute to the stability and the taste of food products. Most of the previous studies in literature have reported a good antioxidant capacity of oats (Mattila et al., 2005).

*β*-Glucan is a soluble fiber readily available from oat grains that has been gaining interest due to its multiple functional and bioactive properties. Its beneficial role in insulin resistance, dyslipidemia, hypertension, and obesity is being continuously documented. The fermentation ability of *β*-glucan and their ability to form highly viscous solutions in the human gut may constitute the basis of their health benefits. Consequently, the applicability of *β*-glucan as a food ingredient is being widely considered with the dual purposes of increasing the fiber content of food products and enhancing their health properties. Therefore, this article explores the role of *β*-glucan in the prevention and treatment of characteristics of the metabolic syndrome, their underlying mechanisms of action, and their potential in food applications. Farming community also get economic benefits from cultivating quality oats thus, quality oat cultivation should be encouraged. The polysaccharides *β*-glucan occurs 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*-glucan. These substances stimulate the immune system, modulating hum oral and cellular immunity, and thereby have beneficial effect in fighting infections (bacterial, viral, fungal and parasitic). *β*-glucan also exhibit hypocholesterolemic and anticoagulant properties. Recently, they have been demonstrated to be anti-cytotoxic, ant mutagenic and anti-tumorogenic, making them promising candidates as pharmacological promoters of health. The present interest in soluble oat fiber originated from reports that showed that dietary oats can help in lowering cholesterol (Braaten et al.,1994; Baeet al., 2010; Drozdowski et al., 2010; Tiwari and Cummins, 2011), postprandial blood glucose level (Wood et al., 2000; Hooda et al., 2010; Regand et al., 2011; Dong et al., 2011; Tiwari and Cummins, 2011) as well as modifying immune response and reducing risk of colon cancer (Mälkki, 2001; Yang et al., 2008).

### Avenanthramides

Avenanthramides consists of an anthranilic acid derivative linked to hydroxycinnamic acid derivative. The three major avenanthramides reported in oat are avenanthramides 1, 3, and 4, which are also known as avenanthramides B, C, and A, respectively (Peterson et al., 2002). Oat flakes have more avenanthramides (26 to 27 µg/g) than oat bran (13 µg/g) (Mattila et al., 2005). These compounds are bioavailable and have anti-inflammatory, anti-atherogenic and antioxidant properties (Peterson et al., 2002).

## BENEFITS FROM *Β*-GLUCAN

It is an immune modulator, by binding to surface receptors and causing activation of macrophages, white blood corpuscles, phygocytosis of neutrophil and activation of lymphocytes thus stimulating antitumor and antimicrobial activate. In cosmetics, because *β*-glucan immune functions activate the langerhans cells which induces cytokine, particularly of interleukin-1(il-1) and that stimulates the proliferation of fibro- blasts (skin cells) and synthesis of collagen, elastin and proteoglycan. *β*-glucan thus acts as an anti-aging, skin soothing agent, film forming substance, moisturizing, U-VA protect ant and in wound healing and as anti-irritant. Vascular injury may contribute to the pathogenesis of *β*-glucan such as zymosan has been shown to be beneficial in wound healing and may increase collagen synthesis; the study has shown that *β*-glucan can help the healing of wound in db/db mice. This is related to *β*-actin activation of macrophage. There is also possibility that *β*-glucan could help the healing of vascular injury.

### Viscosity related properties

Viscosity is the thickness or resistance to flow of a liquid. Many health related effects of oats result from the high viscosity of their soluble B- glucan. It accomplishes some of the nutritional functions by increasing the viscosity of fluids in the gut. Standard oat varieties contain from 4.5 to 5.0% of *β*-glucan content and has been proposed as a target for oat breeding programmes to double this concentration.

### Blood cholesterol and oat *β*-glucan

LDL-cholesterol, which contains the highest concentration of cholesterol, damages blood vessels because of its tendency to infiltrate and accumulate within arterial walls. LDL-cholesterol, and especially small, dense LDL-cholesterol, is also more susceptible to structural modifications including oxidation and glycosylation, which play major roles in the development of atherosclerosis. High concentration of serum high density lipoprotein (HDL)-Cholesterol are protective against CHD, since HDL may scavenge and remove excess cholesterol in the arterial wall and also protect LDL against oxidation.

