doi:10.36849/JDD.32712

 ORIGINAL ARTICLE

Etiology, Treatment Challenges, and the Role of Scalp and Haircare in Managing Dandruff

Maria Hordinsky MD FAAD,[a] Anneke Andriessen PhD,[b] Doris Day MD FAAD,[c] Amy McMichael MD FAAD,[d] Natasha Mesinkovska MD FAAD,[e] Heather Woolery-Lloyd MD FAAD[f]

[a]Clinical Research Division, Department of Dermatology, University of Minnesota, Minneapolis, MN
[b]UMC Radboud, Nijmegen, Andriessen Consultants, Malden, The Netherlands
[c]Director, Day Dermatology and Aesthetics, New York, NY
[d]Department of Dermatology, Wake Forest University School of Medicine, Winston-Salem, NC
[e]Department of Dermatology, University of California Irvine, Irvine, CA
[f]Director, Skin of Color Division Dr Phillip Frost Department of Dermatology and Cutaneous Surgery University of Miami Miller School of Medicine, Miami, FL

ABSTRACT

Dandruff and seborrheic dermatitis are associated with a disrupted scalp barrier that contributes to irritation, pruritus, and flaking of the scalp. The flaking and itch associated with dandruff can significantly impact an individual's self-esteem and quality of life. While the exact pathogenesis of dandruff is still not completely understood, scalp barrier health and its microbiome are thought to play significant roles in disease propagation. Five expert dermatologists with extensive experience in hair, dandruff, and seborrheic dermatitis were selected to participate in discussions that would result in five consensus statements focused on scalp barrier health and dandruff. Results of a systematic literature search and expert panel discussion are presented. These consensus statements aim to reflect expert opinions on the current understanding of scalp health in the context of dandruff and seborrheic dermatitis. The panel addressed challenges to promote scalp health, improve patient comfort, and prevent flares during dandruff management and maintenance. The presented consensus statements urge reframing our current understanding of dandruff and seborrheic dermatitis treatment by refocusing attention on global scalp and hair health.

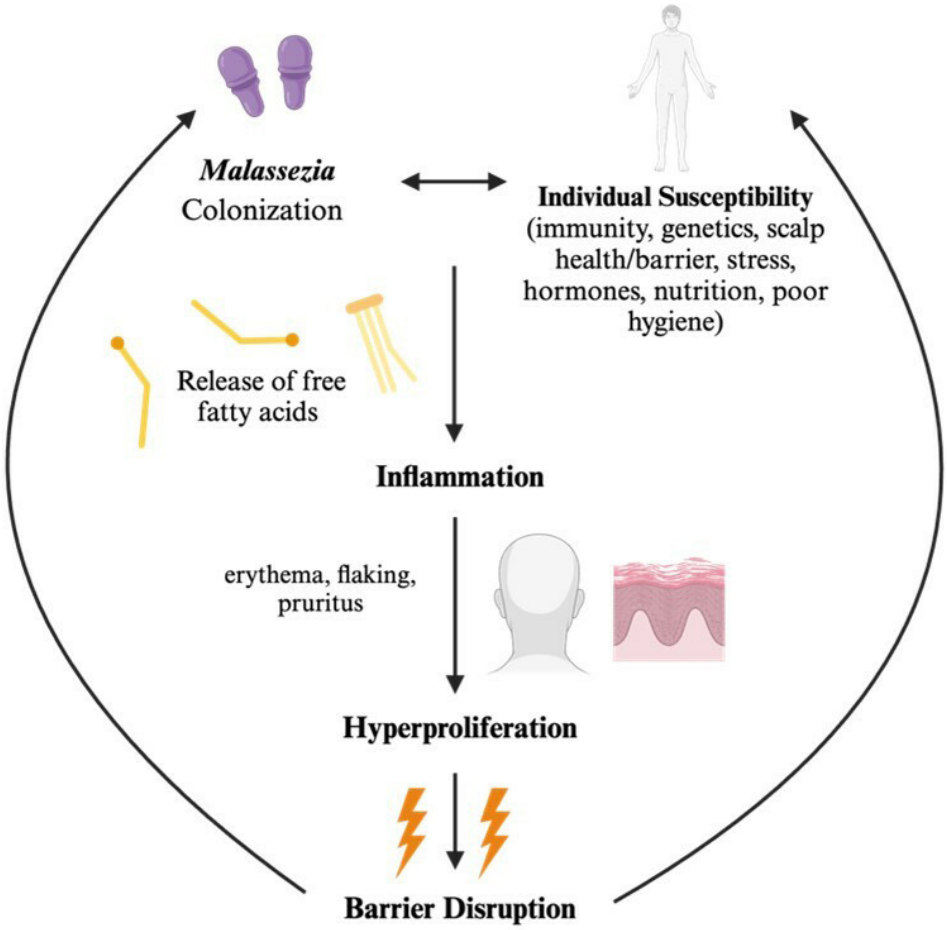
J Drugs Dermatol. 2025;24:2(Suppl 1):s8-14.

