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Review paper

STINGLESS BEE PROPOLIS REVIEW AS BIOCOSMETICS FOR ANTI-ACNE, ANTI-AGING, AND SKIN-WHITENING

Swandari Paramita[1]* ORCID: 0000-0002-6677-3298
Vera Madonna Lumban Toruan[1] ORCID: 0000-0002-6804-7249
Khairunnida Rahma[1] ORCID: 0000-0002-6089-3619
Mona Zubaidah[1]
Enos Tangke Arung[2] ORCID: 0000-0002-1979-6892
Irawan Wijaya Kusuma[2] ORCID: 0000-0002-0177-6615

[1]Faculty of Medicine, Mulawarman University, 75119, Samarinda, Indonesia
[2]Faculty of Forestry, Mulawarman University, 75119, Samarinda, Indonesia

*corresponding author: s.paramita@fk.unmul.ac.id
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Abstract

Data on cosmetic sales has grown significantly recently, with consumers increasingly choosing natural cosmetics or biocosmetics. The natural ingredient that has received attention recently is stingless bee propolis. Stingless bee propolis has been utilized in cosmetics manufacturing and has been extensively studied for its beneficial properties for the skin, including anti-acne, anti-aging, and skin-whitening properties. This review comprehensively analyzes the potential of stingless bee propolis for anti-inflammatory, anti-bacterial, antioxidant, anti-wrinkle, anti-melanogenesis, and sunscreen activity. The chemical compound that has been found in stingless bee propolis and can be used in biocosmetics, including p-coumaric acid, gallic acid, caffeic acid, ellagic acid, ferulic acid, catechin, quercetin, apigenin, kaempferol, glyasperin, broussoflavonol, rutin, methyldiplacone, nymphaeol, geranyl flavonol, oleic acid, palmitic acid, ascorbic acid, and tocopherol. The potential applications of stingless bee propolis in biocosmetics are significant, and there are numerous benefits of using it. Further research is needed to understand its potential applications and benefits for the skin.

Keywords: anti-aging, anti-acne, skin-whitening, stingless bee propolis

INTRODUCTION

The word ‘cosmetic’ is derived from the Greek word ‘kosmetike,’ which means ‘the art of dress and ornament.’ In general, cosmetics treat the external surfaces of the human body directly to maintain excellent skin (Chin et al., 2018; Syahrul & Mayangsari, 2020). Data on cosmetic sales worldwide shows that the cosmetics industry has continued to experience significant growth in recent years. In the cosmetics segment, consumers usually purchase skincare products (Galaburda, 2022; Petruzzi, 2023). The global market for biocosmetics has experienced a remarkable surge in recent years. Fueled by a growing consumer desire for safe, sustainable, and ethically sourced products, the biocosmetic industry has witnessed a significant rise in production and consumption. Statistics show that the global biocosmetic market reached 131.5 billion USD in 2022 and is expected to grow by over 3% between 2022 and 2027 (Global Data, 2023).

The biocosmetic market is segmented into various types and applications, with facial skin care being a significant part. The market is driven by increasing purchasing power, changing lifestyles, and rising awareness of skin issues and conditions. This surge in popularity underscores the increasing consumer interest in natural alternatives for their beauty needs (Goyal & Jerold, 2023). Overall, the most sought-after skincare goal is to have skin that is healthy, bright, and free from skin problems, as well as to prevent signs of premature aging. Cultural factors and societal views that value white and clean skin as a standard of beauty cause this concept (Ali & Yosipovitch, 2013; Shanbhag et al., 2019). In recent years, there has also been a shift in trends where consumers are increasingly choosing natural cosmetics or biocosmetics, which are more environmentally friendly and safe for their skin. This trend has increased the demand for biocosmetics products worldwide (Kanlayavattanakul & Lourith, 2018; Nilforoushzadeh et al., 2018; Wathoni et al., 2018). Stingless bee products, including propolis, have received attention recently because of their potential benefits for skin care. Since ancient times, propolis has been utilized in traditional medicine practices of various cultures. The growing interest in stingless bee propolis research is fueled by its potential to be a natural source of bioactive compounds with a wide range of biological activities. Studies have shown promise for propolis in areas like antimicrobial activity, antioxidant properties and anti-inflammatory effects. These potential biological activities highlight stingless bee propolis as a promising candidate for biocosmetic products (Kurek-Górecka et al., 2020; Tran et al., 2020). The bulk of a stingless bee hive is made of propolis; researchers discovered that the hive contains more than 60% propolis parts (Martinello & Mutinelli, 2021; Goh et al., 2023).

The benefits of stingless bee propolis have been well-studied. It is similar to stingless bee honey and has medicinal properties. In addition to its medicinal characteristics, stingless bee propolis has been utilized in cosmetics manufacturing (Sanches et al., 2017; Al-Hatamleh et al., 2020). Stingless bee propolis has been extensively studied for its beneficial properties for the skin, including anti-inflammatory, anti-bacterial, antioxidant, anti-wrinkle, anti-melanogenesis, and sunscreen activity (Rozman et al., 2022; Zulhendri et al., 2022). The review aims to provide a comprehensive and critical analysis of the potential of stingless bee propolis as a natural ingredient in biocosmetics for anti-acne, anti-aging, and skin-whitening properties.

MATERIAL AND METHODS

In this review, we searched all the relevant literature using the keywords “propolis,” “stingless,” and “cosmetic” as the search query in the last ten years from 2013 until 2023. We compiled all published data using reputable academic databases, including Scopus, Pubmed, Web of Science, and Google Scholar. We incorporated all research articles that elucidate the many biological activities of propolis derived from stingless bees. By filtering the title and abstract and retrieving the whole article from the database search, potentially relevant papers were selected (Zulhendri et al., 2022). Then, full-text articles were downloaded, and their eligibility was evaluated. We obtained 161 journals exploring the potential of stingless bee propolis as biocosmetics, with anti-acne, anti-aging, and skin-whitening properties. Thirty-five species of stingless bees were reviewed in this article: *Geniotrigona thoracica, Heterotrigona itama*, *Homotrigona apicalis*, *H. binghami*, *H. canifrons, H. fimbriata, H. peninsularis, H. vidua, Lepidotrigona terminata, L. ventralis, Lisotrigona cacciae, L. carpenteri, Melipona beecheii, M. fasciculata, M. quadrifasciata*, *M. quadrifasciata anthidioides, M. quadrifasciata quadrifasciata, M. scutellaris*, *Scaptotrigona depilis, S. jujuyensis*, *Tetragona clavipes, Tetragonisca angustula, T. fiebrigi, Tetragonula biroi*, *T. fuscibasis*, *T. fuscobalteata*, *T. iridipennis, T. laeviceps*, *T. reepeni, T. pagdeni, T. sapiens, T. sarawakensis, T. testaceitarsis*, *Tetrigona melanoleuca*, and *Wallacetrigona incisa*.

Stingless Bee Propolis

Stingless bee propolis is a resinous substance collected by stingless bees to protect their hives from bacteria, fungi and other pathogens. Examining and evaluating the compounds obtained from stingless bee propolis demonstrated that phenolics and flavonoids were predominant (Chin et al., 2018; Syed Salleh et al., 2021). The phenolic and flavonoid compounds found in stingless bee propolis are believed to contribute to its anti-bacterial and anti-inflammatory properties, which make it effective against acne-causing bacteria. Stingless bee propolis also helps protect the skin from damage by free radicals. Stingless bee propolis may help brighten the skin and reduce the appearance of dark spots and hyperpigmentation (Salleh et al., 2022; Rocha et al., 2023).

