RCMOS – Revista Científica Multidisciplinar O Saber. ISSN: 2675-9128. São Paulo-SP.

Ano VII, v.1 2026 | submissão: 05/11/2026 | aceito: 12/11/2026 | publicação: 17/11/2026

Between aesthetics and microbiology: analysis of bacterial contamination in shared makeup testers

Entre a estética e a microbiologia: análise da contaminação bacteriana em testers de maquiagem de uso coletivo

Entre la estética y la microbiología: análisis de la contaminación bacteriana en probadores de maquillaje de uso compartido

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Abstract:
Makeup testers in retail stores are a potential source of microbial contamination. Frequent contact with skin and lips and repeated sharing of applicators among customers can transfer microorganisms. This study evaluated bacterial contamination in shared makeup testers, investigating the presence of microorganisms and the potential microbiological risks of sharing these products. We conducted a literature review and a quantitative experimental analysis. Samples from nine types of makeup were collected at a retail store in Caraguatatuba, São Paulo, using sterile swabs with Stuart transport medium. The samples were inoculated onto nutrient agar, BHI agar and potato agar, yielding 54 plates incubated at 37 °C for 48 hours. We assessed microbial growth, counted colony-forming units, examined colony morphology and performed Gram staining. Growth occurred on 25 of the 54 plates, most often on BHI agar, where 13 plates showed growth. Colonies varied in their macroscopic and microscopic features. We observed cocci, rods and structures consistent with fungi, such as hyphae and pseudohyphae. The microorganisms and structures observed varied by product and culture medium. Some of the testers showed microbial contamination, underscoring the importance of disposable applicators, avoiding direct contact with skin and lips, and monitoring the microbiological quality of these products. The lack of confirmatory tests limited identification of the microorganisms found.

Keywords:
Makeup. Microbiological contamination. Cosmetics. Bacteria. Shared testers.

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Resumo:
A utilização de testers de maquiagem em estabelecimentos comerciais representa uma possível fonte de contaminação microbiológica, devido ao contato frequente desses produtos com: a pele, os lábios e os múltiplo uso compartilhado de aplicadores de diferentes consumidores, favorecendo a transferência de microrganismos. Nesse contexto, o presente estudo teve como objetivo avaliar a contaminação bacteriana em testers de maquiagem de uso coletivo, investigando a presença de microrganismos e os possíveis riscos microbiológicos associados ao compartilhamento desses produtos. A pesquisa foi desenvolvida por meio de revisão bibliográfica e análise experimental quantitativa. Foram coletadas amostras de nove tipos de produtos de maquiagem em um estabelecimento comercial de Caraguatatuba, São Paulo, utilizando swabs estéreis com meio de transporte Stuart. As amostras foram inoculadas em três meios de cultura: ágar Nutriente, ágar BHI e ágar Batata, totalizando 54 placas, posteriormente incubadas a 37 °C durante 48 horas. Após esse período, foram realizadas a avaliação do crescimento microbiano, a contagem de unidades formadoras de colônias, a análise morfológica das colônias e a coloração de Gram. Os resultados demonstraram crescimento microbiano em 25 das 54 placas analisadas, com maior ocorrência no ágar BHI, que apresentou crescimento em 13 placas. Também foram observadas diferenças nas características macroscópicas e microscópicas das colônias, incluindo cocos, bacilos e estruturas sugestivas de fungos, como hifas e pseudohifas. A diversidade dos microrganismos e estruturas presentes evidenciou variações entre os produtos e os meios de cultura utilizados. Conclui-se que parte dos testers avaliados apresentou contaminação microbiológica, reforçando a importância de medidas preventivas, como a utilização de aplicadores descartáveis, a prevenção do contato direto com a pele e os lábios e o controle microbiológico desses produtos. Entretanto, a ausência de testes confirmatórios limita a identificação dos microrganismos encontrados.

Palavras-chave:
Maquiagem. Contaminação microbiológica. Cosméticos. Bactérias. Testers de uso coletivo.