INTRODUCTION

Dandruff and seborrheic dermatitis (D/SD) affect about half of the general population worldwide.[1] SD in the scalp is commonly known as dandruff and is considered the same condition with varying degrees of severity.[1] Dandruff appears more prevalent among males, suggesting a potential androgenic component to pathogenesis.[1,2] D/SD commonly affects younger individuals between the ages of 18 and 24, with greater frequency in those over the age of 55 or under the age of 17.[1] Furthermore, SD occurs at a higher prevalence in immune-comprised populations, including patients with HIV/AIDs, neurological or psychiatric conditions (eg, Parkinson's disease, depression, brain and spinal cord injuries) lymphoma, and organ transplant recipients.[1]

Dandruff is characterized by white and yellow flaking on the scalp and hair.[1,3] It can be associated with pruritus and irritation that may also be present on the forehead adjacent to the hairline, eyebrows, and retro-auricular areas.[1] An itchy scalp can significantly impair patient quality of life and may be detrimental to a person's self-esteem. It has been estimated that Americans spend $300 million annually on over-the-counter (OTC) products to treat dandruff-associated flaking and scalp itching.[3]

FIGURE 1. Seborrheic dermatitis and dandruff pathogenesis. Multiple factors have been implicated in the pathogenesis of dandruff and seborrheic dermatitis. *Malassezia* yeast colonization in a susceptible individual (ie, with disrupted skin barriers) produces and releases irritating free fatty acids from sebum and subsequent inflammation, hyperproliferation of the stratum corneum, and further scalp barrier disruption. Disrupted scalp barriers make individuals more susceptible to microbes, itch, and further *Malassezia* colonization, further perpetuating the cycle. Figure made with Biorender.com.



While the underlying mechanism of dandruff and SD remains poorly understood, *Malassezia* is considered to play a role in D/SD pathogenesis.[3] *Malassezia* may trigger a multi-step inflammatory process of the scalp; lipases secreted by *Malassezia* leading to the release free fatty acids (FFA) such as oleic acid and lipid peroxides that may lead to inflammation; inflammatory cytokines such as interleukins IL-1a, IL-1ß, IL-2, IL-4, IL-6, IL-8, IL-10, IL-12, and tumor necrosis factor TNF-a stimulate keratinocyte proliferation and differentiation; and skin barrier breakdown leads to signs symptoms of flaking, pruritus, and erythema (Figure 1).[4] Treating dandruff with zinc pyrithione (ZPT), an antifungal agent, reduces the inflammatory cytokines (IL-1a, IL-8) and epidermal thickness, and improves epidermal barrier integrity markers (keratin 1, 10, 11) and stratum corneum lipids.[5] This suggests that antifungal treatments help to improve overall scalp health.[5]

Individual susceptibility and *Malassezia* colonization in a primed scalp create the ideal conditions for D/SD. Thus, repairing the conditions in which *Malassezia* species colonize is equally important as targeting the fungal component of the disease itself. This consensus paper presents five statements that provide insight into current literature and expert dermatologist consensus on D/SD and current treatment challenges for these conditions.

