REVIEW ARTICLE

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Acne therapy, probiotics and their influence on the microbiota

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Abstract

Introduction and Objective. Many drugs that affect the skin microbiota are used in acne therapy. In recent years, many studies have proved that different groups of drugs change the composition of the microbiota in different ways. The aim of the study is to compare the impact of individual groups of drugs on the microbiota.

Review Methods. The Pubmed and Google Scholar databases were used to search for articles published from 2016–2024.

Brief description of the state of knowledge. Drugs such as benzoyl peroxide, antibiotics, photodynamic therapy, and retinoids, cause clinical improvement of acne in patients and reduce the population of Cutibacterium acnes, but their influence on the diversity of the microbiota is different. A major problem today is the increase in bacterial resistance to antibiotics. As a result, new generation antibiotics have been created, which can be an effective tool in the fight against resistance. Currently, probiotics can be added to conventional therapy, some of which, e.g. PEG-8 Laurate, have a synergistic effect with other forms of treatment. Moreover, probiotics are becoming a promising form of treatment, modifying intestinal and skin microflora, impacting immune function, and restoring balance.

Summary. Acne treatment significantly alters the composition of the human microbiota, which is why it is important to restore the natural composition of the microbiota in the treatment of this disease. Therefore, treatment options should be sought that will change the composition of the microbiota towards that of healthy people.

Key words

probiotics, antibiotics, acne, acne treatment, skin microbiota, Cutibacterium acnes

INTRODUCTION AND OBJECTIVE

Acne vulgaris is one of the most common chronic skin diseases that mainly affects adolescents and young adults [1]. According to the current guidelines of the European and UK National Institute for Health and Care Excellence (NICE), acne treatment includes, topically – azelaic acid, antibiotics in combination with retinoids, as well as a combination of benzoyl peroxide with antibiotics or adapalene. The most commonly used topical antibiotics include clindamycin, erythromycin, and minocycline. Orally – isotretinoin and antibiotics, most often doxycycline and limecycline [2–5].

Depending on the type and number of skin lesions, acne is classified as mild, moderate, and severe. The degree of advancement of the disease determines the selection of the appropriate type of treatment [1].

Probiotics are becoming more and more popular in the treatment of acne, but they are currently not used in the first line of treatment. In recent years, a lot of research has been conducted that has shown their effectiveness in acne therapy, either as monotherapy or in combination with other drugs [6]. The aim of this review is to collate the effects of different forms of acne therapy on the microbiota.

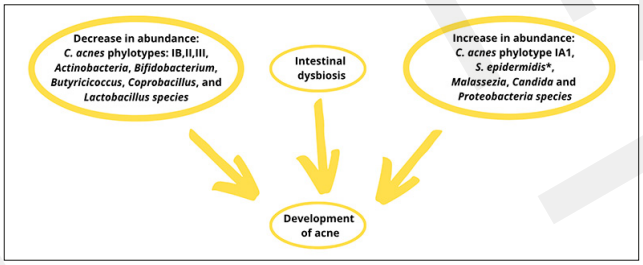

Figure 1. Changes in the microbiota leading to the development of acne. (*C. acnes*) – *Cutibacterium acnes*; (*S. epidermidis*) – *Staphylococcus epidermidis*; * *S. epidermidis* may also have a good impact on skin health [6–12]

MATERIALS AND METHOD

In order to exhaustively identify, extract, and assess all available evidence, a review was undertaken using databases such as PubMed and Google Scholar. The searches were carried out with the predefined key words 'microbiome', 'acne', and 'treatment'. To obtain the most recent data, articles published between January 2016 – October 2024 were searched. Inclusion criteria included primarily original studies, focusing on acne, its treatment, and the impact of treatment on the skin microbiota. Case reports were excluded. Studies written in other than English were rejected to minimize the risk of misinterpretation of texts. The results identified 245 articles on PubMed and 12,200 on Google Scholar. After analysis of the abstracts, studies that either repeated or did not relate to the topic were excluded. For

