e - ISSN - 2249-7722
Print ISSN - 2249-7730

International Journal of Phytotherapy

www.phytotherapyjournal.com

THE NUTRITIONAL AND THERAPEUTIC IMPORTANCE OF *AVENA SATIVA* - AN OVERVIEW

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ABSTRACT

Avena sativa is a rich source of protein, minerals, lipids, β-glucan, avenanthramides, indole alkaloid, flavonoids, triterpenoidsaponins, lipids and sterols. It exerted many pharmacological effects including antioxidant, anti-inflammatory, dermatological, immunomodulatory, antidiabetic, gastrointestinal, hypolipidemic, neurological, cardiovascular and many other biological activities. This paper will highlight its chemical constituents and potential therapeutic effect.

Key words: *Avena sativa*, Oat, Pharmacology, Chemical constituents.

INTRODUCTION

For the past decades, there has been an increasing interest in the investigation of different extract obtained from plants for nutritional and therapeutic purposes.*Avena sativa* is a rich source of protein, minerals, lipids, β-glucan, avenanthramides, indole alkaloid, flavonoids, triterpenoidsaponins, lipids and sterols. It exerted many pharmacological effects including antioxidant, anti-inflammatory, dermatological, immunomodulatory, antidiabetic, gastrointestinal, hypolipidemic, neurological, cardiovascular and many other biological activities.

Synonym

Avena ativa var. abyssinica (Hochst.) Körn. *Avena sativa* var. abyssinica (Hochst. ex A. Rich.) Engl., *Avena sativa* var. barbata (Pott ex Link) Fiori, *Avena sativa* var. biaristata Hack. Ex Trab., ena ativa var. biaristata Alef., *Avena sativa* var. brachytricha (Thell.) Tzvelev, *Avena ativa* var. braunii Körn., *Avena sativa* var. brevis (Roth) Fiori, *Avena sativa* subsp. byzantina (K. Koch) Romero Zarco, *Avena sativa* subsp. chinensis (Fisch. ex Roem. &Schult.) Holub,*Avena sativa* var. chinensis Döll,*Avena sativa* var. chinensis Vilm., *Avena sativa* var. Cinerea Körn., *Avena sativa* var. cinerea (Körn.) Vascon., *Avena sativa* subsp. Contracta (Neilr.) Celak., *Avena sativa* var. contracta Neilr., *Avena sativa* subsp. fatua (L.) Fiori, *Avena sativa* var. diffusa Neilr., *Avena sativa* var. fatua (L) Fiori, *Avena sativa* var. fatua (L) Fiori,*Avena sativa* subsp. fatua (L.) Thell., *Avena sativa* var. flavescens (Peterm.) Soó., *Avena sativa* var. fuscoatra (Peterm.) Soó,Avena sativa var. glaberrima (Thell.) Maire & Weiller, *Avena sativa* var. Glaberrima (Thell.) Parodi, *Avena sativa* var. hildebrandtii Körn., *Avena sativa* var. Hispanica (Ard.)Steud., *Avena sativa* var. kazanensis Vavilov, *Avena sativa* var. Leiantha (Malzev) E. Morren, Avena sativa var. ludoviciana (Durieu) Fiori, *Avena sativa* subsp. macrantha (Hack.) Rocha Afonso, *Avena sativa* var. macrantha Hack.,

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Avena sativa subsp. macrantha Mordv., *Avena sativa var. macrathera* (Thell.) Parodi, *Avena sativa var. macrotricha* (Malzev) Tzvelev, *Avena sativa var. Macrotricha* (Malzev) E. Morren, *Avena sativa var. microtricha* (Malzev) Tzvelev, *Avena sativa var. nigra* E. Krause, *Avena sativa var. nigra* Alph. Wood, *Avena sativa var. nigra* Prov., *Avena sativa subsp. nodipilosa* (Malzev) Vasc., *Avena sativa subsp. nuda* (L.) Gillet & Magne, *Avena sativa var. nuda* (L.) Körn., *Avena sativa subsp. orientalis* (Schreb.) Asch. &Graebn., *Avena sativa subsp. orientalis* (Schreb.) Asch. &Graebn., *Avena sativa var. orientalis* (Schreb.) Alef., *Avena sativa subsp. orientalis* Jessen, *Avena sativa var. pilifera* (Malzev) Tzvelev, *Avena sativa var. pilosa* (Koeler) Tab. Morais, *Avena sativa* subsp. Praegravis (E.L.Krause) Tab.Morais, *Avena sativa subsp. praegravis* (E.L.Krause) Tab.Morais, *Avena sativa subsp. praegravis* (E.L.Krause) Cif. &Giacom., *Avena sativa var. praegravis* E. Krause, *Avena sativa subsp. praegravis* (Krause) Mordv., *Avena sativa var. schimperi* Körn., *Avena sativa var. secunda* Alph.Wood, *Avena sativa var. sericea* Hook.f., *Avena sativa var. setulosa* (Thell.) Parodi, *Avena sativa subsp. sterilis* (L.) De Wet, *Avena sativa var. sterilis* (L.) Fiori, *Avena sativa var. strigosa* (Schreb.) Bonnier & Layens, *Avena sativa var. strigosa* (Schreb.) Fiori, *Avena sativa var. subpilosa* (Thell.) E. Morren, *Avena sativa var. subuniflora* (Trab.) Tzvelev, *Avena sativa var. subuniflora* (Trab.) Thell, *Avena sativa var. Trichophylla* (K.Koch) Griseb., *Avena sativa var. volgensis* Vavilov [1].

