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The outermost layer of the epidermis, the stratum corneum, functions as a two-way physical and chemical barrier: it prevents both the penetration of noxious agents from the environment into the skin and the evaporation of water in the opposite direction. The stratum corneum is formed by corneocytes and intercellular lipids (lamellae), which contain mostly ceramides (50% of the stratum corneum lipid mass), cholesterol (25%) and free fatty acids (10%).[1,2] The specific mixture and organization of these lipids in the space between corneocytes allows the proper maintenance of the permeability barrier. The significance of ceramides for the stratum corneum barrier has been extensively reported and the essential fatty acid (EFA) linoleic acid (LA), contained in ester linkage in acylceramides (ceramide fractions), seems particularly important for the normal barrier function.[2]

An alteration in stratum corneum lipids has been identified in several skin disorders with damaged permeability barrier, including atopic dermatitis (AD). A compromised barrier increases the penetration of irritants, allergens and pathogens, thus causing or furthering skin inflammation.[3,4] A defective barrier is not only a key feature of AD, but the degree of skin barrier damage correlates with the disease severity.[5] For this reason, emollients that repair and protect the stratum corneum are important for the general skin health as well as for the improvement of certain eczematous conditions.[4]

Linoleic Acid and Skin Barrier

LA is one of the most significant lipids for the maintenance of barrier function.[6] In fact, recent studies suggest that LA is essential for the formation of the lamellar phase of the stratum corneum lipids.[2,7] Additionally, studies showed that stratum corneum free fatty acids, including LA, are important for the maintenance of the surface "acid mantle," which, in turn, seems important for both the integrity of the permeability barrier and stratum corneum cohesion.[8]

The importance of LA for a healthy skin barrier has been known since the 1930s, when pre-clinical experiments demonstrated that a prolonged fat-free diet would lead to severe scaly dermatosis and a significant increase in transepidermal water loss (TEWL), and that oral intake of LA would reverse these symptoms.[9] Human clinical studies have subsequently confirmed the reversal of the cutaneous manifestation of EFA deficiency after consumption of LA-rich diet.[10] Since then, studies have shown skin barrier improvement also via topical application of LA or of oils rich in LA (eg, sunflower seed oil).[11,12] In 1975, Prottey et al demonstrated decreased scaliness and decreased TEWL (ie, improved barrier) in EFA deficient patients treated for 2 weeks with sunflower-seed oil applied to the forearms; interestingly, improvement did not occur in the contralateral forearm treated with olive oil, rich in oleic acid.[11]

In preclinical studies, topical LA-rich oils were also shown to improve the skin barrier in EFA deficiency models or in skin disrupted by sodium laurate; in both groups, skin applications of sunflower seed oil normalized the high TEWL.[12] Interestingly, linoleic acid from the sunflower seed oil application was detected in the epidermal lipids of the EFA deficient group.[12] A later study by Elias et al[6] confirmed these results: in an EFA deficient preclinical model, the application of pure LA to the skin quickly improved the barrier function (decreased TEWL), while contralateral application of pure oleic acid produced deterioration of the skin barrier (increased TEWL). In fact, pure oleic acid, in its unbound, free fatty acid form, has been shown to actually increase the skin permeability by disrupting the lamellar lipid arrangement in the stratum corneum and thus functioning as a penetration enhancer.[13,14] It is important to note, though, that the vast majority of oleic components in vegetable oils are present in esterified and bound forms. Topical formulations, containing vegetable oils, are designed with additional stabilization to maintain the structure of the emulsion, to normalize the pH range and to prevent microbial growth. All of these factors are

Table 1. Lipid Class (%) composition in the oat oil of triple oat

Lipid Class	%
Triglycerides	83.4
Free Fatty Acids	6.8
Diacylglycerols	8.9
Phospholipids	0.9

Triglycerides are the most abundant lipids in oat oil. The fatty acids oleic acid (OA) and linoleic acid (LA) are contained in various percentages in each of the four lipid classes (35% to 43% for OA and 36% to 45% for LA).

Table 2. Fatty acid (%) composition in the oat oil of triple oat					
		Phospholipid	Diacylglycerol	Free Fatty Acid	Triglycerides
Palmitic	16:0	12.9	15.3	16.7	14.7
Stearic	18:0	3.2	2.3	1.9	1.6
Oleic	18:1 (n-9)	35.0	42.9	38.3	42.7
Linoleic	18:2	45.3	36.1	39.2	37.0
The majority of fatty acids are esterified in the triglyceride fraction of oat oil.					

beneficial for maintaining the quality of the vegetable oil in the formulation.

The importance of lipid emulsions containing LA in repairing the barrier function has been highlighted in a few studies. A recent study investigated the barrier repair ability of two topical emulsions containing a mixture of lipids, after the skin was damaged by sodium lauryl sulfate (SLS).[15] The emulsion containing LA in combination with ceramides III, IIIB, VI, phytosphingosine and cholesterol produced a significantly faster barrier recovery compared to the emulsion containing only ceramides III and IIIB.