Reducing cholesterol with oats: the hypocholesterolemic properties of oats were first demonstrated in 1963. Oats were significantly hypocholesterolemic, lowering total and LDL- cholesterol by 2 to 23%. Oats future improves lipid profiles by significantly increasing blood concentrations of HDL cholesterol as well as apolipoprotein A-I, a major component of HDL (Glore et al., 1994).

### Diabetes and oat *β*-glucan

Diabetes mellitus is characterized by high blood glucose level with typical manifestations of thirst, polyuria, polydipsia, and weight loss. It is caused by defects in insulin-mediated signal pathways, resulting in decreased glucose transportation from blood into muscle and fat cells. The major risk is vascular injury leading to heart disease, which is accelerated by increased lipid levels and hypertension. Management of diabetes includes: control of blood glucose level and lipids; and reduction of hypertension. Dietary intake of *β*-glucan has been shown to reduce all these risk factors to benefit the treatment of diabetes and associated complications. In addition, *β*-glucan also promotes wound healing and alleviates ischemic heart injury. However, the mechanisms behind the effect of *β*-glucan on diabetes and associated complications need to be further studied using pure *β*-

glucan. Foods rich carbohydrates have high glycemic response or glycemic index (GI) which cause rapid secretion of insulin from pancreas low GI-diet prevents diabetes, cardiovascular disease, metabolic syndrome and obesity. Water-soluble oat B-glucan exerts their effects mainly by increasing viscosity in the small intestine during digestion, resulting in an extended digestion period. When digestion is delayed, blood sugar increases more slowly, causing low insulin response. The oat *β*-glucan form a protective layer along the intestinal wall that acts as a viscous barrier slowing food uptake from the intestine (Mckeown et al., 2004).

## Blood pressure and oat *β*-glucan

High blood pressure (BP) is defined as having a systolic BP greater than 140 mm Hg or a diastolic BP greater than 90 mm Hg due to the increasing internal pressure on the artery; hypertension contributes to endothelial injury and increasing CHD risk by enhancing the infiltration of LDL particles. Hypertension also accelerates the transformation of fatty streaks into fibrous plaques by enhancing smooth muscle proliferation. Oats may help maintain healthy blood pressure by improving the glycemic and insulinemic profiles. The DASH (dietary approaches to stop hypertension) study demonstrated that a diet high in whole grains, fruit, vegetable and low fat dairy, and restricted in fat, lowers BP in hypertension individuals. Dietary consumption of oats is consistent with the DASH recommendations, and may confer benefit due to its fiber content (Contreras et al., 2000).

## Oat *β*-glucan as prebiotics

The lower part of intestine- the colon, has been identified as a key organ affecting general health. The growth and metabolism of the many individual bacterial species inhabiting the colon depend primarily on the substrates available to them, most of which come from the diet. Oat *β*-glucan, which is indigestible in the small intestine but is fermented by bacteria in the colon, is prebiotics. Prebiotics are non digestible food ingredients that selectively stimulate the growth or activities of bacteria in the colon. They beneficially affect a series of intestine functions by modulating the structure, consumption, and metabolic activity of mucosa and microflora in the colon. The end product created from prebiotics fermentation in the colon are short chain fatty acids, e.g., butyric acid, that serve as nutrients for mucosal cells (Malkki and Virtanen, 2013).

## Oat *β*-glucan and weight management

Satiety is a complex bodily sensation that signals that the Stomach is full and it is time to stop eating. When consumed 20 to 30 min before eating a meal, *β*-glucan form a thick viscous fluid in the stomach and small intestine that stimulates the sensation of satiety and help limit appetite. By reducing the desire for food intake, the effect can help in weight control when combined with a healthy, balanced diet and adequate exercise. As a result of the extended period of digestion, nutrients are utilized by the body over a longer period and, thus may contribute to a longer period of satiety in weight management programs. Fiber may impart a textural quality that increases chewing time. Fibbers' have also been reported to prolong gastric emptying, small bowel transit time, and the digestion and absorption of carbohydrates and fat. These actions, which effectively alter glycemic response have been shown to intensify satiety and aid in the control of energy intake. Meals enriched with *β*--glucan elevate plasma levels of cholecystokinin (CCK), a hormone that mediates fat-induced satiety. Faber may also increase fecal energy excretion. Oat protein has also been found to be more satiating than energetic amounts of carbohydrates or fat (Ludwig, 2000).

