Enos Tangke Arung · Widya Fatriasari · Irawan Wijaya Kusuma · Harlinda Kuspradini · Kuniyoshi Shimizu · Yong-ung Kim · Nur Izyan Wan Azelee · Zehra Edis *Editors*

Biomass-based Cosmetics

Research Trends and Future Outlook

Springer

Biomass-based Cosmetics

Enos Tangke Arung • Widya Fatriasari
Irawan Wijaya Kusuma • Harlinda Kuspradini
Kuniyoshi Shimizu • Yong-ung Kim
Nur Izyan Wan Azelee • Zehra Edis
Editors

Biomass-based Cosmetics

Research Trends and Future Outlook

Springer

Editors
Enos Tangke Arung
Faculty of Forestry
Mulawarman University
Samarinda, Kalimantan Timur, Indonesia

Irawan Wijaya Kusuma
Faculty of Forestry
Mulawarman University
Samarinda, Kalimantan Timur, Indonesia

Kuniyoshi Shimizu
Department of Agro-environmental Sciences, Faculty of Agriculture
Kyushu University
Fukuoka, Japan

Nur Izyan Wan Azelee
Department of Bioprocess and Polymer Engineering, Faculty of Chemical and Energy Engineering & Institute of Bioproduct Development
Universiti Teknologi Malaysia
Johor Bahru, Johor, Malaysia

Widya Fatriasari
Research Center for Biomass and Bioproducts
National Research and Innovation Agency
Cibinong Bogor, Indonesia

Harlinda Kuspradini
Faculty of Forestry
Mulawarman University
Samarinda, Kalimantan Timur, Indonesia

Yong-ung Kim
Department of Pharmaceutical Engineering, College of Cosmetics and Pharmaceuticals
Daegu Haany University
Gyeongsangbuk-do, Korea (Republic of)

Zehra Edis
Department of Pharmaceutical Sciences, College of Pharmacy and Health Sciences
Ajman University
Ajman, United Arab Emirates

ISBN 978-981-97-1907-5 ISBN 978-981-97-1908-2 (eBook)
https://doi.org/10.1007/978-981-97-1908-2

This Springer imprint is published by the registered company Springer Nature Singapore Pte Ltd.
The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

Preface

The global cosmetics market by region tends to increase from 2022 until 2029 to account for USD 377,243.22 million by 2029 (Data bridge market research market analysis study 2022). It is indicated that there is a big revenue in this sector in which the new products continuously developed and hit the market. Therefore, the development and innovation in this area grow high. Up to now, industrial cosmetic products in the market are predominantly from chemical-based sources, i.e., nonrenewable fossil sources. Biobased cosmetics ingredients are beginning to be recognized as a feasible solution to address these challenges, nevertheless, when sustainability and renewability are taken into account. Biomass has emerged as a promising renewable resource for biobased cosmetics because it exists in abundance, has great availability, diversity of plant sources, and low cost. Additionally, the creation of biobased cosmetics does not contribute to carbon emissions, can minimize environmental issues throughout the product's life cycle, and is biodegradable in aquatic environments. For example, substances taken from plants and other types of biomasses can be used to extend shelf life and provide UV protection. Additionally, many organic compounds have beneficial bioactive properties like emollient, healing, anti-inflammatory, anti-aging, antioxidant, antimicrobial, relaxing, and healing actions.

In tropical forests, many biomasses have active substances as an ingredient in cosmetic formulation. Besides that, marine and savanna forest are also having a high potential to be explored for active ingredients in cosmetics. As an ingredient, usually biomass is extracted from leaves, bark, steam, or other parts of plants. Therefore, many papers reported this functionality of extracted plants for cosmetics preparation. The main chemical component is derived from the extractives. On the other hand, some polymer from the cell wall of wood and woody biomass has the potential to be used as cosmetics sources such as lignin and polysaccharides regarding their active substance for possible utilization as cosmetic ingredients. Besides that, non-wood products also have a high potential to be used in cosmetic formulations such as Sengkang, essential oil, bee pollen, and silkworm. The exploration of these biomasses sources for cosmetics has not yet been discussed comprehensively.

Considering the background, this book is proposed to highlight the potential of biomass for cosmetics applications. This book covers the discussion on biomass as a source for cosmetics from savanna, marine and tropical forest, trend and market outlook of biobased cosmetics, active substances from biomass for cosmetics, extractives from biomass for cosmetics, other non-wood forest product such as essential oil, tengkawang, and bee pollen. Besides that, the potency of biopolymers such as lignin and polysaccharides will be presented. Activated carbon as cosmetic source will also be discussed in this book. To present more comprehensive information, biomass as anti-aging, anti-acne, sunscreen, anti-melanin, and antimicrobial will be included. Regarding the close contact system with the human in daily life, cosmetic needs to comply in the human system. Therefore, one special chapter will be dedicated to present how the compatibility view of biobased cosmetics in the human body system. Nanomaterials in cosmetics have started to be used by many beauty companies as indicated by nano-related patents. Thus, nanotechnology applications in cosmetic will be elaborated to provide future trends in biobased cosmetics. Some forms of nanomaterials that have been reported include liposomes, nanoemulsion, nanocapsules, solid lipid nanoparticles, nanocrystals, nano-silver, nano-gold, hydrogel, etc. Iodinated aloe vera formulations within polymeric complexes will be presented as examples of bio-antimicrobials. Such compounds are at the crossroads between pharmaceutics and cosmetics. Finally, the environmental and safety impacts of biobased cosmetic development will be discussed as the closure in the last chapter.