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Resumen:
Los probadores de maquillaje en establecimientos comerciales constituyen una posible fuente de contaminación microbiológica. El contacto frecuente con la piel y los labios, así como el uso compartido y reiterado de aplicadores entre clientes, favorece la transferencia de microorganismos. Este estudio evaluó la contaminación bacteriana en probadores de maquillaje de uso compartido e investigó la presencia de microorganismos y los posibles riesgos microbiológicos asociados. Se realizó una revisión bibliográfica y un análisis experimental cuantitativo. Se tomaron muestras de nueve tipos de maquillaje en un comercio de Caraguatatuba, São Paulo, con hisopos estériles y medio de transporte Stuart. Las muestras se inocularon en agar nutritivo, agar BHI y agar de papa. Se obtuvieron 54 placas, que se incubaron a 37 °C durante 48 horas. Se evaluó el crecimiento microbiano, se contaron las unidades formadoras de colonias, se examinó la morfología de las colonias y se realizó la tinción de Gram. Hubo crecimiento en 25 de las 54 placas, con mayor frecuencia en agar BHI, donde se observó en 13 placas. Las características macroscópicas y microscópicas de las colonias variaron. Se observaron cocos, bacilos y estructuras sugestivas de hongos, como hifas y pseudohifas. Los microorganismos y las estructuras observados variaron según el producto y el medio de cultivo. Parte de los probadores presentó contaminación microbiológica, lo que subraya la importancia de usar aplicadores desechables, evitar el contacto directo con la piel y los labios y realizar controles microbiológicos. La falta de pruebas confirmatorias limitó la identificación de los microorganismos encontrados.

Palabras clave:
Maquillaje. Contaminación microbiológica. Cosméticos. Bacterias. Probadores de uso compartido.

1. Introduction

As the cosmetics industry grows and cosmetic products become widely used, makeup in particular is used for appearance and personal expression. Direct contact with the skin, lips and areas near mucous membranes makes it possible for potentially infectious microorganisms to reach these products. Although cosmetics undergo quality control during manufacture, they are not sterile and can become contaminated during use. Certain formulation ingredients, together with improper storage, handling without prior cleaning and use after expiration, can facilitate the introduction and persistence of microorganisms. Studies have reported bacteria such as *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Pseudomonas aeruginosa*, *Escherichia coli* and *Bacillus* spp., as well as fungi, in various cosmetics, highlighting the importance of microbiological control for consumer safety (COSTA et al., 2023; ALSHEHREI, 2023; SILVA; SILVA; RODRIGUES, 2025).

Contamination can occur during manufacture and storage or after a product is opened, in which case it is known as secondary contamination. Repeated contact between cosmetics or their applicators and hands, skin, mucous membranes and environmental surfaces can increase contamination, particularly when products are shared. Makeup testers available in stores,

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pharmacies and other retail settings therefore present a microbiological concern because multiple customers handle and use them.

Microbiological analysis of makeup testers helps clarify the potential risks of shared use. The transfer of microorganisms among users may contribute to cross-contamination and exposure to potentially pathogenic agents. Preventive measures such as individual and disposable applicators, good hygiene practices, proper storage and consumer awareness may help reduce these risks (VASSOLER et al., 2020; ISKANDAR; MARCHIN; ROQUES, 2026).

2. Objective

This study aimed to evaluate bacterial contamination in shared makeup testers, determine whether bacteria were present and discuss the possible microbiological risks of sharing these products.

3. Methodology

3.1 Literature review

A literature review was conducted using the search terms “Makeup,” “Microbiological contamination,” “Microbiological contamination,” “Bacteria” and “Shared testers” in Scientific Electronic Library Online (SciELO), PubMed and Google Scholar. We considered articles published from 2020 through 2026 on microbial contamination of cosmetics, makeup and shared-use products.

ChatGPT, developed by OpenAI, was used to support the review of the manuscript by suggesting grammatical corrections and improving clarity. It also assisted in preparing the flowchart in the discussion. The authors reviewed and validated all the resulting material and remain responsible for the final version.

3.2 Sample collection

In addition to the literature review, we conducted a quantitative experiment to assess the presence of microorganisms in makeup testers. Samples were collected at noon on September 28, 2026, from a busy store in downtown Caraguatatuba, São Paulo, using sterile swabs with

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Stuart transport medium. Nine types of makeup were sampled: lip oil, lipstick, eyeshadow, eyebrow shadow, foundation, cream blush, clear mascara, eyebrow wax and pressed powder.

3.3 Preparation of culture media

Three culture media were used. Nutrient agar served as a general-purpose medium that supports the growth of various bacteria and is suitable for an initial assessment of the microorganisms present. Nutrient-rich BHI agar was used to support the growth of bacteria with more demanding nutritional requirements. Potato dextrose agar (PDA), commonly used to grow fungi and yeasts, was included to detect fungal microorganisms alongside the bacterial assessment performed using the other media.

For microbial isolation and culture, the media were prepared individually in 500 mL batches using distilled water as the solvent. The dehydrated media were weighed on a precision analytical balance using the manufacturers' recommended proportions for this volume: 14.0 g of nutrient agar, 26.0 g of BHI agar and 19.5 g of PDA. The distilled water was measured with a graduated cylinder and transferred to appropriately sized borosilicate Erlenmeyer flasks.