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Table 1. The influence of different forms of treatment on the microbiota

Treatment type	Condition or disease severity	Findings
Benzoyl peroxide (BPO) [14]	Prepubescent patients and children aged 7–10 years	**Reduction** in the number and diversity of bacteria on the skin; microflora composition similar to patients without acne.. **May destroy** the epidermal barrier.
Systemic antibiotic therapy [15]	Moderate to severe	**Minocycline** – clinical improvement: **Reduction** of *C. acnes*. **An increase** in the number of: *Pseudomonas species, Streptococcus,* and probiotic bacteria *Bifidobacterium longum*, and *Leuconostoc mesenteroides.* **Decrease** in the number of *Lactobacillus species*, *C. acnes.* **Doxycycline –** clinical improvement**:** **Reduction** of *C. acnes* population. **An increase** in alpha diversity of bacteria.
Photodynamic therapy [16,17]	Severe acne	**An increase** in the diversity of the skin microbiota. **Reduction** of the population of *C. acnes* and clinical improvement.
Retinoids [18]	Not applicable	**Enhancement** of the patients' clinical status. **An increase** in alpha diversity and reduced *C. acnes* numbers.
Myrtacine® [19]	2–3 degrees in GEA	**Reduction** of the resistance of *C.acnes* to erythromycin. Myrtacine®-based cream alleviated acne.
Supramolecular salicylic acid (SSA) [20,21]	Moderate to severe	**30% SSA treatment** **Decrease** in skin microbiota richness **Improvement** of GAGS results. **2% SSA therapy** **Improvement** clinical results and the α and β diversity index. **Decrease** in the number of *Staphylococcus*, *Ralstonia*, and *Streptococcus*

further analysis, 27 original studies and 22 review papers were used to provide context.

Acne therapy and microbiota in acne. Acne treatment changes the microbiota of patients. In addition to endogenous factors, the composition of skin microorganisms is also influenced by external factors, including medications. A growing number of studies show that the method of treatment affects the type of changes in the skin microflora [13]. Table 1 shows how each form of treatment affects the microbiota.

Topical benzoyl peroxide and microbiota in acne. Benzoyl peroxide (BPO) has been used to treat acne for many years [13]. BPO has a bactericidal effect and does not cause bacterial resistance [2], although in recent years, more and more studies have shown that BPO may affect the skin microflora [13]. To investigate how BPO modulates the microbiota, a pilot study was conducted on children and teenagers (sick and healthy). Initially, there was greater microbiota diversity in adolescents with acne than in those without acne. Interestingly, after treatment, the microbiota of patients with acne became less numerous and diverse and began to resemble the microbiota of healthy individuals [22].

However, a study by Ahluwalia showed that BPO therapy improved the clinical condition of patients with acne, but the diversity of skin microflora was comparable in adolescents before and after treatment, which may indicate that BPO slightly changes the microbiota [23]. A study by Zhou et al. showed that BPO therapy improves the Global Acne Grading System (GAGS) score, reduces the number of *C. acnes*, and reduces porphyrin and red areas. Unfortunately, this therapy also reduces the diversity of bacteria compared to the state before treatment [14]. The advantage of BPO therapy is that it reduces the resistance of *C. acnes* to antibiotics. In one study, treatment with 5% BPO gel reduced the area and number of hair follicles infected by *C. acnes* after 2 days. This indicates that short-term BPO therapy reduces the carriage of antibiotic-resistant *C. acnes*. Moreover, BPO had a bactericidal effect against antibiotic-sensitive and resistant strains [2].

