Oats as a source of beta-glucan for cosmetic use

Joanna Harasym, PhD Eng. Study for Biovelim Private Limited Company 2016

Oatmeal beta-glucan

Oats is characterized by the documented history of safe use in dermatological problems. Comprehensive use in traditional medicine is due to its efficiency, availability and lack of toxicity. Dermatological preparations and oat-containing cosmetics have been shown to relieve itching and reduce redness and pain from minor skin irritations caused by plant burns (poisonous ivy /oak / sumak), insect bites or allergies (US FDA, 2003). There are worldwide reports on beneficial effects of this plant on a wide variety of ailments - traditional medicine in the Southern Appalachian region of the United States of America documents the efficacy of external use of oat with chickenpox (Cavender, 2006). Alcoholic macerate was used as anti-rheumatic and anti-neural remedy in traditional Lebanese medicine (El Beyrouthy, 2008) and on the cold lands of Ladakh desert on the Indian subcontinent as a drug against kidney and urinary system dysfunction (Ballabh et al., 2008).

The widespread acceptance of oats as a raw material for medicinal use in traditional medicine has increased the interest of scientists in this crop, resulting in number of studies on the effects of oatmeal extract on the organism and in particular on the skin.

Oat extracts show properties that prevent, among others, changes in the barrier function of the skin and vascular system that cause irritation.

Characteristics of interactions

Aries et al. (2005) investigated the effect of oatmeal gruel on the metabolism of arachidonic acid and expression of the cPLA2 protein in the human HaCaT keratinocyte cell line. The gruel was obtained from the oily and ground oat caryopsis, from which the flour after the turboselection process was used to make the colloidal suspension. 0.1% suspension solution showed significant ability to inhibit induced Acridonic Acid A23187 (calcicin) activation as well as its metabolites in both cyclooxygenase and 5-lipoxygenase pathways of 27, 30 and 29%, respectively. The study of protein cPLA2 expression in cells stimulated with A23187 and treated with oat-suspension showed highly significant reduction of 85% at the lowest dose of extract (0.01%) to 100% reduction at 0.05 and 0.1% doses. The authors continued the study using TNF-ß as a cPLA2 expression inducer to determine the effect of the extract in both physiological and more pathological environmental conditions. The results obtained were correlated with the previous, oatmeal gruel reduced the expression of cPLA2 protein induced by presence of TNF-β at 67%, 77% and 95%, for 0.01, 0.05 and 0.1% doses, respectively. It has also been established that gruel reduces expression of mRNA cPLA2 in a dose-dependent manner.

The anti-inflammatory effect of oatmeal extract has been determined in clinical trials in the irritation model induced by SLS sodium laurylsulfate (Vie et al., 2002). The extract was dosed on the Vaseline carrier, locally on the investigated areas of the internal part of the patients in the form of occlusion for 2 hours, followed by application

of 1% SLS solution for 24 hours. The inflammation of the tested skin was marked using a color measurment and evaluating the percentage of red colour as well as measuring the skin blood flow using a Doppler laser PF3. At a concentration of 20% oat grain extract significantly reduced the SLS-induced skin redness.

Oatmeal extract with addition of menthol has also been clinically researched in patients with pruritus and keratoconjunctivitis (Pacifico et al., 2005). Patients suffering from these conditions washed the affected areas with the fluid once a day for three weeks, and the efficacy and tolerability were assessed as changes in pH, hydration and skin appearance. After three weeks of treatment, there was a significant improvement in the condition of the skin changes and a decrease in ichiness observed in 96% of patients, and total regression of the skin changes was observed in 88.9%. Skin hydration increased by 36.9 and 46.7%, respectively, after one and three weeks, with simultaneous decrease in skin pH by -4% after one week and by -6.3% at the end of the study.

It is therefore clear that oat extracts show properties that prevent, inter alia, changes in barrier function of the skin and vascular system associated with irritation.

The beneficial effect of oat grains is related primarily to the presence of the key active substance - ß-glucan. Beta-glucans are polysaccharides composed of glucose monomers linked by glyosidic bonds. They are one of the types of valuable dietary fibre in cereals, mushrooms, yeast, some bacteria and seaweed. ß-glucans from different sources have different types of bonds (1-2, 1-3, 1-4, 1-6), chain length and different molecular weight, and what is most important from the perspective of cosmetic applications - diametrically different water solubility and thus different spectrum of impact.