Overall, stingless bee propolis is a promising natural ingredient for biocosmetics due to its beneficial properties for the skin, as shown in Fig. 1. Anti-acne properties of stingless bee propolis focused on anti-inflammatory and anti-bacterial activity. Anti-aging properties focused on antioxidants, anti-wrinkle potential and sunscreen activity. Meanwhile, skin-whitening properties focused on anti-melanogenesis and sunscreen activity.

Stingless bee propolis has properties as an anti-bacterial, anti-inflammatory, antioxidant, and anti-melanogenesis, as shown in Tab. 1. The thirty-five propolis-producing stingless bee species studied in this review originate from the countries of Argentina, Brazil, Brunei, China, Colombia, India, Indonesia, Malaysia, Mexico, Philippines, Thailand, and Vietnam, and the most studies on stingless bee propolis come from Indonesia, followed by Malaysia and Brazil. Propolis has a diversity of species and geographical origins. The inclusion of propolis from various stingless bee species and different countries introduces significant variability in the chemical composition of the samples.

There are five types of extract for propolis: raw propolis, aqueous, ethanolic, hexane, and methanolic extract. In this review, ethanolic extract is the extraction method most often used for propolis-producing stingless bee species. There are discrepancies in extraction methods. The different extraction techniques can yield extracts with varying chemical profiles, which influences the observed biological activities. Most study types for propolis are *in vitro* studies. While *in vitro* studies provide valuable initial insights into the potential bioactivity of compounds, they cannot fully replicate the complex physiological environment of a living organism.

From all the propolis-producing stingless bee species in this review, only three species had extracts that showed anti-bacterial activity against *Staphylococcus epidermidis*, *T. fiebrigi* from Brazil, and *T. laeviceps* and *T. melanoleuca* from Thailand. *T. biroi* propolis extracts from Indonesia showed anti-bacterial activity against *Cutibacterium acnes*. Few specific stingless bee species exhibiting anti-bacterial properties may be due to limited species representation, geographical bias and different extraction methods.

Meanwhile, only seven species have extracts that show anti-inflammatory potential, namely *H. itama*, *M. beecheii*, *M. quadrifasciata anthidioides*, *S. depilis*, *S. jujuyensis*, *T. fiebrigi,* and *T. biroi*. These propolis come from Argentina, Brazil, China, Indonesia, Mexico, and the Philippines. The limited scope of available research on stingless bee propolis hampers a comprehensive understanding of its anti-inflammatory properties. Key factors influencing this limitation is the small number of studied species, geographical bias and differences in research methodologies.

All propolis extracts showed antioxidant activity through the use of DPPH (2,2-diphenyl-1-picrylhydrazyl), ABTS (2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) or FRAP (Ferric Reducing Ability of Plasma) assay, from both Asia (Brunei, China, India, Indonesia, Malaysia, Philippines, Thailand, and Vietnam) and America (Argentine, Brazil, Colombia, and Mexico). DPPH

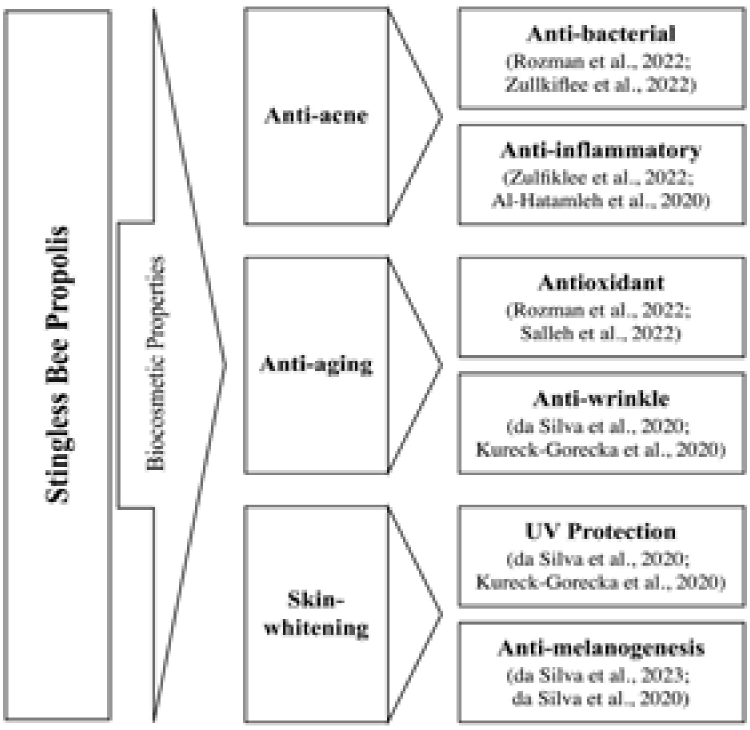

Fig. 1. Diagram of stingless bee propolis potential for anti-acne, anti-aging, and skin-whitening.

Table 1.

Stingless bee propolis properties of anti-bacterial, anti-inflammatory, antioxidant and anti-melanogenesis activity

No	Propolis-producing stingless bee species	Country of origin	Types of extract	Types of study	Measured outcome	References
1	*Geniotrigona thoracica*	Brunei	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH)	(Abdullah et al., 2020)
		Malaysia	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH)	(Adli et al., 2022; Awang et al., 2018; Ibrahim et al., 2016; Nafi et al., 2019)
		Malaysia	Ethanolic and aqueous extract	*In vitro*	Antioxidant activity (DPPH)	(Zullkiflee et al., 2022a)
		Malaysia	Methanol extract	*In vitro*	Antioxidant activity (DPPH)	(Badiazaman et al., 2019)
2	*Heterotrigona itama*	Brunei	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH)	(Abdullah et al., 2020)
		China	Ethanolic extract	*In vitro*	Anti-inflammatory activity (measuring inflammatory mediators)	(Zhang et al., 2020)
		China	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH)	(Zhang et al., 2020)
		Indonesia	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH)	(Fikri et al., 2019)
		Indonesia	Aqueous extract	*In vitro*	Antioxidant activity (DPPH)	(Sulaeman et al., 2021)
		Indonesia	Raw propolis	*In vitro*	Antioxidant activity (DPPH)	(Syafrizal et al., 2020)
		Malaysia	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH)	(Awang et al., 2018; Ibrahim et al., 2016; Nafi et al., 2019)
		Malaysia	Ethanolic and aqueous extract	*In vitro*	Antioxidant activity (DPPH)	(Zullkiflee et al., 2022a)
		Malaysia	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH and ABTS)	(Mohd-Yazid et al., 2018)
		Malaysia	Ethanolic and hexane extract	*In vitro*	Antioxidant activity (DPPH, ABTS, and FRAP)	(Akhir et al., 2017)
3	*Homotrigona apicalis*	Indonesia	Methanolic extract	*In vitro*	Antioxidant activity (DPPH and ABTS)	(Arung et al., 2020)
		Indonesia	Methanolic extract	*In vitro*	Anti-melanogenesis activity (anti-tyrosinase and melanin inhibition assay)	(Arung et al., 2020)

