**RESEARCH PAPER**

# New Perspectives on How Dairy-Based Nutraceuticals and Functional Foods Support Skin Health and Dermatologic Care

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**ABSTRACT**

Bioactive ingredients included in dairy-derived nutraceuticals and functional foods have physiological effects that go beyond simple nourishment. The original nutraceutical literature provides a thorough description of its antioxidant, anti-inflammatory, immunomodulatory, probiotic, and microbiome-balancing properties, which offer a scientific basis for investigating their dermatological implications. Probiotic research, biologically active peptides, and functional dairy fermentation processes provide evidence of potential uses in supporting the skin barrier, modulating inflammatory skin diseases, reducing oxidative stress, and enhancing immune responses, particularly in relation to eczema and atopic dermatitis. This review outlines the potential benefits of dairy-based functional foods for skin health, therapeutic support for common cutaneous illnesses, and preventive dermatology.

**Keywords:** Dairy-based nutraceuticals, Functional foods, Skin health, Dermatologic care

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## 1. INTRODUCTION

Functional foods and nutraceuticals produce health effects beyond basic nutrition and may help prevent or modulate disease. [1,2] Numerous skin conditions, including psoriasis, atopic dermatitis, photoaging, acne, and chronic inflammatory dermatoses, share systemic pathways impacted by oxidative stress, microbiota, immunity, and nutrition. [3] These pathways show a significant translational potential and overlap with the documented biological activities of nutraceuticals produced from dairy. Nutraceuticals have metabolic, immunoregulatory, anti-inflammatory, and antioxidant qualities. [4] Each of these processes is essential for preserving the integrity of the skin barrier, controlling cutaneous immune responses, and delaying both intrinsic and extrinsic aging. Consequently, the dermatological advantages of dairy-based nutraceuticals are both clinically significant and biologically tenable. [5,6,7] According to the "gut–skin axis" notion, both gut and skin health can be restored through immunological regulation by the gut bacteria. Therefore, rather than being a direct result of the gut microbiota shaping the skin microbiome, the changes observed in the facial microbiota and skin conditions following probiotic interference may derive from broader systemic factors. This multifactorial viewpoint is vital for understanding the gut–skin axis and underscores the need for additional research to clarify the complex pathways. [8,9,10,11,12]

## 2. NUTRACEUTICALS

Although the concept of associating dietary ingredients with health benefits has existed for millennia, it wasn't until 1989 that Stephen DeFelice coined the term "nutraceutical." [13] His notion was based on the straightforward idea that some natural food ingredients can prevent or treat illness without having the same effects as prescription medications. The fundamental idea was well known long before the phrase was coined. The same understanding was

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encapsulated almost two millennia ago in Hippocrates' famous advice to "let food be thy medicine." Modern nutraceuticals include a wide collection of biologically active substances derived from plants, animals, and even marine sources. [14] Many of these compounds participate in fundamental cellular processes, including regulating cell growth, supporting antioxidant defenses, and influencing gene expression. [15] Because of these roles, nutraceuticals are discussed as contributors to healthy aging and as supportive measures for conditions linked to modern lifestyles, including cardiovascular disease, diabetes, high cholesterol, metabolic disorders, and several degenerative illnesses. [16] Although often mentioned together, nutraceuticals and functional foods are not identical. Functional foods are ordinary foods enriched with health-promoting components, while nutraceuticals are usually purified or isolated substances presented in concentrated form. Commercial examples illustrate this distinction: some products are designed to strengthen bone health, others aim to improve immunity, reduce cholesterol, or support muscle protein synthesis. [17]