TABLE 1.

Literature Search Objectives and Parameters
Scope: Human studies investigating dandruff/seborrheic dermatitis, OTC skincare products for the scalp as adjuncts or monotherapy, and the role of topical ceramides containing scalp care products.
Search Terms: Search Set 1: Dandruff/seborrheic dermatitis/contact dermatitis AND scalp condition OR scalp irritation OR premature hair loss OR prescription topical medication OR topical OTC treatment OR prevention OR shampoos OR leave-in treatment OR maintenance OR moisturizers Search Set 2: Dandruff/seborrheic dermatitis/contact dermatitis AND ceramide-containing shampoo OR ceramide-containing scalp skincare OR ceramide-containing moisturizers for scalp care OR adjunctive scalp skincare OR education on scalp care OR adherence to treatment OR efficacy of scalp skincare OR safety of scalp skincare OR tolerability of scalp skincare OR skin irritation due to scalp skincare
Included: Randomized controlled trials, observational, cohort, and interventional studies, reviews, systematic reviews, guidelines, consensus, and pathways published in English from January 2010 to January 2024
Excluded: Publications outside the date range, preclinical studies not addressing skincare for dandruff/seborrheic dermatitis and publications in languages other than English

Over-the-counter (OTC)

METHODS

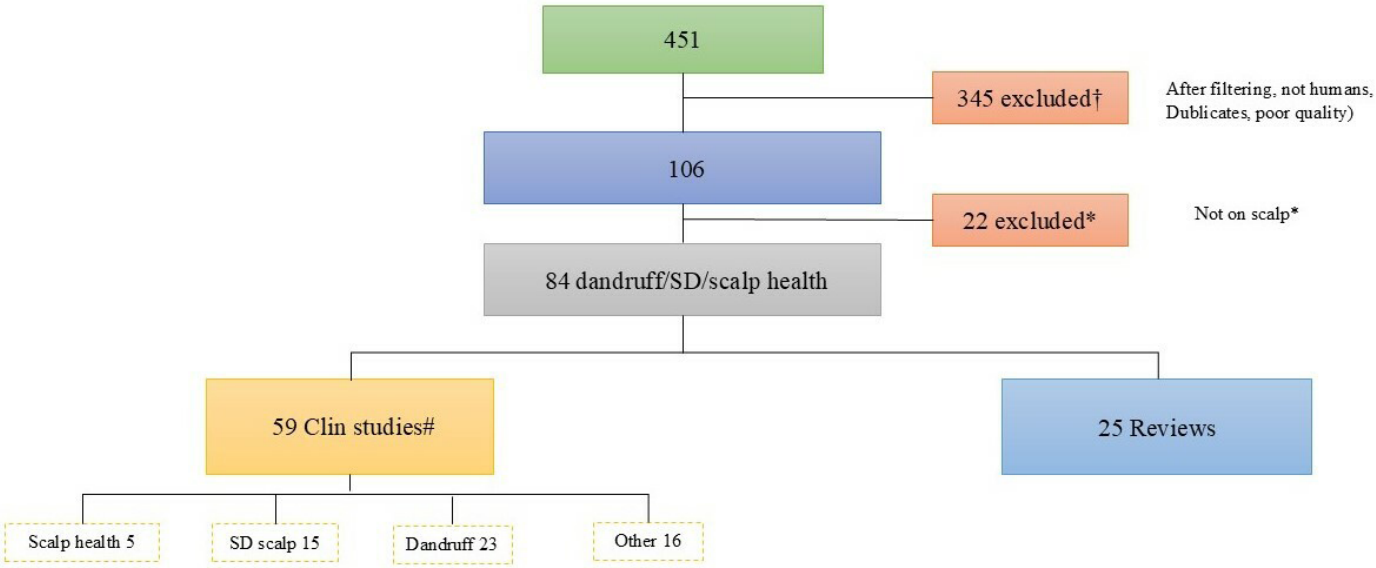
This project was conducted in three phases: systematic literature review, development of consensus statements, and expert discussion and refinement of the consensus statements. A systematic literature review was conducted to inform the development of the consensus statements that would answer the question of what is currently known about D/SD. A structured literature search followed on January 29, 2024, to identify publications on D/SD, OTC skincare products as monotherapy or adjunctive therapy for these conditions, and the role of ceramide-containing scalp care products. Search terms can be found in Table 1. The search included English language publications from January 2010 to January 2024 and was conducted on PubMed and Google Scholar (secondary source) by a dermatologist and a physician/scientist as two independent reviewers. Publications identified through the search were graded for the type of study and the likelihood of changing confidence using the American Academy of Dermatology (AAD) evidence-based guideline development process.[6] A total of 59 clinical studies and 25 reviews met the quality and relevance criteria of the searches (Figure 2). The literature review objectives and parameters are summarized in Table 1. The project used a modified Delphi process comprising face-to-face discussions and an online follow-up to define 5 consensus statements that provide current expert perspectives on D/SD. Five expert dermatologists with experience in scalp, hair, and D/SD were selected to participate in this panel.