After the media were added to the solvent, the Erlenmeyer flasks were heated on a heating mantle with intermittent stirring until the suspensions were fully dissolved and homogeneous, as indicated by the translucency of the liquids. The flasks were then closed with hydrophobic cotton plugs and covered with aluminum foil to preserve the sterile barrier. Finally, they were secured with autoclave tape to prevent leakage of the culture medium.

Sterilization was carried out in a vertical autoclave at 121 °C and a pressure of 1 atm (approximately 14.696 psi) for 15 minutes. After the heating cycle ended and the autoclave was depressurized, the media were cooled at room temperature until they reached the 45–50 °C melting range.

The media were dispensed into plates under strictly aseptic conditions in the microbiological work area of a laminar flow cabinet. Aliquots of approximately 15–20 mL of liquefied agar were poured into individual sterile Petri dishes. After the agar had fully solidified undisturbed, the plates were labeled on their bases, inverted to prevent condensation from collecting on the agar surface, and refrigerated at 2–8 °C until sample inoculation.

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3.4 Inoculation and incubation

After sampling on September 28, the swabs were used to inoculate the culture media. The collected material was distributed over the surface of the media by simple streaking. Two plates of each medium were prepared for each product, for a total of six plates per product. This was repeated for all nine products, yielding 54 plates. After inoculation, the plates were labeled by product and culture medium and incubated at 37 °C in a digital bacteriological incubator (model Q316M). After 48 hours, the plates were assessed for the presence or absence of growth and for the characteristics of any colonies that developed.

3.5 Microbiological analysis

After 48 hours of incubation, on September 30, the plates were examined macroscopically for microbial growth and colony characteristics, including number, size, shape, color and appearance. Colony-forming units (CFU) were then counted to quantify the growth in each sample. The results were recorded and compared across products and culture media.

Gram staining was also performed on the observed colonies to distinguish them based on cell wall characteristics and to examine their morphology. The CFU counts, Gram staining results and colony morphology were used to assess the presence and characteristics of microorganisms found in the different makeup testers.

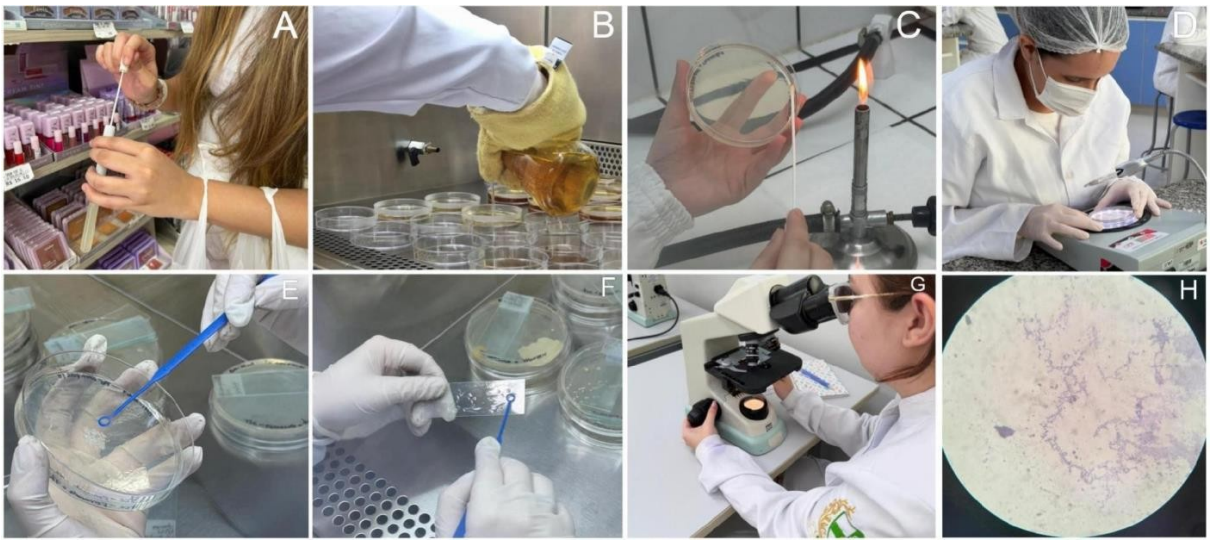


Figure 1 – Experimental steps for the microbiological analysis of shared makeup testers. (A) Sample collection using swabs with Stuart transport medium. (B) Dispensing culture media into Petri dishes under aseptic conditions. (C) Inoculating the media by simple streaking. (D) Macroscopic assessment of colony morphology

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and counting of colony-forming units (CFU). (E) Collecting colonies for microscopy. (F) Transferring the collected material to a slide. (G) Microscopic examination after Gram staining. (H) Micrograph of a stained preparation showing apparent filamentous structures consistent with hyphae. Source: Authors (2026).

