Gut Prebiotic and Probiotic in Skin Aging: Mini Review on Mechanism of Action Aging Delay

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Abstract

The relationship between probiotics and prebiotics and their potential impact on skin aging is a captivating subject that bridges the realms of gut health and skin wellness. Prebiotics, non-digestible fibres that nourish probiotics, live microorganisms that confer health benefits when consumed, have garnered attention for their potential to mitigate the effects of skin aging. This review delves into the intricate interplay between prebiotics and probiotics in gastrointestinal tract, shedding light on their mechanisms and potential applications in promoting youthful and resilient skin. The gut probiotics contributes to enhanced gut barrier function and bolstered immune responses. The resultant systemic effects manifest in skin health, with reduced inflammation and improved antioxidant defenses influencing the aging process. As well prebiotics, by selectively nurturing beneficial gut bacteria, foster a balanced gut microbiome, influencing systemic processes

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such as inflammation regulation, immune response modulation, and nutrient metabolism. The harmonious gut-skin axis emerges as a conduit through which prebiotics orchestrate their effects on skin aging.

Keywords: Skin aging, Prebiotic, Probiotics, Gut microbiome

Introduction

Skin aging is a natural and inevitable process that occurs as we grow older, influenced by both intrinsic and extrinsic factors. While genetic predisposition and environmental exposures play significant roles, emerging research has shed light on the potential impact of the gut-skin axis on the aging process (De Pessemier, 2021). Prebiotics and probiotics, known for their beneficial effects on gut health, are now being investigated for their potential roles in supporting skin health and counteracting skin aging.

Prebiotics are non-digestible fibres and compounds that selectively promote the growth and activity of beneficial microorganisms in the gut. As well as, probiotics are live beneficial bacteria that can improve gut microbial balance and contribute to overall health. The gut-skin axis refers to the bidirectional communication between the gut microbiome and the skin, where changes in gut health can influence skin health and vice versa (Mahmud, M., 2022).

In recent years, researchers have turned their attention to the intriguing connection between prebiotics, probiotics, and skin aging. While the mechanisms involved are still being explored, initial findings suggest that these gut-friendly components may offer a range of benefits for maintaining youthful and radiant skin (Woolery-Lloyd, H., 2023). From reducing inflammation and oxidative stress to supporting the skin's barrier function and collagen production, prebiotics and probiotics may play pivotal roles in the quest for healthy and resilient skin as we age (Gao, T., 2023, Ratanapokasatit, Y., 2022).

This article delves into the current state of research on prebiotics and probiotics in skin aging, examining their potential mechanisms of action, effectiveness, and best practices for incorporating them into skincare routines. By understanding how the gut-skin axis influences the aging process, we can unlock new avenues for holistic approaches to skin care, promoting a harmonious balance between the gut and the skin to enhance overall well-being and maintain youthful skin for longer.

1. Age-Related Skin Aging

Age-related skin aging is a multifaceted process that involves various structural and functional changes in the skin over time. One of the primary contributors to age-related skin changes is the gradual decline in the production of structural proteins such as collagen and elastin (Lee, H., 2021) Collagen provides the skin with strength and support, while elastin imparts elasticity and flexibility (Shin, J., 2019). As these proteins diminish with age, the skin becomes less able to maintain its firmness and resilience, leading to the formation of wrinkles, fine lines, and sagging (Tzaphlidou, M., 2004). This loss of structural integrity is particularly evident in areas of the face that are most exposed to the sun, such as the forehead, around the eyes, and the neck. Another significant aspect of age-related skin aging is the impact of free radical damage and oxidative stress.

Exposure to environmental stressors, such as ultraviolet (UV) radiation, pollution, and cigarette smoke, generates free radicals that can cause cellular damage (Mesa, A., 2017, Raschke, C., 2010). Over time, this damage accumulates, leading to a breakdown of collagen and elastin fibres. Furthermore, free radicals can trigger skin inflammation, exacerbating the aging process (Silva, S., 2017). The result is often an uneven skin tone, the development of age spots, and an overall lacklustre appearance. Intrinsic factors, including genetic predisposition and hormonal changes, also play a role in age-related skin aging. Genetics determine a person's natural skin type, colour, and the rate at which their skin ages (Farage, M.A., 2008). Hormonal changes, particularly during menopause, can lead to a decrease in oil production and hydration levels, contributing to dryness, thinning of the skin, and a decrease in overall skin tone (Farage, M.A., 2008). These hormonal shifts can also affect the skin's ability to heal, potentially prolonging the recovery time for wounds, blemishes, and other skin irritations.

