World Applied Sciences Journal 34 (10): 1269-1275, 2016
ISSN 1818-4952

DOI: 10.5829/idosi.wasj.2016.1269.1275

A Review on Multidimensional Aspects of Oat (*Avena sativa*) Crop and Its Nutritional, Medicinal and Daily Life Importance

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Abstract: In Pakistan, compared to barley and wheat, oats give multiple cuts and are profusely tiller, high yield with greater nutritive value. Oat is used for feed, fodder, hay, haylage, silage chaff, straw for bedding, human food. Mostly, they were rolled or even crushed into oat meal or ground into perfect oat flour. Chiefly oatmeal is eaten as porridge, along with it a variety of baked goods including oatbread, oatmeal cookies, oatcakes, raw material for food, cosmetic products and health care products can be produced from it. The major ingredients of oats contributing its functioning include β-glucans, starch, proteins and oils. Additionally, important minor ingredients include immunomodulators, tocols and avenanthramides with antioxidant properties contributing to livestock and human health. Since, the utilization of oat crop is common in Pakistan but relatively limited research data exists, that can aid the farmer in selecting the best forage harvest schedule to attain high seed and forage yield and good quality forage.

Key words: Oat · Oatmeal · Feed And Fodder · Silage · Immunomodulators · Antioxidants

INTRODUCTION

Oat is locally known as "Jau" and is grown all over the world and ranked at sixth in statistics of cereal production, following wheat, maize, rice, barley and sorghum. During early British era, fodder oats were introduced and 400 cultivars were acquired from Australia, Canada, Europe, New Zealand and USA in 1970s, to lay the foundation of Pakistan's oat improvement program. The Fodder Research Institute, Sargodha, is the main institution handling the basic seed production of improved or promising forages in Pakistan. Essential forage cultivars produced by the Fodder Research Institute and other stations are enlisted in Table 1.

Oat provides assured feed in early winter when sown at the end of August-early September and cut in late November-early December. Oat grain has always remained an important livestock feed because it is rich source of proteins, fibers, minerals. Oats are commonly grown for use as grain, forage and fodder, chaff, hay, haylage, silage and straw for bedding in many parts of the world. Oat grains as feed for livestock, is still the primary use of oat crop, which accounts for around 74% of the world's total usage in 1991 to 1992 [1]. Oats have better adaptability to variable types of soil and their performance is comparatively better on acidic soils than other cereals crops. For growth of oat crop, cool and moist environment is favorable while these are sensitive to hot and dry weather from emergence to maturity. Foods from oat include oatmeal, oat flakes, oat bran and oat flour for use as breakfast cereals and ingredients in other food stuffs [2].

Most of the oat food products utilize entire groat which make it a nutritious cereal grain. In Pakistan, oats show greater adaptability, especially in Western and North- Western regions due to its excellent growing habitat and optimum nutritional value. Improvement of high yielding oat varieties, thus, assumes a significant impact for human consumption [3].

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Table 1: Forage crop cultivars released by various institutes in Pakistan

Crop	Cultivar	Institute and station	Year of release
Oats	Avon	FRI, Sargodha, Punjab*	1983
	PD2-LV 65	FRI, Sargodha, Punjab	1983
	Sargodha-81	FRI, Sargodha, Punjab	1983
Barley	Frontier-87	CCRI, Pirsabak, KPK **	1988
	Jau-83	AARI, Faisalabad, Punjab***	1985
	Jau-87	AARI, Faisalabad, Punjab	1988
Berseem	Agaiti	FRI, Sargodha, Punjab	1986
	Pachaiti	FRI, Sargodha, Punjab	1986
Maize	Akbar	MMRI, Sahiwal, Punjab	1972
	Azam	CCRI, Pirsabak, KPK	1973
	Kisan-90	CCRI, Pirsabak, KPK	1990
	Sultan	MMRI, Sahiwal, Punjab****	1986
	Mazenta (Maize × Teosinte)	FRI, Sargodha, Punjab	1991
Millet (Pennisetum)	Barani bajra	RARI, Bahawalpur, Punjab*****	1986
	Hairy dwarf	RARI, Bahawalpur, Punjab	1986
	Composite-75	RARI, Bahawalpur, Punjab	1986
	MB-87	FRI, Sargodha, Punjab	1991
Sorghum	Jowar-86	RARI, Bahawalpur, Punjab	1986
	BR-307	RARI, Bahawalpur, Punjab	1986
	BR-319	RARI, Bahawalpur, Punjab	1986
Sorghum-Sudan grass	Hybrid Pak-sudax	FRI, Sargodha. Punjab	1986
	SSG-988	Pioneer Seed Pvt. Ltd.	1992
	Ras Bheri	Cargill Seeds Pvt. Ltd	1993

*FRI = Fodder Research Institute, Sargodha;
**CCRI = Cereal Crops Research Institute, Pirsabak, KPK,
***AARI = Ayub Agricultural Research Institute, Faisalabad;
****MMRI = Maize and Millet Research Institute, Sahiwal;
*****RARI = Rainfed Areas Research Institute, Bahawalpur.