4. Results

4.1 Literature review results

The studies reviewed found microbial contamination in various makeup products and shared testers. Bedaida et al. (2025) identified 19 bacterial isolates in 325 tester samples, including *Staphylococcus haemolyticus*, *Staphylococcus warneri*, *Bacillus cereus* and *Bacillus subtilis*. Vassoler et al. (2020) also found bacterial contamination above acceptable limits in more than half of the 30 lipstick testers analyzed, with *Staphylococcus aureus* and *Bacillus* spp., as well as fungi of the genera *Cladosporium* and *Aspergillus*. These results indicate that testers can accumulate microorganisms through continued use by different consumers.

Bacteria were also found in a range of products and accessories. Lazzari et al. (2025) observed growth in 65.79% of 38 samples of shared makeup, with *Staphylococcus epidermidis* and *S. aureus* predominating, particularly on brushes. Leal et al. (2025) observed the greatest growth on makeup sponges, with 42 colonies, including *S. aureus* and Enterobacteriaceae. Other studies identified microorganisms in eyeshadows, pressed powders, blushes, lipsticks, mascaras and other products, showing that contamination can occur in various types of cosmetics (COSTA et al., 2023; FAGUNDES et al., 2025; SOUZA et al., 2025; SILVA et al., 2021).

The literature also identifies sharing as an important factor associated with contamination. Kim et al. (2025) found bacterial growth in 60% of opened lip product testers and no growth in unopened products. Erdem et al. (2026) found contamination in 21.6% of the testers examined and likewise observed no growth in the unopened controls. Iskandar et al. (2026) note that repeated contact with hands, skin and mucous membranes, combined with improper storage and inadequate cleaning of accessories, can promote secondary contamination of cosmetics.

Although most studies reported positive results, some found no growth. Cundari de Oliveira, Antunes and Mobille (2025), for example, observed no microbial growth in 30 samples of new, in-use and expired makeup under the conditions examined. Likewise, Amaral and Caetano (2025) observed no growth in lipstick, mascara or tinted sunscreen, although they

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found microorganisms in used sponges and brushes. The occurrence of contamination can therefore vary with the product, storage conditions, duration of use and handling practices.

Overall, the studies reviewed reported microorganisms more frequently in products and accessories that regularly came into contact with different users. *Staphylococcus* spp., *Bacillus* spp., *Pseudomonas* spp. and Enterobacteriaceae were particularly prominent. Their presence underscores the need for microbiological control and preventive measures such as individual or disposable applicators, good hygiene and appropriate storage.

4.2 Experimental results

The initial assessment showed differences in microbial growth among the media used. Table 1 presents the results.

Table 1 – Distribution of plates by microbial growth and interpretability, by culture medium.

Culture medium	Growth	No growth	Uninterpretable	Total
Nutrient agar	8	8	2	18
BHI agar	13	6	0	19
Potato agar	4	12	1	17
Total	**25**	**26**	**3**	**54**

Source: Prepared by the authors (2026).

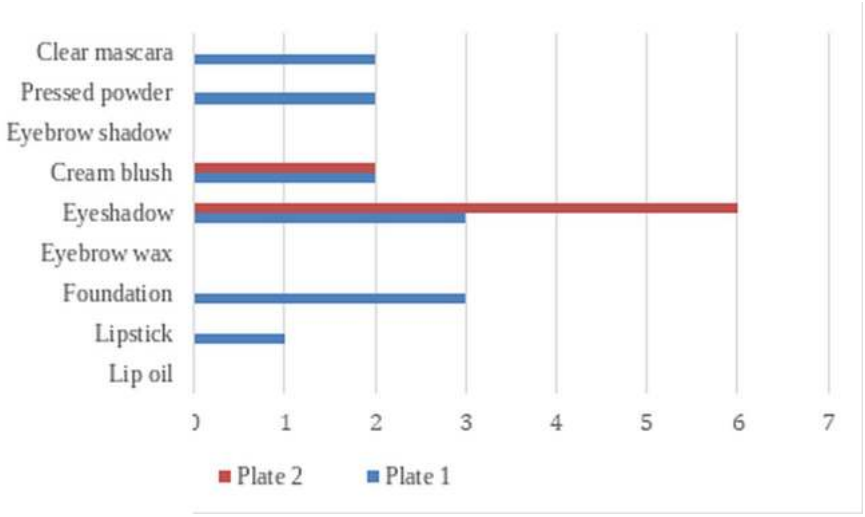
The higher frequency of growth on BHI agar may reflect its nutrient composition, which supports a variety of microorganisms. Growth was also observed on nutrient agar, while potato agar, used mainly to grow fungi and yeasts, showed a different pattern. Comparisons must account for each medium's purpose and characteristics. The absence of growth on a particular medium alone cannot establish that a product is less contaminated.