Scientific interest in these compounds continues to grow. Laboratory studies, both in vitro and in vivo, have explored the biological activity of many nutraceutical molecules, and animal studies have provided additional insight into their physiological effects. Research on botanicals and plant-derived substances has been conducted in parallel, highlighting their long history of use in traditional medicinal systems such as Ayurveda, which has employed preparations resembling nutraceuticals for thousands of years. [18] The nutritional category encompasses a wide range of ingredients. Dietary fibers, polyphenols, probiotics, antioxidants, flavonoids, vitamins, spices, and different polyunsaturated fatty acids are among them. Because these substances naturally occur in foods, they tend to be well-tolerated, readily available, and often have longer physiological activity than many synthetic agents. Different classification systems have been proposed. Some distinguish between compounds with promising epidemiological evidence and those with strong clinical support. Others sort nutraceuticals by origin: plant-derived phytochemicals, microbially sourced nutrients, or animal-derived compounds. Another approach categorizes them by chemical nature, separating fatty acids, prebiotics, flavonoids, vitamins, and other molecular groups. Additional categories include simple nutritional enhancers and functional foods enriched with targeted health-promoting components. [19] Nutraceuticals are anticipated to become increasingly important in customized health plans in the future. The nutraceutical industry is expanding across the food, pharmaceutical, healthcare, and agricultural sectors as consumer demand shifts toward foods with quantifiable benefits. Advances in nutrition science are steadily clarifying how diet interacts with long-term health, and global markets from the United States and Europe to Japan and China are responding with increased research, innovation, and production. [20]

Rich in bioactive substances with immunomodulatory, anti-inflammatory, and antioxidant qualities, nutraceuticals aid in the management and prevention of chronic illnesses. Regular consumption is linked to better neurological, metabolic, and cardiovascular health. [21]) Dietary polyphenols influence metabolic signaling pathways and gut microbiota in ways that go beyond their antioxidant benefits. These activities improve cholesterol and glucose homeostasis and reduce the risk of metabolic diseases. [22] Oral probiotics may improve skin barrier function and reduce inflammation in conditions such as atopic dermatitis, but further clinical studies are needed to confirm their effectiveness as dairy-based supplements. [23] Personalized nutrition approaches based on microbiome profiling show potential benefits for skin diseases; however, more targeted research is required to validate personalized probiotic interventions in dermatology. [24]

### 2. 1. Key Nutraceutical Concepts Relevant to Skin

#### 2.1.1. Bioactive Components in Dairy Products

Dairy contains proteins, peptides, vitamins, minerals, probiotics, and fermentative metabolites that exhibit physiological activity. These components may influence: Skin barrier repair through proteins, amino acids, and ceramide-modulating lipids. Also, through the Redox balance of antioxidant peptides and probiotic-derived metabolites. Inflammation control, such as cytokine modulation and immune regulation. Microbiome stability on the gut–skin axis, LAB probiotics. [25,26]

The outcomes provide evidence-based guidance for nutritional selections supportive of women's bone health, highlighting the likely benefits of milk & yogurt intake and the recognition of whey protein as a key functional constituent. [27]) Probiotics and bioactive peptides found in dairy products enhance metabolic and inflammatory balance and strengthen their status as functional foods by regulating immune function and gut flora. [28]. Kefir fermentation releases stable milk-derived bioactive peptides with immunomodulatory and antioxidant qualities, highlighting fermented dairy as a beneficial nutritional source. [29] Bioactive peptides with antioxidant, antibacterial, and enzyme-inhibitory properties are produced when milk is fermented with multi-strain probiotics, suggesting possible advantages in the management of oxidative stress and inflammation. [30]

### 2.2. Antioxidants and Anti-Inflammatory Agents

Certain lactobacilli strains lessen the buildup of free radicals, and dairy fermentation can generate antioxidant molecules. Chronic eczematous diseases, photoaging, hyperpigmentation, and acne inflammation are all mostly caused by oxidative stress. Thus, dairy-derived antioxidants may contribute to reduced ROS-driven skin aging, improved collagen preservation, and mitigation of inflammatory flares in acne or eczema. [31] Daily intake of lycopene-rich functional foods, such as enriched ice cream or juice, increases plasma and skin lycopene levels and reduces systemic oxidative stress and inflammatory biomarkers. Controlling foods without lycopene does not

produce these effects. These findings highlight the potential of lycopene-containing dairy-based nutraceuticals to improve antioxidant status and support skin health. [32,33] Fermented dairy products and whey-derived probiotics, such as Lactiplantibacillus plantarum, reduce oxidative stress and inflammation, supporting skin health and protecting against photoaging, acne, and eczema. [34,35]