RESULTS

Statement 1: *Scalp conditions such as dandruff have oxidative stress as a common etiology. Oxidative stress interferes with normal scalp keratinization and affects hair follicle and cuticle health.*

Oxidative stress to the skin leads to unhealthy scalp conditions and has been associated with SD and dandruff.5 Pre-emergent hair is intimately connected to the surrounding scalp tissue and may be negatively impacted by poor scalp condition, impacting hair quality.[7] Oxidative stress occurs naturally through age and interaction with our environment; however, increased levels of oxidative stress beyond that may be harmful. The skin has its defenses against oxidative stress known as superoxide dismutase (SOD), glutathione peroxidase (GP), and catalase (CAT) that neutralize ROS.[7,8] Malondialdehyde (MDA) and hydroxyoctadecadienoic acid (HODE) are indicators of lipid peroxidation and oxidation in the skin.[8] In SD, the levels of SOD, CAT, and MDA have been shown to be significantly increased compared to normal scalp skin.[8] It demonstrates a higher level of oxidative stress in these scalps with a greater requirement for antioxidant defenses.[7] In another study, HODE was found to be elevated in both the hair and scalp of SD patients, demonstrating the translation of oxidative agents from the pre-emergent to post-emergent hair environment.[7]

FIGURE 2. Structured literature search results.



†Google Scholar filtering is limited. *Many scalp-related conditions come up as part of publications on AD, dandruff, and SD or as adverse events in clinical trials
#No information was found on skincare as mono or adjunct to treatment. There were insufficient clinical studies found for grading

Used search terms are highlighted in Table 1: We identified 451 English-language articles. From these 451, 345 articles were excluded for irrelevance, and 22 were excluded for duplications. In total, 84 articles related to dandruff/seborrheic dermatitis and scalp health were included. Of the 84 articles, 59 were clinical studies, and 25 were reviews. Clinical studies were further stratified by studies on scalp health, seborrheic scalp, dandruff, and others.
Clin studies, clinical studies; SD, seborrheic dermatitis; RCT, randomized controlled trial

Oxidative stress in the scalp has been shown to significantly reduce the quality and retention of hair, which was shown to be reversible by treatment of the scalp with 1% ZP shampoo.[9] ZP reduced HODE and thereby oxidative stress of the scalp, likely through reduction of *Malassezia* species.[7,9] Applying antioxidant ingredients such as niacinamide, panthenol, and caffeine has demonstrated improvement in hair shedding, total hair count, hair quality, and overall scalp-skin barrier function in a clinical trial.[10]Thus, efficacious D/SD treatments should also target oxidative stress via antioxidant strategies to improve overall scalp health and resultant hair quality.