This book is expected to provide insightful information for those parties who are dealing with biomass or doing research on biomass for a sustainable living. Moreover, this book is also suitable to those policy makers in getting new and latest information on valorizing local biomass while expanding its usage for cosmeceutical purposes. Due to the current environmental problems occurring in our surroundings, this book is seen to be an important tool to spread the awareness on the smart way of utilizing our precious biomass and transforming them into valuable products.

Samarinda, Kalimantan Timur, Indonesia — Enos Tangke Arung
Cibinong Bogor, Indonesia — Widya Fatriasari
Samarinda, Kalimantan Timur, Indonesia — Irawan Kusuma Wijaya
Samarinda, Kalimantan Timur, Indonesia — Harlinda Kuspradini
Fukuoka, Japan — Kuniyoshi Shimizu
Gyeongsangbuk-do, Republic of Korea — Yong-ung Kim
Johor Bahru, Johor, Malaysia — Nur Izyan Wan Azelee
Ajman, United Arab Emirates — Zehra Edis

Contents

About the Editors

Enos Tangke Arung is a scientist in the Forestry Faculty, Mulawarman University, Indonesia. The focus of the research is natural resources from tropical rain forests for medicine and cosmetics, isolating active compounds, non-wood forest products, and stingless bee products for utilization in cosmetics and medicines. He has published more than 55 scientific papers, five granted patents, and three books. He has been granted some awards as an academic leader and researcher in green cosmetics in Indonesia. In addition, he is a reviewer in some reputable scientific journals.

Widya Fatriasari is a senior researcher at the Research Center for Biomass and Bioproducts, National Research and Innovation Agency (BRIN), Indonesia. The primary research areas are biomass conversion, bioenergy, biorefinery, lignin valorization for bioproducts, cellulose-based bioproducts, and biomass chemistry. She has been involved in various research projects, such as lignin for biosurfactants, fire retardants, seed coating, biocomposite, marine biomaterials, cosmetics from biomass, biomedical pulp, and pulp and paper.

Irawan Kusuma Wijaya is a Professor at the Faculty of Forestry, Mulawarman University, Indonesia. His research interests are forest product chemistry and non-timber forest products. His works are related to the exploration of tropical plants having biological activities and the discovery of antimicrobial, antioxidant, and enzyme-inhibitory compounds from plant resources. He has published more than 61 scientific articles in peer-reviewed international journals, four granted patents, and three books (one of them published by the ACS publication). He is an editor and reviewer for several reputable peer-reviewed international journals.

Harlinda Kuspradini is researcher and lecturer at the Faculty of Forestry, Mulawarman University, Indonesia. Her research interest is non-timber forest products, especially on medicinal and aromatic plants. She led the “A Tropical Rainforest Essential Oil” group research, which discovered new types of essential oil and developed the products. She has been involved in various research projects with national and international funding. She has authored five books and possesses many publications, four granted patents, and three national copyrights. She has multiple duties as reviewer and editor in many journals. She has been bestowed with the prestigious "L'Oreal-UNESCO" Award in 2010 for her contribution to the field of Life Science.

Kuniyoshi Shimizu received a PhD in natural product chemistry, graduated from Faculty of Agriculture, Kyushu University in 2000. Then, he worked in Venture Business Laboratory, Kyushu University as a postdoctoral fellow (2000–2002). In 2002, he returned to the Faculty of Agriculture, Kyushu University as an assistant professor. Then, in 2014, he got promoted to an associated professor. His research group has been focusing on how to utilize natural products based on LOHAS (Lifestyles of Health and Sustainability) concept with relevant scientific evidence. He received The Japan Wood Research Society Progress Award in 2006 and The Japan Wood Research Society Award in 2014.

Yong-ung Kim is an associate professor of the Department of Pharmaceutical Engineering, College of Cosmetics and Pharmaceuticals, Daegu Haany University, South Korea. He is a pharmacist and oriental medicine dispenser of South Korea. He received his BS in pharmacy in 1990 and MS and PhD in pharmacy (biological chemistry) in 1992 and 2000, respectively, at Seoul National University, South Korea. He was a postdoctoral fellow in 2000–2005 at College of Pharmacy, Seoul National University, South Korea and in 2005–2007 of Japan Society for the Promotion of Science (JSPS) Postdoctoral Fellowship for Foreign Researchers at Faculty of Agriculture, Kyushu University, Japan. He is a member of the Pharmaceutical Society of Korea and the Korean Society for Applied Biological Chemistry. His achievements include papers and patents for 5α-reductase inhibitors from natural products for curing benign prostatic hypertrophy.

Nur Izyan Wan Azelee is a senior lecturer at Universiti Teknologi Malaysia (UTM) and is currently an associate research fellow at the Institute of Bioproduct Development (IBD). She has obtained her bachelor's degree as well as completed her PhD in Bioprocess Engineering from UTM. Her research expertise is in enzyme technology, enzyme immobilization, carbohydrate analysis, biomass pretreatment, biomass conversion, process optimization, and enzyme kinetics. Currently, she is working on the pretreatment of biomass for efficient delignification, enzymatic hydrolysis and optimization for high sugar production, enzyme immobilization for transesterification for biodiesel production, and bioconversion of biomass into valuable ingredients for cosmetic products. She is an expert in operating HPLC using an RI detector for carbohydrate analysis and Response Surface Methodology (RSM) software for process screening and optimization.

Zehra Edis received a PhD with honors from the University of Cologne Germany in 1999. She worked as a scientific employee at the University of Cologne and Akzo Nobel Chemicals, as well as a research Intern in Bayer AG, Leverkusen, Germany on the properties of conducting polymers. After that, she joined Ajman University and Sharjah University, UAE as a part-time lecturer (2000–2013). Since February 2014 she has been a faculty member and was promoted to Associate Professor in 2021 at Ajman University. She has published more than 50 papers and received eight Internal Research Grants (IRG-Deanship of Graduate Studies and Research) from Ajman University. Since 2021 she is also associated with the Center of Medical and Bio-allied Health Sciences Research, Ajman University.