## Oat and celiac disease

Celiac disease is an autoimmune hereditary disorder of the small intestine that occurs because of sensitivity to gluten in food. Normally the lining of the small intestine has a fluffy 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. When persons with celiac disease take food containing gluten, their immune system responds by damaging the small intestine lining. They fingerlike protrusions, called villi are attacked by the immune system and are eventually destroyed. Malnutrition occurs without these villi; no matter how much food a person consumes, because the nutrients from food pass the gastrointestinal tract (GIT) without being absorbed (malabsorption), leading to diarrhoea, vitamin and mineral deficiencies, anemia, osteoporosis and intestine cancer presently. The only effective treatment of celiac disease is a life-long reliance on gluten-free diet. The injurious constituent of wheat in patients with celiac disease is α-gliadin in the prolamin fraction of wheat gluten. Oats do not contain gliadin and its counterpart is avenin. Oats improve the nutritional value of the gluten-free diet without any negative effect on nutritional status and are appreciated by the patients. Inclusion of oats in the gluten free diet is advantageous, since oats are a good source of dietary fiber and of several and minerals (Huttner and Arendt, 2010).

## Oat *β*-glucan prevents cancer

*β*-glucans have been used in immune-adjuvant therapy for cancers and tumors since 1980. The ability of *β*-glucan to inhibit tumor growth in a variety of experimental tumor models is well established (di Luzio et al., 1979). Many of the scientific studies and published articles were done primarily in Japan. There is a large collection of research data that demonstrates *β*-glucans have antitumor and anticancer activity. Generally, the (1, 3)-*β*-glucan was administered prophylactically and the end-point were tumor growth, tumor volume, degree of metastases, and/or survival. Moreover, the antitumor efficacy of (1, 3)-*β*-glucan seems to relate to the type of tumor, the genetic background of the host animal, the dose, the route, and timing of *β*-glucan administration, as well as the tumor load. Antitumor and anticancer effect of *β*-glucan is not just macrophages that attack tumor cells and destroy them, but also modulation of lymphocyte, neutrophil, and natural killer (NK) cells activity and other components of the innate immune system (Hong et al., 2004).

**Oat milk**

Oat milk is a tasty, nutritious and cheaper alternative to dairy milk. Western herbalists regard oats as a tonic for the nervous system. It has high fiber, zero fat, vitamin E, folic acid, phytochemicals (*β*-carotene), cholesterol and lactose free.

**Industrial benefits**

Viscosity properties of *β*-glucan can be used in the Bakery industry in products such as biscuits and pastas. Its use could also include frozen desserts, breakfast foods, beverages, meats, on-dairy creamers, and canned soups, especially as fat replacer. The cheese industry can benefits from *β*- glucan which optimize the process of raw material and improves the cheese structure. The combination of insulin and *β*–glucan also has very interesting properties that can be used as fat-replacer in products such as low-fat ice-creams. This has been proved to be very successful dietary sources of the soluble fibre *β*-glucan and has been associated with a reduced risk for many diseases.