Statement 2: *Dandruff is associated with an impaired scalp barrier, increasing the vulnerability to environmental pollutants, inflammation, and microbiome changes.*

Scalp barrier dysfunction has been well-characterized in D/SD.[2,5] FFA and subsequent oxidative stress alone have been suggested to suffice for barrier breakdown and subsequent dandruff.[8] Oleic acid has been reported to induce flaking in the absence of *Malassezia* in certain individuals.[8] SD has also been shown to be associated with decreased ceramide levels in the scalp skin.[8,10] Dandruff-affected scalps show significantly reduced stratum corneum barrier lipids levels and increased transepidermal water loss (TEWL) compared to healthy scalps.[11] Dandruff sufferers also report a higher perception of pruritus when topical histamine is applied to the scalp.[11] This suggests an impaired stratum corneum and scalp barrier, which makes the scalp susceptible to environmental pollutants, increased TEWL, and increased inflammation.[5]

While *Malassezia* has been the predominant organism considered to lead to D/SD, newer theories have emerged that suggest that disequilibrium in the major bacterial and fungal populations may be more likely to lead to dandruff.[12]

Propionibacterium and *Staphylococcus* are the two predominant bacteria on the scalp, which negatively regulate one another.[12,13] There is decreased *Propionibacterium* and increased *Staphylococcus* on dandruff-affected scalps, suggesting that the balance between the two may be important in dandruff pathogenesis.[12] High water content and sebum production in the scalp provide ideal conditions for increased *Propionibacterium* growth.[12] Lin et al also observed these microbiome changes, finding that *Staphylococcus* and *Pseudomonas* could be potential biomarkers for SD.[14] Scalp barrier changes are associated with an increased risk of microbiome changes, inflammation, and further oxidative damage by environmental pollutants, exacerbating SD and dandruff.

Statement 3: *The scalp barrier may be disrupted by intrinsic factors (eg, disease) and/or extrinsic factors (eg, allergens, hair treatments).*

Various intrinsic and extrinsic environmental factors may impact the scalp barrier, which may put an individual at a higher risk of developing D/SD. Intrinsic factors include sex, hormone levels, sebaceous gland activity, skin lipid composition, immunity, and genetics.[4] Recent studies have shown that certain human leucocyte antigen (HLA) subtypes may confer a higher risk of D/SD development.[4] Male sex and higher androgen levels have also been associated with D/SD.[2,11] Androgens and adrenal corticosteroids stimulate sebum production, which is directly correlated to D/SD.[4] Increased sebum production provides more substrates for *Malassezia* lipases to act upon, resulting in increased toxic FFA secreted on the skin surface, suggesting that some individuals may have increased sensitivity to fatty acid-induced skin barrier disruption.[4] Individual immunity may also play a role in the scalp barrier and SD. This is suggested by the increased prevalence of SD in patients with HIV/AIDS, leukemia, lymphoma, and organ transplant recipients.[1,4] There is also evidence for neuroendocrine contribution, as many neurologic and psychiatric conditions such as Parkinson's disease, tardive dyskinesia, traumatic brain injury, epilepsy, spinal cord injury, and depression are associated with high rates of SD.[1,4]

Exogenous factors also contribute to scalp barrier integrity and D/SD, including an individual's scalp microbiome and microbial balance, life stressors, hygiene, hair practices, climate, medications, and diet.[4] Medications such as anticancer drugs, epidermal growth factor receptor (EGFR) inhibitors, and psychotropic medications such as haloperidol, lithium, and chlorpromazine have been associated with increased incidence of SD.[4] Common exogenous insults to hair and the scalp barrier include hair products containing bleach or formaldehyde and UV radiation.[4]These exogenous insults contribute to ROS on the scalp and contribute to barrier dysfunction that exacerbates D/SD.