Chapter 1
Potential of Tropical Biomass for the Bioactive Ingredients in Cosmetics

Widya Fatriasari, Yelfi Anwar, Agmi Sinta Putri, and Enos Tangke Arung

Abstract Cosmetic-based biomass continues to show global market growth and is predicted to increase up to 2030 with a CAGR of 4.2% by 2023. It brings continued research and development as well as making innovative innovations such as how to create cosmetic products from bioresources. Tropical biomasses are interesting sources that attract all scientists and companies to find ingredients for cosmetics. Increasing the safe and natural products further encourages innovation in the development of safe and green cosmetic products needed by the global market as an effort to reduce the long-term negative impact of the use of cosmetics from non-renewable sources, namely fossil oil. Because of its abundance, high availability, diversity of plant sources, and low cost, biomass is now recognized as a viable renewable resource for bio-based cosmetics. Tropical biomasses have been reported to contain active compounds that have benefited as a cosmetic ingredient. This chapter discusses the potency of various kinds of biomass from non-wood biomass, woody biomass, and agricultural residue which has basic active compounds as cosmetic ingredients. Mapping the global market growth on cosmetic-based biomass strengthens the concerned scholar to do research and development in this subject started in the introduction. The last section is a picture of the challenge and future direction in the development of cosmetic-based biomass that needs to be addressed.

W. Fatriasari (✉) · Y. Anwar
Research Center for Biomass and Bioproducts, National Research and Innovation Agency (BRIN), Bogor, Indonesia

Research Collaboration Center of Biomass-Based Nano Cosmetic, in Collaboration with National Research and Innovation Agency (BRIN), Samarinda, Indonesia
e-mail: widy003@brin.go.id

A. S. Putri · E. T. Arung
Research Collaboration Center of Biomass-Based Nano Cosmetic, in Collaboration with National Research and Innovation Agency (BRIN), Samarinda, Indonesia

Laboratory of Forest Products Chemistry, Faculty of Forestry, Mulawarman University, Samarinda, Indonesia

E. T. Arung et al. (eds.), *Biomass-based Cosmetics*,
https://doi.org/10.1007/978-981-97-1908-2_1

Keywords Biomass potency · Active agent · Cosmetic products · Wood · Non-wood · Agricultural biomass

1.1 Introduction

The global cosmetics market reached $262.21 billion by 2022 and is anticipated to reach USD 363.80 billion by 2030 (Research 2023), growing at a CAGR of 4.2% between 2023 and 2030. The primary growth drivers in the sector are the aging global population and rising spending on cosmetics like skin creams, lotions, hair dye, and other things (Markets 2023). With billions of dollars in annual income, the commercial sector in this region has been acknowledged as one of the most promising (Kouassi et al. 2022). It is indicated that there is a big revenue in this sector in which the new products continuously develop and hit the market. Therefore, the development and innovation in this area are high. Up to now, industrial cosmetic products in the market are predominantly from chemical-based sources, i.e., non-renewable fossil sources. Bio-based cosmetics ingredients are beginning to be recognized as a feasible solution to address these challenges, nevertheless, when sustainability and renewability are taken into account. Environmental and health awareness is promoting this increase (Programme 2020). In the Asia Pacific region, In the first quarter of 2018, Indonesia's cosmetic sector grew globally by 7.36% (Indonesia 2018). The entire value of Indonesia's cosmetic exports in 2020 was USD 784.9 thousand, a 1.5% rise over the previous year (Tokyo 2021).

The concept of "going back to nature" has been applied widely in the world of research and the growth of the research cosmetic sector, for example, by using plant extracts that are well-liked by customers (Sianipar et al. 2023; Sim and Nyam 2021). Biomass has emerged as a promising renewable resource for bio-based cosmetics because it is abundant, has great availability, diversity of plant sources, and competitive cost. Additionally, the creation of bio-based cosmetics does not contribute to carbon emissions, can minimize environmental issues throughout the product's life cycle, and is biodegradable in aquatic environments. It is popular for various reasons, including the fact that they are natural and free of dangerous chemicals, which reduce the risk of safe to use, adversative health problems, well-matched with all skin types, have no negative effects, and deliver nutrients from natural sources (Kumar et al. 2016). For example, substances taken from plants and other types of biomasses can be used to extend shelf life and provide UV protection. Additionally, many organic compounds have beneficial bioactive properties like emollient, healing, anti-inflammatory, anti-aging, antioxidant, antimicrobial, relaxing, and healing actions. The body absorbs natural-based cosmetics, which are eco-friendly and hypoallergenic (Amberg and Fogarassy 2019; Carvalho et al. 2021).

Indonesia is a global hub of plant diversity, including medicinal plants of enormous significance to the people and the world (Cahyaningsih et al. 2021). This country is habitat to 30–40% of Asia's plant species and 10% of the world's plant species. The ability of Indonesia to create cosmetic products using natural ingredients is one of these potentials (Sianipar et al. 2023). Especially in tropical forests, many biomasses have active substances as an ingredient in cosmetic formulation. Besides that, marine and savanna forests also have a high potential to be investigated for active ingredients in cosmetics. The parts of biomass containing ingredients for cosmetics are usually from leaves, bark, stem, fruit, root, flower, or other parts of plants (Pandurangan et al. 2018). Due to their safety, minimal risk of side effects when used properly, and environmental friendliness, bioactive compounds derived from plants as additions to various cosmetic products have grown in popularity (Rosamah et al. 2023). Therefore, many papers reported this functionality of extracted plants for cosmetics preparation.