Commonnames

Arabic: Shofan, doser, qurtman, khafour, khertal; **English:** Oat, cereal oatand commonoat; **French:** Oats and avoine; **German:** Hafer; **Italian and Spanish**: Avena [1-4].

Taxonomic classification

Kingdom: Plantae
Subkingdom: Tracheobionta
Superdivision: Spermatophyta
Division: Magnoliophyta
Class: Liliopsida
Subclass: Commelinidae
Order: Cyperales
Family: Poaceae
Genus: Avena
Species: *Avena sativa*[5-6].

Description

It is erect tufted annual grass, to 1.2 m tall; culms smooth or scabrous beneath the panicle; leaves 15–30 cm long, 0.6–1.2 cm wide, sheaths long and loose; panicle terminal, 15–30 cm long; spikelets usually 2-flowered, to 2.5 cm long, slender-pedicelled; glumes, several-nerved; lemma glabrous, teeth acute, dorsal awn absent or 1 to a floret, short; kernel 0.6–0.8 cm long, narrow, with nearly parallel sides, hairy, grooved lengthwise on the face,tightly enclosed (in inrolled lemma which also covers the palea on the front [7].

Distribution

Oat has been cultivated for over 5000 years. Oats are the fourth most important crop worldwide.Oat producer's countries (Million metric tons) were: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, and Ukraine 0.8 - 24.6 [2]**.**

Traditional uses

It was used as cardiac and nerve tonic, for spermatorrhoea, palpitation, sleeplessness, antispasmodic, for diarrhoea, dysentery, and colitis. It was also used as thymoleptic, antidepressant and externally as emollient [8].

Part used

Fresh milky seed was used for medicine. The mature seed is eaten as food.

Chemical constituents

Whole oat groat contained high amounts of valuable nutrients such as soluble fibers, proteins, unsaturated fatty acids, vitamins, minerals, and other phytochemicals.Each 100g of oat groat contained 17.1% protein, 67.9% carbohydrates, 8.6% fat, 15-22% dietary fiber, 10.4% β-glucan, 1.3 mg niacin, 171 mg magnesium, 0.17 mg copper, 441 mg potassium and α- tocopherol less than 0.5 mg [9-11]. Silicon dioxide (2%) occurs in the leaves and in the straw in soluble form as esters of silicic acid. Oat straw contained a high iron (39 mg/kg dry weight), manganese (8.5 mg) and zinc (19.2 mg) [8]. However, *Avena sativa* seeds were also rich in body-building nutrients including silicon, manganese, zinc, calcium, phosphorus and vitamins A, B1, B2 and E. [12].

Oat β-glucan was a soluble fiber and viscous polysaccharide made up of units of the monosaccharide D-glucose. The bonds between the D-glucose and D-gluco-pyranosyl units are β1, 3 linkages or β 1, 4 linkages. The (1→3)-linkages break up the uniform structure of the βD-glucan molecule and make it soluble and flexible. In comparison, the oat indigestible polysaccharide cellulose is insoluble. The reason for insolubility is that cellulose consists only of (1→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% [13].

Soluble oligo- and polysaccharides including saccharose, kestose, neokestose, bifurcose, beta- glucans, galactoarabinoxylans, were isolated from *Avena sativa*. It also contained silicic acid, steroid saponins (avenacoside A and B), unusual amino acids (avenic acid A and B), sterols (beta-sitosterol, delta-5-avenasterol), fatty oil and flavonoids [14].

Oat contained 196.1 ug/g polyphenols, 83.5 mg/100g anthocyanins, 17.7 mg /100g flavonoids and 34.6% β-Carotene [9]. Several classes of compounds with antioxidant activity have been identified in oats (*Avena sativa*), including vitamin E, flavonoids, and nonflavonoid phenolic acids [15].

Flavonoids isolated from oat plants (leaves, stems, inflorescences) were included apigenin type flavones: C-glycosyl-apigenins, isovitexin and its 2″-O-arabinoside, 2″-O-glycosides of vitexin and di-C-glucosyl-apigenin; luteolin type: 6-C-glucosyl-luteolin (isoorientin), its 2″-O-glycosides, isoorientin-7-O-glucoside and isoscoparin, 6-C-glucosyl-chrysoeriol and tricin type flavones: appear both as free aglycone and as tricin-4′- and/or -7-O-glycosides [14,16].

Three Avenanthramides compounds were isolated from *Avena sativa* seeds. Spectroscopic analyses suggested that they were amides of 4,5-dihydroxyanthranilic acid with caffeic, p-coumaric, and ferulic acids, respectively [17].

A protein fraction rich in Cys/Gly residues was extracted from oat *Avena sativa* seeds. Quantitative amino acid analysis indicated that it contained a series of heterogeneous Cys/Gly-rich proteins with molecular masses of 3.6-4.0 kDa. From this fraction, a new polypeptide, designated (avesin A), was purified and sequenced by Edman degradation. Avesin A consists of 37 amino-acid residues, with 10 glycine residues and eight cysteine residues forming disulfide bridges, and contained a single chitin-binding domain, which indicated that avesin A is a new member of the putative chitin-binding proteins [18].

PHARMACOLOGICAL EFFECTS

Antioxidant effect

Oats (*Avena sativa* L.), contained many antioxidants (vitamin E, flavonoids, and nonflavonoid phenolic acids). Handelman *et al.*, tested the antioxidant activity of oat. They found that phenolic-rich fractions of oats possessed an antioxidant capacity and the greatest degree of antioxidant capacity was associated with compounds extracted with methanol [15].