Topical antibiotics and microbiota in acne. Antibiotics may modify the skin microflora, which should be taken into account when using them in acne therapy. Chien et al. examined changes in skin microflora in patients treated with minocycline. For this purpose, they conducted a longitudinal cohort study in which 4 patients took minocycline orally for 4 weeks. Changes in the microbiota were checked by 16S ribosomal RNA gene sequencing. They observed clinical improvement in acne. There were also modifications in other types of bacteria. A transient increase in the number of *Pseudomonas species* and a lasting increase in the number of *Streptococcus species* were observed, as well as a permanent decrease in *Lactobacillus species,* which was observed up to 8 weeks after discontinuing treatment [24]. In a similar case-control study, Thompson et al. also checked how minocycline affects the skin microbiota. After therapy, they too observed a decrease in the number of *C. acnes*, a short-term increase in the number of *Pseudomonas*, a constant increase in the *Streptococcus* population, and a lasting decrease in the *Lactobacillus* population. Moreover, the number of probiotic bacteria *Bifidobacterium longum* and *Leuconostoc mesenteroides* on the skin increased, and *Staphylococcus epidermidis* and *Prevotella nigrescens* decreased. There were also changes in the microflora in the intestines. The number of *Lactobacillus salivarius*, *Bifidobacterium adolescentis*, *Bifidobacterium pseudolongum*, and *Bifidobacterium breve* decreased. A decreased ratio of *Firmicutes* to *Bacteroidetes* was also noticed after therapy [15]. These examples show that systemic minocycline therapy affects the skin microflora, and efforts should be made to find more targeted forms of acne therapy [13].

Park et al. conducted a longitudinal cohort study to evaluate the effects of orally administered doxycycline for 6 weeks on the microbiota. Before treatment, *C. acnes* predominated on the skin. After treatment, *C. acnes* was no longer as

abundant, and the acne clinically improved; an increase in the number of *Cutibacterium granulosum* was also observed [25]. In a randomized study, 208 patients used a gel with 2% erythromycin for 12 weeks. This increased the number of erythromycin-resistant coagulase-negative staphylococci on the face. This condition also persisted after treatment, up to 24 weeks [2]. Thus, systemic and local antibiotic therapy changes not only the composition of the skin microbiota, but also its diversity [2, 13].

In addition to affecting the skin microbiota, antibiotics also alter the microbiota of other systems. A retrospective cohort study in the UK, in which 71.7% of 118 496 acne patients received a topical or oral antibiotic for more than 6 weeks, found a 2.15 times greater risk of developing an upper respiratory tract infection in the first year of follow-up in those taking antibiotics [2].

Photodynamic therapy and microbiota in severe acne. Photodynamic therapy (PDT) is clinically effective in the treating of severe acne with good patient tolerance. To investigate the impact of photodynamic therapy on the microbiota, a study was conducted in patients with severe acne treated with PDT using 5- 5-aminolevulinic acid (ALA-PDT) applied once a week for 3 weeks. Before treatment, visible differences were observed in the microbiota composition of the control (healthy) group and the study group. There was less alpha diversity in the acne group. Interestingly, ALA-PDT treatment modified the microbiota and introduced changes, among others, in 15 types of bacteria, among them, *Enhydrobacter*, *Cetobacterium*, and *Streptococcus*. A related prospective study showed that ALA-PDT increased skin microbiota diversity, reduced the dominance of *C. acnes* in hair follicles, and improved the growth of mainly *Bacillus* and *Lactococcus*. It follows that ALA-PDT's ability to alter the skin microbiota is partly responsible for its effectiveness in acne therapy. Moreover, Tao et al. noticed a correlation between the administration of ALA-PDT and increased diversity of skin microflora. Additionally, in their longitudinal cohort study, they found clinical improvement in acne and reduction of *C. acnes* in the skin following ALA-PDT administration. These examples demonstrate that ALA-PDT may be an effective therapeutic option for the treatment of severe acne [16, 17].

Retinoids, acetylsalicylic acid, and microbiota in acne. Oral retinoids and tetracyclines are important in acne therapy because they have anti-inflammatory effects [13]. They indirectly reduce the *C. acnes* population by reducing sebum production and providing clinical improvement [2, 13]. Nolan et al. found that response to treatment was associated with a reducing in the number of *C. acnes* in people treated with oral isotretinoin for 5 months. Otherwise, specific changes in the composition of *C. acnes* strains were noticed after therapy, which corresponded to clinical improvement in patients. In addition, they increased the number of *Streptococcaceae*, *Pasteurellaceae*, and *Corynebacteriaceae*, among others. Furthermore, they increased alpha and beta diversity after treatment [26]; therefore, like antibiotics, they have the potential to modify the microbiota in people with acne [13, 27].