**Other benefits**

Medicinally oats have been used to prevent heart disease and cancers, to enhance immune response to infection and to stabilize blood sugars. They have also been used to treat rheumatism, chronic neurological pain and atonia (weakness) of the bladder. They have been used to treat insomnia, stress, anxiety, depression and nervous exhaustion. Interestingly, an extract of oats was used in traditional Ayurvedic medicine to cure opium addiction. A case report showed 6 out of 10 opium addicts gave up the drug after a treatment period of 27 to 45 days using a decoction of green oats. Oats have also even been used to treat withdrawal from tobacco. Oat straw in particular is a tonic when taken medicinally. It has been prescribed by herbalists to treat general debility and a wide range of nervous conditions gently raising energy levels while supporting an over-stressed nervous system. Infusions of oat straw have also been used for flu and coughs. These uses may or may not have been sanctioned by relevant government bodies or authorities. Oats have a soothing effect on skin. A decoction added to a bath helps soothe dry skin or itchiness, including such conditions as eczema, psoriasis measles, chickenpox, pityriasis rosea and sunburn. Oats can also be used as a skin cleanser and are frequently used as an exfolliant to remove the surface layer of dead skin cells. Oats are therefore a common ingredient in many skincare preparations. Oats can be found in bars of soap as well as in creams and gels. Some oat extracts have been found to have a synergistic sun-blocking effect when used in combination with titanium dioxide. Hydrolysed oat protein has been a popular ingredient in shampoos and conditioners, in particular as a replacement for animal-derived proteins, and it has been reported that the proteins condition and coat damaged hair, prevent hair dryness and improve hair texture. Use for oat starches has been proposed, including as a replacement for talcum powder, which has been linked with various adverse health effects. In combination with certain other oat derivatives the starch may be formulated into dusting powders for surgical gloves containing both smoothness and anti-irritant properties (Ulmiu et al., 2012). Oat hulls are a raw material for the making of furfural (from the latin word *furfur*, meaning bran) and many related compounds (furfuryl alcohol, tetrahydrofurfuryl alcohol, furan, tetrahydrofuran and polytetramethylene etherglycol). Industrial uses of furfural and these compounds includes solvent extraction of crude petroleum, the nylon industry, a solvent for dyes, resins, paints, and varnish, production of elastomers and thermoplastics, manufacture of phenolic resin glues and plywood adhesives, hydrogen peroxide explosives, anti-skid tread composition, as a filter aid in breweries, production of construction board material and production of paper pulp. The starches in oats have also been used in the production of adhesives. Another patented use of oats is an oil spill dispersant which is able to absorb oil, then emulsify and disperse it efficiently. Oat flour can be converted into starch acetates that are used in the production of biodegradable plastics. Oat proteins can be used as carriers and release agents for agricultural chemical sprays. Oat hulls can also be used as growing substrates for yeast and fungi; the production of chemical indicators of toxicity in polluted water; the production of xylitol (a sugar substitute). Oats may also prove to be a good source of the enzyme lipase, which breaks down fat. Oats are an annual grass that is high in calcium. Calcium rich foods and herbs are the basis for remedies that relax the muscles and nervous system. *Avena sativa* should be thought of as the basis for every good nerve relaxing formula. Oatmeal or gruel is an ideal food for convalescents and can be flavored with raisins, lemon, butter, or maple syrup. It is easily digested and is a soothing food for those with fever and a good first food for those who have experienced intestinal illnesses or food poisoning. Oatmeal is an excellent alternative to eggs and sausages or bacon for those desiring a low fat, low cholesterol breakfast routine. The alcohol tincture of Oat straw can be used for nerve complaints and for uterine problems in the standard dose of ten to twenty drops, taken in water, three times a day. Oat straw tea is recommended by herbalists to soothe chest complaints, especially when mixed with a little lemon and honey. A strong brew can be added to the bath to benefit rheumatism, paralysis, liver ailments, gout, and kidney problems. Bladder and bowel conditions, intestinal colic and bedwetting have all been helped by soaking in a bath of Oat Straw. These effects of oat *β*-glucan were well reviewed by Mälkki and Virtanen (2001), Ulmius et al. (2011), Wang et al. (2002) and Dikeman et al. (2006).

## CONCLUSION

Kashmir valley has experienced a long lean period of winter, resulting in scarcity of green and quality fodder which results in drastic decrease in milk and milk production. Therefore, to meet the need of animal products and to maintain good health and potential of livestock in terms of milk, meat and wool, there is a great importance of fodder cultivation to compensate the fodder scarcity during lean period. Development of high yielding varieties of oats therefore, assumed greater importance for human consumption and animal health and also Kashmir valley is ideally suitable for oats cultivation because of its temperate climate. For scientific utilization of elite allelic resources present in the exotic gene pool of oats through hybridization and subsequent selection of recombinants possessing high grain yield potential together with high *β*-glucan, it is imperative to characterize these genotypes on scientific basis. Genotypes having high *β*-glucan content can be used in breeding programmes for increasing the *β*-glucan content of adapted local germplasm. Avena Atlantic genotypes have highest *β*-glucan concentration (2.2 to 11.3%) and are useful source for increasing the *β*-glucan content of cultivated oats. Besides, conventional methods, mapping population have been developed and genomic region associated with *β*-glucan content have been identified. Molecular markers linked to *β*-glucan content and other quality traits have been mapped to dissect the genomic regions contributing to the quality traits.

## Conflict of Interests

The author(s) have not declared any conflict of interests.

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