The antioxidative potential of an oat by-product was compared with the effect of vitamin E on the oxidative stability of pork from pigs fed a diet enriched with linseed oil. The oat by-product, comprising oat hulls and bran, was used at 10 and 20% in the grower and finisher diets, respectively. Diets with the oat by-product increased serum alpha-tocopherol concentration ($p < 0.01$) and decreased the thiobarbituric acid reactive substance (TBARS) levels in the fresh and stored longissimusdorsi muscle ($p<0.05$), without increasing muscle alpha-tocopherol concentration. The obtained results indicate that the phenolic compounds present in oat by-products have a considerable antioxidant potential and a beneficial effect on the pig organism and oxidative stability of meat. However, dietary inclusion with the oat by-product was not as efficient as supplementation with vitamin E [19].

Three Avenanthramides compounds were isolated from *Avena sativa* seeds. Spectroscopic analyses suggested that they are amides of 4,5-dihydroxyanthranilic acid with caffeic, p-coumaric, and ferulic acids, respectively. These compounds showed stronger 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical-scavenging activity than the corresponding avenanthramides with 5-hydroxyanthranilic acid, indicating the involvement of 4,5-dihydroxyanthranilic acid moiety in the scavenging of DPPH radicals [17].

The antioxidant activities from whole oat groats of seven common varieties were evaluated. All oat varieties had very similar oxygen radical absorption capacity compared with other whole grains. Avenanthramide levels did not correlate with the observed antioxidant activities [20].

The protective effect of oat bran extract was evaluated on human dermal fibroblast injury induced by hydrogen peroxide (H_2O_2). Assays for 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging activity indicate that oat peptide-rich extract has a direct and concentration-dependent antioxidant activity. 3-(4,5-Dimethylthiazol-2-yl)-2,5-diphenyl tetrazolium bromide (MTT) colorimetric assay and the TdT-mediated digoxigenin-dUTP nick-end labeling (TUNEL) assay for apoptosis showed that administration of H_2O_2 in human dermal fibroblasts caused cell damage and apoptosis. Pre-incubation of human dermal fibroblasts with the oat for 24 h markedly inhibited human dermal fibroblast injury induced by H_2O_2, but application of oat peptides with H_2O_2 at same time did not. Pre-treatment of human dermal fibroblasts with oat significantly reversed the H_2O_2-induced decrease of superoxide dismutase (SOD) and the inhibition of malondialdehyde (MDA). The results demonstrate that oat peptides possess antioxidant activity and were effective against H_2O_2- induced human dermal fibroblast injury by the enhaning activity of SOD and decreasing MDA level. The results suggest that oat bran have the potential to prevent aging-related skin injury [21].

The efficiency of oats oil (6 g per kg bw) to alleviate oxidative damage of testis induced by deltamethrin (DEL), which is a pyrethroid pesticide that exerts a wide range of effects on non-targeted organisms, was studied . Exposure to deltamethrin at a dose of 5 mg per kg bw per day caused oxidative stress in testis, proven

by a decrease in the epididymal sperm count and motility, an increase in the number of abnormal morphologies in spermatozoa and a significant increase of lipid peroxidation (LP) in the testis when compared to control animals. Co-administration of oats oil to the DEL-treated mice ameliorated the testicular biochemical parameters as well as the histological impairments in testis [22].

Hyolipidemic effects

Oat β-glucan exerted cholesterol-lowering properties. The consumption of oat meal and oat bran reduced total plasma cholesterol and LDL-cholesterol levels. This effect attributed to β-glucan, it interfered with the reabsorption of bile acid in the gut and reduces cholesterol levels The oat bran has been found to be the fiber source that significantly lowered total and low density-lipoprotein cholesterol levels in mild hypercholesterolemics [23].

C57BL/6 NCrl mice responded to oat bran with 19 ± 1 % ($P < 0.001$) lower plasma cholesterol, 40 ± 5% ($P < 0.01$) higher excretion of bile acids and increased expression of the bile acid-producing hepatic enzymes CYP7A1 and CYP8B1, but none of these effects were found in C57BL/6JBomTac mice. However, on control diet, C57BL/6JBomTac had tenfold higher expression of CYP7A1 and levels of hepatic cholesterol esters than C57BL/6NCrl mice [24].

The United States Food and Drug Administration (FDA) approved a health claim for β-glucan soluble fiber from oats for reducing plasma cholesterol levels and risk of heart disease in 1997. Similarly, in 2004 the United Kingdom Joint Health Claims Initiative (JHCI) allowed a cholesterol-lowering health claim for oat β-glucan. Studies conducted during the past 13 years support the suggestion that intake of oat β-glucan at daily doses, of at least 3 g, reduced plasma total and low-density lipoprotein (LDL) cholesterol levels by 5-10% in normocholesterolemic or hypercholesterolemic subjects. Studies also showed that oat consumption is associated with 5% reductions in total cholesterol levels [25].

The effect of oat consumption on serum lipid profiles was studied in Thai hypercholesterolemic adults. Following daily oat consumption, total cholesterol and LDL-cholesterol levels were significantly lower than baseline levels and lower than the levels observed with rice consumption. Oat consumption reduced total cholesterol by 5% and LDL-cholesterol by 10% from baseline levels. In addition, mean and percent changes were significantly different from the levels after consuming rice porridge ($p < 0.05$) [26].

Cardiovascular effect

In addition to its cholesterol lowering effect, it improved the blood pressure when consumed with vitamin C, improved endothelial function and exerted angiotensine converting enzyme inhibition. According to these results, the United States Food and Drug Administration in 1997 approved the heart-health benefit of food containing soluble fiber from oats [19,24-25].

Katz *et al*., reported that a single serving of oatmeal opposed the disturbances in endothelial function observed after the consumption of a high fat meal [27].

