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Antibiofilm Activities of Bioactive Compounds of Local Edible Flowers in Indonesia: A Review

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Abstract
Antimicrobial resistance is a growing global health problem. Biofilm formation is a notable risk factor for patient mortality. Various efforts are needed to prevent biofilm formation. Plants have been utilized in traditional medicine practices for centuries. In this review, we present an ethnobotanical study of the use of edible flowers in Indonesia and their potential development as antibiofilm agents. Local communities in Indonesia have long used various flowering plants for traditional ceremonial purposes, aesthetics, cooking ingredients, and medicine. Only a few types of flowers are utilized as food ingredients or edible flowers. There are 25 types of edible flowers from 19 families in Indonesia. Not all edible flowers in Indonesia have been studied for their antibiofilm activities. The presence of bioactive compounds, e.g., alkaloids, saponins, steroids, terpenoids, flavonoids, and phenolics in edible flowers, suggests that they may have the potential to inhibit biofilm formation. Local communities also use edible flowers in traditional medicine practices, including *Hibiscus sabdariffa, Jasminum sambac, Caesalpinia pulcherrima, Punica granatum, Blumea balsamifera,* and *Lantana camara.* The bioactive compounds showed antimicrobial activity against Gram-positive and Gram-negative bacteria, including *Acinetobacter baumannii, Vibrio cholerae, Staphylococcus aureus, Bacillus cereus, Listeria* spp., *Streptococcus* spp., *Enterococcus faecalis, Salmonella typhi, Shigella dysenteriae, Escherichia coli, Klebsiella* spp., *Proteus* spp., *Porphyromonas gingivalis,* and *Treponema denticola.* We also highlight the need for further research to explore more edible flowers and their specific effects of the compounds on biofilm formation.

Keywords: Antibiofilm; Bioactive; Edible flowers; Ethnobotany; Traditional medicine

1. INTRODUCTION

Antimicrobial resistance is a growing global health problem. Antimicrobial resistance can lead to extended treatment duration, increased morbidity, and patient mortality (Chiang et al., 2022; Salam et al., 2023). Antimicrobial-resistant bacterial infections generally present a more severe clinical picture in patients than infections by non-resistant bacteria (Chiang et al., 2022). Global data shows a high number of deaths caused by antimicrobial resistance. Infection by antimicrobial-resistant bacteria correlates positively with patient mortality. South Asia, East Asia, and Sub-Saharan Africa regions reported the most cases of patient deaths due to antimicrobial-resistant bacterial infections. The most notable resistant bacteria include *Escherichia coli, Klebsiella pneumoniae, Staphylococcus aureus, Acinetobacter baumannii,* *Streptococcus pneumoniae, Mycobacterium tuberculosis, Pseudomonas aeruginosa,* and *Enterobacter faecium*. Antimicrobial-resistant *E. coli*, for example, has caused the deaths of more than 21,000 patients worldwide (Institute for Health Metrics and Evaluation, 2019).

Biofilm is a bacterial defense mechanism against stress, both biotic and abiotic. Biofilm formation can increase antibiotic resistance and help bacteria thrive in the healthcare environment (Gedefie et al., 2023); for example, increased biofilm formation correlates with the expression of carbapenem resistance in *E. coli* and *K. pneumoniae* (Al-Bayati & Samarasinghe, 2022). In hospitalized patients, biofilm is a notable risk factor for patient mortality, especially in bacterimia conditions (Chiang et al., 2022). Therefore, various efforts are needed to prevent and contain the rate of biofilm formation.

Indonesia has a high biodiversity. Local communities have used plants in traditional medicine practices for centuries. People use the leaves as food ingredients and traditional medicine. For example, the people of Baubau, Southeast Sulawesi, use Chinese betel leaf (*Peperomia pellucida*) to reduce hypertension (Slamet & Andarias, 2018). Flowers are rarely used for medicinal or culinary purposes. Generally, flowers are used as decorations at traditional ceremonies. In this review, we present an ethnobotanical study of the use of edible flowers in Indonesia and their potential development as antibiofilm agents. We summarised research articles published over the past ten years from various databases, i.e., Scopus, PubMed, Google Scholar, and Neliti. The results showed that only a few publications have reported on the use of edible flowers by local communities.