Colonies were quantified by counting the colony-forming units (CFU) on plates of the different culture media. The results were grouped separately for nutrient agar, BHI agar and potato agar, by product and sample duplicate. The counts are shown in Charts 1, 2 and 3, respectively.

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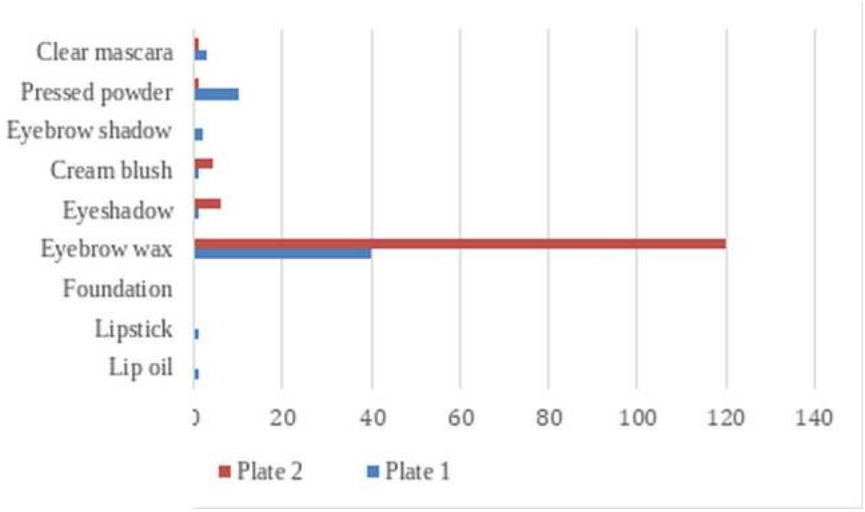
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Chart 1 – CFU counts on nutrient agar



Source: Prepared by the authors (2026).

Chart 2 – CFU counts on BHI agar

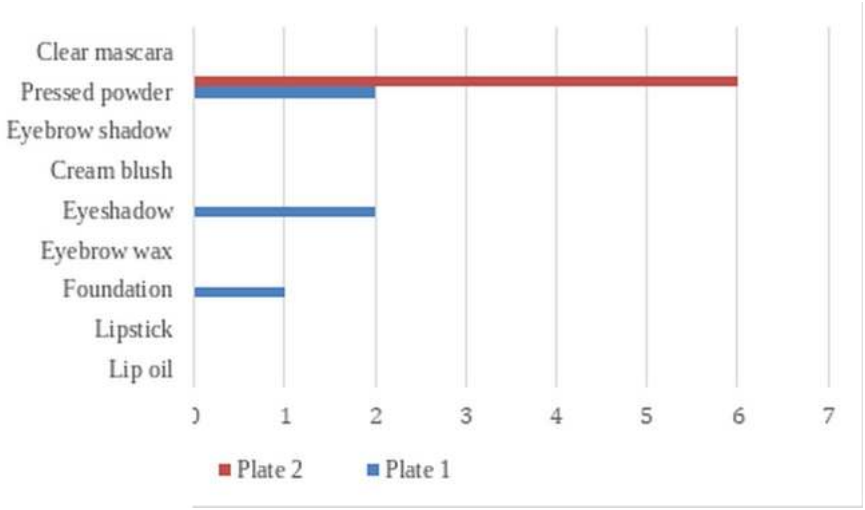


Source: Prepared by the authors (2026).

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Chart 3 – CFU counts on potato agar



Source: Prepared by the authors (2026).

Colony morphology was assessed based on macroscopic characteristics observed after incubation, including shape, margin, elevation, texture, color, optical appearance and surface consistency. These features were recorded for each medium to compare growth patterns across samples. Tables 2, 3 and 4 present the results.

Table 2 – Morphological characteristics of colonies on nutrient agar

Product tested	Shape	Margin	Elevation	Texture	Color	Optical appearance	Consistency
Lipstick	Irregular	Undulate	Flat	Smooth	Yellowish	Opaque	Milky
Foundation	Circular	Entire	Flat	Smooth	Whitish	Opaque	Creamy
Eyeshadow	Irregular	Undulate	Flat	Smooth	Orange	Translucent	Creamy
	Punctiform	Entire	Flat	Smooth	Whitish	Translucent	Dry
Cream blush	Circular	Entire	Flat	Smooth	Whitish	Opaque	Creamy
	Circular and irregular	Entire and irregular	Flat	Smooth	Whitish	Translucent and opaque	Creamy
Pressed powder	Irregular	Erose	Flat	Smooth	Orange	Translucent	Dry
Clear mascara	Circular	Entire	Flat	Smooth	Whitish	Translucent	Creamy

Source: Prepared by the authors (2026).

