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Article

In vitro effects of cosmetic products on the growth of skin-resident bacteria

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SUMMARY

The widespread use of makeup and cosmetic products has attracted increased scientific scrutiny regarding their health effects, including the presence of harmful chemical constituents that may adversely affect human skin. As a result, it is essential for consumers to be informed about these risks before product application. The skin's microbiome comprises diverse bacteria, fungi, mites, and viruses, which play a critical role in immune responses and inflammation. *Staphylococcus epidermidis* and *Micrococcus luteus* are common components of the human skin microbiome. While typically harmless, both species can act as opportunistic pathogens in immuno-compromised individuals. This study investigates the effects of commonly used cosmetic and makeup products on these two bacterial species. We hypothesized that application of makeup products to the skin may negatively influence skin microbiome by inhibiting the growth of resident microorganisms. 18 makeup items from well-known brands, including blushes, primers, concealers, and foundations, were selected. We conducted experiments on nutrient agar plates as cosmetic products precipitated in liquid culture. Our findings indicate that both bacterial species were adversely affected by the tested cosmetic products. At lower concentrations, no growth-promoting or inhibitory effects were observed. However, at higher concentrations, nine of 18 cosmetic products inhibited bacterial growth. Two inhibited the growth of *Staphylococcus epidermidis*, one inhibited *Micrococcus luteus* growth, and six products inhibited the growth of both species. Collectively, these findings suggest that certain cosmetic products can disrupt the skin microbiome, highlighting the need for greater awareness of how routine cosmetic use may influence skin health and microbial balance.

INTRODUCTION

Cosmetic products, including commonly used makeup items, are widely used worldwide. These products are applied directly to the skin to enhance appearance, but their effects on skin health and the skin microbiome remain understudied. In the United States (U.S.), approximately 80% of women spend around an hour per day on personal grooming, with many applying up to 16 cosmetic products each morning (1). The United States is the world's largest beauty and personal care market, valued at nearly $98 billion in 2023, driven by strong consumer demand and spending. Average U.S. household spending on cosmetics, fragrance, and bath products reached $211.8 in 2022, the highest level in over a decade (2). Despite their popularity, cosmetic products have been linked to numerous health concerns, including skin irritation, allergic reactions, premature aging, eye infections, clogged pores, hormone imbalances, and potential carcinogenic effects (3).

The skin microbiome is a protective layer composed of bacteria, fungi, viruses, and mites that play a vital role in maintaining skin health (4). This microbial ecosystem supports immune function, regulates inflammation, promotes wound healing, and helps maintain skin hydration and pH balance (5, 6). Disruption of skin microbiome by external agents such as cosmetic products may lead to adverse skin conditions.

Despite the widespread use of cosmetics, there is a notable knowledge gap regarding their impact on skin microbiomes. One potential mechanism of disruption involves residual activity of common cosmetic preservatives, which persist on the skin following product application and may disrupt microbial balance, such as phenoxyethanol, sodium benzoate, ethylhexylglycerin, 1,2-hexanediol, caprylyl glycol, and benzyl alcohol (7). *In vitro* studies using three-dimensional skin models have demonstrated that some preservative combinations significantly inhibit commensal bacteria like *Cutibacterium acnes* and *Staphylococcus aureus*, while exerting minimal effects on *Staphylococcus epidermidis* (7). These findings suggest that specific cosmetic formulations may contribute to dysbiosis or microbial imbalance potentially affecting skin health (8).

To address this knowledge gap, we investigated the effects of commonly used makeup products on two representative skin bacteria: *Staphylococcus epidermidis* and *Micrococcus luteus.* Previous research indicates that preservatives commonly found in cosmetics can significantly influence the growth of skin-resident microbes, sometimes reducing populations of beneficial bacteria (8). Building on this evidence, we hypothesized that direct application of makeup products will inhibit the growth of the skin-resident bacteria *S. epidermidis* and *M. luteus*. We further proposed that some products may promote bacterial growth or have no effect, depending on the ingredient variability. The cosmetic products we assessed are widely used in the United States, making our findings relevant to a broad consumer population. These findings highlight the potential for everyday cosmetic products to alter the delicate balance of skin microbiome, an essential component of skin health and immune function. By demonstrating that several commonly used formulations inhibit the growth of beneficial skin-resident bacteria, this study underscores the need for greater transparency and evaluation of cosmetic ingredients that may unintentionally disrupt microbial homeostasis. Understanding these effects is particularly important given the widespread, long-term use of

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cosmetics, informing future research, consumer awareness, and regulatory considerations.