Statement 4: *Reducing oxidative stress and promoting a healthy scalp barrier can reverse the detrimental effects of oxidative stress on scalp and hair health.*

Genetic intrinsic factors largely influence hair health in combination with exogenous factors such as hair care habits, treatments (physical and chemical), and overall scalp condition. Growing hair is susceptible to oxidative stress in its surrounding scalp environment.[7] Studies have shown that an unhealthy scalp can transmit negative growth signals to pre-emergent hair, which leads to premature hair loss and reduced hair follicle anchorages.[9] A study demonstrated that ZPT shampoo could reverse oxidative stress on the scalp and hair, leading hair to have lower moisture sorption and decreased water-wetting force, which was associated with stronger, shinier hair.[9] In another study, Kerr et al showed that treatment with ZPT shampoo improved overall scalp condition as measured by inflammation and barrier integrity.[5] Over three weeks, subjects using ZPT shampoo experienced a significant reduction in flaking, inflammatory markers, and improvement in markers of barrier integrity (keratin 1, 10, 11).[9] A reduction in oxidative stress and increased stratum corneum lipids such as ceramide and cholesterol in the scalp was also noted.[9] The application of antioxidant ingredients such as niacinamide and caffeine can also lead to improved hair fullness.[10] In a clinical trial, using these antioxidant ingredients in shampoo decreased scalp HODE and TEWL over 24 weeks.[10] These observations indicate that treating dandruff with antifungals, supporting scalp barrier function, and additional antioxidant ingredients targeting oxidative stress can lead to measurable differences in the scalp barrier and overall hair health.

Statement 5: *Most people suffering from dandruff use haircare products such as shampoos to manage their condition, although many have concerns about the lack of cosmetic elegance.*

The panel commented that although many OTC dandruff shampoos are effective, compliance may be lower due to the suboptimal cosmetic elegance of some products. (ie, most dermatologists/patients think the products work when using them, but compliance is low.)

Topical antifungals have been the gold standard and treatment of choice for D/SD.[1,3] Treatments for D/SD include ketoconazole shampoo, bifonazole shampoo, miconazole cream, ciclopirox olamine shampoo, selenium sulfide, and ZPT.[1,3] Reports of topical corticosteroid and topical calcineurin inhibitor use have also been reported.[1,3] However, despite treatments, D/SD often recurs or fails to adequately respond to treatment. In many cases, this can be linked to a lack of continued compliance due to an unfavorable washing experience or hair texture after washing. Due to dandruff's reoccurring, chronic nature, shampoo treatments must be used regularly. Counseling patients on regular use and more cosmetically elegant anti-dandruff haircare can help to promote compliance and outcomes.

Recent research has suggested D/SD as an inflammatory skin condition similar to atopic dermatitis and psoriasis. Pro-inflammatory cytokines IL-17 and IL-23 appear to promote *Malassezia*-induced inflammation, specifically in disrupted skin.[16] Wikramanayake et al also demonstrated high levels of IL-17 in an SD model.[17] Increasing research and understanding about SD and dandruff will lead to a growing arsenal of available treatment options that will appropriately target the pathogenesis of this condition for lasting, efficacious results in patients.

CONCLUSION

D/SD, scalp health, and hair health are intimately related. D/SD treatment must address the symptoms and signs associated with dandruff, such as itch and flaking, as well as the root of the issue: scalp health, inflammation, scalp barrier disruption, and the long-term promotion of healthy hair and scalp. More research is needed to clarify the role of the scalp barrier and microbiome in dandruff and to identify clinically relevant ethnic variations in scalp microbiome composition to provide inclusive, culturally sensitive, and efficacious treatments to all dandruff sufferers.

DISCLOSURES

All authors (MH, AA, DD, AM, NM, and HWL) disclose receipt of an unrestricted grant from CeraVe International, L'Oreal Dermatological Beauty, to support the research of this work and consultancy fees for their work on this project.

Contributing statement: All authors (MH, AA, DD, AM, NM, and HWL) contributed to developing the manuscript, reviewing this work, and agreeing with the content.

REFERENCES

1. Borda LJ, Wikramanayake TC. Seborrheic dermatitis and dandruff: a comprehensive review. *J Clin Invest Dermatol.* 2015;3(2).

2. Collins LZ, Baines FL, Matheson JR, et al. Sex-related differences in response to zinc pyrithione shampoo vs. non-anti-dandruff shampoo. *Int J Cosmet Sci.* 2018;40(6):583-588.