2. Ethnobotany of edible flowers by local communities in Indonesia

Local communities in Indonesia have long used various flowering plants for traditional ceremonial purposes, aesthetics, cooking ingredients, and medicine. Only a few types of flowers are utilized as food ingredients or edible flowers (Table 1). However, the edible flowers used by local communities are very diverse. In this review, there are 25 types of edible flowers from 19 families, including Fabaceae, Musaceae, Myrtaceae, Zingiberaceae, Schisandraceae, Cariceae, Lamiaceae, Brassicaceae, Malvaceae, Poaceae, Arecaceae, Oleaceae, Asteraceae, Asteraceae, Cucurbitaceae, Punicaceae, Verbenaceae, Gnetaceae, Annonaceae, and Myristicaceae.

Edible flowers can be grown or harvested naturally. They are also often cultivated in private gardens, terraces, and balconies, making them a conveniently accessible source in small or limited spaces. Some edible flowers can be utilized as cooking ingredients, such as *Sesbania grandiflora, Musa paradisiaca, Carica papaya, Brassica oleracea, Saccharum edule,* and *Gnetum gnemon.* Some species of edible flowers are used as cooking spices, including *Etlingera elatior, Syzygium aromaticum, Illicium verum, Ocimum basilicum,* and *Hornstedtia scyphifera* var. *Fusiformis* (Table 1).

3. Potential of edible flowers as antibiofilm agents

The potential of bioactive compounds from edible flowers against biofilm formation is a topic of growing interest. Plant bioactive compounds, such as alkaloids, saponins, flavonoids,

Table 1. Ethnobotanical study of edible flower utilization by local communities in Indonesia.

Local name	Scientific name	Family	Uses	References
Bunga turi	*Sesbania grandiflora*	Fabaceae	cooking ingredients	(Setiawan, 2017, 2018; Umartani & Nahdi, 2021)
Bunga pisang	*Musa paradisiaca*	Musaceae	cooking ingredients	(Agesti et al., 2023; Mukhoyyaroh & Hakim, 2020; Sholekha et al., 2023; Zen et al., 2022)
Bunga telang	*Clitoria ternatea*	Fabaceae	tea	(Haryanti et al., 2015; Tabeo et al., 2019; Zen et al., 2022)
Bunga lawang	*Illicium verum*	Schisandraceae	cooking spices	(Zen et al., 2022)
Bunga pepaya	*Carica papaya*	Cariceae	cooking ingredients	(Agesti et al., 2023; Cahyaningsih et al., 2022; Daeli, 2023; Zen et al., 2022)
Bunga kelapa	*Cocos nucifera*	Arecaceae	traditional medicine: fever	(Sholekha et al., 2023; Slamet & Andarias, 2018)
Bunga kol	*Brassica oleracea*	Brassicaceae	cooking ingredients	(Silalahi & Nisyawati, 2018; Zen et al., 2022)
Bunga rosela	*Hibiscus sabdariffa*	Malvaceae	traditional medicine - anticancer	(Rizal et al., 2021; Zen et al., 2022)
Bunga pala	*Myristica fragrans*	Myristicaceae	cooking spices	(Zen et al., 2022)
Bunga melinjo	*Gnetum gnemon*	Gnetaceae	cooking ingredients	(Umartani & Nahdi, 2021; Zen et al., 2022)
Bunga simanih kuning	*Cassia fistula*	Fabaceae	cooking ingredients	(Agesti et al., 2023)
Bunga si jangkang	*Hornstedtia scyphifera* var. *fusiformis*	Zingiberaceae	cooking spices	(Agesti et al., 2023)
Bunga cengkeh	*Syzygium aromaticum*	Myrtaceae	cooking spices	(Agesti et al., 2023; Sholekha et al., 2023; Zen et al., 2022)

Table 1. Ethnobotanical study of edible flower utilization by local communities in Indonesia (*Continued*).