Table 3 – Morphological characteristics of colonies on BHI agar

Product tested	Shape	Margin	Elevation	Texture	Color	Optical appearance	Consistency
Lip oil	Circular	Entire	Flat	Smooth	Yellowish	Opaque	Milky
Lipstick	Circular	Undulate	Flat	Smooth	Whitish	Opaque	Milky

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Product tested	Shape	Margin	Elevation	Texture	Color	Optical appearance	Consistency
Eyebrow wax	Circular	Entire	Flat	Smooth	Yellowish	Opaque	Creamy
	Circular, irregular and punctiform	Entire, erose and undulate	Flat	Filamentous and smooth	Whitish and yellowish	Translucent	Creamy and milky
Eyeshadow	Punctiform	Entire	Flat	Smooth	Whitish	Translucent	Dry
	Circular and irregular	Entire and undulate	Flat	Smooth	Whitish, yellowish and orange	Translucent	Milky
Cream blush	Circular	Erose	Flat	Smooth	Whitish	Translucent	Milky
	Circular	Entire	Flat	Smooth	Whitish and orange	Translucent and opaque	Milky
Eyebrow shadow	Circular	Entire	Flat	Smooth	Whitish	Translucent	Creamy
Pressed powder	Lobate	Irregular	Raised	Smooth	Whitish	Translucent	Mucoid
	Punctiform and irregular	Entire and undulate	Flat	Smooth	Whitish	Opaque	Creamy
Clear mascara	Irregular	Lobate and undulate	Flat and raised	Smooth and granular	Whitish	Translucent and opaque	Creamy and rough
	Circular	Entire	Flat	Smooth	Whitish	Opaque	Dry

Source: Prepared by the authors (2026).

Table 4 – Morphological characteristics of colonies on potato agar

Product tested	Shape	Margin	Elevation	Texture	Color	Optical appearance	Consistency
Foundation	Irregular	Erose	Flat	Granular	Brown	Opaque	Dry
Eyeshadow	Punctiform	Entire	Flat	Smooth	Whitish	Translucent	Dry
Pressed powder	Punctiform	Erose	Flat	Granular	Orange and brown	Translucent	Milky
	Punctiform and undulate	Irregular	Flat	Smooth	Orange	Translucent	Dry and milky

Source: Prepared by the authors (2026).

Gram staining was performed to characterize the microorganisms in the observed colonies by distinguishing their staining reactions and assessing their cell morphology and microscopic arrangement. Results were grouped by culture medium and are presented in Tables 5, 6 and 7 for nutrient agar, BHI agar and potato agar, respectively.

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RCMOS – Revista Científica Multidisciplinar O Saber. ISSN: 2675-9128. São Paulo-SP.

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Table 5 – Gram staining results for colonies on nutrient agar

Product tested	Gram result	Cell morphology	Cell arrangement	Fungi
Lipstick	Positive	Cocci	Single	—
Foundation	Positive	Cocci	Single	Yeasts
Eyeshadow	Positive and negative	Cocci	Diplococci	Hyphae (bluish)
	Negative	Rods	Single	—
Cream blush	Negative	Rods	Streptobacilli	—
	Negative	Rods	Streptobacilli	—
	Positive	Rods	Single	—
Pressed powder	Positive	Cocci	Single	—
Clear mascara	Negative and positive	Cocci	Clusters and single cells	—
	Positive	Cocci	Chains of cocci	—

Source: Prepared by the authors (2026).

Table 6 – Gram staining results for colonies on BHI agar

Product tested	Gram result	Cell morphology	Cell arrangement	Fungi
Lip oil	Positive	Cocci	Single	—
Lipstick	Positive	Cocci	Chains of cocci	—
Eyebrow wax	Positive	Cocci	Chains of cocci	—
	Negative	Cocci	Single	Yeasts
	Positive	Cocci	Single	—
	Positive	Cocci	Single cells and chains of cocci	—
	Negative	Cocci	Single	—
	Positive	Cocci	Single	—
Eyeshadow	Positive	Rods	Single	—
	Positive	Rods	Streptobacilli	—
	Positive	Rods	Single	—
	Positive	Rods	Streptobacilli	—
	Negative	Cocci	Single	
	Positive	Cocci	Single	Hyphae and yeasts
	Positive	Cocci	Single	—
	Positive	Cocci	Chains of cocci	—
	Negative	Rods and cocci	Single	Yeasts
Cream blush	Positive	Cocci	Single	—
	Negative	Rods	Single	—
	Negative	Cocci	Single	Pseudohyphae
Eyebrow shadow	Negative	Rods	Streptobacilli	—

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Product tested	Gram result	Cell morphology	Cell arrangement	Fungi
Pressed powder	Positive	Rods	Single	—
	Negative	Cocci	Chains of cocci	—
	Negative	Rod	Single	Hyphae
	Positive	Cocci	Single	
	Positive and negative	Cocci	Single	—
	Negative	Rods	Single	
Clear mascara	Positive	Cocci	Single	—
	Positive	Rods	Single	Hyphae

Source: Prepared by the authors (2026).