In overweight patients, beta glucan from oats has been shown to decrease hypertension. Avenanthramide is an oat polyphenol that has been shown to enhance production of nitric oxide, a potent vasodilator, and to inhibit thickening of vascular smooth muscle. Both actions are preventative for developing of atherosclerosis[28-29].

Anti- obesity effect

A clinical trial was carried out to confirm the anti-obesity effect of oat. Subjects with BMI ≥27 and aged 18-65, were randomly divided into a control and an oat-treated group, taking a placebo or beta glucan-containing oat cereal, respectively, for 12 weeks. The result showed that consumption of oat reduced body weight, BMI, body fat and the waist-to-hip ratio. Profiles of hepatic function, including AST and ALT showed decrements in patients with oat consumption. Nevertheless, anatomic changes were not observed by ultrasonic image analysis. Ingestion of oat was well tolerated and there was no adverse effect during the trial [30].

To explored the dose-dependent effect of oat cereal β-glucan on improving metabolic indexes of obesity mice, C57-Bl mice were randomized to chow diet (N) group and high fat diet group and other three doses of oat β-glucan groups (low β-glucan, medium β-glucan, and high β-glucan). Energy intake, glucose, lipids, and appetite related hormones were tested. Dose-dependent relation was observed on oat β-glucan doses and body weight change, average energy intake, total cholesterol, HDL cholesterol, plasma neural peptide Y, arcuate neural peptide Y mRNA, and arcuate neural peptide Y receptor 2 mRNA level. Oat β-glucan helped to increase plasma peptide Y-Y and intestine peptide Y-Y expression in obesity mice [31].

Antidiabetic effect

The treatment with *Avenasativa* increased insulin activity and improved sensitivity for normalizing blood glucose level and reduce glucose production by the liver [32]. The glycaemic and insulinaemic response to oat bread, oat bread with lingonberryfibre, oat-buckwheat bread and buckwheat porridge were tested in a small-scale clinical study (KHSHP E514/09). Nine healthy volunteers consumed test foods after overnight fasting. From samples taken at seven time points during 120 min. The mean glycaemic and C-peptide indexes (C-pepIs) were 32 and 100 for oat bread, 47 and 119 for oat-lingonberryfibre

bread, 58 and 105 for oat-buckwheat bread and 71 and 77 for buckwheat porridge [33].

Oat and barley foods have been shown to reduce human glycaemic response, compared to similar wheat foods or a glucose control. Regression analysis on 119 treatments indicated that change in glycaemic response (expressed as incremental area under the post-prandial blood-glucose curve) was greater for intact grains than for processed foods. For processed foods, glycaemic response was more strongly related to the β-glucan dose alone ($r(2)=0.48$, $P<0.0001$) than to the ratio of β-glucan to the available carbohydrate ($r(2)=0.25$, $P<0.0001$). For processed foods containing 4 g of β-glucan, the linear model predicted a decrease in glycaemic response of 27 ± 3 mmol/min/l. Thus, intact grains as well as a variety of processed oat and barley foods containing at least 4 g of β-glucan and 30-80 g available carbohydrate can significantly reduce post-prandial blood glucose [34].

Antimicrobial effects

The 70% ethanolic extract of the *Avena sativa* exerted antibacterial activity against gram positive bacteria (*Staphylococcus aureus*), and gram negativebacteria (*E. coli, Proteus vulgaris, Pseudomonas aerugiuosa*, and *Klebsiella*). The extract also exerted antifungal activity against *A. niger*, and *Candida* [32]. A protein fraction rich in Cys/Gly residues extracted from oat (*Avena sativa*) seeds possessed weak to moderate antifungal properties to some fungal strains [18].

Dermatological effects

Oatmeal preparations were effective on a variety of dermatologic inflammatory diseases such as pruritus, atopic dermatitis, acneiform eruptions, and viral infections. Additionally, oatmeal plays a role in cosmetics preparations and skin protection against ultraviolet rays [35].

The dried seeds was used to make a decoction to relieve the symptoms of eczema, the soothing emollient activity of the seeds decreased itching and nourished the skin.Oat colloidal extract containing avenanthramides has also proved to have antihistamine and anti-irritation activity [36-38].

MTT, Dimethylthiazol-2-yl)-2,5-diphenyl tetrazolium bromide colorimetric assay and the TdT-mediated digoxigenin-dUTP nick-end labeling (TUNEL) assay for apoptosis showed that administration of H_2O_2 in human dermal fibroblasts caused cell damage and apoptosis. Pre-incubation of human dermal fibroblasts with the oat for 24 h markedly inhibited human dermal fibroblast injury induced by H_2O_2. The results suggest that oat bran have the potential to prevent aging-related skin injury [39].

Avenanthramides have been reported to exhibit anti-inflammatory activity in the skin. Avenanthramides at concentrations as low as 1 parts per billion inhibited the degradation of inhibitor of nuclear factor kappa B-alpha (IkappaB-alpha) in keratinocytes which correlated with decreased phosphorylation of p65 subunit of nuclear factor kappa B (NF-kappaB). Furthermore, cells treated with avenanthramides showed a significant inhibition of tumor necrosis factor-alpha (TNF-alpha) induced NF-kappaB luciferase activity and subsequent reduction of interleukin-8 (IL-8) release [38].

Central nervous effects

An extract of wild green oat (*Avenasativa*) was tested in rats for its behavioural effects after chronic oral administration via extract-admixed food. Rats received 10 and 100 g/kg extract-admixed food showed slight decreased food and fluid intake in the high dose group, with no side effects observed during the treatment. The low dose led to an improvement of active stress response, an enhancement of shock avoidance learning and an increased synchrony in social behavior [40].