Local name	Scientific name	Family	Uses	References
Bunga sawi	*Brassica rapa*	Brassicaceae	cooking ingredients	(Silalahi & Nisyawati, 2018; Zen et al., 2022)
Bunga kenanga	*Cananga odorata*	Annonaceae	traditional medicine: stomachache and malaria	(Reynaldi et al., 2019)
Bunga tebu telur	*Saccharum edule*	Poaceae	cooking ingredients	(Agesti et al., 2023)
Bunga ren	*Arenga pinata*	Arecaceae	cooking ingredients	(Agesti et al., 2023; Sholekha et al., 2023)
Bunga melati	*Jasminum sambac*	Oleaceae	traditional medicine: fever	(R. T. Ningsih et al., 2016; Slamet & Andarias, 2018; Zen et al., 2022)
Bunga merak	*Caesalpinia pulcherrima*	Fabaceae	traditional medicine: fever	(R. T. Ningsih et al., 2016)
Bunga kemangi	*Ocimum basilicum*	Lamiaceae	cooking spices	(Cahyaningsih et al., 2022; Zen et al., 2022)
Bunga sembung	*Blumea balsamifera*	Asteraceae	traditional medicine: respiratory tract infections	(Sholekha et al., 2023)
Bunga pare	*Momordica charantia*	Cucurbitaceae	traditional medicine: stomachache	(Slamet & Andarias, 2018)
Bunga delima	*Punica granatum*	Punicaceae	traditional medicine: gingivitis	(Slamet & Andarias, 2018)
Bunga lantana	*Lantana camara*	Verbenaceae	traditional medicine: respiratory tract infections	(Slamet & Andarias, 2018)
Bunga kecombrang	*Etlingera elatior*	Zingiberaceae	cooking ingredients	(Agesti et al., 2023; Cahyaningsih et al., 2022; Sartika et al., 2021; Sholekha et al., 2023; Silalahi et al., 2018; Silalahi & Nisyawati, 2018; Zen et al., 2022)

terpenoids, and steroids, have received considerable attention due to their diverse pharmacological properties (Table 2). These compounds have been found to possess significant biological and functional values. At the time of writing, there is a lack of direct research specifically addressing the potential of bioactive compounds from edible flowers against biofilm formation. However, the presence of bioactive compounds with antimicrobial properties in edible flowers suggests that they may have the potential to inhibit biofilm formation.

The antimicrobial properties of many natural compounds isolated from edible flowers in Indonesia have been reported. Nature has always been a great contributor to this pharmacological goal. However, not all edible flowers have been studied for their antibiofilm activities. Antibiofilm activity testing was studied on many edible flowers, ranging from their extracts to oils. The bioactive compounds show antimicrobial activity against Gram-positive and Gram-negative bacteria, including *Acinetobacter baumannii, Vibrio cholerae, Staphylococcus aureus, Bacillus cereus, Listeria* spp., *Streptococcus* spp., *Enterococcus faecalis, Salmonella typhi, Shigella dysenteriae, Escherichia coli, Klebsiella* spp., *Proteus* spp., *Porphyromonas gingivalis,* and *Treponema denticola.*

The ongoing endeavor to discover novel antibacterial compounds involves the systematic screening of plant extracts for antimicrobial activity. This review highlighted that people also use edible flowers in traditional medicine practices, including *Hibiscus sabdariffa, Jasminum sambac, Caesalpinia pulcherrima, Punica granatum, Blumea balsamifera,* and *Lantana camara* (Figure 1). Practitioners use flowers to lower fever and treat gingivitis, abdominal pain, respiratory infections, and malaria drugs (Table 2). However, no published data exists on the antimicrobial activity of bioactive compounds from *Blumea balsamifera.*