Table 7 – Gram staining results for colonies on potato agar

Product tested	Gram result	Cell morphology	Cell arrangement	Fungi
Foundation	Positive	Cocci	Single	—
Pressed powder	Positive	Cocci	Single	—
	Negative	Cocci	Single	Pseudohyphae
	Positive	Cocci	Single	—
	Negative	Rods	Streptobacilli	—
Eyeshadow	Negative	Cocci	Single	Yeasts

Source: Prepared by the authors (2026).

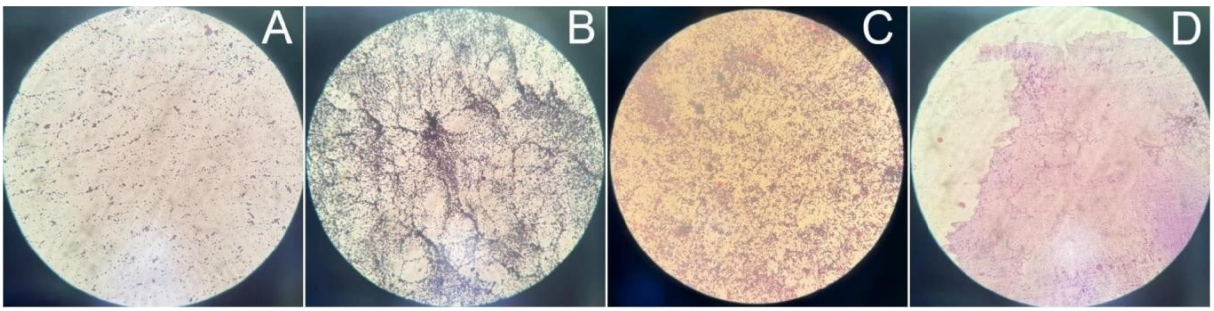


Figure 2 – Photomicrographs of colonies obtained from makeup testers after Gram staining. (A) Irregular white colony from eyebrow wax grown on BHI agar, showing Gram-positive cocci. (B) Yellow colony from eyebrow wax grown on BHI agar, showing Gram-positive cocci. (C) Eyeshadow colony grown on nutrient agar, showing Gram-negative rods. (D) Orange colony from pressed powder grown on potato agar, showing cocci recorded as Gram-negative and pseudohyphae. Source: Authors (2026).