Another interesting therapy seems to be peeling with 30% supramolecular salicylic acid (SSA). To further investigate this method of treatment, patients were exposed to a 30% SSA peel once every 2 weeks for 2 months. Improvements in GAGS scores and skin barrier indices were noted after therapy, as well as a decrease in the number of staphylococci. The studies show that peeling with 30% SSA can result in clinical benefits by changing the skin microflora [20]. Additionally, the study with 2% SSA also improved GAGS scores. Moreover, this treatment method contributed to reducing the relative abundance of several bacterial species, and also changed the distribution of microorganisms on the skin towards healthy skin microbiota. Thus, 2% SSA likely alleviates skin microbiota dysbiosis [21].

Phytotherapy, bee products and microbiota in acne. It is observed that some plant extracts have, or potentially have, a positive effect on the skin condition in the treatment of acne. One of them is *Myrtus communis* plant extract (Myrtacine®) which, thanks to its antibacterial and anti-inflammatory effects, is beneficial in the treatment of acne. Importantly, Myrtacine® cream reduces the population of erythromycin-resistant *C. acnes* (EryR). In addition, this drug causes clinical improvement of acne lesions without changing the overall number of *C. acnes*, which may be related to the fact that it acts only on EryR *C. acnes* [19, 28].

Another plant used in phytotherapy is berberine, which has antibacterial and antimicrobial properties. It inhibits the growth of *C. acnes, Staphylococcus spp.*, and *Malassezia spp*., and as it has antiproliferative effects, it also affects keratinocytes. Moreover, it is mentioned that its effect on acne may be as effective as antibiotic therapy. The well-known green tea extract contains polyphenols, which have anti-inflammatory, anti-cancer, and antimicrobial effects. As a result, they inhibit the growth of *C. acnes,* reduce sebum secretion, and inhibit skin inflammation. Interestingly, the plant extracts included in the Ayurvedic herbal mixture, namely, *Aloe barbadensis*, *Azadirachta indica*, *Curcuma longa*, *Hemidesmus indicus*, *Terminalia chebula*, *Terminalia arjuna*, and *Withania somnifera*, have antibacterial and anti-inflammatory effects. Their positive effects on acne are more effective when taken orally [29].

Melaleuca alternifolia, belonging to the *Myrtaceae* family, is a plant endemic to Australia. The leaves of the plant contain large amounts of an essential oil known as tea tree oil, which has anti-inflammatory, anticancer, and antibacterial properties [30]. The main component of the oil is terpinen-4-ol. There are 6 chemotypes of this oil, which differ in the percentage of the individual components: terpinen-4-ol, 1,8-cineole, and terpinolene [30, 31]. In a study conducted by Najafi-Taher et al., they compared the effectiveness of tea tree oil versus tea tree oil with adapalene. The findings showed that there was a significantly greater reduction in acne severity and number of acne lesions in patients using a gel containing both tea tree oil and adapalene, than in patients using a gel containing adapalene alone [32].

Due to the growing interest in seaweed processing, Matias et al. showed in their study that the red alga *Gelidium corneum* contains compounds that exhibit antimicrobial activity. In particular, attention was paid to its growth-inhibiting effect on *C. acnes* and *S. epidermidis*. The results of this study are promising in the context of the use of new substances in the topical treatment of acne [33].

Another study focused on *Mangifera indica*. This is a plant whose ethanol fraction, obtained from leaves and seeds, is effective in fighting acne due to its antioxidant

and proinflammatory cytokine-inhibiting effects. Moreover, compounds contained in this plant affect the lipase activity of *C. acnes*, thus inhibiting the metabolic activity of these bacteria [34]. In addition, the following bee products are used in local acne treatment: propolis, royal jelly, bee pollen, and bee venom. These products contain several substances that have antibacterial and antimicrobial effects [35].