## 3. PROBIOTICS & THE GUT–SKIN AXIS

Research has provided extensive evidence for the immune and anti-inflammatory benefits of probiotic strains, including Lactobacillus rhamnosus GG, L. paracasei, and Bifidobacterium longum. Probiotics reduce the risk of eczema in infants and modulate cytokine activity in Atopic dermatitis. Enhanced IgA production and improved immune function may support better skin-barrier resilience and skin immunity. Probiotics reduce systemic inflammation and may inhibit inflammatory cascades linked to acne. [36,37] Improving barrier function and gut microbiome integrity can reduce systemic inflammatory mediators that reach the skin. These findings demonstrate that probiotic dairy products could act as functional foods for dermatologic wellness. [38] The Different Benefits of Probiotics on the Skin include skin whitening, skin moisturization, anti-aging, anti-chronological aging, anti-photoaging, and anti-wrinkle. while numerous studies show that disorders in intestinal microbiota might contribute to dermatological diseases, such as acne, psoriasis, rosacea, and atopic dermatitis. [39]

## 4. FUNCTIONAL FOODS

The concept of functional foods emerged from a simple yet powerful observation: some foods do more than satisfy hunger; they influence physiological processes that support long-term health. Japan was the first country to formalize this concept, coining the term and establishing a regulatory category known as "Foods for Specific Health Uses" (FOSHU). This approach acknowledges that, in addition to basic nutrition, the addition, removal, or modification of specific food components can benefit health. [40] There are several techniques to develop functional foods. Some are made more valuable by adding biologically active components such as probiotic bacteria, vitamins, minerals, or omega-3 fatty acids. Others are made functional by a genetic change that improves a desired feature or by selective elimination. Regardless of the method, the primary challenge remains maintaining the stability and biological activity of these components throughout processing and storage. Research has consistently shown that these foods can help manage or reduce the risk of chronic diseases, including cardiovascular disease, diabetes, and hypertension. However, they are not medicines and should not be considered cures. Their role is supportive, not therapeutic. Dairy products occupy a prominent position in the functional food landscape. [41,42] Consumers have always viewed milk, yogurt, and related products as natural staples high in nutrients, and the dairy sector has been quick to adopt health-focused innovations. The public health message of balanced diets is ideally aligned with their high protein, calcium, and vitamin content. In addition to these essential nutrients, dairy products have been modified to include additional bioactive ingredients such as probiotic cultures, conjugated linoleic acid, and sphingolipids, which may broaden their physiological effects.

Dairy has emerged as a potent foundation for creating novel functional meals, driven by the rising demand for foods that combine well-known flavors with added health benefits. One important area of progress is the use of probiotics. These beneficial bacteria, particularly strains of lactic acid bacteria, are selected for their ability to survive in the digestive tract environment, adhere to intestinal surfaces, and produce antimicrobial substances that help them outcompete harmful microbes. Certain probiotic strains have been linked in an increasing number of studies to improvements in vitamin synthesis, immunological regulation, and digestive balance, as well as reductions in intestinal inflammation, diarrhea, and constipation. Additionally, some research indicates that taking probiotics early in life or during pregnancy may be beneficial for treating skin conditions such as atopic dermatitis. Their therapeutic potential is further enhanced by their ability to modulate immunological signals and reduce oxidative stress. [43]

The transformation of traditional foods into functional foods is exemplified by probiotic yogurt.[44] Carefully chosen probiotic strains can supplement the basic fermentation process, which Lactobacillus delbrueckii and Streptococcus thermophilus carry out. This can change the food's texture, acidity, or aroma, but when done correctly, the end product is an inexpensive, readily accessible food with physiological and nutritional benefits.[45] Fermented dairy products also produce bioactive peptides during fermentation, some of which exhibit antihypertensive, immunomodulatory, or anticoagulant activity. [46] The biological pathways impacted by these components are still being mapped by research on functional foods. Many targets are related to gastrointestinal function, including intestinal motility, mucosal health, nutrient availability, and interactions with the gut microbiota. Other targets include systemic processes such as lipid metabolism or immune regulation. Through these mechanisms, functional foods are associated with a range of health outcomes: a reduced risk of cardiovascular disease, improved metabolic balance, stronger memory, stronger bones, and even improvements in overall health or mental clarity. [45,46]