		Malaysia	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH)	(Awang et al., 2018; Nafi et al., 2019)
		Malaysia	Aqueous extract	*In vitro*	Antioxidant activity (DPPH)	(Syed Salleh et al., 2021)
		Malaysia	Ethanolic extract	*In vitro*	Antioxidant activity (ABTS)	(Mohamed et al., 2020)
		Vietnam	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH and FRAP)	(Popova et al., 2022)
4	*Homotrigona binghami*	Brunei	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH)	(Abdullah et al., 2020)
		Malaysia	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH)	(Awang et al., 2018)
		Malaysia	Aqueous extract	*In vitro*	Antioxidant activity (DPPH)	(Syed Salleh et al., 2021)
		Malaysia	Ethanolic and aqueous extract	*In vitro*	Antioxidant activity (DPPH)	(Zullkiflee et al., 2022a)
5	*Homotrigona canifrons*	Malaysia	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH)	(Awang et al., 2018)
6	*Homotrigona fimbriata*	Indonesia	Raw propolis	*In vitro*	Antioxidant activity (DPPH)	(Syafrizal et al., 2020)
		Malaysia	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH)	(Awang et al., 2018)
		Malaysia	Aqueous extract	*In vitro*	Antioxidant activity (DPPH)	(Syed Salleh et al., 2021)
7	*Homotrigona peninsularis*	Malaysia	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH)	(Awang et al., 2018)
8	*Homotrigona vidua*	Malaysia	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH)	(Awang et al., 2018)
9	*Lepidotrigona terminata*	Indonesia	Raw propolis	*In vitro*	Antioxidant activity (DPPH)	(Syafrizal et al., 2020)
		Malaysia	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH)	(Nafi et al., 2019)
		Thailand	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH, ABTS, and FRAP)	(Vongsak et al., 2015)
		Vietnam	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH and FRAP)	(Popova et al., 2022)
10	*Lepidotrigona ventralis*	Thailand	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH, ABTS, and FRAP)	(Vongsak et al., 2015)
		Vietnam	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH and FRAP)	(Popova et al., 2022)
11	*Lisotrigona cacciae*	Vietnam	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH)	(Georgieva et al., 2019)
12	*Lisotrigona carpenteri*	Vietnam	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH and FRAP)	(Popova et al., 2022)

13	*Melipona beecheii*	Mexico	Ethanolic extract	*In vitro*	Anti-inflammatory activity (inhibition of protein thermal denaturation, cell membrane stabilization, and hemolysis assay)	(Ruiz Ruiz et al., 2023)
		Mexico	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH and ABTS)	(Ruiz Ruiz et al., 2023)
14	*Melipona fasciculata*	Brazil	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH)	(Araújo et al., 2016)
15	*Melipona quadrifasciata*	Brazil	Ethanolic and aqueous extract	*In vitro*	Antioxidant activity (DPPH)	(dos Santos et al., 2017)
		Brazil	Ethanolic, methanolic, and aqueous extract	*In vitro*	Antioxidant activity (DPPH)	(Hochheim et al., 2019)
16	*Melipona quadrifascita anthidioides*	Brazil	Ethanolic extract	*In vitro*	Anti-inflammatory activity (hemolysis assay)	(Bonamigo et al., 2017)
		Brazil	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH)	(Pazin et al., 2017)
		Brazil	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH and ABTS)	(Bonamigo et al., 2017)
17	*Melipona quadrifasciata quadrifasciata*	Brazil	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH)	(Torres et al., 2018)
18	*Melipona scutellaris*	Brazil	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH)	(Araújo et al., 2016)
19	Scaptotrigona depilis	Brazil	Ethanolic extract	*In vitro*	Anti-inflammatory activity (hemolysis assay)	(Bonamigo et al., 2017)
		Brazil	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH and ABTS)	(Bonamigo et al., 2017)
20	*Scaptotrigona jujuyensis*	Argentine	Ethanolic extract	*In vivo*	Anti-inflammatory activity (antinociceptive assay on Wistar rats)	(Brodkiewicz et al., 2018)
		Argentine	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH)	(Brodkiewicz et al., 2018)
21	*Tetragona clavipes*	Brazil	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH)	(Pazin et al., 2017)
22	*Tetragonisca angustula*	Colombia	Ethanolic, methanolic, and hexane extract	*In vitro*	Antioxidant activity (ABTS)	(Correa-González et al., 2019)
		Brazil	Ethanolic and aqueous extract	*In vitro*	Antioxidant activity (DPPH)	(dos Santos et al., 2017)
		Brazil	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH)	(Torres et al., 2018)

23	*Tetragonisca fiebrigi*	Brazil	Ethanolic extract	*In vitro*	Anti-bacterial activity (against *Staphylococcus epidermidis*)	(Campos et al., 2015)
		Brazil	Ethanolic extract	*In vitro*	Anti-inflammatory activity (hemolysis assay)	(Campos et al., 2015)
		Brazil	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH)	(Campos et al., 2015)
		Argentine	Ethanolic extract	*In vivo*	Anti-inflammatory activity (antinocicep-tive assay on Wistar rats)	(Brodkiewicz et al., 2018)
		Argentine	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH)	(Brodkiewicz et al., 2018)
24	*Tetragonula biroi*	Indonesia	Methanolic extract	*In vitro*	Anti-bacterial activity (against *Cutibacterium acnes*)	(Arung et al., 2023)
		Indonesia	Methanolic extract	*In vitro*	Anti-inflammatory activity (membrane stabilization assay)	(Arung et al., 2023)
		Indonesia	Ethanolic extract	*In vivo*	Anti-inflammatory activity (carrageenan-induced paw edema on Sprague Dawley rats)	(Sahlan et al., 2019)
		Indonesia	Methanolic extract	*In vitro*	Antioxidant activity (DPPH)	(Arung et al., 2023)
		Indonesia	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH)	(Fikri et al., 2019)
		Indonesia	Raw propolis	*In vitro*	Antioxidant activity (DPPH)	(Syafrizal et al., 2020)
		Philippines	Ethanolic extract	*In vivo*	Anti-inflammatory activity (carrageenan-induced paw edema on mice)	(Calimag et al., 2021)
25	*Tetragonula fuscibasis*	Indonesia	Methanolic extract	*In vitro*	Antioxidant activity (DPPH and ABTS)	(Arung et al., 2020)
		Indonesia	Methanolic extract	*In vitro*	Anti-melanogenesis activity (anti-tyrosinase and melanin inhibition assay)	(Arung et al., 2020)
26	*Tetragonula fuscobalteata*	Indonesia	Methanolic extract	*In vitro*	Antioxidant activity (DPPH and ABTS)	(Arung et al., 2020)
		Indonesia	Methanolic extract	*In vitro*	Anti-melanogenesis activity (anti-tyrosinase and melanin inhibition assay)	(Arung et al., 2020)