RESULTS

To determine how cosmetic formulations interact with bacterial cultures under controlled laboratory conditions, we first attempted to dissolve the products in water. However, due to their lipophilic properties, the products precipitated and formed suspensions, preventing reliable liquid-culture analysis. We initially dissolved cosmetic products in water; however, due to their lipophilic properties, the products precipitated and formed suspensions, preventing reliable liquid culture analysis. Cosmetic products exhibiting measurable antibacterial activity were classified as inhibitory products, whereas products showing no detectable growth inhibition were classified as non-inhibitory products. Dissolving the products in methanol resulted in complete solubilization and did not significantly affect bacterial growth. The amount of methanol used did not produce any significant inhibitory effect on bacterial growth. We obtained optical density (OD_{600}) measurements from these methanol-based liquid cultures of *Micrococcus luteus* to evaluate bacterial growth (**Figure 1, Table 1**). Because OD_{600} reflects the turbidity of the culture, which correlates with bacterial cell density, a decreased OD compared to the negative control indicates growth inhibition. Our initial liquid-culture tests showed that many cosmetic products precipitated and created background turbidity, making OD_{600} measurements unreliable for assessing true bacterial growth. Although methanol improved solubility, the products still produced baseline cloudiness that interfered with OD readings. These limitations led us to shift to nutrient agar plates, where diffusion-based zones of inhibition allowed clearer and more accurate measurement of antimicrobial effects.

Brand	Product Type	Abbreviation
Maybelline	Powder Foundation	M pf
Maybelline	Liquid Blush	M lb
Maybelline	Primer	M p
Maybelline	Eyeshadow	M e
E.L.F.	Highlighter	E h
E.L.F.	Contour	E ct
Revlon	Powder Blush	R pb
Covergirl	Liquid Foundation	C lf
L'Oreal	Concealer	L c
Physicians Formula	Foundation	P b
Maybelline	Liquid Foundation	M lf
E.L.F.	Glow Liquid Filter	E glf
E.L.F.	Primer	E p
L'Oreal	Beautifier Cream	L bc
NYX	Liquid Eyeliner	N le
NYX	Concealer	N c
Covergirl	Primer	C p
Covergirl	Blush	C b

Table 1. Abbreviated nomenclature of cosmetic and makeup products utilized in this study. Abbreviations and corresponding full names of the cosmetic and makeup products used in the study.

We additionally tested combinations of inhibitory and non-inhibitory products to determine whether real-world layering of cosmetics could modify their antimicrobial effects, as individuals commonly use multiple products together during routine application. 18 makeup products were tested for growth inhibition against *S. epidermidis* and *M. luteus* using agar diffusion assays (**Table 1**). All experiments were