The main chemical component of biomass for cosmetics is derived from the extractives. On the other hand, some polymer from the cell wall of wood and woody biomass has the potential to be used as cosmetics sources, such as biopolymers (lignin, cellulose, hemicellulose, starch) as active substances for possible utilization as cosmetic ingredients (Ariyanta et al. 2023; Gupta et al. 2022a). Besides that, non-wood products also have a significant chance to be used in cosmetic formulations such as tengkawang fat, essential oil, bee pollen, and silkworm. Each of these items has a variety of uses, functions, unique features, conformation, production processes, and chemical and physical factors, necessitating a wide variety of polymers (Gupta et al. 2022a). Up to now, the exploration of these tropical biomass sources for cosmetics has not yet been discussed comprehensively.

Based on Publish and Perish bibliometric with G-scholar database observation from 2018–2023 using the keyword "biomass for cosmetic", "wood", "non-wood," and "agricultural residue", can be found the 936 papers that discuss this topic with network visualization presented in Fig. 1.1. There is a tendency to increase paper numbers from that period indicating cosmetics from biomass became interested in research and development. There is a connection between some subjects in research on this topic, such as biomass with valorization, biomass with medicine, and cosmetic products. The bigger circle in the figure shows higher research attention on this subject, such as biomass, cosmetics, and production (Fig. 1.1). Some extracts from tropical biomass, including roots, leaves, stems, and aerial parts, have been reported to have potency for cosmetic applications regarding pharmaceutical activity. For example, macaranga has active activity such as being anti-inflammatory, antimicrobial, and antioxidant, and the tyrosinase inhibitory effect (Rosamah et al. 2023) is required in herbal cosmetic formulation. The other tropical wood, such as *Eupatorium sp* (boneset) has rich active compounds such as anti-tyrosinase, antioxidant, anti-acne anti-melanin or melanogenesis, and anti-inflammatory (Putri et al. 2022). Considering the background, this chapter highlights the potential of tropical biomass from woody biomass, non-woody biomass, and agricultural residue for cosmetics applications. Besides that, the prospects and challenges in developing cosmetics from biomass are also covered in the discussion. This chapter is seen to be an important tool to spread awareness on the smart way of utilizing our precious biomass and transforming it into cosmetic products for contributing to solving environmental problems occurring in our surroundings.

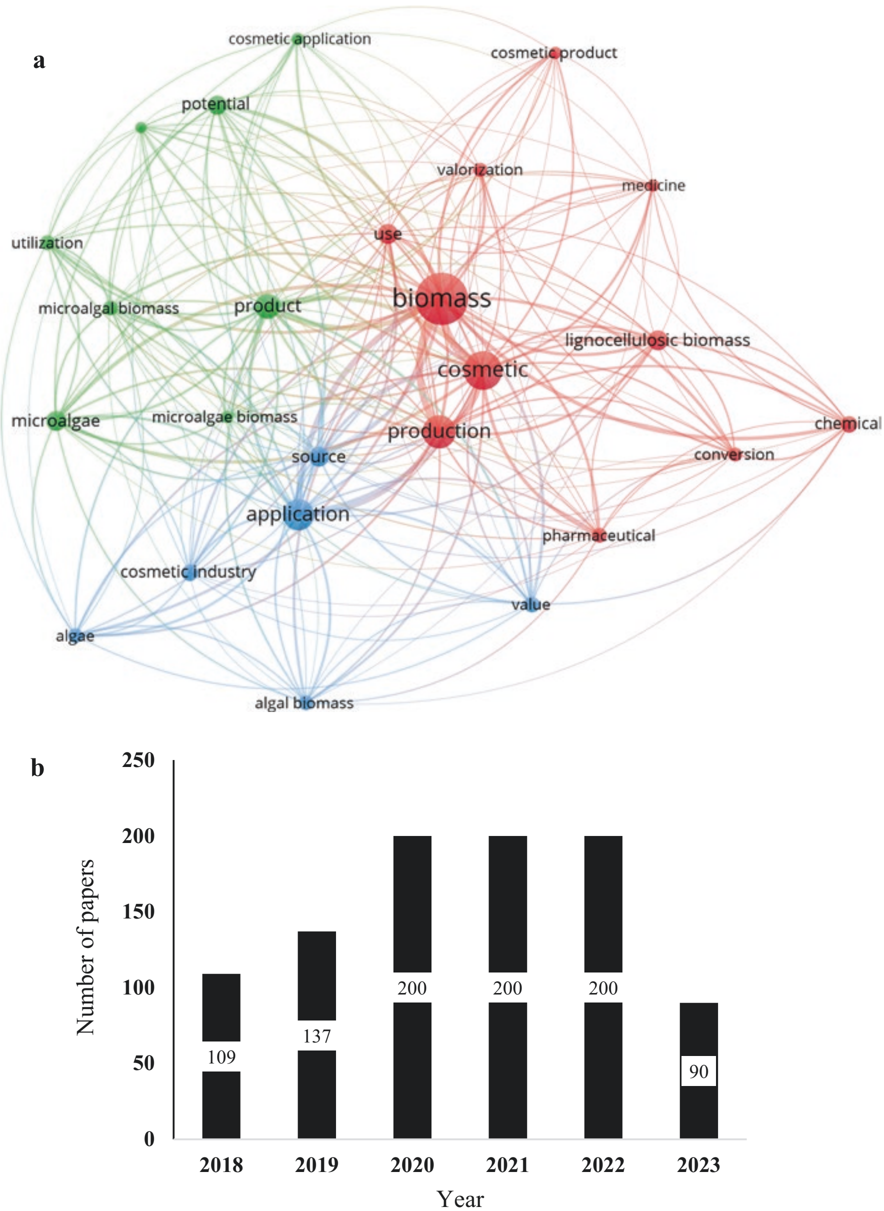

Fig. 1.1 The network visualization by Vos Viewer analysis based on G-scholar database (**a**), number of papers (**b**) using the keyword "biomass for cosmetic" for the period 2018–April 2023

