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Beyond the Kitchen: Unlocking the Antifungal and Anti-Inflammatory Power of Curd Against Dandruff

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Abstract: Dandruff remains a global concern, estimated to affect nearly half of the post-pubertal population worldwide; it is characterized by scalp flaking, itching, and inflammation. Despite conventional treatments targeting the Malassezia yeast, resistance, recurrence, and adverse effects pose major concerns; thus, alternatives are urgently needed. In this review, curd is repositioned as a multifaceted natural remedy due to its dual action through antifungal and anti-inflammatory pathways. We analyzed the bioactive components of curd-lactic acid, probiotics, and lipids-and showed how this traditional remedy addresses both microbial imbalance and inflammation in addition to restoring the barrier function of the scalp. The traditional evidence, studies in vitro, and clinical research provide a logical scientific rationale for its efficacy. Although further randomized controlled trials need to be done, the existing evidence presents curd as a complementary approach in dandruff management that links traditional wisdom with modern dermatological science, offering a multi-targeted and sustainable therapeutic strategy.

Keywords: *Curd, Dandruff, Antifungal, Anti-Inflammatory, Probiotics, Lactic Acid, Malassezia, Scalp Health.*

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I. INTRODUCTION

❖ *From a Common Culinary Staple to a Dermatological Treatment*

The journey of curd from being a kitchen staple to a probable dermatological treatment represents a fascinating convergence of traditional wisdom and modern scientific inquiry(1). This section explores the historical context and modern understanding that frames curd's therapeutic potential for dandruff management.

A. Historical Context and Traditional Use

Curd has been an integral part of traditional medicine systems across various cultures, especially in Ayurveda, where it has been employed as a topical remedy for skin and hair conditions for hundreds of years(2,3). The ancient Ayurvedic texts describe the "Shita" or cooling properties of curd and its action of balancing the Pitta dosha, which is said to govern metabolism and inflammation in the body(4). Traditional usages include applying curd on the scalp for soothing itching and flaking and improving overall hair health(2). These traditional applications, handed down through generations, form the fundamental evidence for the therapeutic potential of curd, although they had no scientific validation according to modern standards(2).

B. Contemporary Understanding of Dandruff

Modern dermatology recognizes dandruff as a complex multifactorial condition affecting approximately 50% of the post-pubertal population worldwide. The condition is characterized by visible flaking, chronic itching, and inflammation of the scalp in varying degrees(5,6). Currently, Malassezia globosa and Malassezia restricta are identified as the main etiological agents: lipophilic yeasts that metabolize sebum triglycerides into free fatty acids, particularly oleic acid. These fatty acids penetrate the stratum corneum of predisposed individuals, provoking inflammatory reactions that give rise to increased cell turnover, a defect in barrier function, and the characteristic symptoms of dandruff(7).

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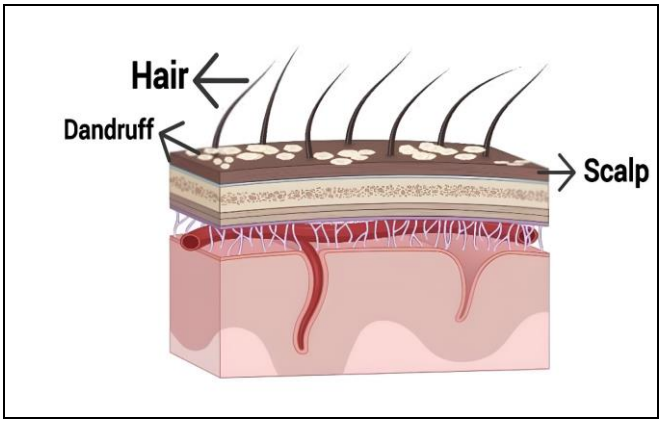

Fig 1 Schematic Representation of Dandruff on the Scalp

C. Limitations of Current Antifungal Therapies

An understanding of the complex pathophysiology of dandruff reveals significant limitations in conventional treatments that mainly target fungal elimination. Antifungal agents, such as ketoconazole and zinc pyrithione, are effective in the short term; however, there are several challenges with their long-term use:

Table 1 Limitation of Commonly Used Antifungal Agents

Treatment type	Primary mechanism	Key limitations
Ketoconazole	Ergosterol synthesis inhibition	Emerging resistance, scalp irritation, recurrence
Zinc Pyrithione	Antifungal and antimicrobial	Decreasing efficacy over time, limited penetration
Selenium Sulfide	Cytostatic effect on cells	Hair discoloration, oiliness, irritation
Ciclopirox Olamine	Metal chelation and fungicidal	Limited efficacy in severe cases, occasional irritation

These limitations create a compelling need to explore alternative approaches that address the multifactorial nature of dandruff beyond simple antifungal activity(8,9).