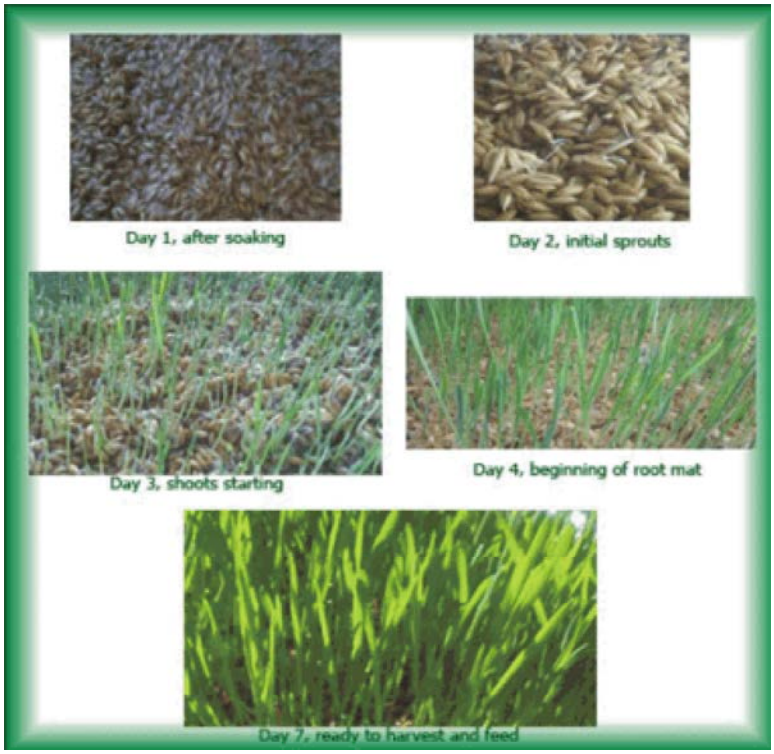

Fig. 1: Oat crop

Fig. 2: Mature oat plant

Country Wise Oats Production in 1000 MT

Year of Estimate: 2015

Rank	Country	Production (1000 MT)
1	EU-27	7,640.00
2	Russian Federation	4,550.00
3	Canada	3,430.00
4	Australia	1,300.00
5	United States	1,300.00
6	China	600.00
7	Argentina	485.00
8	Chile	470.00
9	Kazakhstan	250.00
10	Norway	236.00
11	Turkey	210.00
12	Algeria	110.00
13	Mexico	90.00
14	Serbia	66.00
15	Morocco	56.00
16	New Zealand	34.00
17	Switzerland	9.00
18	Colombia	4.00
19	Kyrgyzstan	3.00
20	Georgia	3.00
21	Japan	1.00

Source: United States Department of Agriculture

Table 2: Nutritional value per 100g

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

Source: United States Department of Agriculture (2013)

Oat as Human Food: Oat whole milk is a delicious, nutritious and economical alternative to popular dairy milk. European herbalists ranked oat like a tonic for neurological system. This has higher content of fiber, folic acid, vitamin E, phytochemicals (β-carotene) while it is free from fats, cholesterol and lactose. Oat consumption by humans has increased rapidly owing to their nutritional advantages as well as nutritional value (Table 2). Oats also contribute in developing taste and stability to the food products [4]. Health benefits of oat mainly rely on β-glucans and total dietary fiber content [5]. The fame of oatmeal as well as oat products improved after January,

1998 due to conclusion by the Drug Administration and Food to allow food organization to create health statement on foods labeling of food items containing soluble fiber from oats (Oat flour, oat bran & rolled oats). It was reported that 3.0g of soluble fiber everyday from these oat food decrease the chance of heart problems. Oats are enriched sources of soluble fibers, well balanced and healthy proteins, minerals and vitamins, important for health and fitness [6].