1.2 Non-wood Forest Products as Sources of Bioactive Ingredients in Cosmetics

Cosmetics are materials or preparations intended for use on the exterior of the human body such as the epidermis, hair, nails, lips, and external genital organs, or teeth and oral mucous membranes primarily to cleanse, fragrance, change appearance, and/or improve body odor or protect or maintain the body in good condition (Indonesia 2023). These items come in various formats, including lotions, creams, powders, and more (Fig. 1.2). Skincare products are used to moisturize, protect, and clean the skin. Consumers typically choose to select cosmetics that are less damaging to their skin. Many pharmaceutical industries have now created "cosmeceutical" goods. A cosmeceutical is a topical cosmetic and pharmaceutical or drug-like properties combined to enhance beauty with active chemicals that have biological activities related to the skin. The incorporation of active substances into cosmetic goods is necessary to improve skin health in addition to other activities such as acne treatment, moisturizing, and anti-aging. Cosmeceuticals are used to nourish and improve the appearance of the skin, and they have also been shown to be useful

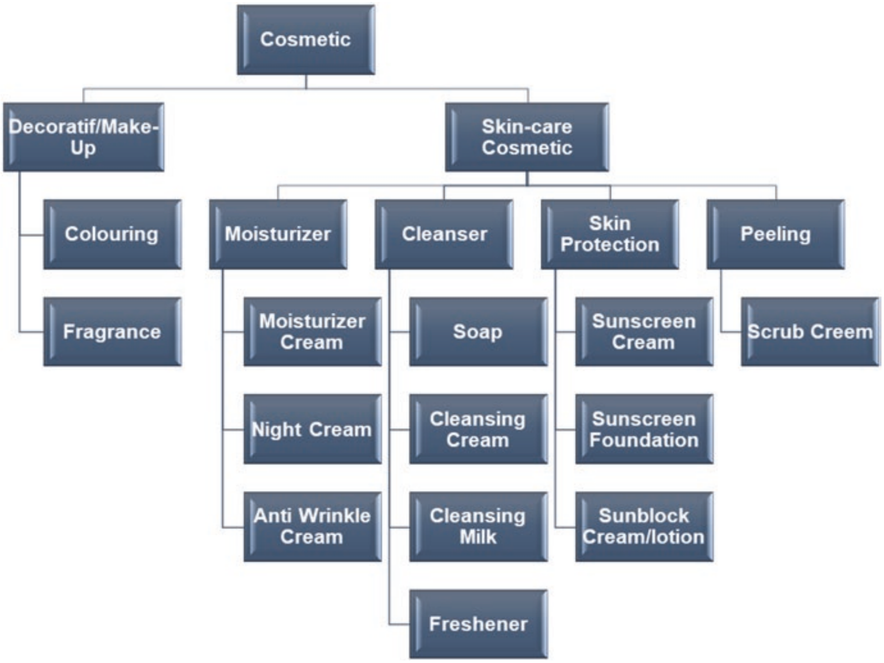

Fig. 1.2 Classification of Cosmetics according to their use for the skin. Excerpted from Tranggono and Latifah (2007)

agents for treating a variety of dermatologic disorders (Vaishali et al. 2013). Antioxidants are employed in topical cosmetics to shield human skin from free radicals and ultraviolet radiation (UVR) harm (Kusumawati and Indrayanto 2013; Vaishali et al. 2013).

Pharmaceutical sectors are extremely interested in antioxidant chemicals. As antioxidants work to combat free radicals, they can be included in cosmetic preparations. However, the majority of antioxidants are not stable and can lead to a variety of issues when used in the creation of cosmetics. In cosmetic compositions, antioxidant selection and concentration must be optimized. Natural antioxidants obtained from plants are now favored over synthetic antioxidants for use in cosmetics. Plant-derived antioxidant extracts typically include a variety of natural substances that may work in concert to produce superior effects with lower toxicity (Chermahini et al. 2011).

Indonesia has 191,357,868 hectares of land, and 62.97% is covered in forests. A total of 125,817,022.96 ha is surrounded by land and water forests, compared to 120,495,701.96 ha by land forests. Conservation forests, protected forests, restricted production forests, permanent production forests, and convertible production forests are among the types of forests in Indonesia. 21.97% of the land and water forests are contained inside the conservation area, comprising waterways and land. Protection forests and permanent production forests make up the majority of the forming forest area, accounting for 23.51% and 23.225% of the total land area, respectively. Expanding the circular economy is one of the economic pillar's strategic goals, actualizing the economic potential of forest resources and the environment. The strategic goals of the economic pillar, the actualization of the economic potential from forest resources and the environment, are to increase the following: (a) the circular economy of waste; (b) the sustainable use of forest resources; (c) the export of more forest products, wildlife plants, and bioprospecting; and (d) the state revenue from forestry and the environment (Istandia 2020).