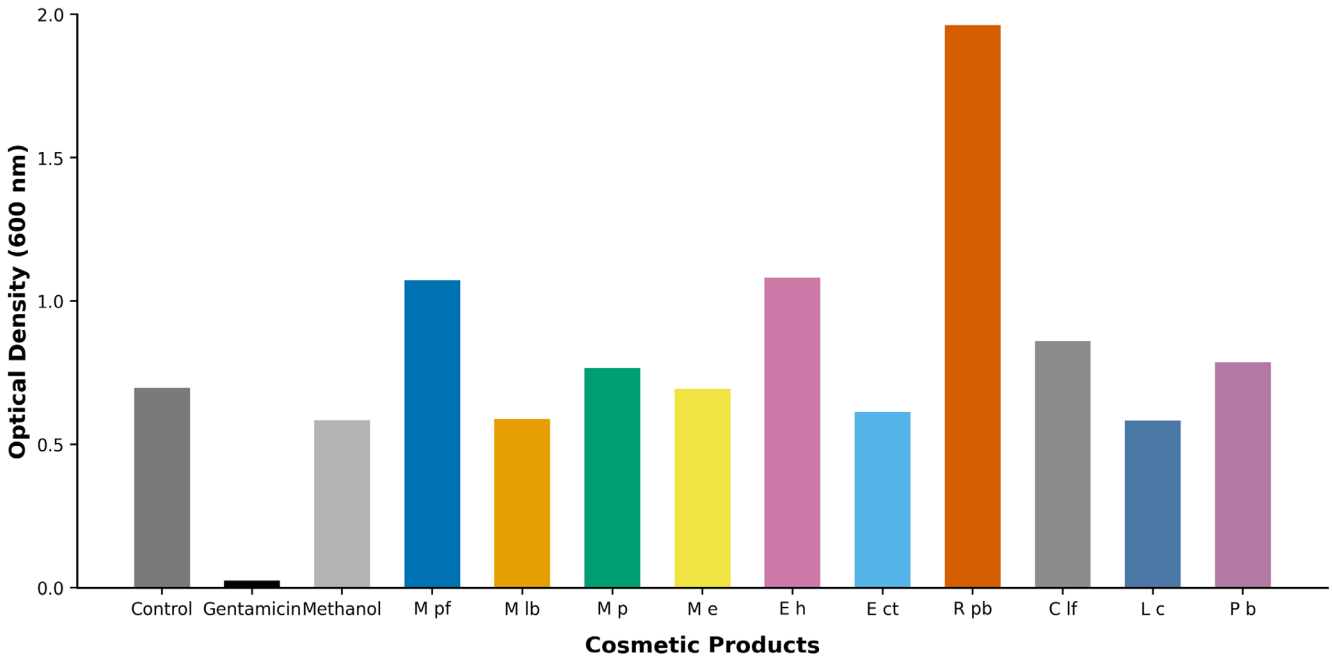

Figure 1. Effect of makeup cosmetics on *Micrococcus luteus* growth in methanol-based liquid culture. Ten cosmetic products were tested in nutrient broth using methanol as the solvent. Optical density at 600 nm (OD_{600}) was measured using a spectrophotometer to assess bacterial growth. Methanol alone produced minimal inhibition (<10% at 100 µL). Cosmetic product precipitation and background turbidity interfered with OD_{600} measurements; therefore, these preliminary measurements were not used for quantitative assessment of antibacterial activity. Product abbreviations are defined in Table 1.

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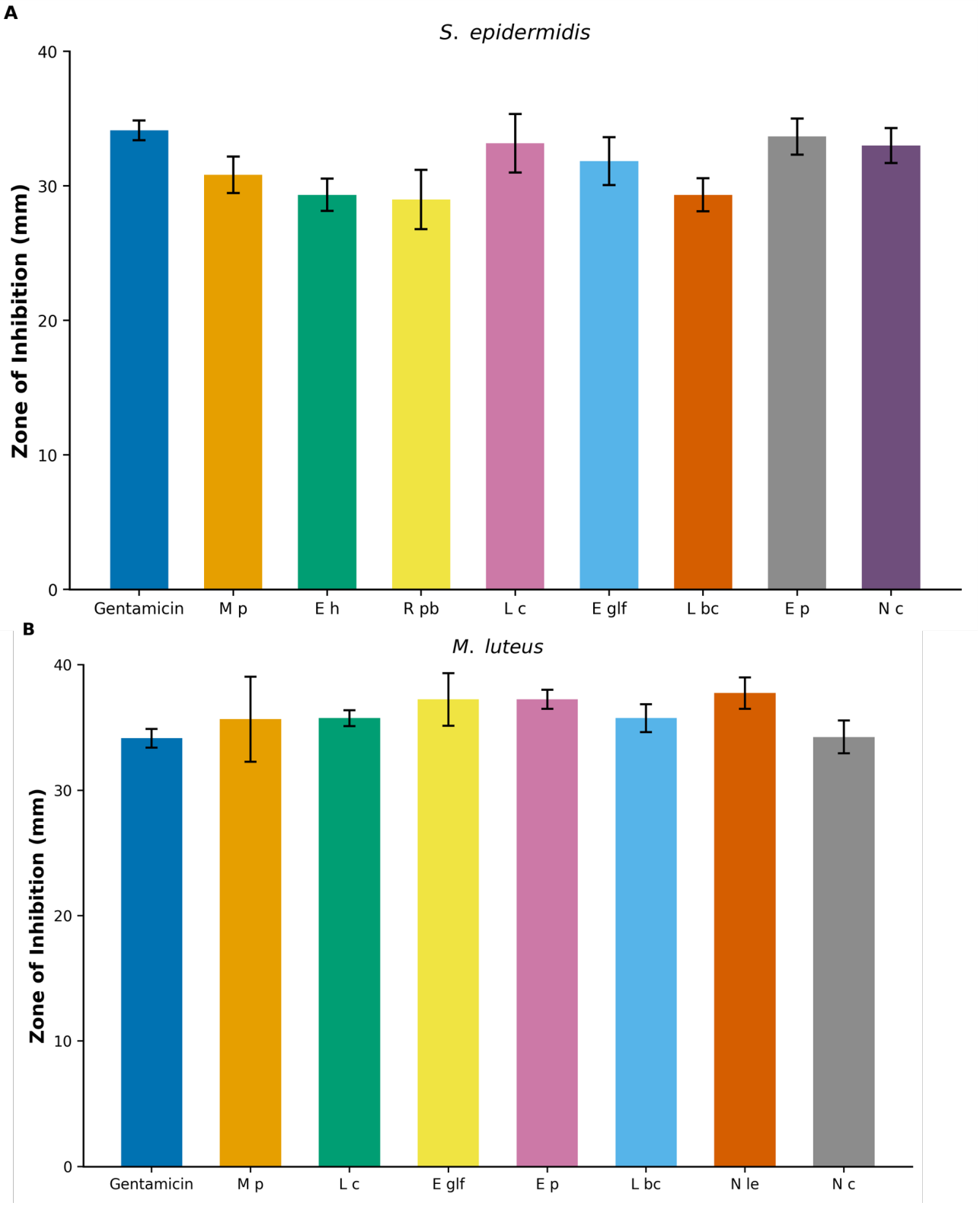