II. DECONSTRUCTING CURD

❖ *A Synergistic Bio-Active Cocktail*

Biochemical composition and each component of curd will be explained here as to how they contribute to its anti-dandruff effect(2).

A. Lactic Acid: The Dual-Action Agent

The limitations of conventional monotherapies find their solution in curd's multi-component approach, beginning with lactic acid's dual mechanisms of action. As a natural alpha-hydroxy acid (AHA), lactic acid provides gentle yet effective exfoliation by disrupting corneocyte adhesion in the stratum corneum, effectively removing visible flakes without the abrasive action of physical exfoliants(10,11). Simultaneously, its pH-modulating capacity creates an environment (pH 4.0-4.5) that suppresses Malassezia proliferation and reduces lipase activity by up to 60%, addressing both symptoms and underlying microbial imbalance. However, while lactic acid effectively manages the environmental factors and symptomatic presentation, its action alone cannot fully resolve the condition's microbial and inflammatory components(12,13).

B. Live Probiotics: The Microbial Warriors

The limited antimicrobial scope of lactic acid is made up by the probiotic components in curd, which introduce a sophisticated biological dimension to dandruff management(14). Lactobacillus strains from curd exhibit multiple antimicrobial strategies: competitive exclusion for nutrition and space, production of bacteriocins with specific anti-Malassezia activity, and production of hydrogen peroxide that generates an additional antimicrobial environment(2,15). Research indicates that probiotic strains can inhibit the growth of Malassezia in vitro with more than 90% inhibition rates(15). Additionally, there is emerging evidence of probiotic capability in disrupting Malassezia biofilms-structured communities that confer treatment resistance-thus addressing one of the most challenging features of dandruff management. However, even these comprehensive antimicrobial approaches require complementary action against the inflammatory response for the full resolution of dandruff symptoms(2,16).

C. Bioactive Lipids and Proteins: The Barrier Fortifiers

The lipid fraction, particularly in full-fat curd, provides immediate emollient action that soothes irritated scalp, reduces transepidermal water loss by up to 40%, and forms a protective occlusive layer that shields nerve endings from external stimuli(17)(18). Simultaneously, the protein components, enhanced by fermentation-derived bioactive peptides, demonstrate anti-inflammatory properties and provide building blocks for barrier repair. This comprehensive barrier support helps break the itch-scratch cycle that perpetuates dandruff, while creating conditions unfavorable for Malassezia proliferation through improved barrier integrity(19).

III. MECHANISM 1: UNLOCKING THE ANTIFUNGAL ARSENAL

Antifungal properties of Curd are mediated through a variety of complementary mechanisms operating at different levels in the life cycle and ecological adaptation of Malassezia(20).

A. Environmental Control by pH Modulation

The antifungal strategy of curd is based on the creation of conditions that are absolutely adverse for Malassezia and favorable for beneficial microbiota. Lactic acid establishes and maintains scalp pH at 4.0-4.5, levels that strongly suppress Malassezia metabolic activity and reduce lipase production, which is necessary for digestion of sebum(21). The pH modification thus exerts a selective pressure,

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favoring acid-tolerant beneficial bacteria while inhibiting Malassezia. Research has demonstrated a 70% reduction of fungal viability at pH 4.5, compared to neutral conditions(22). Complementing this environmental control, probiotic organisms interactively compete for adhesion sites and nutrients, hence limiting access by Malassezia to those resources it needs for proliferation and biofilm formation. However, environmental modification alone may not suffice in case of established populations of resilient Malassezia; thus, more direct antimicrobial approaches may be required(23).

B. Direct Antimicrobial Action

The solution to the challenge of established Malassezia colonization is found in the direct antimicrobial mechanisms of curd, along with its potential biofilm-disruptive capabilities. Probiotic strains in curd primarily produce specific antimicrobial compounds such as bacteriocins against Malassezia cell membranes, organic acids that disrupt cellular pH, and hydrogen peroxide, which generates oxidative stress in fungal cells. Laboratory studies have demonstrated that cell-free supernatants from Lactobacillus cultures can inhibit Malassezia growth by 60-80% within 24 hours(24). More significantly, certain Lactobacillus strains show promise in the disruption of Malassezia biofilms through production of biofilm-degrading enzymes and competitive inhibition of adhesion mechanisms, thereby overcoming one of the major barriers to effective dandruff treatment. However, even these comprehensive antifungal approaches need to be coupled with anti-inflammatory action in order to address the complete dandruff pathology(25).