New-generation antibiotics and microbiota in acne. VB-1953 is classified as a new generation of bactericidal antibiotics against resistant *C. acnes* strains. Batra et al. noticed a reduction in inflammatory and non-inflammatory lesions after using 2% VB-1953 gel. In addition, the use of VB-1953 significantly reduced the number of clindamycin-resistant *C. acnes* strains. It is worth mentioning that only minor side-effects occurred in the study, which suggests that it is a fairly safe and effective acne therapy [36].

CBT-SL5, which is an antimicrobial peptide from *Enterococcus faecalis* SL5, is effective in the fight against *C. acnes*. An important fact is that CBT-SL5 reduces inflammation caused by *C. acnes* by inhibiting NF-κB activation. Han et al. conducted a randomized control trial in which they noticed that on the side of the face where CBT-SL5 was used, the severity of acne decreased after 4 weeks of therapy compared to placebo. They also proved that the balm with *Enterococcus faecalis* CBT SL-5 extract is effective in mild acne and does not cause resistance to antibacterial agents. Furthermore, this peptide reduces the phylogenetic diversity of the skin microbiota, indicating its effectiveness [37]. Thus, new-generation antibiotics may be an effective weapon in the fight against increasing antibiotic resistance, whether used alone or as an adjunct to antibiotic therapy [13].

Probiotics in acne therapy. Probiotics are 'live microorganisms that, when administered in appropriate amounts, confer health benefits on the host'. Probiotics are safe to use and have a protective effect against diseases, including cancer. They are safe when they are non-pathogenic and non-toxic. Probiotics can be used in various forms as cosmetics, medicines, food, dietary supplements, or food additives. Post-biotics and probiotics should be differentiated. Post-biotics are 'preparations of non-living microorganisms and/or their components that provide health benefits to the host' [6]. Human clinical trials on probiotics are sparse, but *in vitro* studies have demonstrated some interesting properties of probiotic strains. *In vitro* studies are mainly focused on assessing the ability of probiotic microorganisms to produce antimicrobial substances against *C. acnes* [38]. However, it should be remembered that probiotics, in addition to producing antimicrobial substances, can also bind to the epidermis and modulate the functioning of the immune system, which leads to the inhibition of bacterial growth [6]. Table 2 shows some of the latest research on probiotics.

A few years ago, an *in vitro* study was conducted that demonstrated the beneficial effects of *Lactiplantibacillus plantarum* and *Weisella viridescens* strains in the pathogenesis of acne. Chae et al. noticed the antimicrobial effect of *Lactiplantibacillus plantarum* APsulloc 331261 and APsulloc 331266 strains [39]. In another study, Espinoza-Monje et al. showed that *Weissella viridescens* UCO-SMC3 is resistant to unfavourable conditions in the stomach and intestines and reduces the adhesion of *C. acnes* to keratinocytes. Additionally, in mouse models, a reduction in *C. acnes* replication in lesions and modulation of the immune response were observed using *Weissella viridescens* UCO-SMC3 orally and topically. Moreover, *Weissella viridescens* UCO-SMC3 administered orally resulted in a stronger anti-inflammatory response [40]. Marito et al. noted that PEG-8 Laurate is a carbon source for fermentation exclusively for *S. epidermidis*. Moreover, it reduced the risk of developing antibiotic resistance, which may be a breakthrough in low-dose antibiotic therapy in the future [44].