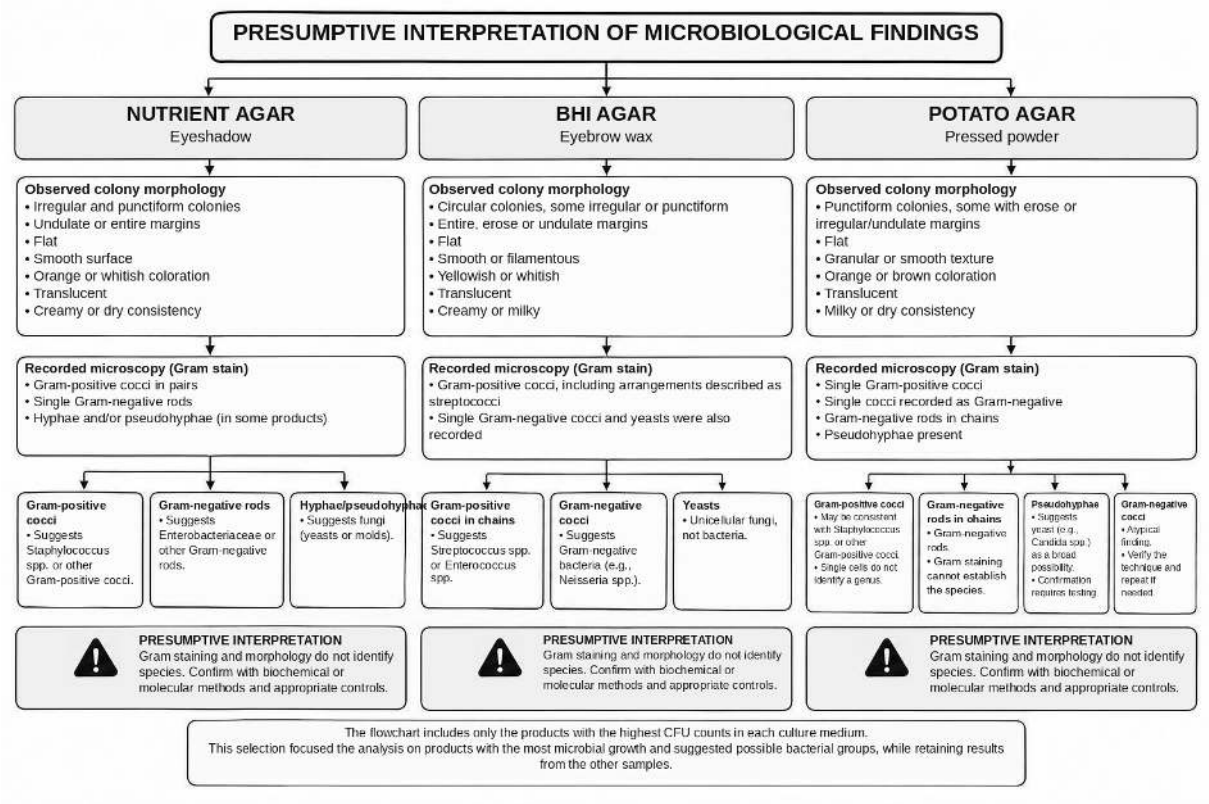
5. Discussion

The microorganisms observed suggest that some of the makeup testers examined were contaminated, as indicated by colony growth and the variety of morphological characteristics. Differences between media show that microbial recovery depends on culture conditions and the nutrient composition of each medium. Microbial growth alone, however, does not establish the presence of pathogenic microorganisms.

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Colony morphology and Gram staining were assessed for all samples that showed growth, providing macroscopic and microscopic information about the recovered microorganisms. The flowchart, however, includes only the products with the highest number of colony-forming units (CFU) on each medium. This selection allowed a closer examination of those products and an assessment of possible bacterial groups based on the observed characteristics. The results from the other samples were retained.



Source: Prepared by the authors (2026) with assistance from ChatGPT (OpenAI).

Published studies report similar findings on contamination in shared makeup. Vassoler et al. (2020) identified bacterial and fungal contamination in lipstick testers, while Bedaida et al. (2025) reported bacteria in makeup testers, including antimicrobial-resistant isolates. These studies support the possibility that shared products can act as reservoirs for microorganisms through repeated contact with skin, lips and applicators. Some published samples showed no growth, indicating that contamination may vary by product, conditions of use and storage.

Gram staining and cell morphology can suggest the presence of different bacterial groups. These observations alone cannot confirm identification at the species level. The groups proposed in the flowchart should therefore be treated as hypotheses that require confirmation.

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Structures such as hyphae and pseudohyphae may signal the presence of fungi and should be distinguished from bacterial findings.

Study limitations include the small number of products analyzed, sampling at a single store and the absence of confirmatory tests, such as biochemical assays, that could identify the organisms more conclusively at the genus or species level. Simple streaking also limits the ability to determine the concentration of microorganisms per gram or milliliter of product. Selecting the products with the highest CFU counts for the flowchart enabled a focused analysis, but may not capture the microbial diversity of all samples or establish which products pose the greatest health risk.

The results underscore the importance of preventive measures in retail settings. These include using disposable applicators, preventing direct contact between testers and consumers' skin or lips, and adopting appropriate storage and microbiological control practices. Future research should sample more stores and cosmetic products, standardize quantification procedures and use biochemical tests or molecular methods to confirm microbial identity. It would also be useful to examine how duration of use, storage conditions and hygiene practices affect product contamination.

Concluding remarks

This study evaluated bacterial contamination in shared makeup testers using microbial culture, colony morphology and Gram staining. Microbial growth occurred in some samples and varied across products and culture media, highlighting the importance of microbiological evaluation of these items.

Macroscopic and microscopic characteristics suggested possible groups of microorganisms in the samples selected for the flowchart. The lack of confirmatory tests limited identification and precluded any conclusion about the presence of specific pathogenic species. The microorganisms observed in the testers underscore the need for precautions when sharing cosmetics, especially using disposable applicators, avoiding direct contact with skin and lips, and adopting appropriate preservation and microbiological control measures.

This study adds to the understanding of the microbiological quality of makeup testers and highlights the importance of preventive measures in retail settings. Future studies should examine a wider range of products and locations and use complementary methods to identify

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microorganisms and better characterize contamination and its potential implications for consumer health.

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