IV. MECHANISM 2: FREE THE ANTI-INFLAMMATORY SOOTHING POWER

The inflammatory component of dandruff demands approaches that are equally sophisticated in targeting immediate symptoms and underlying immune dysregulation(26).

A. Immunomodulation and Cytokine Regulation

The inflammation associated with dandruff, usually aggravated by conventional antimycotic therapy, is a feature that curd resolves through its sophisticated immunomodulatory capabilities(27). Probiotic organisms present in curd interact with scalp immune cells via pattern recognition receptors, modulating cytokine production toward anti-inflammatory profiles while reducing pro-inflammatory mediators like IL-1α, IL-8, and TNF-α. Studies have shown that certain strains of Lactobacillus are capable of reducing the production of inflammatory cytokines by approximately 50% in keratinocyte models, which gives a biological basis for the traditional use of curd to soothe inflamed scalp. This immunomodulatory action represents a definite advantage over conventional therapy that usually reduces inflammation only indirectly through fungal suppression, often along with causing additional irritation due to its chemical composition(28).

B. Barrier Repair and Physical Soothing Mechanisms

While immunomodulation addresses the underlying inflammatory processes, the immediate symptomatic relief required by sufferers finds solution in the physical soothing and barrier-repairing properties of curd(29). The lipid components form a protective occlusive layer that immediately reduces itching and irritation by shielding nerve endings, while it simultaneously reduces trans epidermal water loss by 30-40% and improves barrier function within days of application. This rapid symptomatic relief helps break the destructive itch-scratch cycle that perpetuates dandruff, while the improved barrier function creates long-term resistance to irritant penetration and microbial invasion. The combination of immediate physical soothing and sustained barrier support complements the slower immunomodulatory effects and provides comprehensive anti-inflammatory action across different timeframes(30).

V. THE EVIDENCE BASE: BRIDGING ANECDOTE AND SCIENCE

Traditional use to evidence based therapy necessitates the assessment of the entire spectrum of evidence supporting the efficacy of curd in managing dandruff(31).

A. Traditional Wisdom and Anecdotal Evidence

The application of curd in the management of dandruff has a deep-rooted history in traditional medicine, with Ayurvedic texts documenting its application for various inflammatory skin and scalp conditions for over 3,000 years(32). Traditional practices across South Asia, the Middle East, and Eastern Europe have consistently utilized curd as a hair treatment, with remarkable consistency in reported benefits including reduced itching, decreased flaking, and improved hair texture(33). The fact that these practices remain persistent across generations and geographical boundaries, regardless of modern alternatives, gives strong anecdotal evidence for the efficacy of curd(34). However, while traditional wisdom may offer valuable insights and historical validation, it is inadequate to establish therapeutic efficacy when set against rigorous scientific evidence(35).

B. In-Vitro and Preclinical Evidence

The limitations of anecdotal evidence have been overcome by laboratory studies that have mechanistically validated the traditional use of curd(36). In-vitro studies have shown that certain strains of Lactobacillus, including L. acidophilus and L. plantarum, possess significant anti-Malassezia activity, as evidenced by inhibition zones of 15-25mm in agar diffusion assays(37). Studies on lactic acid have reinforced its twin role in not only inhibiting fungal growth but also facilitating healthy desquamation, as seen by 40-60% reduction in Malassezia viability at achievable concentrations by topical application of curd(38). Animal dermatitis models have also demonstrated significant improvement in scaling and inflammation parameters upon the application of fermented milk products(39). The preclinical investigations provide a definite scientific backbone for the traditional use of curd; however, their exact translation into human clinical efficacy needs to be directly validated(40).

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C. Clinical Evidence and Research Gaps

The promising preclinical findings create a compelling case for clinical investigation; however, the current evidence base reveals both supporting evidence and significant research gaps(41). There are few direct RCTs exploring plain curd application, although several clinical studies offer indirect support:

Table 2 Indirect Clinical Evidence Related to Curd Application(42)

Study Type	Key Findings	Relevance to Curd
Probiotic Lotion Study	34% reduction in dandruff severity scores	Supports probiotic efficacy
Lactic Acid Formulations	45% improvement in scaling	Validates lactic acid mechanism
Fermented Ingredient Trials	Significant microbiome improvement	Supports fermentation benefits

While these studies have not directly dealt with curd, they provided sufficient indirect evidence of its probable therapeutic potential(43). The existing evidence justifies both practical application and further rigorous research with a view to establishing uniform protocols and efficacy parameters(44).