Oat has β-glucans, which have antioxidant properties, these are involved in glucoregulation and also cause reduced serum cholesterol level in humans beings [6]. The use of oats is consequently beneficial diet for hypercholesterolemic patients [7]. It has an essential role in hypertension, dyslipidemia, insulin resistance and obesity. The fermentative capability of β-glucans to form highly viscous solution in guts constitutes the basis for their health reimbursement. Consequently, the applicability of β-glucans as food is due to enhancing fiber content of food and their health properties. It stimulates the defense system via modulating humoral as well as cellular immunity, thus providing support against infections. Currently, they had been demonstrated with anti-cytotoxic, anti-tumorogenic and anti-mutagenic effects and can be used as pharmacological promoters of health [8, 9] postprandial blood glucose level [10, 11] and decreasing chance of colon tumors [12].

Fig. 3: Green fodder Oat crop

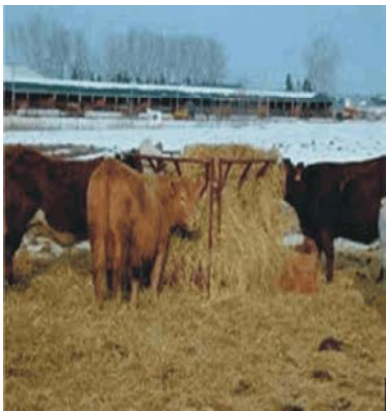

Fig. 4: Dry fodder Oat crop (Hay)

Oat as Animal Feed: Oat like a forage crops has advantages of becoming winter hardy and also serves as cash crops [13]. It is actually preferred animal feed because its straw is soft. Oat grains are also used as most important feeds for poultry, horses, dairy cows, as well as breeding animals. The increased demands of milk, meat and also their byproducts, owing to increased human population can be overcome by oat, because oat protein is almost alike to soy protein, which have been approved by the World Health Organization as equivalent to milk, meat as well as egg proteins [14]. Farmers face shortage of fodders in winter, therefore, high yielding varieties of forages should be developed. Interest in oat hay for feedlot and horse dairy industries has developed in now days because of improvement in oat hay quality [15].

Blood Cholesterol Control by Oat: Low density lipoproteins (LDL-cholesterol) contains the highest cholesterol concentration, damage blood vessels due to its infiltration and accumulation in arterial walls. It is also more inclined to structural alterations including glycosylation and oxidation, which results in the development of atherosclerosis. High density liporotein (HDL)-cholesterol are protective against CHD, because HDL scavenges the excess cholesterol in arterial walls and also prevents LDL oxidation. In 1963, it was reported for the first time that oats reduce cholesterol significantly due to its hypocholesterolemic properties i.e. lowering total and LDL-cholesterol by 2 to 23% [16].

Weight Management: Satiety is complex sensation of body signaling the stomach, as full to stop eating more. Consuming β-glucans 30 minutes before meals, it produces a thick layer of viscous fluid in stomach and small intestines, which induces satiety and helps in limiting the appetite. Thus, by decreasing the desire for intake of food, these can prove helpful in management of weight control in combination to exercise and healthy foods. Fiber imparts textural quality to the food, increases chewing time, prolongs gastric emptying, transit time of small intestines and aids in digestion and absorption of fats and carbohydrates. Plasma cholecystokinin (CCK) level is elevated with β-glucans enriched meals and mediates fat-induced satiety [17].

Oat Prevents Cancer: β-glucans have been traditionally used in immune adjuvant therapy for tumors and cancers, since 1980. The capability of β-glucans as anti-tumor components is well established in variety of experimental models [18]. Anticancer and antitumor properties of β-glucans are by modulating of neutrophils, lymphocytes and natural killer (NK) cells and other components of the innate immunity [19].

Benefits from Oat β-Glucans: β-glucans are soluble non-starch and complex polysaccharides abundantly found in bacterial, fungal, oats and barley cell walls also play their vital role in anti-microbial immunomodulation.

Blaszczyk *et al.* [20] described the immunopotent effect of food consistency on gastrointestinal tract. The study involved effect of two oat β-glucans fractions on spleen for pathological lesions. Rats were arranged into three groups with higher and lowered weighed oat derived β-glucans as well as control dietary supplementation. Spleen exhibited immunostimulant effect in terms of improved digestion. Higher and lowered leveled oat derived β-glucans were used for antioxidant potentials against lipids in terms of oxidative products. High weighed β-glucans supplemented rats showed decreased oxidative stress and intestinal inflammatory lesions. These results concluded the therapeutic efficacy of β-glucans against enteritis due to their viscous consistency.