ß-glucan is a linear polymer with an average of 70% of β-1-4 and 30% of β-1-3 bonds combining D-glucopyranosyl monomers (Johansson et al., 2004). For this reason, 1-3, 1-4-ß-D - glucan from oats is the most water-soluble ß-glucan. Because it is a part of the dietary fibre – its influence on application in food industry, and especially its immunomodulatory, anti-diabetic, anti-carcinogenic, cholesterol-lowering and structural activity dependence properties have already been described (Parzonko et al., 2015; Choromańska et al., 2015; Rieder et al. Volman et al., 2008; Chen and Raymond, 2008). The quality and credibility of these studies have been reviewed several times by the governments of different countries (FDA - USA, JP) as well as by the European Union bodies, resulting in granting of permits (also by the European Food Safety Authority - EFSA) on application of health claims on foods containing particular substance - in this case oat beta-glucan (authorization for two health claims for lowering blood cholesterol levels and reducing the post-meal sugar peak).

The ability to use ß-glucan from oats in cosmetics and dermatological products is, thus, firmly justified in the present state of knowledge. The effect of this polysaccharide on wound healing, skin aging and formation of wrinkles or moisturizing, antioxidant or reducing the UV radiation effects properties is significant.

Wound healing properties

Scientific studies indicate that oat ß-glucan is a film-forming, moisturizing biological response modifier and wound healing promoter. Wound healing is a complex process in which the skin (or other tissue) is repaired spontaneously after injury (Nguyen et al., 2009). The classic model of wound healing is divided into three phases: inflammation phase, proliferation phase and re-modeling phase (Stadlemann, 1998). Suggested effects of utilizing ß-glucan in wound healing are associated with transport of macrophages to the injured area of body (Browder et al., 1988), tissue granulation stimulation (Delatte et al., 2001), epithelialisation (Kougias et al., 2001) as well as improvement of collagen acculmulation (Portera et al., 1997). Some studies have shown that macrophages play a key role in improving wound healing in patients after injuries (Browder et al., 1988, 1990). The main task of macrophages is phagocytosis of bacteria and damaged tissue; macrophages remove damaged tissue by releasing proteases (Deodhar and Rana, 1997). Tissue graining involves formation of new blood vessels, fibroblasts, inflammatory cells, epithelial cells, myofibroblasts and components of the new extracellular matrix. Initially, fibroblasts use cross-linked fibrin fibres to migrate through the wound and then attach to fibronectin (Romo and Pearson, 2006). In next phase, fibroblasts deposit matrix in the wounded area, and in then collagen to which they may glue in order to begin the process of migration (Rosenberg and de la Torre, 2008).

The spectacular effect of oat beta-glucan was demonstrated by Delatte et al. (2001) in studies of healing second-degree burns in children. The results show that such injuries can be effectively treated with a dressing made of oat ß-glucan and collagen. The results of the treatment were comparable with the standard treatment with the use of silver sulfadiazine and antibiotic. In addition, it was noted that oat ß-glucan compress eliminated the necessity of changing the dressing every day and thereby painfully removing it. The beta glucan compress was a semi-coagulant wound covering that reduced water loss and heat loss as well as a barrier to bacterial contamination. It also simplified the patient care and seemed to significantly reduce the post traumatic pain.

Anti-wrinkle and anti-ageing properties

Oats beta-glucan, apart from immune-modulating properties, is also an anti-oxidant. As the oxidation stress constitutes one of the major mechanisms of skin ageing and dermatological problems, fitocompounds with confirmed anti-oxidation properties may be useful in treatment of various skin problems and ageing (Singh and Agrawal, 2009). Oats beta-glucan has low ability to remove free radicals during in vitro research (DPPH, ABTS, ORAC) but during in vivo treatments, significant anti-oxidation and anti-inflammatory properties of oats beta-glucan was confirmed through the analysis of beta-glucan impact on the anti-oxidation defence parameters SOD, TAS, GSH, GSSG and inflammation markers such as TBARS, TNF-ß, IL-10 and IL-12 (Wilczak i in., 2015; Suchecka i in., 2015; Błaszczyk i in., 2015).