Figure 2. Antibacterial activity of cosmetic products against *Staphylococcus epidermidis* and *Micrococcus luteus* on nutrient agar plates. This figure illustrates the inhibitory effects of seven cosmetic and makeup products each dissolved solely in methanol, on two representative skin bacteria. For each product, 75 µL was applied to nutrient agar plates inoculated with either *S. epidermidis* or *M. luteus*. A gentamicin disc served as the antibiotic positive control. Data are presented as mean ± standard error of the mean (SEM). **(A)** Bar graph showing the diameter of inhibition zones (mm) for *S. epidermidis* exposed to each cosmetic product. **(B)** Bar graph showing the diameter of inhibition zones (mm) for *M. luteus* under identical conditions. Each bar color corresponds to a specific product as indicated in the figure legend.

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performed in triplicate, and data are presented as mean ± SEM (**Figures 2A, B**)**.** The negative control demonstrated no zone of inhibition in any experiment (0 mm), confirming the absence of antimicrobial activity and serving as a reference for comparison with the experimental groups. Nine out of 18 products inhibited bacterial growth. Of these, six inhibited both bacterial species, two inhibited only *S. epidermidis*, and one inhibited *M. luteus* only (**Figure 2**). Of the nine products that demonstrated measurable antibacterial activity, six inhibited the growth of both bacterial species: L'Oreal Beautifier Cream, Maybelline Liquid Blush, Maybelline Powder Foundation, E.L.F. Primer, Physicians Formula Foundation, and Covergirl Liquid Foundation. Two products, NYX Liquid Eyeliner and NYX Concealer, inhibited only *Staphylococcus epidermidis*, while one product, E.L.F. Highlighter, inhibited *Micrococcus luteus* only (**Figure 2, Table 1**). "Inhibition" was defined as any reproducible, non-zero zone of inhibition larger than the methanol-only control, which consistently measured 0 mm. These differences were clear and consistent across triplicate experiments, so formal statistical testing was not used, though future analyses could incorporate tests such as t-tests to quantify significance. To determine inhibitory concentrations for each product, we performed volume-dependent inhibition assays using four volumes (3 µL, 10 µL, 30 µL, and 60 µL) (**Figure 3**). Seven of the nine inhibitory products produced a clear dose-response relationship, meaning that the diameter of the inhibition zone increased consistently with larger applied volumes. When compared to gentamicin, an antibiotic, all seven products produced smaller zones overall, but followed the same directional trend of increasing inhibition with higher volumes. Most products began to show measurable inhibition at 10 µL, with more pronounced and reproducible inhibition observed at 30 µL and 60 µL. These trends allowed us to calculate IC_{50} values for each product based on the point at which approximately 50% inhibition of *S. epidermidis* growth was achieved. A methanol-only control was also included to account for solvent effects; this control exhibited less than 10% inhibition at 100 µL, which was not statistically significant.

Finally, combined product experiments were performed to assess potential interactions between products. One strongly inhibitory product (L'Oreal Beautifier Cream) was combined with three non-inhibitory products (Physicians Formula, Maybelline Liquid Blush, Maybelline Powder Foundation) in equal volumes. Maybelline Powder Foundation (M pf) reduced the inhibitory effect of L'Oreal Beautifier Cream (L bc) on both bacterial species, while the other products did not alter inhibition. Further tests confirmed that this interaction was specific to the L bc and M pf combination (**Figures 4A–4C**). This experiment differed from the earlier single-product assays because the products were mixed before application, allowing us to assess whether direct chemical interactions could modify their inhibitory effects.

DISCUSSION

Cosmetic products are widely used across demographics, with U.S. consumers spending billions of dollars annually on makeup and personal care items (5). While makeup products are designed to enhance appearance, their potential impact on the skin microbiome remains underexplored (2, 6). In this study, we demonstrate that certain makeup cosmetics exhibit inhibitory effects on the growth of *S. epidermidis* and *M. luteus*, two representative skin-resident bacterial species. These findings align with previous studies showing that preservatives commonly found in cosmetic formulations, such as phenoxyethanol and sodium benzoate, can disrupt microbial balance (8, 9).

Interestingly, the most inhibitory products were primarily liquid formulations, such as foundations and primers. These products often contain higher concentrations of preservatives and alcohol-based stabilizers, which may contribute to their antimicrobial effects (4, 8). In contrast, powder-based products like blush and bronzer were generally non-inhibitory, due to lower preservative content. These differences suggest that formulation type and ingredient composition play a critical role in microbial growth inhibition.

A particularly notable observation was the interaction between one inhibitory product L'Oreal Beautifier Cream (L bc) and a non-inhibitory product Maybelline Powder Foundation (M pf), where the latter reduced the inhibitory effect of the former. This phenomenon may indicate chemical interactions that neutralize antimicrobial components in formulations, such as emulsifiers or fatty alcohols, counteracting preservative activity. However, this effect was rare and observed only in one product combination, indicating that such interactions may be formulation specific (9).