Hibiscus sabdariffa belongs to the Malvaceae family and is commonly found in the tropics and subtropics. It has many beneficial uses, including food flavorings, the food industry, drinks, and herbal medicine. *H. sabdariffa* has abundant phytochemical compounds, such as flavonoids, alkaloids, phenols, triterpenoids, saponins, glycosides, and tannins. *H. sabdariffa* has antibacterial and antibiofilm activities against Gram-positive and Gram-negative bacteria. Petal extract of *H. sabdariffa* inhibited *S. mutans* in Hard-Candy products with 8.43 mm inhibition zone; therefore, the extract potentially prevents dental plaque (Kustyawati et al., 2022).

Jasminum sambac belongs to the Oleaceae family. The methanol and chloroform extracts of *J. sambac* flowers have antibacterial action against foodborne pathogens, such as *B. cereus, L. monocytogenes, S. flexneri, S. enterica* serovar *typhi, S. aureus,* and *E. coli.* The phytochemical study showed the presence of alkaloids, flavonoids, saponins, tannins, proteins, amino acids, and phenolic compounds. The MIC value of methanol and chloroform extracts of *J. sambac* against *L. monocytogenes, S. typhi*, and *B. cereus* was 62.5 µg/mL. Meanwhile, the extracts had MIC values of 125 µg/mL against *S. aureus* and *E. coli* and 250 µg/mL against *S. flexneri* (Senbagam et al., 2016).

Caesalpinia pulcherrima, or bunga merak, belongs to the Fabaceae family and was reported to have antimicrobial activity. Mustapa and Tomoni (2016) studied the bioactivity of *C. pulcherrima* against *S. aureus* and *E. coli.* The phytochemical screening shows that the flower contains flavonoids and saponins. The ethanol extract of *C. pulcherrima* flowers produces robust antimicrobial activity, i.e., 20.6 mm inhibition zone against *S. aureus* and 18 mm against *E. coli.*

Punica granatum, commonly referred to as delima or pomegranate, belongs to the Punicaceae family. *P. granatum* is an abundant potential herbal medicine for various conditions, such as cancer, cardiovascular diseases, diabetes, dental issues, and bacterial infections. The therapeutic components of the plant encompass its flowers, bark, fruits, roots, and seeds (Ökmen et al., 2023). The flowers are employed for treating bronchitis, diarrhea, and bloody diarrhea. Meanwhile, its tisane is employed to address throat and mouth inflammation. Pomegranate flowers are recognized for their diverse secondary metabolites, including polyphenols like gallic acid, ellagic acid, and ethyl brevetoxin-carboxylate. The extract of pomegranate flowers significantly decreased the formation of bacterial biofilm on the orthodontic wire by various strains, including *S. sanguinis* ATCC 10556 by 93.7-100%, *S. sobrinus* ATCC 27607 by 40.6-99.9%, *S. salivarius* ATCC 9222 by 85.2-86.5%, *S. mutans* ATCC 35608 by 66-4-84.4%, and *E. faecalis* CIP 55142 by 35.5-56.3% (Dastjerdi et al., 2014).