Ageing is a slow process which results in dysfunctionality of all parts of the body. Anti-ageing research refer mainly to slowing, preventing or removing the results of ageing. The human skin shows an interesting contrast between the “programmed” or “natural” age, i.e. changes connected only with the passing time, and the additional losses or “accelerated ageing” resulting from damage caused by the environment (Kosmadaki and Gilchrest, 2004). A

naturally ageing skin has minor wrinkles, is loosened, dried and rough, showing the loss of skin cells and the protein structure connected with subtle changes of the epidermal differentiation. Crosslinking of proteins in the skin causes secondary chemical changes resulting in ageing of the skin. Crosslinking of proteins is caused by non-ensymatic glycation or oxidation of certain amino-acids in sensitive proteins such as collagen or elastin. Such oxidation can be prevented through using anti-oxidants which results in lower crosslinking of proteins in the ageing skin (Oresajo et. al., 2012).

Wrinkles mean visible creases of the skin. Wrinkles which have less than 1 mm in depth and length are called minor wrinkles, while those above 1 mm - major wrinkles. Wrinkles constitute one of the basic features of skin ageing. The typical reason for minor wrinkles is loss of the structural protein (type 1 collagen) in the dermis layer. The proteins from the collagen family are the most common proteins in the skin. Collagen constitutes about 70-80% of dry skin mass and contributes to structural stabilisation and integration of the tissue. Building up of collagen is controlled and depends on the physiological condition of the organism. Gradual weakening of collagen 1 synthesis in the dermis layer results in wrinkles and skin ageing. Therefore, the collagen metabolism control should potentially be applicable in various therapeutic and cosmetic treatments. Pillai with colleagues (2005a, 2005b) examined the penetration ability of the oats beta-glucan on the human skin model in order to clinically assess its effectiveness in decreasing minor lines and wrinkles using clinical test on 27 people. After eight weeks, silicon skin replicas were made for image analysis which proved significant reduction of wrinkles depth and the general skin roughness.

Hydrating properties

The content of water in epidermis and lipids on the skin surface constitute significant factors affecting its appearance and functioning (Cheng, 2007). Hydrating substances slow the water loss and minimise minor wrinkles (Baumann, 2007). They also improve epidermis hydration, physical and chemical properties of the skin surface making it more hydrated, smooth and soft (KIm et. al., 2007). Traditional hydrating substances such as pantothenic acid (Kobayashi et. al., 2011), 6-palmityl-L-ascorbic acid (Uner et. al., 2005) and hyaluronic acid (Pavicic et. al., 2011) are famous for their effective hydration in cosmetic formulations. However, certain polysaccharides such as okra polysaccharides (Kanlayavattanakul et. al., 2012) or oats beta-glucan (Kurtz and Wallo, 2008) may also play an important role in the cosmetic and pharmaceutical sector.

Protection against UV radiation

UV radiation constitutes one of the factors causing DNA damage and inflammation, causing also various skin damage, such as photo-ageing or photocarcinogenesis (Scharffetter-Kochanek et. al., 2000, Pillai et. al. 2005a, 2005b). Many inflammatory reactions induced by UV radiation is initiated by free oxygen radicals which activate pro-inflammatory mediators such as prostaglandins, leukotrienes and cytokines causing further damage to cells and tissue (Oresajo et. al. 2012). Anti-oxidants with simultaneous anti-inflammatory properties, such as oats beta-glucan can block creation of free oxygen radicals induced by UV radiation and activate anti-inflammatory and anti-ageing mechanisms (Oresajo et. al. 2008). Short- and long-term changes to the skin caused by sunlight exposure

drew attention of the dermatologists and resulted in the necessity to search for new substances which can reduce the negative impact of UV radiation on the skin.

Skin permeation properties

It has been known for a long time that large bio-polymers such as protein, glycosaminoglycans and glycoproteins have low skin permeability if used in the form of a cream. However, penetration research conducted on human belly skin with a single application of 0.5% of beta-glucan solution in a dose of 5 mg for cm2 proved that beta-glucan, regardless of its high molecular weight deeply penetrates the epidermis and the dermal layer (Pillai et. a;., 2005a, 2005b). The scientists state that beta-glucan does not directly penetrate the cells but permeates to the skin through intracellular areas.

Summary

Beta-glucan constitutes one of valuable fibres which have an extensive potential concerning health support applications. It was confirmed that beta-glucan is a promising ingredient with anti-ageing, anti-oxidation, hydrating and healing improvement properties.

Bibliography

Aries, M.F., Vaissiere, C., Pinelli, E., Pipy, B. & Charveron, M. 2005. Avena Rhealba inhibits A23187-stimulated arachidonic acid mobilization, eicosanoid release and cPLA2 expression in human keratinocytes: potential in cutaneous inflammatory disorders. Biological & Pharmaceutical Bulletin, vol. 28, no. 4: 601.