We determined IC_{50} values for seven inhibitory products tested against *S. epidermidis*, with most achieving 50% growth inhibition at approximately 10 µL applied to agar. While this provides a comparative measure of inhibitory potency, it does not represent concentrations experienced by skin-resident microbes *in vivo*. Cosmetic products are typically applied in larger volumes and interact with sebum, sweat, and other skin components (6,10). Future studies should isolate individual ingredients to identify which components drive the observed inhibition, as has been implicated with the use of preservatives and certain surfactants (8).

We acknowledge several limitations to this study. Dissolving cosmetic products in methanol and applying them to agar plates does not fully replicate real-world skin conditions, where products are layered on skin and interact with a complex microbiome and host environment. Agar pockets were used to enable controlled diffusion of viscous cosmetic products, as surface application of semi-solid or hydrophobic formulations can be inconsistent. Future studies could address this limitation by using *in vitro* skin models or cell-culture systems to better mimic real-world conditions. Although methanol-only controls showed minimal inhibition (<10%), they may still alter diffusion or compound availability. Additionally, agar-based assays do not mimic the skin's lipid-rich environment, which could influence bacterial growth and susceptibility. As a result, the findings should be interpreted as evidence of inhibitory potential under in vitro conditions rather than direct predictors of *in vivo* effects.

Another limitation is the restricted range of bacterial species examined. *S. epidermidis* and *M. luteus* are common skin commensals, but the skin microbiome also includes taxa such as *Cutibacterium acnes* and *Corynebacterium*, which can promote skin health yet also contribute to disease under specific conditions. Including these organisms would

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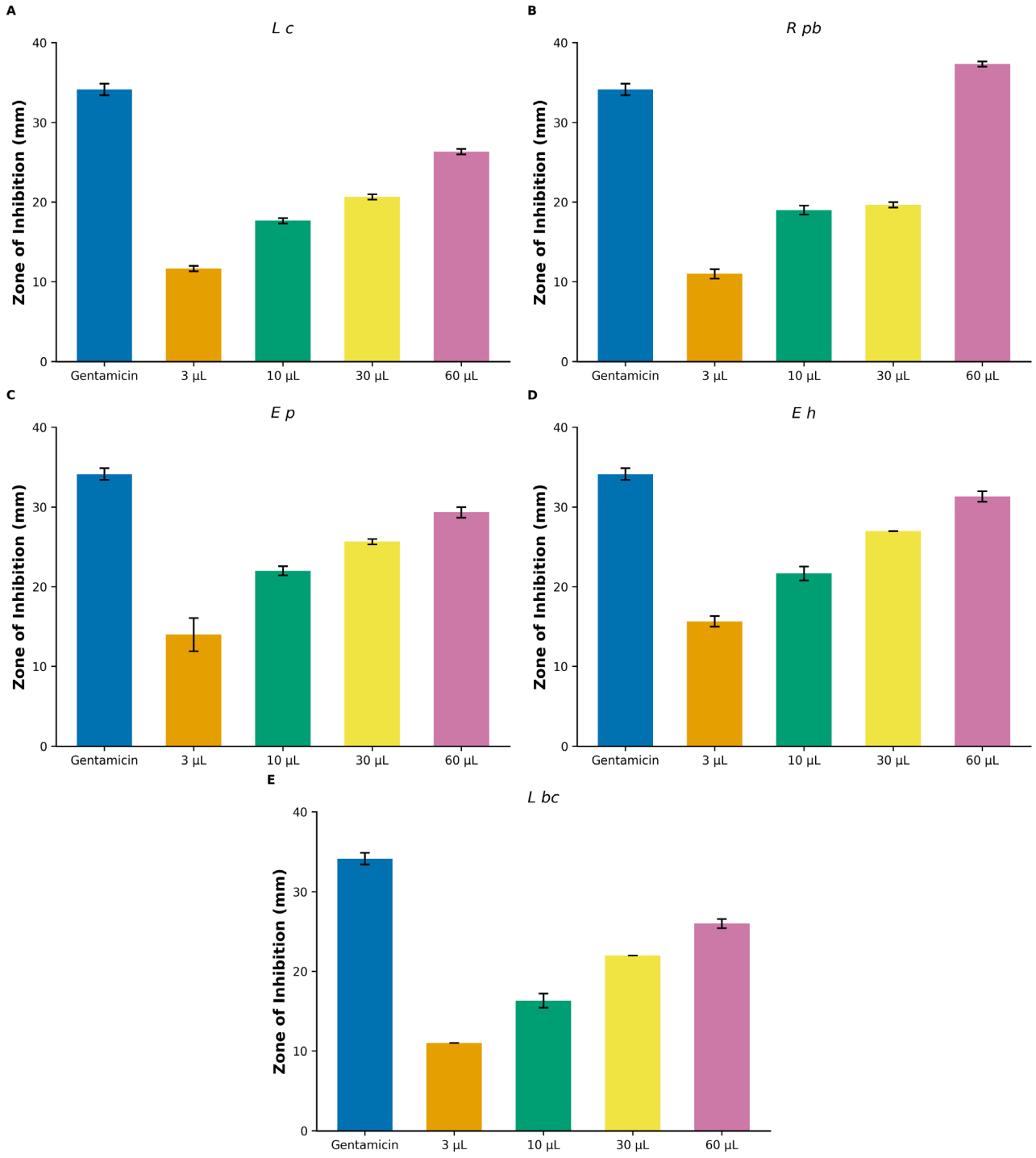