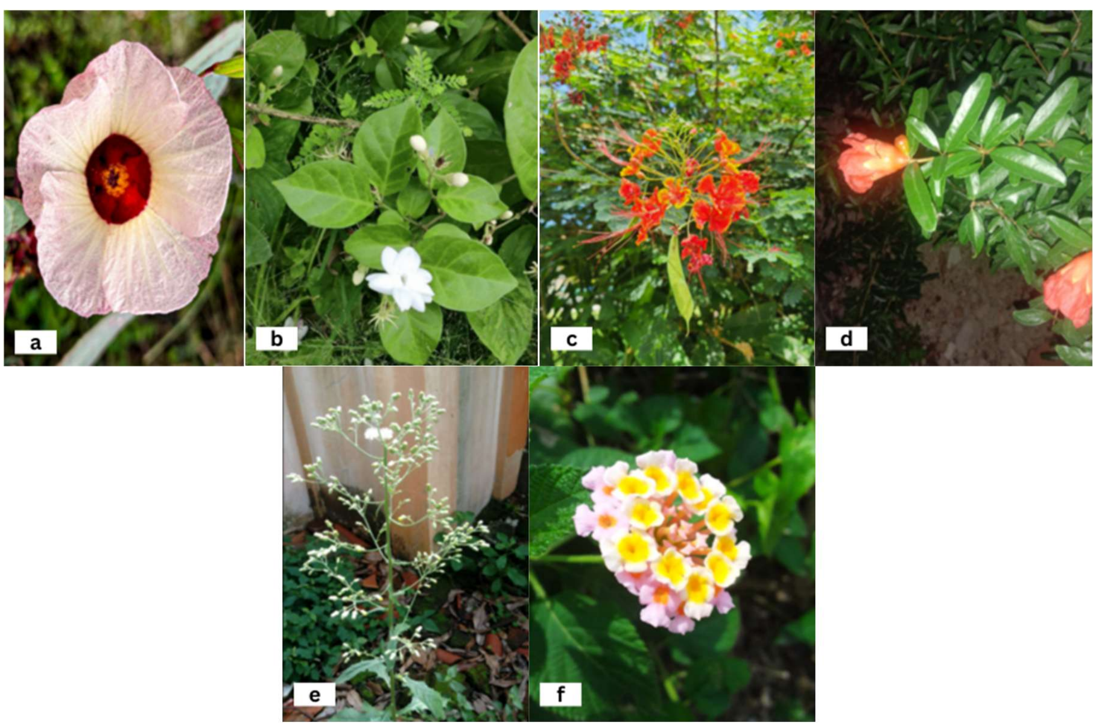

Figure 1. Local communities also use edible flowers in traditional medicine practices, including (a) *Hibiscus sabdariffa*; (b) *Jasminum sambac*; (c) *Caesalpinia pulcherrima*; (d) *Punica granatum*; (e) *Blumea balsamifera*; (f) *Lantana camara* (Source: iNaturalist, 2024)

Table 2. Potential bioactive compounds of edible flowers as antibiofilm agents. *Description*: No data (ND), Minimum inhibitory concentration (MIC), Minimum bactericidal concentration (MBC).

Edible Flowers	Bioactive	Target Bacteria	Activities	Notes	References
Sesbania grandiflora	Tannins, alkaloids	*Vibrio cholerae*	MIC = 0.98 mg/mL	Antibiofilm	(Guzman et al., 2018)
Musa paradisiaca	Alkaloids, saponins, tannins, flavonoids	*Staphylococcus aureus*	Inhibitory zone = 20.39 mm	Antimicrobe	(A. P. Ningsih et al., 2013)
	Alkaloids, saponins, tannins, flavonoids	*Escherichia coli*	Inhibitory zone = 18.96 mm	Antimicrobe	(A. P. Ningsih et al., 2013)
Clitoria ternatea	Flavonoid, saponin, tannin, alkaloid, terpenoid	*Staphylococcus aureus*	3.41 ppm	Antibiofilm	(Besan et al., 2023)
	Tannin, flavonoid, alkaloid, saponin, steroid, and terpenoid	*Porphyromonas gingivalis*	OD≥6.00	Antibiofilm	(Widyarman et al., 2018)
Syzygium aromaticum	Eugenol, caryophyllene, and 2-(octadecyloxy)-etanol	*Staphylococcus aureus*	MIC = 1.25 µL/mL MBC = 2.5 µL/mL	Antibiofilm	(Alanazi et al., 2022)
Etlingera elatior	Dodecanal, 1-dodecanol, and α-pinene	*Acinetobacter baumannii*	80% inhibition at an oil concentration of 0.7%	Antibiofilm	(Naushad et al., 2022)
Punica granatum	Polyphenols (including gallic acid), ellagic acid, and ethyl brevifolin-carboxylate.	*Streptococcus sanguinis, Streptococcus sobrinus, Streptococcus salivarius, Streptococcus mutans, Enterococcus faecalis*	40.6-100% reduction	Antibiofilm	(Dastjerdi et al., 2014; Ökmen et al., 2023)
Illicium verum	Flavone compound (5,7-dihydroxy-3-phenylchromen-4-one)	*Escherichia coli*	Inhibitory zone = 19 mm	Antimicrobe	(Joicy et al., 2021)
Ocimum basilicum	Fatty acids, phospholipids, phytosterols, carotenoid pigments and essential oils	*Staphylococcus aureus* ATCC-25923	MIC = 0.125 µg/mL	Antimicrobe	(Bobakulov et al., 2020; Yibeltal et al., 2022)