Addressing age-related skin aging requires a holistic approach that considers both intrinsic and extrinsic factors. Protecting the skin from UV radiation through consistent sunscreen use and sun avoidance can significantly mitigate the effects of photoaging (Zhang, S., 2018.). A balanced diet rich in antioxidants and nutrients supports the skin's natural repair mechanisms, while staying hydrated and managing stress helps maintain healthy skin function. Incorporating a skincare routine with products containing ingredients like retinoids and hyaluronic acid can enhance skin texture and hydration (Zhang, S., 2018). For individuals seeking more targeted interventions, dermatological treatments such as chemical peels and laser therapies can help stimulate collagen production and improve overall skin appearance (Chng, W.Q., 2021). By understanding the complex interplay of factors contributing to age-related skin aging, individuals can make informed choices to support their skin's health and appearance as they journey through the aging process.

2. Pathophysiology of skin aging

The pathophysiology of skin aging is a multifaceted process that involves a combination of intrinsic and extrinsic factors working in concert to bring about the visible changes observed in aging skin. Intrinsic aging, often referred to as chronological aging, is influenced by genetic factors and the natural biological processes that occur over time (Zhang, S., 2018). Extrinsic aging, on the other hand, is primarily driven by external environmental factors and lifestyle choices that accelerate the aging process (Zhang, S., 2018). At the cellular level, a key contributor to skin aging is the decline in the production of structural proteins like collagen and elastin. Collagen provides the skin with its structural integrity, helping it remain firm and resilient, while elastin allows the skin to stretch and then recoil to its original shape. As the body ages, the synthesis of these proteins decreases, and their structural organization becomes disrupted. This results in the loss of skin elasticity, contributing to the formation of wrinkles, fine lines, and sagging (Al-Atif, H., 2022). Exposure to UV radiation from the sun and other environmental stressors amplifies the aging process. UV rays generate free radicals, which are highly reactive molecules that cause cellular damage (Gromkowska-Kępka., 2021). This oxidative stress triggers inflammation and activates enzymes like matrix metalloproteinases (MMPs) that degrade collagen and elastin (Pittayapruek, P., 2016). As these vital proteins break down, the skin's structural support weakens, leading to a loss of firmness

and the development of visible signs of aging (Tu, Y., 2016). Another significant contributor to skin aging is glycation, a process where sugar molecules bind to proteins, including collagen. This process forms cross-links between collagen fibres, making them more rigid and less flexible. These rigid collagen fibres impair the skin's ability to bounce back, resulting in the characteristic loss of suppleness and the emergence of wrinkles and fine lines (Snedeker, J.G., 2014.). In addition to these factors, the skin's natural antioxidant defenses can become overwhelmed by the accumulation of free radicals, leading to oxidative stress and further damage (Tu.Y., 2016). Hormonal changes, especially in postmenopausal women, can contribute to reduced skin thickness, dryness, and diminished wound healing capabilities, all of which contribute to the aging appearance (Lephart, E.D., 2021). Inflammation also plays a critical role in skin aging. Chronic low-grade inflammation, often driven by UV exposure and environmental pollutants, accelerates the breakdown of collagen and elastin. This inflammation disrupts the skin's barrier function, impairing its ability to retain moisture and protect against external aggressors (Zhuang, Y., 2014).

Overall, the pathophysiology of skin aging involves a complex interplay of genetic, cellular, and environmental factors. Collagen and elastin degradation, oxidative stress, glycation, inflammation, and hormonal changes collectively contribute to the visible signs of aging such as wrinkles, fine lines, sagging, and an uneven skin tone (Nanzadsuren, T., 2022). Understanding these mechanisms is essential for developing effective preventative and therapeutic strategies aimed at preserving skin health and promoting graceful aging.