Figure 3. Relationship between bacterial inhibition and increasing concentrations of cosmetic products. Five cosmetic products that previously demonstrated inhibitory effects against *Staphylococcus epidermidis* were tested at four volumes (3 µL, 10 µL, 30 µL, and 60 µL). Data are presented as mean ± standard error of the mean (SEM). Panels A–E show individual inhibition plots for five specific cosmetic products: **(A)** Maybelline Liquid Blush (M lb), **(B)** L'Oreal Beautifier Cream (L bc), **(C)** Maybelline Powder Foundation (M pf), **(D)** E.L.F. Primer (E p), and **(E)** Physicians Formula (P b).

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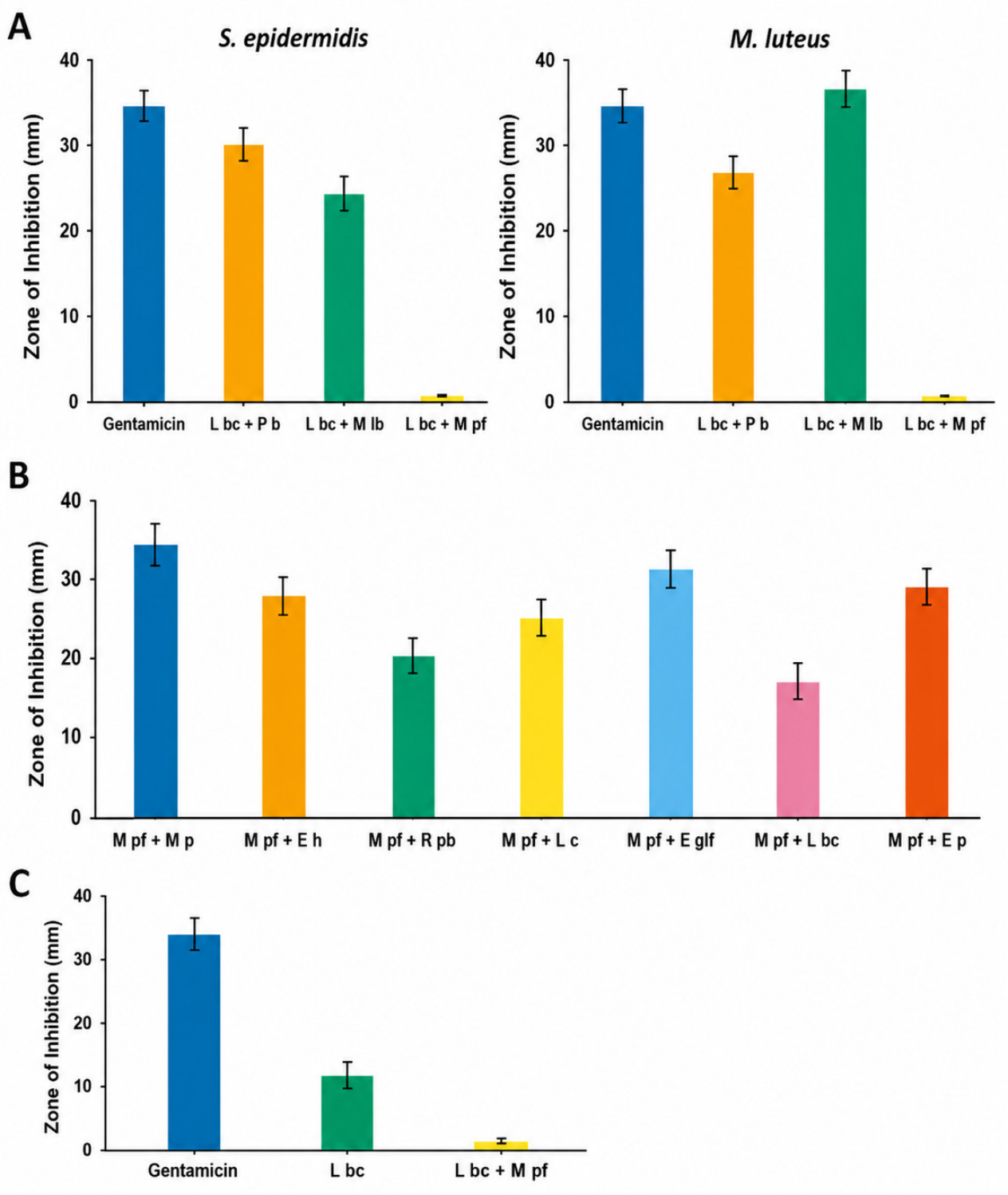