Table 2. Potential bioactive compounds of edible flowers as antibiofilm agents. *Description*: No data (ND), Minimum inhibitory concentration (MIC), Minimum bactericidal concentration (MBC) (*Continued*).

Edible Flowers	Bioactive	Target Bacteria	Activities	Notes	References
Carica papaya	Flavonoids and polyphenols	*Escherichia coli*	Inhibitory zone = 15 mm	Antimicrobe	(Chandra et al., 2023)
	Flavonoids and polyphenols	*Staphylococcus aureus*	Inhibitory zone = 14 mm	Antimicrobe	(Chandra et al., 2023)
Lantana camara	Alkaloids, glycosides, saponins, steroids, terpenoids, carbohydrates, flavonoids, and coumarins	*Staphylococcus aureus, Acinetobacter baumannii, Pseudomonas aeruginosa, Klebsiella* spp., *Proteus* spp.	Inhibitory zone = 8-18 mm	Antimicrobe	(Hussein, 2023)
Hibiscus sabdariffa	Flavonoid, tannin, phenolic, saponin	*Streptococcus mutans*	Inhibitory zone = 8.43 mm	Antimicrobe	(Kustyawati et al., 2022)
	Alkaloid, flavonoid, saponin	Methicillin-resistant *Staphylococcus aureus* (MRSA)	74% inhibition	Antibiofilm	(Jaddoa & Ghrab, 2021)
	Alkaloid, saponin, tannin, phenolic, flavonoid, triterpenoid, glycosides	*Porphyromonas gingivalis* and *Treponema denticola*	OD = 0.045	Antibiofilm	(Winson et al., 2023)
Brassica oleracea	Glucosinolates	*Bacillus cereus,*	74.8% inhibition	Antimicrobe	(Gudiño et al., 2022)
	ND	*Staphylococcus aureus*	83.4% inhibition	Antimicrobe	(Gudiño et al., 2022)
	ND	*Listeria innocua*	80.4% inhibition	Antimicrobe	(Gudiño et al., 2022)
Cananga odorata	Trans- and cis-nerolidol	*Escherichia coli, Staphylococcus aureus*	80% inhibition	Antibiofilm	(Tan et al., 2015)
Caesalpinia pulcherrima	Flavonoids, saponins	*Staphylococcus aureus*	Inhibitory zone = 20.6 mm	Antimicrobe	(Mustapa & Tomoni, 2016)
		Escherichia coli	Inhibitory zone = 18 mm		

Table 2. Potential bioactive compounds of edible flowers as antibiofilm agents. *Description*: No data (ND), Minimum inhibitory concentration (MIC), Minimum bactericidal concentration (MBC) (*Continued*).