3. Schwartz JR, Messenger AG, Tosti A, et al. A comprehensive pathophysiology of dandruff and seborrheic dermatitis-towards a more precise definition of scalp health. *Acta Derm.* 2013;93(2):131-137.

4. Adalsteinsson JA, Kaushik S, Muzumdar S, et al. An update on the microbiology, immunology and genetics of seborrheic dermatitis. *Exper Dermatol.* 2020;29(5):481-489.

5. Kerr K, Darcy T, Henry J, et al. Epidermal changes associated with symptomatic resolution of dandruff: biomarkers of scalp health. *Int J Dermatol.* 2011;50(1):102-113.

6. Begolka WS, Elston DM, Beutner KR. American Academy of Dermatology evidence-based guideline development process: responding to new challenges and establishing transparency. *J Am Acad Dermatol.* 2011;64(6):e105-e112.

7. Schwartz JR, Henry JP, Kerr KM, Mizoguchi H, Li L. The role of oxidative damage in poor scalp health: ramifications to causality and associated hair growth. *Int J Cosmet Sci.* 2015;37:9-15.

8. Ozturk P, Arican O, Kurutas EB, Karakas T, Kabakci B. Oxidative stress in patients with scalp seborrheic dermatitis. *Acta Dermatovenerol Croatica.* 2013;21(2):80-0.

9. Schwartz JR, Henry JP, Kerr KM, et al. Incubatory environment of the scalp impacts pre-emergent hair to affect post-emergent hair cuticle integrity. *J Cosmet Dermatol.* 2018;17(1):105-111.

10. Davis MG, Piliang MP, Bergfeld WF et al. Scalp application of antioxidants improves scalp condition and reduces hair shedding in a 24-week randomized, double-blind, placebo-controlled clinical trial. *Int J Cosmet Sci.* 2021;43:S14-S25.

11. Turner GA, Hoptroff M, Harding CR. Stratum corneum dysfunction in dandruff. *Int J Cosmet Sci.* 2012;34(4): 298-306.

12. Xu Z, Wang Z, Yuan C, et al. Dandruff is associated with the conjoined interactions between host and microorganisms. *Sci Reports.* 2016;6(1):24877.

13. Tamer F, Yuksel ME, Sarifakioglu E, Karabag Y. Staphylococcus aureus is the most common bacterial agent of the skin flora of patients with seborrheic dermatitis. *Dermatol Pract Concept.* 2018;8(2):80.

14. Lin Q, Panchamukhi A, Li P, et al. (2021). *Malassezia* and Staphylococcus dominate scalp microbiome for seborrheic dermatitis. *Biopro Biosyst Engineering.* 2021;44, 965-975.

15. Trüeb RM. The impact of oxidative stress on hair. *Int J Cosmet Sci.* 2015;37:25-30.

16. Sparber F, De Gregorio C, Steckholzer S et al. The skin commensal yeast *Malassezia* triggers a type 17 response that coordinates antifungal immunity and exacerbates skin inflammation. *Cell Host Microbe.* 2019;25(3):389-403.

17. Wikramanayake TC, Hirt P, Almastadi M, et al. Increased IL-17-expressing γδ T cells in seborrhoeic dermatitis-like lesions of the Mpzl3 knockout mice. *Exper Dermatol.* 2018;27(12):1408-1411.

18. Lebwohl MG, Papp KA, Stein Gold L, et al. Trial of roflumilast cream for chronic plaque psoriasis. *New Eng J Med.* 2020;383(3):229-239.

19. Zirwas MJ, Draelos ZD, DuBois J, et al. Efficacy of roflumilast foam, 0.3%, in patients with seborrheic dermatitis: a double-blind, vehicle-controlled phase 2a randomized clinical trial. *JAMA Dermatol.* 2023;159(6):613-620.

AUTHOR CORRESPONDENCE

Anneke Andriessen PhD

E-mail:..... anneke.a@tiscali.nl