3. Skin aging prevention

Preventing skin aging involves adopting a holistic approach that addresses both intrinsic and extrinsic factors contributing to the aging process. Sun protection is a cornerstone of prevention. Regularly applying a broad-spectrum sunscreen with sufficient SPF helps shield the skin from harmful UV rays that can accelerate skin aging (Hughes, M.C., 2013). Complementing this with protective clothing, sunglasses, and seeking shade during peak sun hours further reduces UV exposure (Ganceviciene, R., 2012). A healthy lifestyle plays a crucial role in preventing skin aging. A diet rich in antioxidants, vitamins, and minerals supports the skin's health and resilience. Adequate hydration maintains skin hydration and helps combat dryness (Janson, M., 2006). Avoiding smoking and excessive alcohol consumption minimizes oxidative stress and inflammation that contribute to premature aging (Goodman, G.D., 2019). Effective stress management techniques, sufficient sleep, and consistent skincare practices contribute to overall skin health and longevity. Several prebiotic products are available that can help combat skin aging by fostering a healthy gut microbiome including polysaccharide from natural products.

3.1 Skincare and Topical Treatments

Skincare products containing active ingredients can help address early signs of aging and maintain skin vitality. Retinoids, derivatives of vitamin A, stimulate collagen production, promote cell turnover, and reduce the appearance of wrinkles and fine lines (Carlomagno, F., 2022). Antioxidants like vitamin C and E protect the skin from free radicals and environmental damage (Rattanawiwatpong, P., 2020). Peptides encourage collagen synthesis, improving skin firmness and texture. Hyaluronic acid, a moisture-retaining molecule, hydrates the skin and

minimizes the appearance of wrinkles (Papakonstantinou, E., 2012). Quality moisturizers bolster the skin's barrier function, preventing water loss and maintaining skin suppleness. Regular exfoliation with gentle chemical or physical exfoliants removes dead skin cells, enhancing skin texture and radiance Elias, M., 2018). Incorporating prebiotic in skincare products can offer substantial benefits for skin aging prevention. By fostering a healthy and diverse skin microbiome, prebiotics help regulate systemic skin inflammation and support skin immune responses, which are crucial for maintaining youthful, resilient skin.

3.2 Medical Interventions:

For individuals seeking more advanced interventions, various medical procedures can address visible signs of aging. Chemical peels involve applying chemical solutions to the skin to exfoliate and improve skin texture (Rendon, M.I., 2010). Microdermabrasion mechanically removes the top layer of skin, revealing smoother skin underneath (Karimipour, D., 2010). Laser and light therapies utilize targeted energy to stimulate collagen production and address pigmentation, wrinkles, and other concerns (Tull, S., 2011). Injectables, including dermal fillers and Botox, offer temporary solutions for wrinkles and volume loss. Microneedling creates controlled micro-injuries, stimulating collagen production and skin rejuvenation (Matsa, S., 2021). Personalized consultations with dermatologists allow individuals to receive tailored recommendations based on their skin type, concerns, and goals. Dermatologists may prescribe topical medications, recommend specific procedures, or advise on a combination of treatments for optimal results.

3.3 Lifestyle Considerations

While prevention and treatments play significant roles, lifestyle choices remain paramount. Avoiding excessive sun exposure, maintaining a balanced diet, staying hydrated, not smoking, managing stress, and getting adequate sleep collectively contribute to skin health and aging gracefully (Clatici, V.G., 2017). The prevention and treatment of skin aging involve a comprehensive approach that encompasses daily skincare practices, protective measures, and medical interventions (Clatici, V.G., 2017). By adopting these strategies, individuals can proactively preserve their skin's youthfulness, mitigate the effects of aging, and promote a radiant and healthy complexion for years to come. Integrating prebiotic and probiotic foods into dietary intake can promote a healthy gut microbiome, which in turn supports skin health. By consistently including a variety of these foods in diet and adopting a holistic approach to health, enhance skin's resilience, hydration, and overall appearance.

