Oat Oil, Linoleic Acid, and the Permeability Barrier

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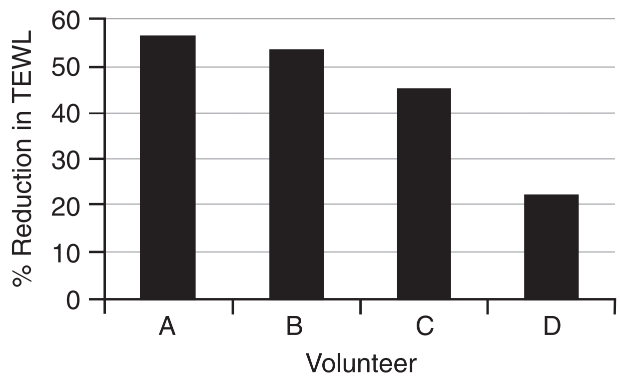
Introduction: Oats and Skin

Oats have been recommended for topical skin care since the time of the ancient Romans, who promoted the use of oat flour for a variety of dermatologic conditions.[1,2] More recent centuries have found benefits for both topically applied and orally ingested oat preparations. For example, in the early 1800s Henry Potter, a London pharmacist, produced a tincture of oats known as Potter's Compound of Avena with Helionas Mixture No. 108A and Tonic No. 1.[3] For the next hundred years, oats were regarded as so powerfully healthful that they were available almost exclusively at pharmacies.[4] Contemporary literature finds a role for oat preparations as adjunctive therapy in a number of pruritic conditions such as atopic dermatitis, allergic or irritant contact dermatitis, chicken pox, poison ivy, poison oak and sumac, insect bites, winter itch, cercarial dermatitis, ichthyosis, prickly heat, hives, sunburn, and rashes.[5-14] These recognized benefits of topical oat preparations are due to the fortunate coincidence that compounds essential for the natural development of the grain have positive effects on humans. For use on skin, oats can be formulated as either a finely ground whole-oat powder that preserves the chemical spectrum of the intact grain, or they can be separated into carbohydrate, protein, lipid, and other fractions to enhance desirable biologic activities. One such activity is barrier function maintenance, reviewed here in terms of the oat oil fraction and its linoleic acid component, which has been recognized as essential in establishing and maintaining the epidermal water barrier.[15-17]

Oat Lipids

Oats are generally regarded as having the highest lipid content of any cereal grain (~ 7% to 10%) and as an excellent source of unsaturated fatty acids.[18-21] Whole oat oil is a remarkable extract that reduces transepidermal water loss (TEWL) by as much as 56%, resists ultraviolet B (UVB) degradation, and protects skin lipids from UVB-induced peroxidation.[22] Oat oil, like the oat grain itself, can be considered as a single natural product, or as a mixture of active natural products, each with its own biologic properties. When fractionated, oat oil is found to be composed of around 50% triglycerides, 14% mono- and diglycerides, and 10% free fatty acids, with smaller amounts of sterols,

Figure 1. Oat oil reduces TEWL compared to control sites



Adapted from Potter.[22]

phosphatidyl choline, phosphatidyl ethanolamine, and other compounds, all of which are affected to some extent by cultivation conditions, plant genetics, and the method of lipid extraction.[19-21] Oat lipids contain about 80% unsaturated fatty acids, which in turn are about 42% to 52% linoleic acid, 27% to 32% oleic acid, and 17% to 21% palmitic acid, with small amounts of stearic and linolenic acids.[20] Protecting this spectrum of oat lipids from decay are potent natural antioxidants, including alpha tocopherol and alkyl phenolic compounds that are as effective as the commercial antioxidant butylhydroxytoluene (BHT).[23,24]

Skin Lipids

Like oat lipids, skin lipids are vitally important and variably present. They are an essential part of the stratum corneum permeability barrier, where they form an intercellular matrix of multilamellar sheets in which protein-enriched corneocytes are embedded.[25-27] This arrangement has been described as a "bricks and mortar" barrier, because the corneocytes act as bricks and the lipids as mortar.[27]