27	*Tetragonula iridipennis*	India	Aqueous extract	*In vitro*	Antioxidant activity (DPPH)	(Kothai & Jayanthi, 2014)
		India	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH, ABTS, and FRAP)	(Kasote et al., 2019)
		Indonesia	Raw propolis	*In vitro*	Antioxidant activity (DPPH)	(Syafrizal et al., 2020)
		Vietnam	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH and FRAP)	(Popova et al., 2022)
28	*Tetragonula laeviceps*	Indonesia	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH)	(Fikri et al., 2019)
		Indonesia	Raw propolis	*In vitro*	Antioxidant activity (DPPH)	(Syafrizal et al., 2020)
		Thailand	Ethanolic extract	*In vitro*	Anti-bacterial activity (against *S. epidermidis*)	(Sanpa et al., 2015)
		Thailand	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH)	(Ishizu et al., 2018)
		Thailand	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH, ABTS, and FRAP)	(Vongsak et al., 2015)
		Thailand	Methanolic extract	*In vitro*	Anti-melanogenesis activity (anti-tyrosinase assay)	(Meemongkolkiat et al., 2023)
		Vietnam	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH and FRAP)	(Popova et al., 2022)
29	*Tetragonula reepeni*	Indonesia	Raw propolis	*In vitro*	Antioxidant activity (DPPH)	(Syafrizal et al., 2020)
30	*Tetragonula pagdeni*	Thailand	Methanolic extract	*In vitro*	Anti-melanogenesis activity (anti-tyrosinase assay)	(Meemongkolkiat et al., 2023)
31	*Tetragonula sapiens*	Indonesia	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH)	(Pratami et al., 2023; Pujirahayu et al., 2019)
32	*Tetragonula sarawakensis*	Indonesia	Raw propolis	*In vitro*	Antioxidant activity (DPPH)	(Syafrizal et al., 2020)
33	*Tetragonula testaceitarsis*	Indonesia	Raw propolis	*In vitro*	Antioxidant activity (DPPH)	(Syafrizal et al., 2020)
34	*Tetrigona melanoleuca*	Malaysia	Ethanolic extract	*In vitro*	Antioxidant activity (DPPH)	(Awang et al., 2018)
		Thailand	Ethanolic extract	*In vitro*	Anti-bacterial activity (against *S. epidermidis*)	(Sanpa et al., 2015)
35	*Wallacetrigona incisa*	Indonesia	Methanolic extract	*In vitro*	Anti-melanogenesis activity (anti-tyrosinase and melanin inhibition assay)	(Arung et al., 2020)
		Indonesia	Methanolic extract	*In vitro*	Antioxidant activity (DPPH and ABTS)	(Arung et al., 2020)

Note: ABTS (2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid), DPPH (2,2-diphenyl-1-picrylhydrazyl), FRAP (Ferric Reducing Ability of Plasma) was the most frequently used antioxidant activity assay, followed by ABTS and FRAP assays. Ethanol extracts of propolis from all stingless bee species exhibit antioxidant activity, except for *G. thoracica*, *H. apicalis*, *H. binghami*, *H. fimbriata*, *H. itama*, *L. terminata*, *M. quadrifasciata*, *T. angustula*, *T. biroi*, *T. fuscibasis*, *T. fuscobalteata*, *T. iridipennis*, *T. laeviceps*, *T. pagdeni*, *T. reepeni*, *T. sarawakensis*, *T. testaceitarsis*, and *W. incisa*, which used raw propolis and aqueous, hexane and methanolic extract. The antioxidant capacity of stingless bee propolis is evident across various species, as indicated by consistent results from DPPH, ABTS, and FRAP assays. However, a comprehensive understanding of the antioxidant properties requires a broader approach.

From all the propolis-producing stingless bee species, *H. apicalis*, *T. fuscibasis*, *T. fuscobalteata* and *W. incisa* from Indonesia had methanolic extracts that demonstrated anti-melanogenesis activity through the use of anti-tyrosinase, and melanin. *T. laeviceps* and *T. pagdeni* from Thailand had methanolic that demonstrated inhibition assay and anti-melanogenesis activity through the use of anti-tyrosinase assay. The limited data on anti-melanogenesis activity in stingless bee propolis necessitates further research. The small sample size of studied species, exclusive focus on methanolic extracts and geographical bias hinder a comprehensive understanding of propolis' potential to inhibit melanogenesis.

Chemical compounds from stingless bee propolis

The chemical compounds in propolis believed to contribute to its anti-bacterial, anti-inflammatory, antioxidant, and anti-melanogenesis activities (Lim et al., 2023) are required for biocosmetics products anti-acne, anti-aging, and skin-whitening properties, as shown in Tab. 2. The twelve chemical compounds are broussoflavonol F, caffeic acid, catechin, ellagic acid, ferulic acid, gallic acid, glyasperin A, oleic acid, palmitic acid, p-coumaric acid, quercetin and rutin, and they are derived from the stingless bee species, *M. fasciculata*, *M. quadrifasciata*, *M. quadrifasciata anthidioides*, *M. quadrifasciata quadrifasciata*, *S. bipunctata*, *T. angustula,* and *T. biroi*. Most of the chemical compounds were identified qualitatively with the use of HPLC (High-Performance Liquid Chromatography) and showed potential for antioxidant activity for their development as biocosmetic products.

The variety of bee species and their geographic distribution can have a considerable influence on the composition of propolis. Various bee species may exhibit preferences for distinct plant resins, which impact the ultimate composition of the propolis. The intricate combination of these chemicals adds to the varied biological actions of propolis. The composition and amounts of these chemicals differ based on the plant from which they originate and the species of bee involved (Pyrgioti et al., 2022). The solvent selection substantially influences the content and bioactivity of the resulting extract. Various extraction techniques may exhibit an efficiency for particular categories of chemicals. The wide range of bioactive chemicals in propolis enhances its potential for numerous biocosmetic uses (Kasote et al., 2022). The qualitative analysis methods enable the identification and characterization of the diverse chemical components found in propolis extract. The intricate structure of propolis, combined with the absence of standardized extraction techniques and reference benchmarks, obstructs precise measurement (Vică et al., 2022). Qualitative approaches provide a thorough analysis, comparing various propolis samples and identifying specific components that serve as markers. Although quantitative data is valuable, combining qualitative and quantitative methods offers a more thorough comprehension of propolis. This approach enables precise measurement of essential chemicals and facilitates correlation studies between chemical profiles and biological activity (Graikini et al., 2019).

P-coumaric acid was a chemical compound found in propolis from *M. quadrifasciata*, *M. quadrifasciata quadrifasciata*, *S. bipunctata,* and *T. angustula* through qualitative analysis of all the propolis-producing stingless bee species in this review**.** However, p-coumaric acid was also found in *T. iridipennis* through quantitative analysis for 0.16 µg/mg in HPLC (Kasote et al., 2019). The most abundant reported compounds from stingless bee propolis samples are p-coumaric

Table 2.

Chemical compounds identified with qualitative analysis from stingless bee propolis with their biocosmetic properties

No	Propolis-producing Stingless Bee Species	Chemical Compound	Types of Extract	Qualitative Method for Identification of Chemical Compound	Biocosmetics Properties	References
1	*Melipona fasciculata*	Ellagic acid	Hydroalcoholic extract	14.7 TIC % in HPLC-UV	-	(Dutra et al., 2019)
		Gallic acid	Hydroalcoholic extract	22.30 TIC % in HPLC-UV	-	(Dutra et al., 2019)
		Palmitic acid	Hydroalcoholic extract	0.52 TIC % in HPLC-UV	-	(Dutra et al., 2019)
2	*Melipona quadrifasciata*	Catechin	Hydroalcoholic extract	8.57 RT (min) in HPLC-ESI-MS/MS	Antioxidant activity (DPPH)	(Hochheim et al., 2019)
		Gallic acid	Aqueous extract	6.0 RT (min) in HPLC-UV	Antioxidant activity (DPPH)	(dos Santos et al., 2017)
		p-coumaric acid	Hydroalcoholic extract	24.9 RT (min) in HPLC-UV	Antioxidant activity (DPPH)	(dos Santos et al., 2017)
			Hydroalcoholic extract	10.24 RT (min) in HPLC-ESI-MS/MS	Antioxidant activity (DPPH)	(Hochheim et al., 2019)
		Quercetin	Hydroalcoholic extract	5.2 RT (min) in HPLC-UV	Antioxidant activity (DPPH)	(dos Santos et al., 2017)
		Rutin	Aqueous extract	4 RT (min) in HPLC-UV	Antioxidant activity (DPPH)	(dos Santos et al., 2017)
3	*Melipona quadrifasciata anthidioides*	Ellagic acid	Ethanolic extract	16.4 RT (min) in HPLC-DAD-MS	-	(Campos et al., 2022)
4	*Melipona quadrifasciata quadrifasciata*	Ellagic acid	Ethanolic extract	3.62 RT (min) in UPLC-MS/MS	-	(Surek et al., 2021)
		Ferulic acid	Ethanolic extract	3.73 RT (min) in UPLC-MS/MS	-	(Surek et al., 2021)
		Gallic acid	Ethanolic extract	0.45 RT (min) in UPLC-MS/MS	-	(Surek et al., 2021)
			Ethanolic extract	2.68 RT (min) in HPLC-DAD	Antioxidant activity (DPPH)	(Torres et al., 2018)
		Oleic acid	Ethanolic extract	15.11 RT (min) in UPLC-MS/MS	-	(Surek et al., 2021)
		Palmitic acid	Ethanolic extract	14.91 RT (min) in UPLC-MS/MS	-	(Surek et al., 2021)
		p-coumaric acid	Ethanolic extract	3.32 RT (min) in UPLC-MS/MS	-	(Surek et al., 2021)
			Ethanolic extract	12.73 RT (min) in HPLC-DAD	Antioxidant activity (DPPH)	(Torres et al., 2018)
		Quercetin	Ethanolic extract	24.45 RT (min) in HPLC-DAD	Antioxidant activity (DPPH)	(Torres et al., 2018)