Functional foods and nutritional preparations are similar in function, though structurally distinct. These are usually concentrated or pure substances, frequently derived from plants, animals, or marine life, intended to produce specific physiological effects. [47] Lutein, folic acid, cod liver oil, and rich omega-3 supplements are typical examples. These drugs are frequently used to help manage inflammation, regulate blood sugar, support cardiovascular health, and improve cognitive function. [48] Their potential to affect illness risk with fewer adverse effects than conventional drugs is what makes them appealing. When combined, functional foods and supplements indicate a shift toward

preventive nutrition.[49] Instead of relying solely on medical treatments, individuals are increasingly turning to everyday dietary choices to support long-term health. As science continues to elucidate the interactions between food components and human physiology, this field is likely to remain central to public health, food innovation, and personalized nutrition strategies. [47,49]

### 4. 1. Functional Dairy Products and Their Cutaneous Applications

Recent findings showed that yogurt, probiotic milk, and fermented dairy products are the most advanced functional food category globally. [50] A study validates that a composite postbiotic extract derivative from *Lactobacillus bulgaricus* promotes wound healing through complementary antimicrobial, immunomodulatory, and pro-regenerative properties. [51]

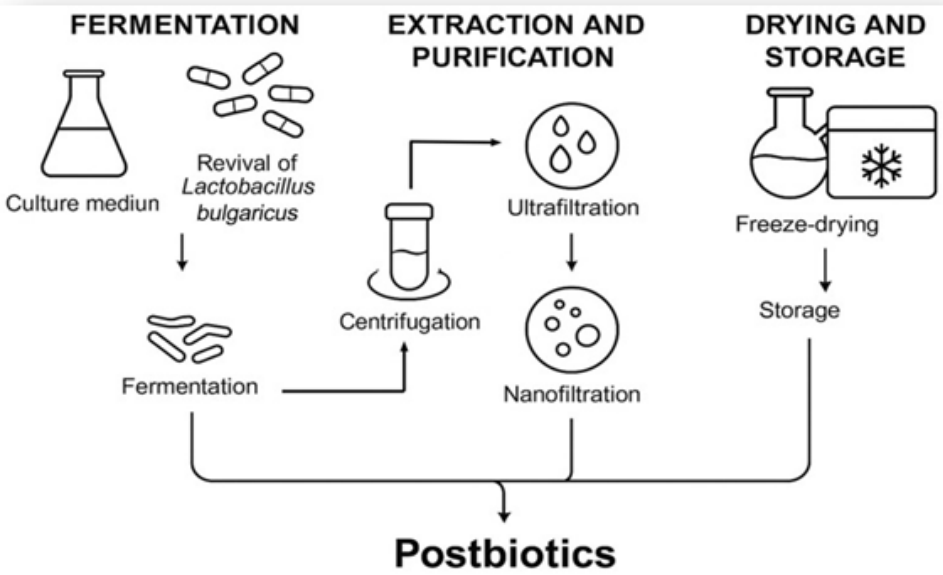



**Figure 1. Schematic image of the postbiotic extract preparation procedure:** Workflow for postbiotic production from Lactobacillus bulgaricus, including fermentation, centrifugation, sequential filtration, and freeze-drying for storage. [51]