4. Gut-Skin Microbial Interaction in skin aging

The relationship between gut microbes and skin function is an emerging area of scientific exploration that highlights the interconnectedness of different body systems. While the direct influence of specific gut microbes on skin health is still being unravelled, certain strains have been identified for their potential role in supporting skin function.

Bifidobacterium and Lactobacillus are prominent members of the gut microbiome that have garnered attention for their potential to indirectly impact skin health. Bifidobacterium species, particularly *Bifidobacterium longum*, are associated with anti-inflammatory effects and the reinforcement of the gut barrier function (Rastogi, S., 2022). A well-functioning gut barrier helps

prevent the leakage of inflammatory molecules into the bloodstream that could exacerbate skin conditions. Lactobacillus strains, often found in probiotics and fermented foods, contribute to a balanced gut microbiome. Their role in promoting gut health may have systemic effects, affecting immune responses and inflammation that indirectly influence the skin (Rastogi, S., 2022, Varela-Trinidad, G.U., 2022). *Akkermansia muciniphila*, another member of the gut microbiome, has gained attention for its potential impact on gut health and its association with a healthy gut lining. A strong gut lining contributes to the prevention of inflammatory molecules from reaching the bloodstream, potentially benefiting skin health by minimizing systemic inflammation (Jian, H./2023). The production of short-chain fatty acids (SCFAs), such as butyrate, by certain gut bacteria like Roseburia and some Clostridium strains, has implications beyond gut health (Nie, K., 2021, Grenda, T., 2022) SCFAs have anti-inflammatory properties and can influence immune responses. This systemic effect may have a positive impact on skin health by mitigating inflammation that contributes to aging and skin conditions.

Overall, the relationship between specific gut microbes and skin function is complex and multifaceted. While research is ongoing, the potential influence of these gut bacteria on systemic inflammation, immune responses, and gut barrier function suggests that a balanced gut microbiome could contribute to healthier skin. However, the gut-skin axis is just one component of skin health, and factors such as genetics, diet, lifestyle, and skincare routines also play crucial roles.

5. Mechanism of anti-aging mechanism by gut microbiome

The mechanism by which the gut microbiome exerts potential anti-aging effects involves a complex interplay of processes that impact inflammation, immune regulation, nutrient metabolism, and systemic health (Du, Y., 2021). While the exact mechanisms are still being elucidated, several key pathways have been identified that highlight how a balanced gut microbiome can contribute to promoting overall longevity and mitigating the effects of aging. Inflammatory modulation is a fundamental aspect of the gut microbiome's anti-aging influence (Nagpal, R., 2018). Dysbiosis or an imbalance in the gut microbiome, can lead to a state of chronic low-grade inflammation, known as inflammaging. Inflammaging is associated with aging-related diseases and can accelerate the aging process by contributing to oxidative stress and tissue damage (Ren, J., 2023). A balanced gut microbiome, rich in beneficial bacteria, helps regulate the production of pro-inflammatory and anti-inflammatory molecules. This regulation can minimize the systemic inflammation that accelerates aging and negatively affects various bodily systems, including the skin (Xu, X., 2023). The gut microbiome's influence on immune regulation also plays a pivotal role in anti-aging mechanisms. A well-balanced microbiome supports the development and function of immune cells that help maintain tolerance to harmless substances and prevent excessive immune responses (Wu, H.J., 2012). Normal gut microbiota promoting immune system balance, by stimulate antigen presenting cells (APCs) which co-evolved with microbiota to protect the body against infection or components of the bacteria themselves, including lipopolysaccharides, cell capsule carbohydrates and other endotoxins, may also be released and result in secondary effects to the host and still maintaining immune tolerance (Wu, H.J., 2012). The gut microbiome contributes to reducing autoimmune reactions, by limited number of bacteria that are transported to the mesenteric lymph nodes (MLN)