Ballabh, B., Chaurasia, O.P., Ahmed, Z., Singh, S.B., 2008. Traditional medicinal plants of cold desert Ladakh e used against kidney and urinary disorders. Journal of Ethnopharmacology 118: 331–339.

Baumann L. 2007. Skin aging and its treatment. J Pathol 211: 241–251.

Błaszczyk, K., Wilczak, J., Harasym, J., Gudej, S., Suchecka, D., Królikowski, T., Lange, E., Gromadzka-Ostrowska, J. 2015. Impact of low and high molecular weight oat beta-glucan on oxidative stress and antioxidant defense in spleen of rats with LPS induced enteritis. Food Hydrocolloids, 51: 272–280.

Browder, W., Williams, D., Lucore, P., Pretus, H., Jones, E., Mcnamee, R. 1988. Effect of enhanced macrophage function on early wound healing. Surgery 104: 224–230.

Browder, W., Williams, D., Pretus, H., et al. 1990. Benefical effect of enhanced macrophage function in trauma patients. Ann Surg 211: 605–613.

Cavender, A., 2006. Folk medical uses of plant foods in southern Appalachia, United States. Journal of Ethnopharmacology 108: 74–84.

Chen, J.Z., Raymond, K. 2008. Beta-glucans in the treatment of diabetes and associated cardiovascular risks. Vasc Health Risk Manag 4: 1265–1272.

Cheng, Y., Dong, Y.Y., Dong, M.X., et al. 2007. Moisturizing and antisebum effect of cosmetic application on facial skin. J Cosmet Dermatol 6: 172–177.

Choromańska, A., Kulbacka, J., Rembiałkowska, N., Pilat, J., Olędzki, R., Harasym, J., & Saczko, J. 2015. Anticancer properties of low molecular weight oat beta-glucan – an in vitro study. International Journal of Biological Macromolecules, 80: 23–28.

Delatte, S.J., Evans, J., Hebra, A., Adamson, W., Othersen, H.B., Tagge, E.P. 2001. Effectiveness of beta glucan collagen for treatment of partial thickness burns in children. J Pediatr Surg 36: 113–118.

Deodhar, A.K., Rana, R.E. 1997. Surgical physiology of wound healing: a review. J Postgrad Med 43: 52–56.

El Beyrouthy, M., Arnold, N., Delelis-Dusollier, A., Dupont, F., 2008. Plants used as remedies antirheumatic and antineuralgic in the traditional medicine of Lebanon. Journal of Ethnopharmacology 120: 315–334.

Johansson, L., Tuomainen, P., Ylinen, M., Ekholm, P., & Virkki, L. 2004. Structural analysis of water-soluble and insoluble ß-glucans of whole-grain oats and barley. Carbohydrate Polymers, 58(3): 267–274.

Kanlayavattanakul, M., Rodchuea, C., Lourith, N. 2012. Moisturizing effect of alcohol-based hand rub containing okra Polysaccharide. Int J Cosmet Sci 34: 280–283.

Kim, M.S., Park, Y.D., Lee, S.R. 2008. Preparation method of beta-glucan from schizophyllum commune and composition for external application comprising the same. US patent 2008/016043A1, Jun. 3.

Kobayashi, D., Kusama, M., Onda, M., Nakahata, N. 2011. The effect of pantothenic acid deficiency on keratinocyte proliferation and the synthesis of keratinocyte growth factor and collagen in fibroblasts. J Pharm Sci 115: 230–234.

Kosmadaki, M.G., Gilchrest, B.A. 2004. The role of telomeres in skin aging/photoaging. Micron 35: 155–159.

Kougias, P., Wei, D., Rice, P.J., et al. 2001. Normal human fibroblasts express pattern recognition receptors for fungal (1!3)-b-Dglucans. Infect Immun 69: 3933–3938.

Kurtz, E., Wallo, W. Colloidal oatmeal: history, chemistry and clinical properties. 2007. J Drugs Dermatol. 6(2): 167–170.

Nguyen, D.T., Orgill, D.P., Murphy, G.F. 2009. Chapter 4: The Pathophysiologic Basis for Wound Healing and Cutaneous Regeneration. Biomaterials for Treating Skin Loss. Woodhead Publishing (UK/ Europe) & CRC Press (US): Cambridge/Boca Raton: 25–57.

Oresajo, C., Stephens, T., Hino, P.D., et al. 2008. Protective effects of a topical antioxidant mixture containing vitamin C, ferulic acid, and phloretin against ultraviolet-induced photodamage in human skin. J Cosmet Dermatol 7: 290–297.