Edible Flowers	Bioactive	Target Bacteria	Activities	Notes	References
Brassica rapa	Glucosinolates, isothiocyanates, flavonoids, phenylpropanoids, phenolics, indoles, and carbohydrates.	*Shigella dysenteriae, Salmonella typhimurium, Escherichia coli, Staphylococcus aureus*	MIC = 3.12-200 µg/mL	Antimicrobe	(Alotaibi et al., 2021)
Cassia fistula	Alkaloid, saponin, triterpenoid, glycosides, anthraquinone, flavonoid, steroid, phenolic	*Staphylococcus aureus*	MIC = 40 µg/mL	Antimicrobe	(Seyyednejad et al., 2014)
		Escherichia coli	MIC = 5 µg/mL	Antimicrobe	(Seyyednejad et al., 2014)
		Staphylococcus epidermidis	MIC = 40 µg/mL	Antimicrobe	(Seyyednejad et al., 2014)
Cocos nucifera	Phenolic	*Escherichia coli* ATCC 25922	Inhibitory zone = 13.8 mm	Antimicrobe	(Shen et al., 2017)
		Escherichia coli 0157: H7 ATCC 33150	Inhibitory zone = 6.8 mm		
		Staphylococcus aureus ATCC 2392	Inhibitory zone = 12.3 mm		
Jasminum sambac	Alkaloid, flavonoid, tannin, anthraquinones, phenolic, steroid	*Listeria monocytogenes*	MIC = 62.5 µg/mL Inhibitory zone =15 mm	Antimicrobe	(Senbagam et al., 2016)
		Salmonella typhi	MIC = 62.5 µg/mL Inhibitory zone = 16 mm		
		Bacillus cereus	MIC = 62.5 µg/mL Inhibitory zone = 16 mm		
		Staphylococcus aureus	MIC = 125 µg/mL Inhibitory zone = 15 mm		
		Escherichia coli	MIC = 125 µg/mL Inhibitory zone = 13 mm		

Lantana flower revealed the ability to impede the growth of both Gram-positive and Gram-negative bacteria. *Lantana camara* has been recognized as a significant medicinal plant globally, known for various biological activities, including anti-protozoal, anti-inflammatory, antibacterial, and antioxidant properties. The Lantana extracts exhibited moderate to high inhibitory activities against various clinical bacterial isolates, with susceptibility increasing proportionally with extract concentration. Notably, a substantial inhibition zone was observed in *Klebsiella* spp. is 18 mm, followed by *Proteus* spp., *S. aureus*, *A. baumannii*, and *P. aeruginosa,* i.e., 16, 15.5, 14.5, and 15 mm, respectively. This antimicrobial activity is attributed to the presence of bioactive compounds in the extract, including flavonoids, tannins, and phenols (Hussein, 2023).

Biofilms are communities of bacteria that adhere to surfaces encased in a sticky matrix (Figure 2). Biofilm development is a well-defined series of stages, including 1) initial attachment, where free-floating bacteria, called planktonic cells, come into contact with a surface; 2) microcolony formation, where bacteria adhere more firmly to the surface, often through specific interactions with molecules on both the bacteria and the surface. Bacteria start producing an extracellular polymeric substance (EPS), a slimy matrix that helps them stick together and provides protection; 3) maturation, where the EPS matrix creates a complex and protective environment for the biofilm. Bacterial cells within the biofilm differentiate, meaning they take on specialized roles within the community. Communication between bacterial cells increases, allowing them to coordinate activities like nutrient acquisition and defense; and 4) dispersion, where specific signals or environmental conditions trigger the release of some bacteria from the biofilm. These dispersed cells return to the planktonic state and can go on to colonize new surfaces (Besan et al., 2023; Hussein, 2023; Jaddoa & Ghrab, 2021).