Oat

Oat is a natural agent that contains a variety of active compounds, including: lipids with a high percentage of unsaturated fatty acids, starches and hydrocolloid β-D-glucan, avenanthramides and other antioxidants (mostly phenolic esters), saponins and vitamins.[16,17] The total lipid content is relatively high (around 6% to 12% in groats) compared to other cereals; of the groat lipids, about 41% are triglycerides and 5% free fatty acids.[18] Oats are particularly rich in unsaturated fatty acids, with polyunsaturated LA (18:2) and monounsaturated oleic acid (18:1) accounting for approximately 40% and 36% (averages) of the total groat fatty acid pool, respectively.[18] Other fatty acids include palmitic acid (16:0, about 19%) and minimal amounts of linolenic, stearic and myristic acids.[18] It should be noted, though, that the percentages of oat oil fractions reported in the literature vary depending on cultivars, storage and extraction method.[18]

The chemical polymorphism of oats is at the basis of their multiple beneficial effects, including barrier protection, moisturization, anti-inflammatory, soothing, cleansing, etc. For decades, oat-containing emollients have been used in various eczematous conditions and recent studies have confirmed their importance in the treatment of AD[19-21] and xerosis.[22] Oat is currently used in topical formulations either as colloidal oatmeal or as its separated fractions. Colloidal oatmeal is derived from the whole dehulled grain and is categorized as an over-the-counter (OTC) skin protectant drug, regulated by the FDA.[23] Additional recent investigations have focused on the specific biological effects of active compounds extracted from oat, such as avenanthramides and oat oil. Avenanthramides are phenolic molecules that have shown potent anti-inflammatory activity both in vitro and in vivo.[17] Oat oil has also been recently studied for its beneficial dermatological effects and it is likely that its LA fraction plays a major role in the maintenance of the epidermal water barrier.[24]

Oat Oil Experience

In view of its potential benefits, oat oil has been recently incorporated in new topical products. In this article, we review a novel moisturizer formulated with a mixture of three active oat compounds (triple oat): colloidal oatmeal, avenanthramides and oat oil. Each oat ingredient is carefully sourced to ensure quality and consistency. The specific oat crop, used in the manufacture of this oat oil, is grown from selected soils in a particular region of northwestern Europe, virtually free of the risk of pollution. Additionally, the extracted oat oil is carefully processed to retain its biologically active compounds and its quality is assured through standardization of extraction procedures with non-toxic solvents and relatively low temperatures.

The oat oil in triple oat contains more than 70% unsaturated fatty acids. LA, in particular, constitutes approximately 37% of the total fatty acid fraction, present in part as free fatty acid, and in part esterified to various lipids (mostly triglycerides) (**Tables 1, 2**). The high phospholipid content and relatively high unsaturated fatty acid content found in oat oil are very different from other natural oils. Most extracted natural oils (eg, olive oil) are primarily composed of triglycerides, with no phospholipids, and very few fatty acids.

A 2-week study was performed to evaluate the effectiveness of a triple oat lotion (colloidal oatmeal, oat oil and oat extract) on individuals with mild to moderate itch due to extra dry skin on the lower legs. Twenty-nine patients applied the triple oat lotion twice a day for 2 weeks. Clinical evaluations demonstrated significant improvements ($p<0.05$) in dryness, scaling and roughness after 1 day of use. In addition, patients perceived significant improvements in itch ($p<0.05$) after 1 day of use. Skin barrier improvements were measured (TEWL) after 7 and 14 days of use. In conclusion, this study showed that triple oat lotion was very effective in alleviating itch, improving the skin barrier and improving the dryness and roughness associated with moderate to severe dry skin.[25]

More recently, a 5-week clinical study was conducted to evaluate the effectiveness of a triple oat moisturizing cream versus a leading moisturizing cream containing

ceramides, in improving barrier function and moisturization in moderate xerosis.[25] Thirty-five patients with at least moderate dry skin on both lower legs completed the study. Each subject tested both products, one on each leg according to randomization. Each formulation was applied for 3 weeks. Both products showed significant improvement ($p<0.05$) in TEWL and moisturization measurements during the treatment phase and the regression phase. The triple oat moisturizing cream was significantly better than the ceramide product in improving moisturization at all timepoints during the treatment phase.[25] Additionally, the triple oat moisturizer was as effective as a leading ceramide cream in improving skin barrier, although triple oat showed significant better performance after 1 and 2 weeks of treatment.

Conclusions

Oat oil is rich in LA, an essential polyunsaturated fatty acid critical for the maintenance of the skin permeability barrier.[6] Many studies have confirmed the efficacy of topical applications of LA or LA-containing oils in improving barrier function in EFA deficient conditions or in stratum corneum previously damaged by surfactants. Moreover, a multi-oat cream containing oat oil has been shown to be highly effective in improving moisturization and skin barrier in individuals with moderate dry skin and to be similar or better than a leading ceramide formulation.

Further research and publications on skin benefits from natural agents will help the practitioner make better and more informed decisions on skin care alternatives.■

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