Dietary oat β-glucan enhanced the endurance capacity of rats and facilitated their recovery from stress and fatigue. Sparsgue-Dawley rats, fed with/without oat β-glucan 312.5 mg/ kg/day for 7 weeks, were subjected to run on a treadmill system to make them exhausted. All rats were immediately sacrificed after prolonged exercise, and the major metabolic substrates were measured in serum and liver. Feeding dietary oat β-glucan to rats significantly reduced the body weight and increased the maximum running time compared with normal control ($P<0.05$). Furthermore, dietary oat β-glucan decreased the levels of blood urea nitrogen, lactate acid, and creatine kinase activity in serum, and increased the levels of non-esterified fatty acids, lactic dehydrogenase activity in serum, and the content of liver glycogen [41].

Avenasativa improved overall mental fitness and supported cognitive performance in stressful situations. *Avenasativa* has been shown to positively affect the activity of brain enzymes closely related to mental health and cognitive function *in vitro*. Additionally, preclinical and clinical studies have confirmed that *Avena sativa* specifically interacted with brain structures and neurotransmitters implicated in cognition, memory and motivation.*Avena sativa* boasted a dual activity profile on monoamino oxidase-B (MAO-B*)* and phosphodiestrase 4 (PDE4)thus displayed in its ability to meditate a strengthening and balancing effect on the brain and mind [13].

The dried seeds and fresh plant exerted antidepressant activity, and it was useful where lowered mood is associated with anxiety and nervous exhaustion, especially during menopause. The fresh plant is a tonic remedy for all types of nervous debility, and can help to improve sleep duration and quality where the person is literally too tired to sleep [12]. A dose of 1600 mg of oat herb extract acutely improve attention and concentration and the ability to maintain task focus in older adults with

differing levels of cognitive status [42]. However, the aqueous extract prepared from the tincture did not affect the seizure threshold to bemegride or nicotine or the sleeping time induced by barbitone sodium [14].

For smokers and opium addicts

The biological effects of *Avenasativa* have been investigated in laboratory animals following a report that tincture of *Avenasativa* reduced the craving for cigarettes in man. On the other hand, when the tincture evaporated to dryness, re-constituted in an equal volume of water and administered by stomach tube or intraperitoneal injection, it antagonized the antinociceptive effect of morphine in two separate test (hot-plate and tail flick). Compared with animals made dependent on morphine, mice pretreated with repeated injections of morphine plus extract passed a smaller number of stools and tended to jump less after administration of nalorphine [43].

An alcoholic extract of green oats was tried on opium human addicts. Six chronic opium addicts gave up opium completely, two reduced their intake and two showed no change following regular use of 2 ml three times daily. A significant diminishment of the number of cigarettes used by habitual tobacco smokers resulted from using 1 ml (four times daily) offresh *Avena sativa* alcoholic extract of mature plants [8].

The pressor response to intravenously administered nicotine in urethane-anaesthetized rats was also antagonized by prior administration of *Avena sativa* [14]. An alcoholic extract of common oats (*Avena sativa*) has been reported to reduce both the craving for, and the number of, cigarettes smoked per day [44]. Hundred non-hospitalized smokers with an average consumption of 20 cigarettes per day were treated with an alcoholic extract of *Avenasativa*. There was difference of disaccustoming between light and heavy smokers. The rate of disaccustoming was higher for light smokers than for smokers with a high consumption of cigarettes [45].

Gastrointestinal effects

Two broiler experiments with almost identical basal diets were conducted to investigate the effect of dietary oat hulls, access to litter and the antimicrobial compound narasin on gizzard erosion and ulceration syndrome (GEU). The effects on particle size of duodenal digesta, ileal starch concentration, caecal *Clostridium perfringens* counts, necrotic enteritis and production performance were also examined. Oat hulls reduced GEU severity and starch levels in the ileum in both experiments. Access to litter reduced GEU scores when oat hulls were included in the feed. Access to litter also improved feed efficiency and reduced *C. perfringens* counts. Oat hulls were associated with improved feed efficiency in Experiment 1 and impaired feed efficiency in Experiment 2. The inconsistent effect of oat hulls on production performance appeared to be related to an association between oat hulls and high *C. perfringens* counts in Experiment 2; an association that was absent in Experiment 1. In general, oat hulls interacted with litter access and narasin in exerting a positive effect on gizzard health. However, the association between oat hulls and necrotic enteritis detected in Experiment 2 suggests that the positive effect of oat hulls on GEU occasionally may be outweighed by a negative effect on gut health [46].

The potential inhibitory effects of oat β-glucan (1%, 5%, or 10%) added to a specific pathogen-free diet was investigated in Nonalcoholic steatohepatitis (NASH) induced in mice by intraperitoneally injected lipopolysaccharide (LPS). Intraperitoneal injection of LPS for 6 weeks increased serum LPS levels; decreased serum glucagon-like peptide-2 levels; triggered abnormal aminotransferase activity, glucose intolerance, and insulin resistance; and increased hepatic proinflammatory cytokines (tumor necrosis factor-α, interleukin-6, interleukin-1β), triglyceride, and malonyldialdehyde levels; but reduced hepatic superoxide dismutase activity. Histologic evaluation revealed evidence of hepatic steatosis, inflammation, and mild necrosis in LPS-treated mice. Dietary supplementation of oat β-glucan prevented most of the LPS-induced metabolic disorders, and improved hepatic steatosis and inflammation, although a dose-dependent effect was not observed [47].