by mononuclear phagocytes to promotes the development and maturation of the immune system such as Th1, Th2, Tregs and Th17 (Sai, A., 2024). Gut microbiome also supressed chronic inflammation, and cellular damage, by produced a lot of SCFAs may have anti-inflammatory and immunomodulatory effects, all of which are associated with aging-related conditions (Bosco, N., 2021). Nutrient metabolism and absorption are critical components of the gut microbiome's anti-aging effects. A diverse and balanced gut microbiome assists in breaking down complex nutrients and facilitating their absorption (Rowland, I., 2018). This process ensures that essential nutrients, including antioxidants, vitamins, and minerals, are available for the body's overall health and the skin's protection against oxidative stress and collagen degradation. Adequate nutrient absorption is essential for the maintenance of skin elasticity, hydration, and overall appearance. Microbial metabolites, such as short-chain fatty acids (SCFAs), produced by gut bacteria contribute to the gut microbiome's anti-aging influence (Conlon, M.A., 2014). SCFAs, like butyrate, have been shown to possess anti-inflammatory properties and can modulate immune responses. There are many pathways linked in the alteration of gut bacteria metabolites, which can disturb the host’s normal physiological functions including mTOR regulates cell proliferation, autophagy and apoptosis pathway by promoting dietary amino acids and protein synthesis for response to nutritional availability (Donati, Z. S., 2022). In addition, dysregulation diet sensing pathways, for example insulin growth factor-1 (IIS), mTOR, AMP-activated protein kinase (AMPK) and SRs, has been related to an increased risk in skin aging. SCFA activated FOXO pathway to restore the functionality of stem cells, reverse an old muscle to activate regenerative processes that delay young muscle (Kasprzak, A., 2021). These metabolites can enter the bloodstream and impact various bodily systems, including the skin, by reducing inflammation and oxidative stress, which are key contributors to aging-related damage (Silva, Y.P., 2020, Nogal, A., 2021).

So, the gut microbiome's potential anti-aging mechanisms are rooted in its ability to regulate inflammation, immune responses, and nutrient metabolism. A balanced gut microbiome contributes to systemic health by minimizing chronic inflammation, supporting immune system balance, ensuring nutrient absorption, and producing beneficial microbial metabolite (Zheng, D., 2020, Zhang, P., 2022). As research continues to uncover the intricate details of these mechanisms, harnessing the power of a healthy gut microbiome presents an exciting avenue for promoting graceful aging and maintaining vibrant skin health.

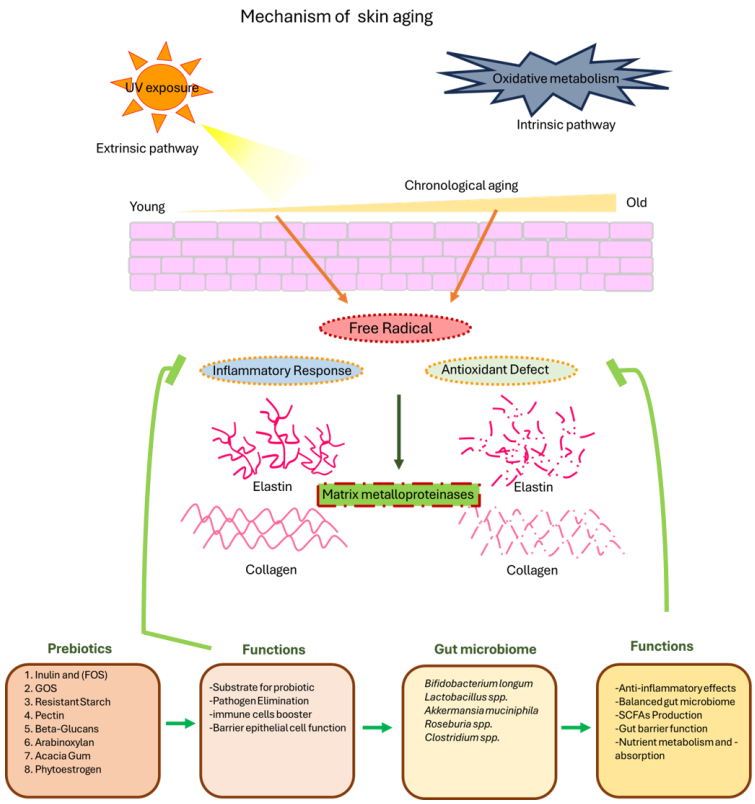

Figure 1 Probiotics relation to regulate aging and gut health modulation.