The microbial fortresses pose a significant threat, causing chronic infections in medical devices, wounds, and lungs. Traditional antibiotics often falter against biofilms, highlighting the urgent need for new agents. Research increasingly reveals the remarkable ability of flower bioactive compounds to inhibit biofilm formation and even dismantle existing ones. There are some proposed mechanisms of action, including disruption of initial adhesion by tannins, flavonoids, and terpenoids (Besan et al., 2023); disruption of biofilm matrix production by saponins, quinones, and essential oils (Hussein, 2023); and disruption of biofilm matrix or communication between bacteria cells within the biofilm by flavonoids and terpenoids (Jaddoa & Ghrab, 2021).

Several standard methods are used to test the ability of bioactive antibiofilm (Skogman et al., 2016). The in vitro method is widely performed because it is easy. In vitro testing is commonly used to test the antibacterial activity of bioactives against a single bacterium or a mixture of bacteria. In vitro methods include assays for 1) inhibition of biofilm growth, where measure the ability of compounds to inhibit biofilm growth; 2) inhibition of biofilm formation, where measures the ability of compounds to inhibit biofilm formation; and 3) inhibition of biofilm dissemination by measuring the time of biofilm formation or the number of bacteria attached to the surface.

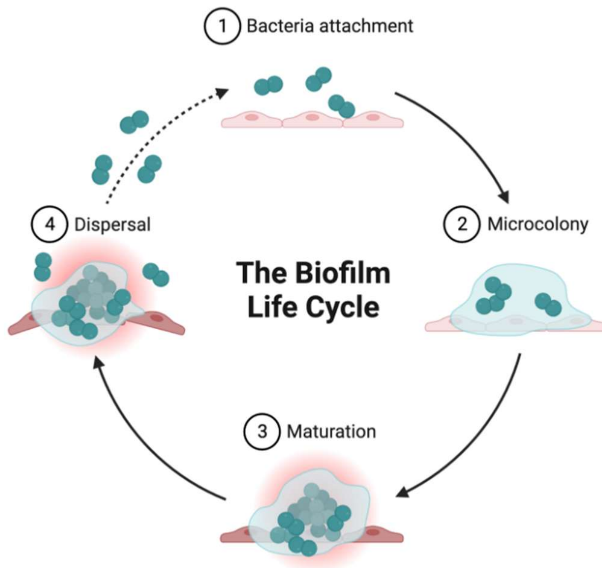

Figure 2. Cycle of biofilm formation and development.

Plants produce a large number of specialized metabolites that have specific roles. Research on floral bioactives against biofilms is still in its early stages, but the potential is immense. Scientists are exploring ways to isolate and purify these compounds, potentially leading to novel biofilm-disrupting drugs. Further research explicitly addressing this potential is warranted to fully understand the role of edible flowers in combating biofilm-related issues. However, harvesting flowers for large-scale production might not be sustainable. Instead, researchers investigate sustainable cultivation methods and even genetically modify plants to enhance their bioactive content. The future may hold flower farms buzzing with bees and teeming with the promise of a future free from biofilm-related infections. Edible flowers could provide a natural alternative to synthetic antibiotics. Natural products can sometimes have fewer side effects and may be better tolerated by the body. Also, it may lead to the developing of new medicines that are more accessible and affordable for local people.

4. CONCLUSION

Given the limited direct evidence, this review provides an overview of the bioactive compounds in edible flowers and their implications for inhibiting biofilm formation. There are 25 types of edible flowers from 19 families in Indonesia. Local communities also use edible flowers in traditional medicine practices, including *Hibiscus sabdariffa, Jasminum sambac, Caesalpinia pulcherrima, Punica granatum, Blumea balsamifera,* and *Lantana camara*. The bioactive compounds show antimicrobial activity against various Gram-positive and Gram-negative bacteria. Not all edible flowers in Indonesia have been studied for their antibiofilm activities. The presence of bioactive compounds with antimicrobial properties in edible flowers suggests that they may have the potential as antibiofilm agents.

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CONFLICT OF INTEREST

The author declares that there is no conflict of interest in this paper.

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