VI. DISCUSSION

❖ *Curd in the Modern Cosmetic Landscape*

Positioning curd within contemporary dermatological practice demands a discussion of both its present applications and future scope in cosmetic science(45).

A. Comparative Therapeutic Analysis

A systematic comparison of curd with conventional dandruff treatments brings out its unique value proposition(46). Whereas single-mechanism pharmaceutical approaches are the more common strategy for treatment, curd represents a polypharmacological strategy, wherein multiple pathways of dandruff are targeted simultaneously(47). Common conventional antifungal agents, while often demonstrating good initial efficacy, usually do not provide continued long-term control because of resistance development and the scant attention to the inflammation component(48). The multifaceted approach with curd gives generally much milder, more sustainable management with less risk for resistance, though perhaps it needs longer application times to show significant results(49). A comparative profile would suggest an integrated approach wherein curd serves as the maintenance therapy alongside conventional treatments for acute flare-ups(50).

B. Future Directions and Commercial Potential in Cosmetic Science

Although these practical limitations do not diminish the therapeutic potential of applying raw curd directly to the scalp, they point to exciting opportunities for innovation in cosmetic science and product development(51). The increasing consumer demand for natural, sustainable personal care products, combined with the rapidly improving scientific understanding of skin microbiome ecology and fermentation science, has created fertile ground for translating the benefits of curd into sophisticated cosmeceutical formulations(52). The future of curd in dermatology will likely involve the development of standardized products containing postbiotics-inactivated probiotic cells and their metabolites-that offer the demonstrated benefits of fermentation while overcoming practical limitations such as variable potency, messiness, and odor associated with raw curd application(53). Major cosmetic manufacturers have already begun investing in research on fermented ingredients, with several recent patent applications describing stable formulations of Lactobacillus ferment lysates for scalp care products(54). These advanced formulations could potentially deliver enhanced efficacy through improved penetration systems ensuring that active components reach target sites in the hair follicles and scalp epidermis(55). Furthermore, the development of microbiome-friendly shampoos and conditioners that incorporate curd-derived components represents a promising approach to maintaining scalp health while providing gentle cleansing and conditioning(56). Commercial potential extends beyond mere product development to standardized testing protocols to ensure consistent biological activity across production batches, quality control measures for maintaining probiotic viability in products where live cultures are desired, and clinical validation of efficacy claims through properly designed trials(57). This evolution from kitchen remedy to evidence-based cosmeceutical represents not just commercial opportunity but a meaningful integration of traditional wisdom with modern scientific innovation, creating products that honor historical knowledge while meeting contemporary standards for safety, efficacy, and user experience(58).

VII. CONCLUSION AND FUTURE DIRECTIONS

This review creates a sound basis on which to recognize curd as a potential complementary approach to dandruff management-as indeed its multifactorial nature is best tackled by the synergistic antifungal and anti-inflammatory mechanisms at play(59). The traditional wisdom supporting the use of curd finds validation in modern scientific understanding of its bioactive components and their multifaceted actions against the pathology of dandruff(60). Curd's unique combination of lactic acid, probiotics, and barrier-supportive components creates a comprehensive therapeutic profile directed at dandruff through environmental modification, direct antimicrobial action, immunomodulation, and repair of the barrier in a way that no conventional treatment based on single mechanisms is able to replicate(61). Accordingly, several concrete research directions would significantly advance our understanding and application of curd in the management of dandruff(62). First, efficacy and optimal application protocols must be established through properly designed randomized controlled trials using standardized curd preparations(63). Second, research that pinpoints the most potent probiotic strains specifically against Malassezia species would allow for the targeted selection of cultures for home use and for the development of commercial products(64). Third, the biofilm-disruptive capability of various probiotic strains could open

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new avenues of addressing treatment resistance, which bedevils chronic dandruff sufferers(65). Fourth, formulation of stable, cosmeceutical preparations capable of maintaining the bioactive components of curd yet enhancing user experience would clearly help bridge the gap between traditional remedy and modern consumer product(66). Lastly, studies that explore the broader scalp microbiome composition after topical application of curd would yield much-needed insights into its ecological effects beyond a simple suppression of pathogens(67). The accumulating evidence from traditional wisdom, mechanistic studies, and clinical research presents a compelling case for the use of curd in the management of dandruff(68). While not a substitute for standard therapy in cases of severe disease, it provides a useful complementary modality in maintenance therapy, in mild-to-moderate dandruff, and in patients desiring non-pharmacological treatment(69). By building on traditional knowledge through rigorous scientific validation, we will realize the full potential of this ancient remedy in modern dermatological practice-as we take curd "beyond the kitchen" into the realm of evidence-based therapeutic agents(70).

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