As shown in Figure 1, postbiotics are produced through a stepwise process that involves fermenting Lactobacillus bulgaricus, followed by extraction, purification, and stabilization. Human breast milk exhibits antifibrotic and regenerative effects in wound healing. It controls macrophage polarization to the M2 phenotype, augments angiogenesis, and improves skin elasticity. Human breast milk triggers IGF-1 and PDGFC coding in macrophages, activating BMP paths that induce myofibroblast heterogeneity and hair follicle renewal. These mechanisms enable scar-reduced, near-normal skin healing, spotlighting the potential of human breast milk in regenerative medicine. [52] Milk fat-globule epidermal growth factor 8 (MFG-E8) is a key factor in wound healing. It involves regulating blood coagulation, mediating macrophage uptake of apoptotic cells, shifting macrophages from an inflammatory to an anti-inflammatory phenotype, promoting angiogenesis, enhancing vascular endothelial growth factor (VEGF) signaling, and assisting wound tissue perfusion. [53] Some Propionic Acid Bacteria naturally prevent human skin, chiefly *Cutibacterium* (formerly *Propionibacterium acnes*). They live in hair follicles & sebaceous glands, helping preserve skin balance. They can develop opportunistic pathogens and cause acne once overgrown. Recent research has focused on genetic analysis to understand the role in skin health and the Development of powerful therapies. [54]

#### 4.1.1. Fermented Dairy & Skin Benefits

Fermented dairy produces bioactive peptides with immunomodulatory and antihypertensive activity. [55] These mechanisms work through immunomodulatory peptides and may reduce flare frequency in immune-mediated dermatoses (e.g., eczema, psoriasis). Also, bioactive proteins may support skin hydration and maintain keratinocyte differentiation. [56] A meta-analysis of clinical studies involving humans only concluded that there is early and limited evidence that fermented dairy products, used both topically and orally, may benefit skin health. However, existing studies are limited, and further studies will be important to assess efficacy more comprehensively and the mechanisms involved. [57] Fermented dairy products contain components and bacterial derivatives (postbiotics) that may positively influence skin health. Preliminary evidence suggests that these bacterial extracts, even if not alive, can support the skin microbiome balance, improve barrier function, and reduce inflammation through compounds such as organic acids and bacterial proteins. However, scientific evidence is still limited, and larger studies are needed to confirm the precise benefits and mechanisms. [58] Fermented dairy consumption may indirectly improve skin health by influencing gut microbiota and immunological responses, according to this comparative investigation in schoolchildren ages 3–6. These effects may help reduce

inflammation and support the gut–skin axis, although evidence remains limited. [59]

#### 4.1.2. Vitamins and Minerals in Dairy Products & Skin Benefits

Researchers note that dairy naturally provides vitamin A, B-complex vitamins, folate, magnesium, and zinc. These are essential for keratinocyte turnover and for modulating acne. [60] Zinc is beneficial for wound healing, acne reduction, and anti-inflammatory action. [61] While B vitamins can reduce dermatitis risk and support skin metabolism. [62] Vitamin D deficiency is also associated with scarring alopecia. [63] Patients with photosensitive disorders often avoid sun exposure, increasing their risk of vitamin D deficiency. Therefore, maintaining adequate serum vitamin D levels is important for patients with conditions such as atopic dermatitis, psoriasis, vitiligo, alopecia areata, systemic lupus erythematosus, and melanoma. [64]

Nutritional dermatoses are typically discussed in the context of developing countries, famine, population displacement, and limited access to health care, with a focus on micronutrient and macronutrient deficiencies, such as zinc, selenium, copper, and vitamins, which are commonly found in dairy products like milk, cheese, and yogurt. [65,66,67]

A review study of the effect of a vegan diet (avoiding food groups such as dairy and other animal-based products) in Dermatology, Nutritional deficiencies associated with a vegan diet are shown in Table 1, while Inflammatory skin diseases and benefits from aspects of the vegan diet are shown in Table 2. [68]

**Table 1:** Nutritional deficiencies associated with a vegan diet. [68]

| Nutritional Deficiency | Associated Dermatologic Conditions |
|---|---|
| Riboflavin (B2) | Angular cheilitis Glossitis |
| Vitamin A | Phrynoderma, Xerosis Hair casts |
| Protein (Kwashiorkor) | Dermatosis is described as “peeling enamel paint.” |