Three major oat components, β-glucan, starch, and protein, and their interactions were evaluated for the impact on viscosity of heated oat slurries and *in vitro* bile acid binding. Oat flour from the experimental oat line "N979" (7.45% β-glucan) was mixed with water and heated to make oat slurry. Heated oat slurries were treated with α-amylase, lichenase, and/or proteinase to remove starch, β-glucan, and/or protein. Oat slurries treated with lichenase or lichenase combined with α-amylase and/or proteinase reduced the molecular weight of β-glucan. Heat and enzymatic treatment of oat slurries reduced the peak and final viscosities compared with the control. The control bound the least amount of bile acids ($p<0.05$); heating of oat flour improved the binding. Heated oat slurries treated with lichenase or lichenase combined with α-amylase and/or proteinase bound the least amount of bile acid, indicating the contribution of β-glucan to binding. Oat slurries treated with proteinase or proteinase and α-amylase together improved the bile acid binding, indicating the possible contribution of protein to binding [48].

Oats have been shown to absorb intestinal toxins and increase excretion of intestinal toxins. The combination of taurine and oat were investigate on endotoxin release in a rat liver ischemia/reperfusion model. The results showed that the combination of taurine (300mg/kg/ day) and oat fiber (15g/kg/ day) significantly reduced endotoxin levels in the portal vein by 36.3% when compared to the control group (0.168±0.035Eu/ml in the treatment group vs 0.264±0.058Eu/ml in the control

group, P<0.01). The treatment by taurine and oat fiber induced 21.5% and 18.4% reduction in endotoxin levels respectively, when compared to the control group (P<0.05) [49]. Oat bran has been proposed as a dietary treatment for ulcerative colitis and has been shown to increase endogenous butyrate production and provide symptomatic relief of abdominal pain [50].

Immunological and anti-inflammatory effects

β- glucan helped neutrophils to reach the site of infection more rapidly and enhanced their ability to eliminate the bacteria [51].

The different immunological aspects of β-glucans derived from different food sources (oat, barley and shiitake) was examined on phorbolmyristate acetate (PMA)-differentiated THP-1 macrophages. Inflammation-related gene expression kinetics (IL-1β, IL-8, nuclear factor kappa B [NF-κB] and IL-10) were evaluated after 3, 6 and 24 h of stimulation with 100 μg/ml β-glucan. All tested β-glucans were mildly up-regulated the observed inflammation-related genes with differential gene expression patterns. Similar gene expression kinetics, but different fold induction values, was found for the crude β-glucan extracts and their corresponding commercial forms. Pre-incubation of THP-1 macrophages with β-glucans prior to lipopolysaccharide (LPS) exposure decreased the induction of inflammation-related genes compared to LPS treatment. No production of nitric oxide (NO) and hydrogen peroxide was detected in β-glucan stimulated THP-1 macrophages. Phagocytic activity was not differ after stimulation by β-glucan samples. Based on these *in vitro* analyses, β-glucans have varying levels of immunomodulating properties, which are likely related to structure, molecular weight and compositional characteristic of β-glucan [52].

The anti-inflammatory activities from whole oat groats of seven common varieties were evaluated. Oat variety CDC Dancer inhibited tumor necrosis factor-α induced nuclear factor-kappa B activation by 27.5% at 2 mg/ml, whereas, variety Deiter showed 13.7% inhibition at a comparable dose. Avenanthramide levels did not correlate with the observed anti-inflammatory activities[20].

Avenanthramides have been reported to exhibit anti-inflammatory activity on the skin. Keratinocytes treated with avenanthramides showed a significant inhibition of tumor necrosis factor-alpha (TNF-alpha) induced NF-kappa B luciferase activity and subsequent reduction of interleukin-8 (IL-8) release [38].

Other pharmacological effects

In an experimental study, oat straw stimulated the release of luteinizing hormone from the adenohypophysis of rats [8].*Avenasativa* containedoestrone which been shown to induce ovulation[53-55].

Contraindications and side effects

No health hazards or side effects are known in conjunction with the proper administration of designated therapeutic dosages. Oat bran products should be taken with large amounts of water to assure that the fiber is well dispersed in the bowel. It was contraindicated in patients with coeliac disease and intestinal obstruction. The side effects of the herb were included flatulence and anal irritation [14, 56].

Dosage

The herb was used in combination therapy, as a tea for internal use. To make a tea, 3 gm of the plant was boiled in 250 ml water, which was strained after cooling. The tea is taken repeatedly throughout the day and shortly before going to bed[14].

CONCLUSION

The paper reviewed *Avena sativa* for its nutritional and therapeutic potentials. It is a promising medicinal plant with wide range of pharmacological activities which could be utilized in several medical applications because of its effectiveness and safety.

REFERENCES

1. The plant list, a working list of all plant species, http://www.theplantlist.org/tpl/search?q=*Avena sativa*
2. Chatueved N, Yadav CS and Shukla K. Diversified therapeutic potential of *Avenasativa*: An exhaustive review. Pelagia Research Library. *Asian Journal of Plant Science and Research*, 1(3), 2011, 103-114.
3. USDA, ARS, National Genetic Resources Program. Germplasm Resources Information Network - (GRIN) [Online Database]. National Germplasm Resources Laboratory, Beltsville, Maryland,http://www.ars-grin.gov2/cgi-bin/npgs/html/taxon. pl? 6123 [14 April 2006].
4. Wisconsin Botanical Information System. *Avena sativa* L. Wisconsin State Herbarium - University of Wisconsin-Madison [14/4/2006].
5. USDA, NRCS. The Plants Database, 6 March 2006. National Plant Data Center, Baton Rouge, LA 70874-4490 USA 2006.
6. Gramene, Avina, Oat taxonomy, http://archive.gramene.org/species/avena/oat_ taxonomy.html, 2006.
7. James AD. Handbook of Energy Crops. 1983.
8. Khare CP. Indian medicinal plants- An illustrated dictionary. Springer Science and Business Media, LLC. 2007: 74.