Andersson *et al.* [21] reported that hypocholesterolemic potential of oat is based on fiber and β-glucans contents. Artherogenesis might be affected by oat antioxidants. Female mice were supplemented with various oat bran levels for lipid plasma content, 27 and 40% oat bran were supplemented to mice. Both these barley bran levels resulted in dose based reduction of blood cholesterol profile including triglycerols and lipoproteins. Moreover, enhanced excretion of bile acids and cholesterol were also seen in feaces with decreased artherosclerosis in aorta. Fibrinogen and VCAM-1 were also lowered in mice. These results showed hypocholestrolemic and anti-arthersclerotic potentials of dietary supplemented oat bran.

Chan *et al.* [22] reported the receptor based mode of action of β-glucans with respect to natural or acquired immunity in terms of lymphocytic proliferation and differentiation in reticuloendothelial system (RES). Plant extracted β-glucans were used *in vitro*. β-glucans activate immune cells through acting on their receptors for immunostimulation. Orally administered β-glucans undergo breakdown in the small intestine, then transported to RES by macrophages for immune response in animal models.

Gannon *et al.* [23] demonstrated the immunomodulatory potential of oat and wheat bran dietary supplementation in rat. Wheat bran supplemented rats exhibited reduced hepatic IL-4 concentrations and T lymphocytes count in mesenteric lymph node with elevated other leukocytes count as well as reduced caecal IgA level. Both oat and wheat bran supplementations stimulated the intestinal microflora for immunomoduation. This dietary supplementation might exert the immunostimulant effects along with improvement of gut health. Avenanthramides comprises anthranilic acid derivatives associated with hydroxycinnamic acid derivatives. In oat, three major avenanthramides 1, 3, 4, also termed as avenanthramides B, C and A, respectively [24]. Oat flakes have higher avenanthramides quantity (26-27μg/g) than oat bran (13μg/g) [25]. These compounds showed greater bioavailability with anti-atherogenic, anti-inflammatory and antioxidant properties [26].

Dhillon and Bhatia [27] evaluated the antioxidant potential of oat derived β-glucans for phenolic and fatty acid contents. The study involved black hulled covered and yellow hulled naked as well as covered oat varieties. 2, 2-azino-di-3-ethylbenzthiazoline sulphanate and 2, 2-diphenyl-1-picrylhydrazyl based tests resulted in higher antioxidant activity of black hulled oat than yellow hulled and others. Moreover, black oats were rich in phenolic contents as compared to yellow and naked oat varieties without effecting fatty acids. *In vivo* immunomodulatory potential of oat extracted β-glucan in mice. Immunomodution was based on inducible nitric oxide synthetase (INOS), phagocytosis, nitro blue tetrazolium reduction (NBT) and ELISA. Aqueous oat seed extract exhibited higher immunostimulant efficacy than leaf extract due to rich active ingredient content.

Yun *et al.* [28] reported the immunostimulant potential of oat derived β-glucan against *Staphylococcus aureus* and *Eimeria vermiformis* infestations in mice. Abdominal cavity isolated macrophages were used for the study. These macrophages were also evaluated for their phagocytic potential. An increased phagocytosis was observed for these macrophages. β-glucan exhibited an enhanced immunity against *S. aureus* infections. Moreover, decreased fecal oocyst count was also

recorded with β-glucan supplementation in *E. vermiformis* infected mice than control group. Similarly specified antibodies level was higher against *Eimeria* treated with β-glucans than control group. Increased spleenocytic count with Interferon gamma through peritoneal route enhanced the resistance against diseases in treatment group. β-glucans also increased lymphocytic proliferation in intestinal epithelium of *E. vermiformis* infected mice. The results revealed the immunostimulation of orally and parentally administered oat β-glucan against *E. vermiformis* and *S.aureus* infections in mice.

CONCLUSION

Dairy farmers of the Pakistan have taken fodder oat as promising winter forage crops to alleviate fodder scarcity and sustain milk production. Fodder oat has been found to increase the milk production during lean season, so it is playing a significant role in income generation of the dairy farmers. Farmers could also be benefited to a greater extent by producing fodder oat seed. Oats have proved to be outstanding winter forage throughout Pakistan, particularly for the peri-urban dairies supplying the big cities and in the high altitude temperate northern regions. Growing oats ensures production of maximum quantities of early, nutritious forage in the deficit periods in winter. It is safe to claim that oats have brought a winter forage green revolution in Pakistan. Over the past two decades, improved oat cultivars have had a significant impact in improving quality and availability of livestock feed and, hence, on the lives of people living in resource-poor areas of Pakistan. Forage from oats has helped significantly in mitigating livestock starvation and in improving nutrition, both of animals and of the human population.

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