**Table 2:** Inflammatory skin diseases and benefits from aspects of the vegan diet. [68]

| Inflammatory Skin Disease | Vegan Diet | Associated Benefits |
|---|---|---|
| Acne vulgaris | Dairy avoidance Low-GI diet | Anti-inflammatory effect and reduced acne lesion counts. |
| Psoriasis | Plant-based diet No animal-based products | Anti-inflammatory effect Skin improvement and prevention of comorbidities |
| Hidradenitis suppurativa | Dairy avoidance Low-GI diet | Possible prevention of new lesions or progression of existing lesions |
| Atopic dermatitis | Fruits and vegetables Fast food avoidance | Antioxidant and anti-inflammatory effects |

## 5. SKIN-RELEVANT HEALTH BENEFITS

While nutraceuticals enhance cardiovascular disease, cancer, obesity, metabolic disease, and immune modulation, these pathways translate directly into skin-related mechanisms. [69] Dairy bioactives like whey enhance skin health by improving barrier function, increasing antioxidants, and reducing enzymes linked to aging and pigmentation. Fermented dairy and probiotics may further support skin via the gut–skin axis. These ingredients show potential for dermatologic care. [70]

### 5.1. Immune Modulation

Improved T-cell and cytokine regulation can help reduce eczema/atopic dermatitis activity, improve tolerance in allergic skin conditions, and potentially have adjunctive effects in psoriasis or chronic urticaria. [71] In Atopic Dermatitis, Probiotic-Enriched functional foods can modulate T-cell responses and inflammatory cytokine production, thereby reducing the severity of atopic dermatitis and improving immune balance. [72] Also, probiotic supplementation may enhance immune tolerance in allergic skin diseases by modulating gut microbiota and inflammatory responses, leading to improved clinical outcomes. [73] In Psoriasis, Probiotics may influence psoriasis through immune modulation via the gut–skin axis, reducing systemic inflammation and cytokine-driven skin responses. [74] Adjunctive probiotic supplementation has shown potential to improve immune regulation and symptom control in chronic urticaria. [75]

### 5.2. Oxidative Stress Reduction

The antioxidant effects of fermented dairy strains may help reduce UV-induced damage, protect against premature aging, and mitigate chronic inflammation in acne and rosacea. [76] Limosilactobacillus fermentum and other probiotics increase skin antioxidant activity, lowering free radical damage and preventing photoaging. [77] By lowering ROS and boosting systemic antioxidant defenses, fermented dairy products can shield skin from UV-induced oxidative damage. [78] Fermented Solanum melongena L. Peel Extracts' Enhanced Antioxidant and Protective Properties Against UVB-Induced Skin Damage. [79] Dairy probiotic strains promote antioxidant enzymes and reduce reactive oxygen species (ROS), which lessen oxidative stress and persistent skin irritation. [80]

### 5.3. Metabolic Balance and Skin Conditions

Certain probiotics have anti-obesity effects, and because metabolic disorders are linked to acne, hidradenitis suppurativa, and psoriasis, this can indirectly benefit by reducing systemic inflammation, improving hormonal balance in acne, and improving wound healing. [81] By modifying gut microbiota and reducing systemic inflammation associated with immunological and metabolic abnormalities, oral probiotics can lessen the severity of acne. Functional dairy-based probiotics may improve acne through metabolic and immunomodulatory effects. [82] Psoriasis is linked to metabolic imbalance and gut microbiota dysbiosis; probiotics may improve metabolic markers and reduce systemic inflammation. [83] Acne is associated with metabolic syndrome features like insulin resistance, contributing to inflammation; probiotics may improve metabolic balance and reduce acne severity. [84] Obesity and metabolic disorders affect skin microbiota and inflammation; modulating gut microbiota through functional foods can improve metabolic and immune pathways in skin diseases. [85]