6. Prebiotic in skin aging prevention

6.1 Inulin and Fructooligosaccharides (FOS)

Inulin and FOS are widely studied prebiotic fibers found in various plant-based foods. They selectively stimulate the growth of beneficial gut bacteria, particularly Bifidobacteria and Lactobacillus strains. These bacteria are associated with maintaining gut health and potentially influencing systemic inflammation and immune responses that indirectly impact skin aging (Kaewarsar, E., 2023). FOS and inulin can stimulate other beneficial bacteria in the gut, such as *Akkermansia, Eubacterium, Faecalibacterium*, and *Roseburia* (Lordan, C., 2020). The increased abundance gut microbiome can provide benefits to the host, by promote modulating immune cells as well as resisting invasion by pathogens. In addition, these prebiotics can improve intestinal integrity and function, lower intestinal pH, and reduce levels of nitrogenous metabolites by generate of important metabolites such as SCFAs, which inhibit inflammatory responses and butyric acid that maintain intestinal barrier function by stabilising specific transcription factors, assembling tight junction proteins and mucins secreted protein (Davani D.D., 2019).

6.2 Galactooligosaccharides (GOS)

GOS are prebiotic compounds found in dairy products and certain legumes. They have been linked to the promotion of beneficial gut bacteria, contributing to a balanced gut microbiome (Petrov, A., 2022.) A balanced microbiome supports the gut-skin axis by regulating inflammation, immune responses, and nutrient absorption that influence skin health (Mei, Z., 2022). GOS showed strongly stimulate bifidobacteria growth in the gut, as well as *Bacteroidetes* and

lactobacilli. Bifidobacteria produce SCFAs and strongly associated with intestinal epithelial barrier improvement and intestinal permeability (Marzorati, M., 2023). In addition, GOS can promote bifidobacteria induced host immunomodulation and also able to produce folate in gut systems (Gavzy, SJ., 2023).

6.3 Resistant Starch

Resistant starch (RS) is a type of dietary fiber that resists digestion in the small intestine and reaches the colon intact. This provides a food source for beneficial gut bacteria, promoting their growth and diversity (Hanes, D., 2022). Resistant starch has been associated with producing short-chain fatty acids (SCFAs), such as butyrate, which have anti-inflammatory effects that can impact skin health and aging (Kadyan, S., 2022). The links between of gut microbiome and RS digestion in fermentation of RS to butyrate including *Faecalibacterium prausnitzii, Eubacterium rectale*, and *Ruminococcus bromii* (Teichmann, J., 2021).

6.4 Pectin

Pectin is a prebiotic fiber found in fruits like apples and citrus fruits. It supports the growth of beneficial gut bacteria and has potential anti-inflammatory properties (Frederick, O.A., 2023) Pectin's influence on the gut microbiome may contribute to systemic effects that benefit skin health (Blanco-Pérez, F., 2021). The ability of pectins to support the growth of specific bacterial populations including, *Bifidobacteria, lactobacilli, Faecalibacterium prausnitzii, Roseburia* spp. and *Eubacterium rectale* which is produce primary pectin-degraders, possessing carbohydrate-active enzymes (CAZymes) such as enzymes lyases, methylesterases, and acetylesterases facilitate the breakdown of pectins (Pascale, N., 2022). Variations in microbiota composition, enzyme capabilities and fermentation substrates, depend on pectin substrates and microbial communities.

6.5 Beta-Glucans

Beta-glucans are prebiotic fibres found in oats, barley, and certain mushrooms. They have been associated with immune system modulation and inflammation reduction (Singh, R.P., 2023). By promoting immune balance and reducing inflammation, beta-glucans may indirectly impact skin health and the aging process (Jayachandran, M., 2018). *Bacteroides* and *Bifidobacterium* are degraders for utilizing complex and simpler glycans which increase beneficial bacterial communities' population and promote microbial metabolites such as 2-methyl-propanoic, butyric acid, propionic acid, and acetic acid (Singh, R.P., 2023).