In addition to the wood products industry, the local economy depends on non-wood forest products like berries harvested and used from the forest. Berries are a seasonal product. The most popular species for the export market is bilberry. *Reishi Ganoderma lucidum* can be grown but also naturally grows in boreal woods. Its medical benefits of boosting physical stamina and immunity are well-known in Southeast Asia, especially in China and Japan. For a brief period in the spring, birch trees can be harvested for their sap. Magnesium, manganese, vitamin C, and other minerals and antioxidants are all present in birch sap. Fresh birch sap can be consumed, a common element in cosmetics and beverages. Instances of markets berries are used as a raw material in beverages, cold-pressed juices, smoothies' alcoholic beverages, snacks, and extracts. Chaga is a raw ingredient for food supplements, tea extracts, functional health beverages, and cosmetics skin care (Xiaoqian and den Herder 2022). Table 1.1 summarizes non-wood forest products as sources of bioactive ingredients in cosmetics.

Table 1.1 Non-wood forest products as a source of bioactive ingredients in cosmetics

Function	Non-wood forest products	Part of uses/use in cosmetics as	Bioactive ingredients	References
Antioxidant	Aloe vera	Pure compound or isolated plant extracts	Aloesin	Chailap and Nuanyai (2022), Kim et al. (2017)
Antioxidant	*Psidium guajava*	Pure compound or isolate	Quercetin (flavonol)	Okoye et al. (2015)
Antioxidant, antibacterial	Red propolis from Apis mellifera bees	Extract	Phenolic and flavonoid	Segueni et al. (2022)
Antioxidant, antibacterial	*Anadenanthera peregrina* stem bark	Extract	Cardiac glycosides, organic acids, reducing sugars, hemolytic saponins, phenols, coumarins, condensed tannins, flavonoids, catechins, depsides, and depsidones derived from benzoquinones	Marinho et al. (2021)
Exhibit depigmenting effects by inhibiting tyrosinase and melanin production, along with potent anti-inflammatory properties.	*Eucalyptus globulusis*	Extract	Essential oil: 1,8-cineole, and the phenolic acids in the hydro distillation residual water (HRW) included gallic acid as the main phenolic constituent	Moreira et al. (2022)
Antidiabetic, anti-hyperlipidemic, antioxidant, anti-inflammatory, wound healing, antidiarrheal, antivenom activity including a host of other curative properties.	Chironji (*Buchanania lanzan* Spreng.)	Extract	Celidoniol, vomicine, epinitol	Phogat et al. (2020)

1.3 Wood as a Source of Bioactive Ingredients in Cosmetics

Plants are a vital source of physiologically active natural compounds with aesthetic and dermatological applications. For a very long time, natural ingredients have been used for skincare, as well as to repair the look and function of damaged or aging skin. The most often used ingredients include polyunsaturated, carotenoids, fatty acids vitamins, plant polyphenols oligosaccharides, and bioactive peptides (Herranz-López and Barrajón-Catalán 2020). Polyphenolic extracts are emphasized in this context because they have demonstrated antioxidant, anti-aging, anti-inflammatory, antibacterial, and supportive activity in solar photoprotection (de Lima Cherubim et al. 2020). The development of eco-friendly products with a high concentration of green raw materials, notably those for skin and anti-aging therapy, has benefited greatly from the positive effects of polyphenols in the cosmetics industry (Oliveira et al. 2008; Oroian and Escriche 2015).

Wood, as a biomass material, is extremely significant in productivity and human life. Its extractives, which mostly consist of aliphatic compounds, terpenoids, phenolic compounds, and terpenoids, have a significant influence on color, durability, processing, and wood utilization (Kirker et al. 2013). This is due to the fact that wood extractives have a variety of uses, including in food, medicine, and cosmetics in addition to helping to identify and classify wood (Schultz and Nicholas 2000).

1.3.1 Antioxidant

Antioxidant molecules, which may have an endogenous origin, help reduce the damage induced by radicals. Carotenoids, vitamins, and phenolic compounds are the most common antioxidant-active substances. As a preventive strategy, certain antioxidants can inhibit the unfavorable effects of free radicals, resulting in normal skin structural protein formation (Morais et al. 2013; Ratz-Lyko et al. 2012). Cosmetics that contain antioxidants have a lower risk of oxidative damage, making them an effective option for the treatment and prevention of premature aging. It also has photoprotective properties and aids in the treatment of sun-stressed or sensitive skin due to its anti-inflammatory properties (Arct and Pytkowska 2008). Although antioxidant use is encouraging, there have been few human clinical trials exploring the effect of antioxidants in skin aging prevention (Hoang et al. 2021).

Antioxidants can be natural or synthetic, and both are utilized in cosmetic products (Babbush et al. 2020). Natural antioxidants used in the beauty business comprise a variety of chemicals and extracts obtained from various plants, fruits, and cereals that are capable of protecting products from oxidative destruction or lowering oxidative stress on the skin (He et al. 2021). An overview of plant wood extracts' natural antioxidants as a source of cosmetic components is shown in Table 1.2.

Table 1.2 Natural antioxidants potential from the wood part of several plants as cosmetic ingredients