9. Czerwinski J, Bartnikowska E, Leontowicz H, Lange E, Leontowicz M, Katrich E, Trakhtenberg S and Gorinstein S. Oat (*Avenasativa* L.) and amaranth (*Amaranthus hypochondriacus*) meals positively affect plasma lipid profile in rats fed cholesterol containing diets. *Journal of Nutritional Biochemistry*, 15, 2004, 622-629.
10. Welch R, Brown J and Leggett J. Interspecific and intraspecific variation in grain and groat characteristics of wild (Avena) species: very high groat (1→3) (1→4)- β-D-glucan in an *Avina atlantica* genotype. *J Cereal Sci*, 31(3), 2002, 273-279.
11. Saunders RM. Rice bran: composition and potential food uses. *Food Rev Int*, 1(3), 1985, 465–495.
12. Dr. Boxall's Products containing SceletiumTortuosum with *Avenasativa*.www.drboxalls.com
13. Vetvicka V, Dvorak B, Vetvickova J, Richter J, Krizan J, Sima PY and Vin JC. Orally administered marne (1→3)- β-glucanphycarine stimulates both humoral and cellular immunity. *Int J of Biol Macromolecules*, 40(4), 2007, 291-298.
14. PDR for herbal medicines. 4th ed. Montvale (NJ): Thomson Healthcare Inc, 2000, 551-553.
15. Handelman GJ, Gao G, Walter MF, Nightingale ZA, Paul GL, Prior RL and Blumberg JB. Antioxidant capacity of oat (*Avenasativa* L.) extracts 1. Inhibition of low-density lipoprotein oxidation and oxygen radical absorbance capacity. *J Agric Food Chem*, 47, 1999, 4888–4893.
16. Gheorghe P, Gottfried W, Marie-Louise BG and Jean Chopin. Isolation and Characterization of flavonoids from *Avena sativa* L. *ZeitschriftfürPflanzenphysiologie*, 85 (2), 1977, 103-115.
17. Ishihara A, Kojima K, Fujita T, Yamamoto Y and Nakajima H. New series of avenanthramides in oat seed.*BiosciBiotechnolBiochem*, 13, 2014, 1-9.
18. Li SS and Claeson P. Cys/Gly-rich proteins with a putative single chitin-binding domain from oat (*Avena sativa*) seeds. *Phytochemistry*, 63(3), 2003, 249-255.
19. Sobotka W, Flis M, Antoszkiewicz Z, Lipiński K and Zduńczyk Z. Effect of oat by-product antioxidants and vitamin E on the oxidative stability of pork from pigs fed diets supplemented with linseed oil. *Arch AnimNutr*, 66(1), 2012, 27-38.
20. Chu YF, Wise ML, Gulvady AA, Chang T, Kendra DF, Jan-Willem van Klinken B, Shi Y and O'Shea M. *In vitro* antioxidant capacity and anti-inflammatory activity of seven common oats. *Food Chem*, 139(1-4), 2013, 426-431.
21. Feng B, Ma LJ, Yao JJ, Fang Y, Mei YA and Wei SM. Protective effect of oat bran extracts on human dermal fibroblast injury induced by hydrogen peroxide. J Zhejiang UnivSci B 2013; 14(2), 2013, 97-105.
22. Ben Halima N, Ben Slima A, Moalla I, Fetoui H, Pichon C, Gdoura R and Abdelkafi S.Protective effects of oat oil on deltamethrin-induced reprotoxicity in male mice.*Food Funct*, 5(9), 2014, 2070-2077.
23. Saltzman E, Das SK and Lichtenstein AH. An oat-containing hypocaloric diet reduces systolic blood pressure and improves lipid profile beyond effects of weight loss in men and women. *J Nutr*, 131, 2001, 1465-1470.
24. Andersson KE, Axling U, Xu J, Swärd K, Ahrné S, Molin G, Holm C and Hellstrand P. Diverse effects of oats on cholesterol metabolism in C57BL/6 mice correlate with expression of hepatic bile acid-producing enzymes. *Eur J Nutr*, 52(7), 2013, 1755-1769.
25. Othman RA, Moghadasian MH and Jones PJ. Cholesterol-lowering effects of oat β-glucan. *Nutr Rev*, 69(6), 2011, 299-309.
26. Thongoun P, Pavadhgul P, Bumrungpert A, Satitvipawee P, Harjani Y and Kurilich A. Effect of oat consumption on lipid profiles in hypercholesterolemic adults. J Med Assoc Thai 2013; 96 (Suppl 5), 2013, S25-S32.
27. Katz DL, Nawaz H, Boukhalil J, Giannamore V, Chan W, Ahmadi R, and Sarrel PM. Acute effects of oats and vitamin E on endothelial responses to ingested fat. *Am J Prev Med*, 20, 2001, 124-129.
28. Maki KC, Galant R, Samuel P, Tesser J, Witchger MS, Ribaya-Mercado JD, Blumberg JB and Geohas J. Effects of consuming foods containing oat beta-glucan on blood pressure, carbohydrate metabolism and biomarkers of oxidative stress in men and women with elevated blood pressure. *Eur J ClinNutr*, 61(6), 2007, 786-795.
29. Nie L, Wise ML, Peterson DM and Meydani M. Avenanthramide, a polyphenol from oats, inhibits vascular smooth muscle cell proliferation and enhances nitric oxide production. *Atherosclerosis*, 186(2), 2006, 260-266 .
30. Chang HC, Huang CN, Yeh DM, Wang SJ, Peng CH and Wang CJ. Oat prevents obesity and abdominal fat distribution, and improves liver function in humans. *Plant Foods Hum Nutr*, 68(1), 2013, 18-23.
31. Lin N, Li Y, Tang L, Shi J and Chen Y. *In vivo* effect of oat cereal β-glucan on metabolic indexes and satiety-related hormones in diet-induced obesity C57-Bl mice. *MolNutr Food Res*, 57(7), 2013, 1291-1294.
32. Ahmed A, Al-Amiery H, Ali A, Al-Temimi RW, Abood H. A study of the biological activities of *Avena sativa* extracts. *Af J Pure Applied Chem*, 4, 2010, 31-34.
33. Rokka S, Ketoja E, Järvenpää E and Tahvonen R. The glycaemic and C-peptide responses of foods rich in dietary fibre from oat, buckwheat and lingonberry. *Int J Food SciNutr*, 64(5), 2013, 528-534.
34. Tosh SM. Review of human studies investigating the post-prandial blood-glucose lowering ability of oat and barley food products. *Eur J ClinNutr*, 67(4), 2013, 310-317.
35. Pazyar N, Yaghoobi R, Kazerouni A and Feily A. Oatmeal in dermatology: a brief review. *Indian J DermatolVenereolLeprol*, 78(2), 2012, 142-145.