Figure 4. Inhibitory effects of selected cosmetic product combinations against *Staphylococcus epidermidis* and *Micrococcus luteus*. Cosmetic products exhibiting antibacterial activity were tested individually and in combination to evaluate potential interactions affecting bacterial growth. Data are presented as mean ± standard error of the mean (SEM). **(A)** L'Oreal Beautifier Cream (L bc) was combined with Physicians Formula Foundation (P b), Maybelline Liquid Blush (M lb), or Maybelline Powder Foundation (M pf), and inhibition was measured against both *Staphylococcus epidermidis* and *Micrococcus luteus*. **(B)** Inhibition resulting from combinations of Maybelline Powder Foundation (M pf) with Maybelline Primer (M p), E.L.F. Highlighter (E h), Revlon Powder Blush (R pb), L'Oreal Concealer (L c), E.L.F. Glow Liquid Filter (E glf), L'Oreal Beautifier Cream (L bc), and E.L.F. Primer (E p). **(C)** Comparison of inhibition produced by L'Oreal Beautifier Cream alone and in combination with Maybelline Powder Foundation. Product abbreviations are defined in Table 1.

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deepen our understanding of microbiome responses to cosmetics. Including these species would provide a more comprehensive understanding of microbiome responses to cosmetic exposure, particularly for conditions like acne, where microbial composition is altered (4). Similarly, expanding the range of products tested to include sunscreens, moisturizers, and cleansers could also reveal broader trends.

Despite these limitations, our findings have important implications for public health. Disruption of the skin microbiome can compromise barrier function and alter immune regulation, potentially increasing susceptibility to infections or inflammatory conditions (2, 6). Given the widespread and long-term use of cosmetics, understanding their microbiological effects is essential for informed consumer choices and regulatory oversight (1, 7). Future research should combine *in vitro* assays with *in vivo* studies and ingredient-level analysis to clarify mechanisms and assess real-world relevance.

MATERIALS AND METHODS

Materials and equipment

18 commercially available cosmetic products, including foundation, concealer, primer, highlighter, blush, bronzer, and eyeliner, were selected for analysis. All cosmetic products were provided in the United States and were from different brands (**Table 1**).

Bacterial strains

Staphylococcus epidermidis (Strain: ATCC 12228) and *Micrococcus luteus* (Strain: ATCC 4698) cultures were obtained from Carolina Biological Supply. *S. epidermidis* (Strain: ATCC 12228) is a Gram-positive bacterium that is a major component of the normal human skin microbiota but can act as an opportunistic pathogen in immunocompromised individuals. *M. luteus* (Strain: ATCC 4698) is a yellow-pigmented, spherical bacteria commonly found on human skin and is generally considered nonpathogenic, but it may cause but occasionally can cause opportunistic infections under certain conditions.

Each product was dissolved in methanol, and 75 µL was added to pockets in the agar. We used the antibiotic gentamicin as a positive control and methanol-only wells as negative solvent-only controls to account for the effects of methanol on growth. Plates were incubated at 37 °C for 14–16 hours, and zones of inhibition were measured in millimeters using scaled photographs and a digital caliper.

Broth-based assays of bacterial growth

For broth-based assays, 3 mL of nutrient broth and 25 µL of bacterial culture were added to sterile tubes. Prior to use, each bacterial strain was grown overnight in nutrient broth at 37 °C to reach mid-log phase, ensuring active and standardized cultures for inoculation. Two controls were included: one without any cosmetic products and one with 1 µL gentamicin (10mg/mL). Experimental tubes received varying volumes of cosmetic products dissolved in methanol. Broth cultures were incubated in a shaker at 100 rpm for 14–16 hours at 37 °C. Optical density was measured in liquid cultures only at 600 nm (OD_{600}) using a spectrophotometer. Each reading was taken from 3 mL of culture in cuvettes, blanked against the appropriate control. Each experiment was performed in triplicate.

Agar-based assays of bacterial growth

For agar-based assays, 25 µL of *S. epidermidis* or *M. luteus* was spread onto nutrient agar plates using a sterile bacterial spreader (sterilized with methanol and flame). Small pockets were created in the agar using 200 µL pipette tips, and cosmetic products dissolved in methanol were added to each pocket at volumes of 3 µL, 10 µL, 30 µL, or 60 µL. Methanol-only wells served as negative solvent controls, and gentamicin (10 mg/mL, 10 µL) was used as a positive control. Plates were incubated at 37 °C for 14–16 hours, after which zones of inhibition were measured in millimeters. Plates were randomized and coded to ensure blind measurement of inhibition zones and reduce measurement bias gentamicin (10mg/mL) was added instead the cosmetic products to serve as the positive control, and methanol-only wells were included as negative solvent controls. Plates were incubated at 37 °C for 14–16 h. Zones of inhibition were measured by photographing each plate, scaling images in PowerPoint, and measuring the diameter of inhibition zones diagonally in millimeters using a digital caliper.