One clinical study showed clinical improvement in patients treated with orally administered fermented milk with lactoferrin. After the therapy, the amount of sebum, inflammatory lesions, total lesions, and the severity of acne decreased [38]. A few years ago, Rahmayani et al. examined changes in IL-10 concentrations in 33 patients treated for 30 days with a mixture of oral probiotics. An increase in anti-inflammatory response was observed in them [41]. Recently, Rinaldi et al., in a randomized controlled trial on a group of patients with mild and moderate acne, assessed the effectiveness of a mixture of probiotic strains, *Bifidobacterium breve* BR03 DSM 16604, *Lacticaseibacillus casei* LC03 DSM 27537, and *Ligilactobacillus salivarius* LS03 DSM 22776, and a botanical extract from *Solanum melongena* and *Echinacea*. There was a good clinical response to treatment in people treated with a mixture of probiotics and plant extract, as well as both preparations at once, compared to placebo. [42]. Korean scientists checked the synergistic effect of *Curcuma longa rhizome* extract (CLE) and probiotic lactic acid bacteria (LAB) in combating *C. acnes*. It turned out that therapy using LAB and CLE has an additive antibacterial effect. Therefore, the use of these preparations in the treatment and alleviation of acne should be considered in the future [43].

Probiotics can also be used topically to treat acne. Topical therapy with probiotics is a safer form of treatment compared to standard, aggressive acne therapy. Unfortunately, there is a lack of research to confirm the effectiveness of topical probiotics, which may undermine the effectiveness of many commercialized topical preparations [38]. Those available on the market include: a topical probiotic spray containing *Nitrosomonas eutropha,* which causes the release of nitric oxide and nitrite from sweat, which have anti-inflammatory and antibacterial effects against *C. acnes*. In a phase 2 clinical trial, a significant reduction in the severity of acne in the Investigators Global Assessment for acne was observed [47]. Additionally, several *in vitro* studies have been conducted, in which it was found that topical probiotics can improve the function of the skin barrier, and secrete substances that inhibit the growth of *C. acnes*. In 2022, Sathikulpakdee et al., in a randomized controlled trial, compared the effectiveness of a lotion containing probiotics with a lotion with 2.5% benzoyl peroxide in patients suffering from both mild and moderate acne. The balm containing probiotics was obtained from the culture supernatant of *Lactobacillus paracasei* MSMC 39–1. This bacterium inhibits the growth of *C. acnes*. In both cases, it turned out that a probiotic-based lotion would be a safer and equally effective alternative to the 2.5% BPO lotion [46]. In another study, a base cream was used on the left side of the face and a base cream with heat-killed *L. plantarum*-GMNL6 (1 × 109 cells/g of cream) on the right side. The probiotic cream reduced collagen production and *C. acnes* counts, moisturized the skin, and improved the clinical condition in terms of spots and porphyrins. It also reduced melanin production [48]. In the next study,