Source	Part of uses/use in cosmetics as	Compounds	Potential activity	References
Artocarpus heterophyllus wood (sapwood)	Pure compound or isolated plant extracts	Artocarpanone	Antioxidant and skin-whitening agent	Arung et al. (2006)
Chestnut wood	Pure compound or isolated plant extracts	Ellagic acid (phenolic compound)	Antioxidant, anti-inflammatory, and antimicrobial agent	Moccia et al. (2022)
Rhus typhina L. wood/ branches	Hydroalcoholic extract	Phenolic acid (gallic acid), polualcohol and (arbitol), sugars, and flavonoid (catechin)	Antioxidant (IC_{50} 2.41 ± 0.08 µgext/mL), TPC (86.00 mg_{GAE}/g)	Arlandini et al. (2021)
	Essential oil	Non-oxygenated sesquiterpenes (76.52%), γ-cadinene, (9.91%), δ-cadinene (22.07%), γ-muurolene (8.91%), aromandendrene (5.96%), and oxygenated sesquiterpenoids (amounting to 6.50%), among 95 them there is τ-muurolol (1.94%	TPC (4.72 ± 0.22 mg_{GAE}/ml_{EO}), antiradical (IC_{50} 5.80 ± 0.18 µL/mL), antimicrobial	
Kraft lignin	Extract	2-(4-allyl-2-methoxyphenoxy)-1-(4-hydroxy-3-methoxyphenyl)-1-propanol, benzyl benzoate, fisetinidol, phenyllactic acid, 2-phenylpropionic acid, 6, 30 -dimethoxyflavone, and vanillin	DPPH radical scavenging activity, total phenolics content (TPC) (0.42–50 mg gallic acid equivalents), trolox equivalent antioxidant capacity (TEAC) (35–277 mg trolox equivalents), and	Qazi et al. (2017)
Schinopsis lorentzii wood	Extract	Gallic acid eriodictyol, pyrogallol, taxifolin, and catechin	Hypoglycemic activity, antioxidant	Cardullo et al. (2020)
Alnus glutinosa bark	Extract	Polyphenol	Proanthocyanin, antioxidant	Lauberts and Pals (2021)

(continued)

Table 1.2 (continued)

Source	Part of uses/use in cosmetics as	Compounds	Potential activity	References
Litchi chinensis wood vinegar	Extract	Phenolic, flavonoid, 2-methoxyphenol (guaiacol, 12.36%), 2, 6-dimethoxyphenol (syringol, 29.54%), and 3, 5-dimethoxy-4-hydroxytoluene (11.07%)	Antioxidant, antibacterial	Yang et al. (2016)
Caesalpinia sappan L. heartwood	Pure compound or isolated plant extracts	One coumarin, one xanthone, three chalcones, three homoisoflavonoids, two flavones, and brazilin	Antioxidant, antibacterial, antiacne, anti-inflammatory, hypoglycemic, vasorelaxation, hepatoprotective	Nirmal et al. (2015)
Stem wood of *Pterocarpus marsupium*	Extract	Alkaloids, saponins, glycosides, tannins, carbohydrates, cardiac glycosides, proteins, terpenoids, and flavonoids	Antioxidant, analgesic, antidiabetic, anti-inflammatory	Pant et al. (2017)
Caesalpinia decapetala (Roth) wood	Extract	Flavonoids, polyphenols, flavonol	Antioxidant (DPPH, nitric oxide radical superoxide radical)	Pawar and Surana (2010)
Salicornia ramosissima J. Woods	The ethanol extract, the water extract	Phenolic compounds, flavonoids, anthocyanidins, carotenoids	Antioxidant and inhibitory effect toward enzymes related to diabetes, hyperpigmentation, obesity, and neurogenerative diseases	Hulkko et al. (2023)
Paulownia (Scrophulariaceae)	The extracts of the paulownia flower	Flavonoids, phenylpropanoids, terpenoids, volatile components, polysaccharides, lignans, and iridoids	Antioxidant, anti-inflammatory, antibacterial, antiviral, anticancer, hypoglycemic, hypolipidemic, neuroprotective, and immunoregulation activities.	Guo et al. (2023)

Clarisia racemosa (guariúba), Moraceae	The hydroalcoholic extract	Cellulose, hemicellulose, lignin, phenolics	Antioxidant, antiglycan	Albuquerque Nerys et al. (2022)
Eucalyptus	Extract	Resveratrol (phenolic compound)	Antioxidant	Costa et al. (2021)
Macaranga pruinosa	*The methanol leaf extracts*	Prenylated flavonoid: Glyasperin A	Antioxidant and inhibited melanin in B16 melanoma	Arung et al. (2019)
Acacia mangium (acacia), Paraserianthes falcataria (sengon) and Swietenia mahagoni (mahoni) barks	Extract	Phenolic compounds	Antioxidant and antifungal	Rosdiana et al. (2017)

1.3.2 Anti-Melanogenic

Skin hyperpigmentation illnesses are both clinical and aesthetic concerns caused by aberrant melanin synthesis caused by UV irradiation. Melanin is a pigment found in animal and human skin that is produced by tyrosinase from L-tyrosine (Putri et al. 2022). Tyrosinase is regarded as a target enzyme in therapeutic interventions linked with melanin hyperpigmentation because it catalyzes the rate-limiting steps in mammalian melanogenesis. Many tyrosinase inhibitors have been studied in cosmetics and medications to reduce melanin overproduction in the epidermal layers. The study of variables that affect tyrosinase, the rate-limiting enzyme in the melanogenic pathway, has concentrated on substances that impede tyrosinase function. Given the necessity of avoiding skin damage by counteracting oxidative stress induced by UV radiation, it is equally critical to identify a multifunctional skin-whitening agent with antioxidant characteristics capable of inhibiting melanin formation (Arung et al. 2006). Since many known drugs are harmful, there has been a growing push to discover other tyrosinase inhibitors, particularly from natural sources (Chaita et al. 2017).