The importance of stratum corneum lipids in the permeability barrier was established by clinical and laboratory investigation. It has long been known that clinical conditions with impaired barrier function, such as xerosis, atopic dermatitis, and ichthyotic disorders, were linked to changes in stratum corneum lipid levels.[26,28] Furthermore, topical lipid application has been shown to improve permeability barrier function and improve clinical outcomes in these disorders.[29,30] Other studies have shown that the skin heals itself by a transient burst of lipid synthesis after disruption of the barrier by organic solvents or detergents.[25]

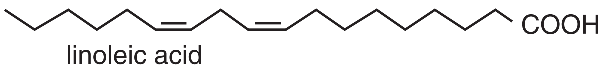
Although lipids account for only a small percentage of total stratum corneum weight (~10%), they provide the permeability barrier that is required for terrestrial life.[31] The chemical profile of stratum corneum lipids has been described as approximately equimolar amounts of sphingolipids, cholesterol, and free fatty acids, which translate to 50% ceramides, 25% cholesterol, and 15% free fatty acids by weight, with very little phospholipid.[17,29] There is no "ideal" skin, however, and the actual lipid content of the stratum corneum varies with anatomic site, permeability, age, and season, with an inverse relationship between neutral lipid concentration and permeability.[26,32,33] For example, the concentration of lipids ranks highest in the face, followed by the abdomen, leg, and sole, which is contrary to their known permeability. Consistent with these permeability measurements, the concentration of linoleic acid is threefold higher in the face and abdomen than it is in the leg and foot.[32]

Linoleic Acid and the Permeability Barrier

The relationship between linoleic acid and the permeability barrier goes back more than 30 years, when it was noted that disruption of the barrier was one of the major abnormalities in essential fatty acid (EFA) deficiency and that the scaling and thickening of the skin, as well as the increased transepidermal water loss, could be reversed by topical application of linoleic acid-rich sunflower oil.[15,16,34] The barrier disturbance in EFA deficiency can be corrected by linoleic acid only and not by the related oleic acid, which actually causes barrier deterioration. Additionally, linoleic acid, but not oleic acid, can repair the barrier in detergent-damaged skin.[28] Furthermore, linoleic acid acts directly on the permeability barrier rather than through participation in prostaglandin biosynthesis.[28]

Although linoleic acid may have a central role in barrier function, it does not necessarily act alone. Replenishment studies after sodium dodecyl sulfate-induced chapping and scaling of normal skin in volunteers showed that a complete preparation of stratum corneum lipids, including linoleic

Figure 2. Linoleic acid is an 18-carbon unsaturated fatty acid that enhances the permeability barrier.



acid and other free fatty acids, was able to restore the barrier function and normal appearance, but sebum lipids were not.[35] A similar study investigated the repair of skin damaged by either acetone, which removed surface lipids, or sodium lauryl sulfate (SLS), which induced disruption of the entire stratum corneum structure. After SLS damage, barrier recovery was significantly more rapid with topical application of an emulsion of linoleic acid, cholesterol, and phytosphingosine, compared to barrier recovery obtained with an emulsion of ceramide III and ceramide IIIB.[36] The linoleic acid mixture also improved the hydration state of the acetone-treated skin significantly more than the ceramide mix.[36]

Another essential role for linoleic acid is maintaining the stratum corneum "acid mantle," which is important for both impermeability and cutaneous antimicrobial defense.[37] An acidic stratum corneum is needed to activate pH-sensitive lipid hydrolases, which process secreted phospholipid to free fatty acid, a sequence required for normal barrier function and acidity.[37] If phospholipase activity is inhibited experimentally, skin becomes less acidic, but the effect can be reversed with application of fatty acids such as linoleic acid, palmitic acid, and stearic acid. [37]

Summary

The most abundant polyunsaturated fatty acid in human skin is the 18-carbon fatty acid linoleic acid.[16] It is now accepted that a specific and essential function of linoleic acid in mammalian skin is its involvement in establishing and maintaining the epidermal water barrier.[15-17] Linoleic acid is also the most abundant unsaturated fatty acid in oat oil, which has been shown effective in reducing transepidermal water loss and restoring the skin permeability barrier.[20,22] Without a doubt, the centuries-old wisdom of treating skin with oat extracts will continue as modern techniques reveal more about the active natural components of oats.

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