Oresajo, C., Pillai, S., Manco, M., Yatskayer, M., McDaniel, D. 2012. Antioxidants and the skin: Understanding formulation and efficacy. Dermatol Ther 25: 252–259.

Pacifico, A., De Angelis, L., Fargnoli, M.C., De Felice, C., Chimenti, S. & Peris K. 2006. Clinical trial on Aveeno skin relief moisturizing lotion with itching accompanied by skin lesions and xerosis. The Journal of Applied Research, vol. 5, no. 2: 325–330.

Parzonko, A., Makarewicz-Wujec, M., Jaszewska, E., Harasym, J., & Kozłowska-Wojciechowska, M. (2015). Pro-apoptotic properties of (1,3)(1,4)-ß-d-glucan from avena sativa on human melanoma HTB-140 cells in vitro. International Journal of Biological Macromolecules 72: 757–763.

Pavicic, T., Gauglitz, G.G., Lersch, P., et al. 2011. Efficacy of creambased novel formulations of hyaluronic acid of different molecular weight in anti-wrinkle treatment. J Drugs Dermatol 10: 990–1000.

Pillai, R., Redmond, M., Roding, J. 2005a. Anti-wrinkle therapy: significant new findings in the non-invasive cosmetic treatment of skin wrinkles with beta-glucan. Int J Cosmet Sci 27: 292.

Pillai, S., Oresajo, C., Hayward, J. 2005b. Ultraviolet radiation and skin aging: roles of reactive oxygen species, inflammation and protease activation, and strategies for prevention of inflammation induced matrix degradation. Int J Cosmet Sci 27: 17–34.

Portera, C.A., Love, E.J., Memore, L., et al. 1997. Effect of macrophage stimulation on collagen biosynthesis in the healing wound. Am J Surg 63: 125–131.

Rieder, A., Samuelsen, A.B. 2012. Do cereal mixed-linked b-glucans possess immune-modulating activities? Mol Nutr Food Res 56: 536–547.

Romo, T., Pearson, J.M. 2006. Wound Healing, Skin. Emedicine.com. Accessed December 27, 2006.

Rosenberg, L., de la Torre, J. 2008. Wound Healing, Growth Factors. Emedicine.com. Accessed January 20, 2008.

Scharffetter-Kochanek, K., Brenneisen, P., Wenk, J, et al. 2000. Photoaging of the skin from phenotype to mechanisms. Exp Gerontol 35: 307–316.

Singh, R.P., Agarwal, R. 2009. Cosmeceuticals and silibinin. Clin Dermatol 27: 479–484.

Stadelmann, W.K., Digenis, A.G., Tobin, G.R. 1998. Physiology and healing dynamics of chronic cutaneous wounds. Am J Surg 176: 26S–38S.

Suchecka, D., Harasym, J.P., Wilczak, J., Gajewska, M., Oczkowski, M., Gudej, S., Błaszczyk, K., Kamola, D., Filip R., Gromadzka-Ostrowska, J. 2015. Antioxidative and anti-inflammatory effects of high beta-glucan concentration purified aqueous extract from oat in experimental model of LPS-induced chronic enteritis. Journal of Functional Foods, 14: 244–254.

Vié, K., Cours-Darne, S., Vienne, M.P., Boyer, F. & Fabre, B. 2002. Modulating effects of oatmeal extract in the sodium lauryl sulphate skin irritancy model. Skin Pharmacology and Applied Skin Physiology, vol. 15: 120–125.

Volman, J.J., Ramakers, J.D., Plat, J. 2008. Dietary modulation of immune function by b-glucans. Physiol Behav 94: 276–284.

Wilczak, J., Błaszczyk, K., Kamola, D., Gajewska, M., Harasym, J.P., Jałosińska, M., Gudej, S., Suchecka, D., Oczkowski, M., Gromadzka-Ostrowska, J. 2015. The effect of low or high molecular weight oat beta-glucans on the inflammatory and oxidative stress status in the colon of rats with LPS-induced enteritis. Food and Function, 6(2): 590–603.

United States FDA, Federal Register, 68 (2003) 35346-35348.

Uner, M., Wissing, S.A., Yener, G., Muller, R.H. 2005. Skin moisturizing effect and skin penetration of ascorbyl palmitate entrapped in solid lipid nanoparticles (SLN) and nanostructured lipid carriers (NLC) incorporated into hydrogel. Pharmazie 60: 751–755.