Dose-response assays and IC_{50} determination

For cosmetic products showing reproducible inhibition, dose-response assays were performed using nutrient agar plates. Seven inhibitory products were tested against *S. epidermidis* at volumes of 3 µL, 10 µL, 30 µL, and 60 µL. Each condition was tested in triplicate, and zones of inhibition were measured in millimeters. The resulting dose-response curves were used to estimate the volume at which approximately 50% inhibition occurred. Data are presented as the mean ± standard error of the mean (SEM).

Combined product experiments

For combined-product experiments, selected cosmetic products were mixed in equal volumes and tested using the agar-based assay. L'Oreal Beautifier Cream (L bc), an inhibitory product, was initially combined with three non-inhibitory products—Physicians Formula Foundation (P b), Maybelline Liquid Blush (M lb), and Maybelline Powder Foundation (M pf)—and tested against both *S. epidermidis* and *M. luteus*. For each combination, 50 µL of each product was used, for a total volume of 100 µL. Because M pf reduced the inhibitory effect of L bc, M pf was subsequently tested in combination with the other inhibitory products. The L bc + M pf combination was then tested in triplicate and compared with L bc alone and gentamicin. Zones of inhibition were measured in millimeters, and data are presented as mean ± SEM.

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REFERENCES

1. Mafra, A. L., et al. "The Contrasting Effects of Body Image and Self-Esteem in the Makeup Usage." *PLoS ONE*, vol. 17, no. 3, 2022, e0265197. www.doi.org/10.1371/journal.pone.0265197.

https://doi.org/10.59720/25-182

2. "U.S. expenditure on cosmetics, perfume, and bath preparation." Statista, www.statista.com/topics/3138/cosmetics-consumer-behavior-in-the-us/?srsltid=AfmBOooWWot9EEyr5usgkB2Cttb28G9lmIKKudUzElhJF4IsIC6s3a27#topicOverview
3. Balwierz, R., et al. "Potential Carcinogens in Makeup Cosmetics." International Journal of Environmental Research and Public Health, vol. 20, no. 6, 2023, p. 4780. www.doi.org/10.3390/ijerph20064780.
4. Grice, E. A., and J. A. Segre. "The Skin Microbiome." Nature Reviews Microbiology, vol. 9, no. 4, 2011, pp. 244-253. https://doi.org/10.1038/nrmicro2537.
5. Smythe, P., and H. N. Wilkinson. "The Skin Microbiome: Current Landscape and Future Opportunities." International Journal of Molecular Sciences, vol. 24, no. 4, 2023, p. 3950. www.doi.org/10.3390/ijms24043950.
6. Panico, A., et al. "Skin Safety and Health Prevention: An Overview of Chemicals in Cosmetic Products." Journal of Preventive Medicine and Hygiene, vol. 60, no. 1, 2019, pp. E50-E57. www.doi.org/10.15167/2421-4248/jpmh2019.60.1.1080.
7. Nasrollahi SA, Fattahi M, Khamesipoor A, Amiri F, Ahmadi M, Kavkani MS, Lotfali E, Ayatollahi A, Skandari SE, Firooz A. Effects of Cosmetic Preservatives on Healthy Facial Skin Microflora. J Clin Aesthet Dermatol. 2022 Aug;15(8):34-37. PMID: 36061480; PMCID: PMC9436228.
8. Aguinaldo, E. R., and J. J. Peissig. "Who's Behind the Makeup? The Effects of Varying Levels of Cosmetics Application on Perceptions of Facial Attractiveness, Competence, and Sociosexuality." Frontiers in Psychology, vol. 12, 2021, p. 661006. www.doi.org/10.3389/fpsyg.2021.661006.
9. Pinto, D., et al. "Effect of Commonly Used Cosmetic Preservatives on Skin Resident Microflora Dynamics." Scientific Reports, vol. 11, 2021, p. 8695. www.doi.org/10.1038/s41598-021-88072-3.
10. Mim, M. F., et al. "The Dynamic Relationship Between Skin Microbiomes and Personal Care Products: A Comprehensive Review." Heliyon, vol. 10, no. 14, 2024, e34549. www.doi.org/10.1016/j.heliyon.2024.e34549.
11. Lee, H. J., et al. "Effects of Cosmetics on the Skin Microbiome of Facial Cheeks with Different Hydration Levels." Microbiology Open, vol. 7, no. 2, 2018, e00557. www.doi.org/10.1002/mbo3.557.