5	*Scaptotrigona bipunctata*	Ellagic acid	Ethanolic extract	3.62 RT (min) in UPLC-MS/MS	-	(Surek et al., 2021)
		Ferulic acid	Ethanolic extract	3.73 RT (min) in UPLC-MS/MS	-	(Surek et al., 2021)
		Gallic acid	Ethanolic extract	0.45 RT (min) in UPLC-MS/MS	-	(Surek et al., 2021)
		Oleic acid	Ethanolic extract	15.11 RT (min) in UPLC-MS/MS	-	(Surek et al., 2021)
		Palmitic acid	Ethanolic extract	14.91 RT (min) in UPLC-MS/MS	-	(Surek et al., 2021)
		p-coumaric acid	Ethanolic extract	3.32 RT (min) in UPLC-MS/MS	-	(Surek et al., 2021)
6	*Tetragonisca angustula*	Caffeic acid	Hydroalcoholic extract	14.9 RT (min) in HPLC-UV	Antioxidant activity (DPPH)	(dos Santos et al., 2017)
		Gallic acid	Aqueous extract	5.8 RT (min) in HPLC-UV	Antioxidant activity (DPPH)	(dos Santos et al., 2017)
			Ethanolic extract	2.69 RT (min) in HPLC-DAD	Antioxidant activity (DPPH)	(Torres et al., 2018)
		p-coumaric acid	Hydroalcoholic extract	24.9 RT (min) in HPLC-UV	Antioxidant activity (DPPH)	(dos Santos et al., 2017)
		Quercetin	Hydroalcoholic extract	5.2 RT (min) in HPLC-UV	Antioxidant activity (DPPH)	(dos Santos et al., 2017)
			Aqueous extract	5.3 RT (min) in HPLC-UV	Antioxidant activity (DPPH)	(dos Santos et al., 2017)
7	*Tetragonula biroi*	Broussoflavonol F	Ethanolic extract	30 RT (min) in HPLC-RP	-	(Miyata et al., 2020)
		Glyasperin A	Ethanolic extract	50 RT (min) in HPLC-RP	-	(Miyata et al., 2020)

Note: HPLV-UV (High-Performance Liquid Chromatography - UV Detection); HPLC-RP (High-Performance Liquid Chromatography - Reversed Phase Chromatography); HPLC-ESI-MS/MS (High-Performance Liquid Chromatography - Electrospray Ionization - Tandem Mass Spectrometry); HPLC-DAD (High-Performance Liquid Chromatography - Diode Array Detection); HPLC-DAD-MS (High-Performance Liquid Chromatography - Diode Array Detection - Mass Spectrometry); UPLC-MS/MS (Ultra Performance Liquid Chromatography - Tandem Mass Spectrometry); RT (Retention Time); TIC (Total Ion Chromatogram)

acid and gallic acid (Rozman et al., 2022). P-coumaric acid, also known as 4-hydroxycinnamic acid, benefits human health and is the most available coumaric acid derivative of cinnamic acid. It has been found to possess bioactive properties that could be incorporated into cosmetics products (Kaur & Kaur, 2022). The most significant attributes of cosmetics use appear to be depigmenting potential, antioxidant, anti-collagenase, anti-bacterial, and anti-inflammatory effects (Taofiq et al., 2017). P-coumaric acid has been found to have more inhibitory effects on tyrosinase than arbutin and kojic acid (Liu, 2022). The synthesis of melanin occurs within melanocytes with the enzymatic assistance of tyrosinase, and p-coumaric acid functions as an anti-melanogenic agent by its ability to disrupt the pathway involved in melanin formation (Roychoudhury et al., 2021). Preliminary investigations have indicated that p-coumaric acid can potentially safeguard skin cells from damage generated by UV radiation. Hence, the potential anti-melanogenic properties of p-coumaric acid in UV-exposed skin are believed to be mediated by many pathways, including UV absorption, suppression of new tyrosinase production and inhibition of the catalytic activity of existing tyrosinase (Boo, 2019). Gallic acid was a chemical compound found in the propolis from *M. fasciculata*, *M. quadrifasciata*, *M. quadrifasciata quadrifasciata*, *S. bipunctata*, and *T. angustula* through qualitative analysis. However, it was also found through quantitative analysis in *T. iridipennis* for 1.27 µg/mg in HPLC (Kasote et al., 2019), *T. laeviceps* for 1.03 µg/ml in HPLC, and *T. melanoleuca* for 0.34 µg/ml in HPLC (Mamoon et al., 2020). Gallic acid, a phenolic phytochemical compound widely distributed as a secondary metabolite across several plant species, exhibits powerful antioxidant, antimicrobial and anti-inflammatory activities (Choubey et al., 2018). Gallic acid has been used as a cosmetic ingredient because of its advantageous characteristics in addressing such skin disorders as hyperpigmentation and promoting anti-aging effects (Khan et al., 2018). Gallic acid has tyrosinase-inhibiting properties; it reduces dopaquinone to L-DOPA (levodopa or l-3,4-dihyroxyphenylalanine) via the redox cycle and also functions as a substrate, slowly oxidizing in the absence of L-DOPA (Liu, 2022). The efficacy of gallic acid as a skin protectant has been shown by investigations of its anti-melanogenic and anti-tyrosinase properties. Gallic acid exhibits a significantly higher inhibitory effect on tyrosinase than kojic acid (Badhani et al., 2015).

Broussoflavonol F, a chemical compound, was found in propolis from *T. biroi* through qualitative analysis. Broussoflavonol, derived from *Broussonetia papyrifera*, is extensively utilized in the cosmetics industry for its skin-whitening and moisturizing properties (Nguyen, 2022). Broussoflavonol has been reported to be one of the flavonoid derivatives found in the root bark of *B. papyrifera* and demonstrated higher efficacy than kojic acid in inhibiting the activity of the enzyme tyrosinase (Panzella & Napolitano, 2019). Broussoflavonol is a compound from several such *Macaranga* species as *M. adenantha* and *M. indica* (Rosamah et al., 2023).