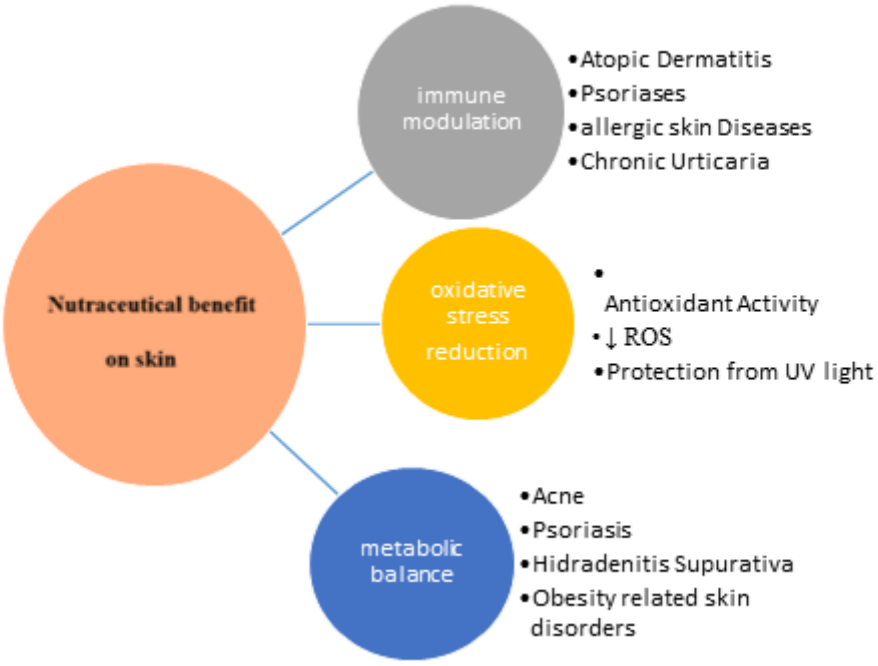



**Figure 2. Skin-Related Health Benefits of Dairy-Based Nutraceuticals:** Schematic overview of the skin-related benefits of dairy-derived nutraceuticals, highlighting their roles in immune modulation, reduction of oxidative stress, and maintenance of metabolic balance.

As illustrated in Figure 2, dairy-derived nutraceuticals exert beneficial effects on skin health through immune modulation, reduction of oxidative stress, and maintenance of metabolic balance.

## 6. FUTURE DIRECTIONS FOR DERMATOLOGY-FOCUSED NUTRACEUTICAL RESEARCH

The rapidly expanding global market for nutraceuticals and the increasing scientific interest in skin health suggest a growing potential for meticulously studied:

- Dairy-derived bioactive peptides as cosmeceuticals
- Topical applications of fermented dairy extracts
- Oral probiotic dairy supplements for skin barrier conditions
- Personalized nutrition for dermatology, paralleling the personalized nutrition concept discussed in the source article

Dairy-derived peptides show antioxidant and anti-inflammatory effects, supporting their future use as dermatologic cosmeceuticals. Further research is needed to validate their clinical dermatologic applications. [86] Future studies are needed to determine the safety, formulation stability, and therapeutic efficacy of topical fermented dairy extracts, which may enhance skin microbiota and barrier function. [87] Although more randomized controlled trials are required to confirm their significance in skin barrier diseases, oral probiotic dairy supplements have an impact on skin health through the gut–skin axis. [88] Future studies are required to identify customized probiotic strategies based on microbiome profiling. Personalized nutrition is a promising strategy in dermatology. [89] More mechanistic and clinical research is needed to comprehend the connections between dairy-based nutraceuticals, immunological regulation, and skin health. [90] The original authors' demand for more thorough clinical validation of functional foods is mirrored by a specific need for dermatology-focused clinical trials.

## 7. CONCLUSION

Reinterpreting the original nutraceutical framework into a dermatologic context highlights a promising relationship

between dairy-based functional foods and skin wellness. Probiotic strains, antioxidant metabolites, vitamins, and bioactive peptides from dairy products exhibit mechanisms that support barrier repair, reduce inflammation, strengthen immunity, and protect against oxidative stress. While functional foods are not medications, the article's emphasis on their preventive and supportive roles in maintaining skin health aligns with the broader concept of using nutrition to promote wellness. More dermatology-specific studies are required, but the scientific basis for future applications is strong.

## CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest.

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