36. Chevallier A. Herbal remedies. Dorling Kindersley Limited. London, New York, Melbourne, Munich and Delhi, 2007, 74.
37. Kurtz ES and Wallo W. Colloidal oatmeal: history, chemistry and clinical properties. *J Drugs Dermatol*, 6, 2008, 167-170.
38. Sur R, Nigam A and Grote D. Avenanthramides, polyphenols from oats, exhibit anti-inflammatory and anti-itch activity. *Arch Dermatol Res*, 300, 2008, 569-574.
39. Feng B, Ma LJ, Yao JJ, Fang Y, Mei YA and Wei SM. Protective effect of oat bran extracts on human dermal fibroblast injury induced by hydrogen peroxide. *J Zhejiang UnivSci B*, 14(2), 2013, 97-105.
40. Schellekens C, Perrinjaquet-Moccetti T, Wullschleger C and Heyne A. An extract from wild green oat improves rat behaviour. *Phytother Res*, 23(10), 2009, 1371-1377.
41. Xu C, Lv J, Lo YM, Cui SW, Hu X and Fan M. Effects of oat β-glucan on endurance exercise and its anti-fatigue properties in trained rats. *CarbohydrPolym*, 92(2), 2013, 1159-1165.
42. Berry NM, Robinson MJ, Bryan J, Buckley JD, Murphy KJ , and Howe PRC. Acute Effects of an *Avenasativa* herb extract on responses to the stroop color–word Test. *The Journal of Alternative and Complementary Medicine*, 17(7), 2011, 635-637.
43. Connor J, Connor T, Marshall PB, Reid A and Turnbull MJ. The pharmacology of *Avenasativa*. *J Pharm Pharmacol*, 27(2), 1975, 92-98.
44. Anand CL. Effect of *Avenasativa* on cigarette smoking. *Nature*, 233, 1971, 496.
45. Schmidt K and Geckeler K. Pharmacotherapy with *Avenasativa* - a double blind study.*Int J ClinPharmacolBiopharm*, 14(3), 1976, 214-216.
46. Kaldhusda M, Hetland H and Gjevre AG. Non-soluble fibres and narasin reduce spontaneous gizzard erosion and ulceration in broiler chickens. *Avian Pathol*, 41(2), 2012, 227-234.
47. You S, Hu X, Zhao Q, Chen X and Xu C. Oat β-glucaninhibitslipopoly saccharide-induced nonalcoholic steatohepatitis in mice. *Food Funct*, 4(9), 2013, 1360-1368.
48. Kim HJ and White PJ. Interactional effects of β-glucan, starch, and protein in heated oat slurries on viscosity and *in vitro* bile acid binding.*J Agric Food Chem*, 60(24), 2012, 6217-6222.
49. Wan XY, Luo M, Li XD, He P and Wu MC. Inhibitory effects of taurine and oat fiber on intestinal endotoxin release in rats. *ChemBiol Interact*, 184(3), 2010, 502-504.
50. Hallert C, Björck I, Nyman M, Pousette A, Grännö C and Svensson H. Increasing fecal butyrate in ulcerative colitis patients by diet: controlled pilot study. *Inflamm Bowel Dis*, 9(2), 2003, 116-121.
51. Mantovani MS, Bellini MF, Angeli JPF, Oliveira RJ, Silva AF and Ribeiro LR. β-glucan in promoting health: Prevention against mutation and cancer.*Mutat Res*, 658(3), 2008, 154-161.
52. Chanput W, Reitsma M, Kleinjans L, Mes JJ, Savelkoul HF and Wichers HJ. β-glucans are involved in immune-modulation of THP-1 macrophages.*MolNutr Food Res*, 56(5), 2012, 822-833.
53. Farnsworth NR and Cordell GA. A review of some biologically active compounds isolated from plants as reported in the 1974-75 literature. Lloydia, 39, 1976, 420-455.
54. Paris RR and Moyse H. Precis de Matiere Medicate, Masson etCie, Paris, II, 1967, 26.
55. Heftman E. Steroid hormones in higher plants. Insect molting hormones. *Lloydia*, 38, 1975, 195-209.
56. Braun L and Cohen M. Herbs and natural supplements: an evidence-based guide. 2nd ed. Marrickville (NSW), Debbie Lee, 2007.