Caffeic acid, chemical compound found in propolis from *T. angustula* was found in this review through qualitative analysis. However, caffeic acid was also found through quantitative analysis in *M. quadrifasciata anthidioides* for 6.1 mg/g in HPLC-DAD (Bonamigo et al., 2017) and *T. iridipennis* for 0.02 µg/mg in HPLC (Kasote et al., 2019). Caffeic acid, known as 3,4-dihydroxycinnamic acid, is a metabolite belonging to the hydroxy-cinnamate and phenylpropanoid classes. Caffeic acid is a prevalent phenolic acid frequently seen in various dietary sources, including coffee beverages (Taofiq et al., 2017). The compound is synthesized by hydroxylation of p-coumaric acid and possesses several therapeutic applications in managing dermatological conditions (Magnani et al., 2014). Caffeic acid influences aging by enhancing skin suppleness and preventing wrinkles. Furthermore, besides its antioxidant properties, the capacity of caffeic acid to hinder premature aging has been well-documented (Birková et al., 2020). Caffeic acid showed better tyrosinase inhibitory activity than kojic acid. Caffeic acid induces the contraction of collagen fibers and promotes the synthesis of new collagen (Liu, 2022). It shows an inhibitory effect on nitric oxide generation as antioxidant characteristics through scavenging free radicals (da Silva et al., 2020).

Catechins were a chemical compound found in propolis from *M. quadrifasciata* through qualitative analysis. Catechins are a polyphenolic chemical class widely distributed in many plant species, but tea leaves are considered the most optimal source (Gadkari & Balaraman, 2015). Catechin is essential in the cosmetics industry due to its diverse biological effects, abundant composition (Bae et al., 2020) and anti-inflammatory properties (Sianipar et al., 2023). Catechin was reported as an excellent antioxidant and showed photoprotective activity against UV radiation. As an anti-wrinkle agent, catechin had the best docking score on binding the active site of elastase, collagenase and hyaluronidase enzymes (Koch et al., 2019). Liu (2022) reported it to have a lower docking score than the inhibitor kojic acid when it came to binding to the active site of the tyrosinase enzyme.

Ellagic acid was a chemical compound found in propolis from *M. fasciculata, M. quadrifasciata anthidioides, M. quadrifasciata quadrifasciata,* and *S. bipunctata* through qualitative analysis. Ellagic acid is a bioactive polyphenolic molecule naturally present as a secondary metabolite in several plants. Ellagic acid has significant interest due to its antioxidant and anti-inflammatory characteristics. As a functional component in cosmetic products, ellagic acid is based on its skin-whitening and sunscreen characteristics (Sharifi-Rad et al., 2022). Ellagic acid can prevent skin damage caused by exposure to UV radiation. Numerous investigations have elucidated the properties of ellagic acid to mitigate skin wrinkle development caused by collagen degradation (Ortiz-Ruiz et al., 2016). Ellagic acid is a well-known tyrosinase inhibitor used as a skin-whitening agent. Ellagic acid is recognized as a medication for managing hyperpigmentation problems due to its ability to disrupt the melanin synthesis pathway (Couteau & Coiffard, 2016; Ríos et al., 2018).

Ferulic acid was a chemical compound found in propolis from *M. quadrifasciata quadrifasciata* and *S. bipunctata* through qualitative analysis. However, ferulic acid was also found through quantitative analysis in *T. iridipennis* for 0.39 µg/mg in HPLC (Kasote et al., 2019). Ferulic acid has antioxidant properties by functioning as a scavenger of free radicals. This product has been extensively employed in cosmetics (Cavalcanti et al., 2021), because it protect the integrity of crucial skin components, including keratinocytes, fibroblasts, collagen, and elastin (Kumar & Pruthi, 2014). The structure of ferulic acid resembles that of tyrosine, leading to the belief that ferulic acid exerts its inhibitory effects on melanin synthesis by competitively inhibiting tyrosine. The compound is commonly utilized in skincare formulations for its efficacy as a photoprotective agent, its ability to postpone skin photoaging processes and its contribution to skin whitening (Zduńska et al., 2018).

Glyasperin A was a chemical compound found in propolis from *T. biroi* through qualitative analysis. Glyasperin A, a prenylated flavonoid derived from *Macaranga pruinosa*, inhibited melanin production significantly (Arung et al., 2019). The biological impacts of the Glyasperin derived from *Glycyrrhiza* spp. extract are primarily attributed to the presence of flavonoids. Glyasperin C, derived from *Glycyrrhiza glabra*, has been recognized for inhibiting the tyrosinase enzyme (Zolghadri et al., 2019). Using a facial cream containing *G. glabra* extract has produced many such results as encompassing skin whitening, wrinkle reduction, anti-aging properties, and sun protection (Cerulli et al., 2022).

Oleic acid was a chemical compound found in propolis from *M. quadrifasciata quadrifasciata* and *S. bipunctata* through qualitative analysis. A naturally occurring fatty acid, oleic acid explicitly demonstrates the ability to enhance skin penetration in topical treatments (Atef et al., 2022). As the predominant fatty acid identified in converter insects, oleic acid demonstrates an anti-inflammatory effect in a model of UV exposure-caused skin inflammation (Pegoraro et al., 2020). In commercial palm oil, oleic acid is observed to be the prevailing fatty acid (Franco et al., 2021). Oleic acid can also be used to treat hyperpigmented skin. Finally, this compound reduces melanin synthesis and tyrosinase activity levels (Liu, 2022).

Palmitic acid was a chemical compound found in propolis from *M. fasciculata*, *M. quadrifasciata quadrifasciata,* and *S. bipunctata* through qualitative analysis. As the main constituent of palm oil, palmitic acid contributes to lipid barrier formation in human skin, ensuring its health and integrity (Mancini et al., 2015; Mieremet et al., 2019). It also modulates immune responses and functions as an anti-inflammatory agent. Its acidity property endows it with antimicrobial properties (Johnson & Abugri, 2014). Furthermore, palmitic acid, the most dominant fatty acid component of rubber seed oil, has been found to inhibit melanogenesis and exhibit antioxidant activity (Chaikul et al., 2017). It also treats skin with hyperpigmentation by reducing melanin synthesis and tyrosinase activity levels (Liu, 2022).

Quercetin was a chemical compound found in propolis from *M. quadrifasciata*, *M. quadrifasciata quadrifasciata,* and *T. angustula* through qualitative analysis. However, quercetin was also found through quantitative analysis in *M. quadrifasciata anthidioides* for 9.9 mg/g in HPLC-DAD (Bonamigo et al., 2017), *T. iridipennis* 0.89 µg/mg in HPLC (Kasote et al., 2019), and *T. melanoleuca* for 1.13 µg/ml in HPLC (Mamoon et al., 2020). Quercetin is extensively researched and widely distributed among various food sources; its broad spectrum of biological activities and potential therapeutic applications make it a subject of interest for the cosmetic industry (Kim & Park, 2018). Fascinating sources of polyphenols encompass by-products derived from the food manufacturing process, like quercetin, which may be observed in grape skin extracts (Zillich et al., 2015). Quercetin eliminates free radicals generated by neutrophils, which are responsible for inflammation reduction and antioxidant activity (da Silva et al., 2020). Additionally, quercetin is effective in slowing down skin-aging and tyrosinase inhibitory activities. Choi & Shin (2016) have extensively have used quercetin to develop efficacious whitening agents.

Rutin was a chemical compound found in propolis from *M. quadrifasciata* and was found in this review through qualitative analysis. Rutin is a flavonol compound that is widely distributed in many plant species. The term 'rutin' is derived from the botanical species *Ruta graveolens*, which is also a natural source of rutin (Ganeshpurkar & Saluja, 2017). It is a photoprotective polyphenolic secondary plant metabolite for sun-protective cosmetics (Korkina et al., 2018) and has been found to exert biological effects on skin aging produced by Reactive Oxygen Species (ROS) (Choi et al., 2016).