Table 2. Probiotics in the treatment of acne

Author	Description of the experiment	Probiotics	Results
Chae [39]	*In vitro.*	*L. plantarum* APsulloc 331261 i APsulloc 331266	Inhibition of the growth of pathogenic microflora.
Espinoza-Monje [40]	*In vitro* and mouse model study.	*Weissella viridescens* UCO_SMC3	C. acnes growth inhibition and anti-inflammatory effect.
Rahmayani [41]	Pre-experimental clinical trial with pre-test/post-test.	*B. lactis* W51, *B. lactis* W52, *L. acidophilus* W55, *L. casei* W56, *L. salivarius* W57 and *Lactococcus lactis* W58,	Increased the level of IL-10 after the treatment.
Rinaldi [42]	RCT (randomized controlled trial), double-blind, placebo-controlled study. 114 patients; 8 weeks of treatment; 4 research groups (first group – placebo, second group – study agent, third group – botanical extracts, fourth group – probiotics).	*B. breve* BR03, *L. casei* LC03, and *L. salivarius* LS03 with *Solanum melongena* and *Echinacea* extract; 1 sachet/day	Reducing the number of *C. acnes*, reducing the number of acne lesions, reducing sebum secretion, and exfoliation of the epidermis. Stronger effect of the probiotic with botanical extract.
Jina Kim, Hyaekang Kim [43]	Experimental study.	*L. acidophilus* A001F8, *L. rhamnosus* A001G8, *L. paracasei* A002C5, *L. plantarum* A003A7, *L. casei* A003D4	The synbiotics of probiotic lactic acid bacteria and *Curcuma longa rhizome* extract showed synergistic antibacterial effects against *C. acnes*
Marito [44]	*In vitro* and mouse model study.	PEG-8-Laurate	Inhibition of *C. acnes* growth and reduction of the level of MIP-2 (macrophage-inflammatory protein-2). Fermentation of PEG-8-Laurate by *S. epidermidis* increases the activity of low-dose clindamycin against *C. acnes*.
Podrini [45]	*Ex vivo* study on human sebaceous cells models.	*Lactiplantibacillus plantarum*	Reduction in lipid production and populations of *C. acnes* and *S. epidermidis*.
Sathikulpakdee [46]	RCT (randomized controlled trial). 104 patients with mild to moderate acne; 4 weeks of treatment. Treatment with a probiotic and 2.5% benzoyl peroxide lotion was compared.	*Lactobacillus paraceasei* MSMC 39–1 (topical)	Reduction of acne lesions and erythema index.
AOBiome [47],	RCT (randomized controlled trial), randomized, double-blind, placebo-controlled study. 358 adults with mild to moderate acne; 12 weeks of topical treatment with *Nitrosomonas eutropha*.	*Nitrosomonas eutropha*	A 2-grade improvement in acne severity was observed in the Investigator's Global Assessment (IGA).
Tsai [48]	RCT (randomized controlled trial). 15 women; 2 months. The cream with the tested strain was applied to one side of the face, and the base cream was applied to the other side of the face.	*L.plantarum*-GMNL6	Probiotic, among others, reduced the number of *C. acnes*, improved the clinical condition of patients, and reduced *S. aureus* biofilm.
Liang [49]	Randomized and open-label trail. 105 patients were divided into 3 groups. All groups received doxycycline for the first 4 weeks. Group I received isotretinoin orally, group P received *Lactobacillus plantarum* MH-301 orally, and group IP received both drugs simultaneously. The treatment lasted 12 weeks.	*Lactobacillus plantarum* MH-301	A significant reduction in the number of skin lesions was observed in the IP group compared to the other groups.

Podrini et al. studied a topical probiotic with *Lactobacillus plantarum* and concluded that it has antibacterial properties [38]. Furthermore, Liang et al. observed that isotretinoin combined with *L. plantarum* MH-301 reduced the number of skin lesions to a greater extent compared to isotretinoin alone in patients with acne. It turned out that *L. plantarum* MH-301 restores the diversity of the skin microbiota by reducing the number of the main microflora of skin lesions, *Cutibacterium* and *Corynebacterium*. Additionally, this probiotic promotes the growth of the genera *Lactobacillus*, *Bifidobacterium*, *Coprococcus,* and *Bacteroides* within the intestines [49]. It follows that probiotics may be an alternative to conventional acne therapy, whether used alone or in combination with other medications [38].

CONCLUSIONS

The skin microbiota is modified not only in the natural course of the disease but also during treatment. All treatments result in clinical improvement, and most of them also reduce the dominance of *C. acnes* on the skin. Depending on the type of therapy, diverse changes in the microbiota are observed. Therapies reducing the diversity of the skin microbiota include BPO therapy and 30% SSA therapy, while increased diversity is observed during the use of systemic antibiotic therapy, photodynamic therapy, and retinoids. Interestingly, some drugs, such as minocycline, increase the number of probiotic bacteria. In addition to their positive effects on health, some medications cause side-effects. These include BPO, which contributes to the destruction of the epidermal barrier.

Probiotics may be an alternative treatment option for acne, but confirming their effectiveness requires further research. Significant clinical improvement was noted when using the following bacterial strains: *Lactobacillus*, *Lactococcus*, *Bifidobacterium*, *Lacticaseibacillus*, *Ligilactobacillus*, *Nitrosomonas*, *Lactiplantibacillus*, and *Weisella*. A particular advantage of probiotics is the fact that there are not as many side-effects as when using conventional forms of therapy.

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