6.6 Arabinoxylan

Arabinoxylan is found in whole grains like wheat and rye. It has been shown to positively influence gut bacteria associated with health benefits (Mendis, M., 2016). A healthy gut microbiome supported by arabinoxylan consumption may play a role in maintaining the gut-skin axis (Geraylou, Z., 2013). Dietary interventions with short-chain fractions of arabinoxylan resulted in an enriched abundance of bacterial species such as *Bifidobacterium adolescentis* and *Bifidobacterium longum* that can either utilize arabinoxylan oligosaccharides (AXOS) directly. *Anaerobutyricum hallii* and *Faecalibacterium prausnitzii* can use (AXOS) metabolite by-products promote their growth (Hald, S., 2016)

6.7 Acacia Gum (Gum Arabic)

Acacia gum is a soluble fibre extracted from the acacia tree. It's been used as a prebiotic to support gut health by promoting the growth of beneficial bacteria (Gu, I., 2021). Acacia gum's potential to enhance the gut microbiome could have implications for skin health and aging (Rawi, M.H., 2021). The potential of gum arabic has been noted an increase in the numbers of lactic acid-producing bacteria, Bacteroides and Bifidobacterium in healthy human volunteers. as determined in faecal samples (Calame, W., 2008).

6.8 Phytoestrogen

Certain prebiotic compounds, which serve as food sources for beneficial gut bacteria, can influence the metabolism of phytoestrogens (Ionescu, V.S., 2021). A balanced gut microbiome supported by prebiotic consumption can potentially enhance the metabolism of phytoestrogens into beneficial metabolites that contribute to hormone balance and overall health (Lephart, E.D., 2022, Cady, N., 2020). Several gut bacteria such as *Prevotella, Parabacteroides, Adlercreutzia*, and *Bifidobacterium* can metabolize dietary phytoestrogen. The significance of phytoestrogen and phytoestrogen metabolizing gut microbiota such as isoflavones which is a type of phytoestrogen are protected from oxidative stress (Shrode, R.L., 2022).

While these prebiotics hold promise in the realm of skin aging prevention, individual responses may vary. Incorporating a variety of prebiotic-rich foods into the diet can contribute to a diverse gut microbiome, and in turn, potentially impact the gut-skin axis incorporating prebiotics into diet in a way that supports skin health.

Conclusion

The interplay between prebiotics and probiotics in the context of skin aging represents a captivating fusion of science that underscores the profound link between gut health and skin wellness. These dynamic entities, prebiotics as nourishers of beneficial gut bacteria and probiotics as live microorganisms, hold the potential to wield substantial influence over the aging process, echoing the intricate connections between inner equilibrium and outward vibrancy. The gut-skin axis emerges as a pivotal conduit through which the effects of prebiotics and probiotics extend beyond their conventional roles. Prebiotics, by nurturing a balanced gut microbiome, demonstrate the power to attenuate age-associated inflammation, a hallmark of the aging process, thereby contributing to the preservation of youthful skin. Meanwhile, probiotics, with their ability to diversify and strengthen the gut ecosystem, offer a multi-dimensional approach to combating aging, influencing immune responses and oxidative stress, which inevitably reflect on skin vitality.

Ultimately, the synergy between prebiotics, probiotics, and skin aging underscores the interconnectedness of various bodily systems. The journey toward graceful aging, one that embodies both inner resilience and outward radiance, is no longer confined to topical measures alone. Instead, the integration of prebiotics and probiotics into skincare heralds a transformative paradigm, harnessing the power of our inner ecosystem to illuminate the path towards a more holistic and harmonious approach to aging gracefully. The future of prebiotics and probiotics in skin aging prevention is promising, with vast potential for research and practical applications. As scientific understanding advances, these natural interventions may become integral components of

anti-aging strategies, offering safe, effective, and accessible solutions for maintaining youthful and healthy skin. By fostering a balanced gut microbiome through targeted dietary and clinical approaches such as dietary supplements, personalized nutrition, functional food, combination therapies and lifestyle integration which pave the way for innovative and holistic skincare paradigms that promote skin healthy.

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Conflict of interested

The authors have no conflicts of interest to declare.

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