Anti-Acne Properties of Stingless Bee Propolis

Stingless bee propolis has anti-acne properties due to its anti-bacterial and anti-inflammatory activity. In this review, no chemical compounds from propolis identified through qualitative analysis were tested for their anti-acne properties. However, 3'-O-methyldiplacone, 5,7,3',4'-tetrahydroxy-6-geranyl flavonol, and nympaheol A were the chemical compounds from *T. biroi* propolis identified through quantitative analysis; they were tested for their anti-bacterial and anti-inflammatory activity for their potential development as anti-acne biocosmetics (Arung et al., 2023). From all the propolis-producing stingless bee species in this review, the propolis extracts of *T. fiebrigi*, *T. laeviceps,* and *T. melanoleuca* showed anti-bacterial activity against *S. epidermidis*, and *T. biroi* showed anti-bacterial activity against *C. acnes.* Meanwhile, propolis extracts of *H. itama*, *M. beecheii*, *M. quadrifasciata anthidioides*, *S. depilis*, *S. jujuyensis*, *T. fiebrigi*, and *T. biroi* showed anti-inflammatory potential. Acne is an inflammatory skin disease which impacts approximately 9% of the global population and most adolescents, making it the eighth most prevalent skin disease (Bhate & Williams, 2013; Eichenfield et al., 2021; Heng & Chew, 2020). Normal skin bacteria consist of *S. epidermidis* and *C. acnes*, which cause local skin inflammation and produce pro-inflammatory mediators. Colonization with those bacteria may induce inflammation via such various mediators as interleukins and tumor necrosis factor (Fox et al., 2016; Mahto, 2017). Numerous biocosmetics contain natural active ingredients, such as anti-bacterial and anti-inflammatory ingredients, claim to have a medical effect on the skin, including treating acne (Dall'Oglio et al., 2014; Araviiskaia & Dréno, 2016; Khan et al., 2023).

The anti-bacterial and anti-inflammatory properties of propolis are responsible for its use in treating acne. The chemical compound in stingless bee propolis extract can be used in biocosmetics for anti-acne properties. The activities of phenolic and flavonoid compounds in stingless bee propolis may be responsible for its anti-bacterial and anti-inflammatory properties (Rozman et al., 2022; Salleh et al., 2022; Zullkiflee et al., 2022b). Phenolic and flavonoid compounds suppress nitric oxide synthesis, also have an antioxidant effect by scavenging free radicals and show anti-inflammation activities. The inhibitory effect of the ethanol extract of propolis extends to *C. acnes* and *S. epidermidis*. Propolis is more effective against Gram-positive bacteria; it may interact with lipids in the plasma membrane, which increases membrane permeability and inhibits bacterial motility (da Silva et al., 2020; Kurek-Górecka et al., 2020).

Anti-Aging Properties of Stingless Bee Propolis

Stingless bee propolis has anti-aging properties due to its antioxidant activity. All chemical compounds in this review showed antioxidant activity and thus have the potential to developed as anti-aging biocosmetics. Biocosmetics products for photoprotection, increased skin elasticity, increased collagen formation or antioxidant activity prevent or reduce the signs of aging skin (Ramos-e-Silva et al., 2013; Campa & Baron, 2018). However, all chemical compounds above have not been tested for anti-wrinkle and sunscreen activity. Strategies for the treatment of aging skin include preventing photoaging, which has a substantial impact on the appearance of aging skin, in addition to the consequences of chronological aging. The signs of aging can be reduced through the use of sunscreens and formulations. With natural anti-aging ingredients added as moisturizing, antioxidants, and sunscreen agents (Shanbhag et al., 2019; Ahmed et al., 2020). The cumulative effects of intrinsic (chronologic) and extrinsic (primarily ultraviolet or UV radiation) factors contribute to aging skin, and wrinkling is one of the most noticeable symptoms. The antioxidant, anti-wrinkle, and sunscreen activity of propolis is responsible for its use in skin-aging treatment. The chemical compound, which includes groups of phenols and flavonoids found in stingless bee propolis extract can be used in biocosmetics for anti-aging properties. Propolis has the capacity to absorb UV light, which may be attributed to caffeic acid, coumaric acid and ferulic acid inside propolis (Kurek-Górecka et al., 2020). Polyphenols and flavonoids, as the main components of propolis, protect against UV in various ways. Polyphenols show potential as an efficient UV radiation filter, and flavonoids can absorb UV light. Propolis has promise as a cosmeceutical because of its capacity to offer UV protection and display antioxidant qualities (da Silva et al., 2020). Ascorbic acid, tocopherols, and polyphenols are antioxidants that can scavenge free radicals and help prevent skin aging. Quercetin shows promise in slowing down the aging process, and polyphenols can slow down the aging process. These compounds influence collagen metabolism, which in turn stimulates the production of collagen and elastic fibers (Liu, 2022).

Skin Whitening Properties of Stingless Bee Propolis

Stingless bee propolis has skin-whitening properties due to its anti-melanogenesis activity. In this review, no chemical compounds from propolis were been tested for their anti-melanogenesis activity for potential development as skin-whitening biocosmetics. However, extracts from propolis of *H. apicalis*, *T. fuscibasis*, *T. fuscobalteata*, *T. laeviceps*, *T. pagdeni*, and *W. incisa* showed anti-melanogenesis activity in this review. Skin whitening is a process that involves the use of natural or synthetic compounds to diminish the concentration of melanin in the skin, resulting in a lighter skin tone. Numerous chemical compounds have demonstrated efficacy in achieving depigmentation and have been included in cosmetic products for skin-whitening purposes (Couteau & Coiffard, 2016). UV radiation can affect skin pigmentation; increased melanin production causes the pigmentation to be visible. In reaction to UV light, melanocytes undergo the process of melanogenesis, which produces melanin (Liu, 2022). Whitening products can inhibit melanin formation via the tyrosinase enzyme, primarily targeting specific reactions involved in melanogenesis. Tyrosinase inhibitors, including hydroquinone, arbutin, kojic acid, azelaic acid, ascorbic acid, ellagic acid, and tranexamic acid, have been employed as skin whitening (Pillaiyar et al., 2017). Considering the inherent safety concerns associated with whitening chemicals, the most efficacious approach to avoid hyperpigmentation is prevention and the application of sunscreen products (Burger et al., 2016).

Propolis has demonstrated efficacy for anti-melanogenesis activity, and its tyrosinase inhibitor and sunscreen activity are responsible for its use in skin whitening. The chemical compound in stingless bee propolis extract can be used for anti-melanogenesis properties (Liu, 2022). Ellagic acid, ascorbic acid, and ferulic acid, substances in the stingless bee propolis compound, are known to be tyrosinase inhibitors and are used to lighten skin. Stingless bee propolis compounds as tyrosinase inhibitors are apigenin, catechin, kaempferol, quercetin, caffeic acid, p-coumaric acid, and oleic acid (Schroeder da Silva et al., 2023). Propolis protects against UV radiation; this ability to absorb UV light can be linked to the presence of phenolic and flavonoid compounds within its composition (Kurek-Górecka et al., 2020). Polyphenols exhibit promising characteristics as an effective filter for UV radiation, whereas flavonoids can absorb UV light (da Silva et al., 2020).

Advantages of Stingless Bee Propolis in Biocosmetics

Stingless bee propolis exhibits a distinct chemical profile similar to honeybee propolis. Because stingless bees build their hives using propolis, propolis is the main constituent of their hives. Researchers studied species of stingless bees and discovered that the hive was comprised of 64% propolis, 21% bee bread and 15% honey. The composition of products obtained from stingless bees varies based on their botanical and geographical source, the bee species employed, and the regional climate (Al-Hatamleh et al., 2020; Goh et al., 2023). Research suggests stingless bee propolis may be more prosperous in certain bioactive compounds. Stingless bee propolis is comprised of about 150 chemicals, including polyphenols, flavonoids, aglycones, phenolics, and ketones.

The two most often reported chemicals are p-coumaric acid and gallic acid. These compounds contribute to the anti-bacterial, anti-inflammatory, and antioxidant properties which are desirable in biocosmetic ingredients (Al-Hatamleh et al., 2020; Zullkiflee et al., 2022b). Studies have shown promising results for stingless bee propolis: protection against wrinkles, melanogenesis and UV damage. These properties could position stingless bee propolis as a valuable ingredient for anti-aging, skin-whitening, and anti-acne products in biocosmetics (da Silva et al., 2020; Kurek-Górecka et al., 2020).

Stingless beekeeping offers a sustainable and environmentally friendly approach to propolis production. Stingless bees are essential to the ecosystem by pollinating crops and sustaining biodiversity. Additionally, because of their small size, stingless bees pollinate smaller flowers that the comparatively larger honey bees cannot (Salleh et al., 2022). Stingless bees are efficient pollinators. Using stingless bee farming can promote bee conservation, as bees' natural habitats are diminishing due to human activities. Stingless bees are highly effective pollinators which thrive in diverse habitats, including tropical/subtropical habitats and rainforests (Rozman et al., 2022).

Furthermore, stingless bees possess distinct traits that set them apart from honeybees. These bees are non-stinging, capable of pollinating small flowers, loyal to their colony and more resistant to disease, and their products are easily extracted (Al-Hatamleh et al., 2020). Stingless bees exhibit non-aggressive behavior, which makes them more amenable to manipulation within an artificial hive. In contrast, common honey bees are more prone to diseases and frequently desert their hives.

Stingless bees also contribute to the ecosystem. The bees can endure and adapt to seasonal variations and harsh environmental circumstances (Rozman et al., 2022). Furthermore, research has demonstrated that, compared to other bee species, stingless bees produce more abundant propolis and of greater quality, because they do not have stings; propolis serves as their defense mechanism (Salleh et al., 2022).

This aspect aligns with the growing consumer demand for sustainable and ethical pros in the biocosmetics market. Stingless bee propolis has received significant attention in research due to its distinct chemical composition. Propolis products derived from stingless bees have been examined as extracts to promote health and cosmetics (Salatino, 2022). Nevertheless, the scarcity of stingless bee goods and their significant demand result in a considerably higher selling price than conventional honeybee products. Thankfully, the cultivation of stingless bees, including propolis, is becoming increasingly popular in several regions of the tropical and subtropical world (Salatino et al., 2019).

Adverse Effects of Stingless Bee Propolis on Biocosmetics

Stingless bee propolis has gained popularity for its potential health benefits. While initial studies suggest it may be safe and helpful at low doses, a closer look reveals a more complex picture. On the positive side, research shows stingless bee propolis might be nontoxic and non-mutagenic but more research is needed to fully understand its effects (da Silva et al., 2020). The potential for allergic reactions is a crucial concern; like other bee products, stingless bee propolis can trigger allergies, commonly causing contact dermatitis or skin irritation. The increasing use of propolis in various products raises concerns about potential allergic reactions in unsuspecting users (Salatino, 2022).

Another cause for caution is the lack of research on the safety of different propolis types. Stingless bee propolis composition varies depending on the source and plant life around the beehive. Some propolis varieties may be harmless, and others might have a higher risk of allergic reactions. While research on stingless bee propolis focuses on its potential health benefits, concerns exist regarding its safety (Balica et al., 2021). Studies have revealed traces of toxic metals and pesticides in some propolis samples, highlighting the importance of responsible sourcing and quality control to minimize potential contaminant risks (Lavinas et al., 2019). The assumption that natural products are inherently safe needs to be challenged, and more research is crucial to understand the safety profile of propolis, particularly regarding different types and long-term use. Additionally, studies are needed to explore the mechanisms by which propolis exerts its effects (Zulhendri et al., 2021).

Potential Applications for Formulation of Stingless Bee Propolis in Biocosmetics

The potential applications of stingless bee propolis in biocosmetics for anti-acne, anti-aging, and skin-whitening properties are significant. Stingless bee propolis has been shown to have anti-bacterial and anti-inflammatory properties, which make it effective against acne-causing bacteria and help reduce inflammation in the skin. It can be used in such biocosmetics as cleansers, toners and moisturizers, to help prevent and treat acne (Rocha et al., 2023). Stingless bee propolis has antioxidant properties that help protect the skin from damage caused by free radicals, which can lead to premature aging. It can be used in such biocosmetics as serums, creams and masks to help reduce the appearance of fine lines and wrinkles and promote a more youthful complexion (Zulhendri et al., 2022). Stingless bee propolis may also help brighten the skin and reduce the appearance of dark spots and hyperpigmentation. It can be used in such biocosmetics as serums, creams and masks to help even out skin tone and promote a brighter, more radiant complexion (Wieczorek et al., 2022).

Propolis is typically found in the form of aqueous or ethanol extracts and according to the International Nomenclature of Cosmetic Ingredients (INCI), it can be listed as “propolis” or “propolis extract” on product labels. The most often utilized propolis extracts are ethanolic. Propolis is extracted with 70% ethanol and then condensed under reduced pressure settings (Kurek-Górecka et al., 2020). The raw propolis is conventionally extracted using extraction solvents composed of different ethanol and water mixes. The resulting dark brown liquid is frequently employed as an Active Cosmetic Ingredient (ACI) in manufacturing diverse cosmetic products (Šuran et al., 2021).

Propolis is widely used as a treatment and can be found in cosmetics, either pure or mixed with other natural ingredients (Al-Hatamleh et al., 2020). Propolis is anticipated to become more prevalent in the cosmetics sector. In global research for topical health problems, propolis is the best herbal alternative among the various natural sources that are accessible (da Silva et al., 2020). Natural ingredients like stingless bee propolis in biocosmetics have numerous benefits. Natural ingredients are often gentler on the skin than synthetic ingredients and may be less likely to cause irritation or allergic reactions. Natural ingredients like stingless bee propolis are often rich in beneficial compounds that help nourish and protect the skin. The use of natural ingredients in biocosmetics can also be more sustainable and environmentally friendly than synthetic ingredients. Overall, stingless bee propolis has significant potential as a natural ingredient in biocosmetics for anti-acne, anti-aging, and skin-whitening properties. Further research is needed to understand its potential applications and benefits for the skin.

CONCLUSION

Based on the search results, the following are the critical points of the review on stingless bee propolis as a natural ingredient in biocosmetics for anti-acne, anti-aging, and skin-whitening properties. The phenolic and flavonoid compounds found in stingless bee propolis are believed to contribute to its anti-bacterial, anti-inflammatory, and antioxidant properties, which make it effective against acne-causing bacteria and help protect the skin from damage caused by free radicals. Stingless bee propolis may also help reduce the appearance of fine lines and wrinkles, brighten the skin, and reduce the appearance of dark spots and hyperpigmentation. Stingless bee propolis is a promising natural ingredient for biocosmetics due to its beneficial properties for the skin.

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