As anti-browning, anti-melanogenesis, and anti-tyrosinase agents, some prenylated flavonoids, including artocarpesin, cycloartocarpin, artocarpin, brosimone I, cycloartocarpesin, cudraflavone B, isoartocarpesin, and carpachromene, were isolated from the wood of *A. heterophyllus*. 3-Prenyl luteolin, which is found in *A. heterophyllus* sapwood and artocarpanone, which is found in *A. heterophyllus* heartwood and the MeOH extract of sapwood, are promising compounds to treat hyperpigmentation and serve as skin-whitening agents (Arung et al. 2006; Arung et al. 2010). In addition to the five known flavonoid compounds norartocarpetin, liquiritigenin, artocarpanone, dihydromorin, and steppogenin, Nguyen et al. (2016) have discovered two novel flavonoid compounds, artocaepin F and artocaepin E. Artocaepin, E Artocarpanone, and steppogenin demonstrated the strongest inhibitory effects on tyrosinase activity. These findings imply that these substances might be used as structural models for the creation of new tyrosinase inhibitors from *A. heterophyllu*s that are efficient anti-browning cosmetic ingredients.

The methanol extract of *Morus alba* wood was discovered to be the most effective tyrosinase inhibitor by Chaita et al. (2017). The reference ingredient kojic acid was discovered to be only slightly less powerful than the methanol extract. They identified 2,4,30-trihydroxydihydrostilbene and dihydrooxyresveratrol as the most effective tyrosinase inhibitors found in nature. It is a very hopeful source of phytochemicals for the development of effective anti-melanogenic compounds. In the cell-free mushroom tyrosinase assay technique, *C. formosana* wood essential oil displayed significant mushroom tyrosinase activity with an IC_{50} value of 2.72 g/mL. The main ingredients were terpineol (23.47%), terpinen-4-ol (12.23%), shonanic acid (10.45%), thymol (5.3%), piperitone (3.44%), berbenone (2.81%), thujic acid (1.65%), and chaminic acid (0.13%). Additionally, the anti-melanogenic properties of *C. formosana* wood oil have been related to the active component thymol (Hsiao et al. 2022). The study on plant wood extracts regarding the inhibition of tyrosinase enzymes is still limited, thus creating opportunities to explore the potential of other wood species.

1.4 Agricultural Residue as a Source of Bioactive Ingredients in Cosmetics

Concern over the bioactive substances found in agro-industrial wastes as potential tools for improving certain elements of our lives has grown over the past few decades. Since the now available technologies enable their recycling and sustainable usage, agro-industrial by-products can be employed for various uses giving economic benefits. Also, their processing lessens the environmental effects of their removal environmental effects (due to their low pH and high organic load). Currently, there is no European legislation governing the removal of agro-industrial wastes; instead, each nation's regulations govern this matter (levels of several chemical compounds, such as Cd, Mn, Fe, Pb, Zn, and Cu, and microbial parameters) (Libutti et al. 2018). These remaining bioactive chemicals can help the skincare and cosmetic industries, as several have demonstrated promising skin photoprotective qualities (Evans and Johnson 2010).

The sun care sector, in particular, has benefited from the growing public knowledge of the risks associated with sun exposure. UV irradiation in sunlight continuously endangers human skin, and severe UV exposure causes skin photoaging. Many bioactive substances with cosmetic and/or dermatological applications protect the skin from UV rays and enhance the epidermis' antioxidant capacity, which helps to regulate epidermal homeostasis. Plant extracts are sources of therapeutically potent active substances that can be consumed orally or applied topically to improve skin conditions. Since several of them have demonstrated potential qualities as skin photoprotectants, there is currently an increasing call for the bioactive compound application found in agro-industrial by-products in sun care products. Before they could be used regularly, though, well-conducted clinical studies were needed to demonstrate their efficacy and safety. As a result, approaches for recovering these chemicals from agro-industrial wastes and transforming them into novel, high-value natural components utilized in cosmetic formulations are being investigated (Simitzis 2018).

The production of agricultural residues varies greatly geographically, as do the ecological restrictions on recovering these residues. With the transition to high-input agricultural management, the majority of locations in the globe can increase the manufacture of agricultural residues. Climate and dietary changes throughout time may impact the potential for greater residue production and may both oppose and support higher production. The absence of data on agricultural residue generation severely hampers accurate modeling of residue production. Reliable statistics are required if agricultural residues are anticipated to contribute more to the future provision of energy and materials (Bentsen et al. 2014).

Because of the better yields of wheat and rice compared to other crops and the backing of an input and output price structure, Punjabi agriculture has essentially transformed into a rice-wheat monoculture. The state's groundwater supplies have been overused due to the rice-wheat cycle. The problem of crop residue management has been made worse by combined harvesters, which leave much rice residue that must be burned in the open fields. The issue of burning agricultural waste is brought to light. The quantified pollution produced by burning rice residue and its detrimental effects on human health has been reported (Kumar et al. 2014).

Schizophyllan is manufactured for use in cosmetics and pharmaceutical products. However, Schizophyllan's distinctive physical characteristics imply that it might have been used in biomaterials. A high molecular weight schizophyllan derived from agricultural waste showed features of solution viscosity resembling those of commercially generated material. Using biomass substrates might lower the price of schizophyllan synthesis and give integrated biorefineries of the future a new value-added bioproduct (Sutivisedsak et al. 2013).

The rind of *Nephelium lappaceum*, a well-known agricultural residue, is a prospective source of phenolic antioxidants. The extracts' phenolic content, antioxidant capacity, anti-tyrosinase activity, and flavonoid content were assessed. The findings indicate that *N. lappaceum* rind extract's phenolic content and antioxidant activity may be preserved for at least 16 weeks at a temperature between 4 and 45 °C with or without oxygen exposure when used as anti-aging or a nutraceutical ingredient in cosmetics (Thitilertdecha 2022).

A (16)-D-glucan called lasiodiplodan is an exopolysaccharide with significant commercial value and numerous uses in food, medicine, and cosmetics. The majority of the present industrial synthesis of -glucans from crops uses chemical methods, creating harmful and dangerous waste. Alternate sustainable and environmentally friendly routes are therefore highly desired. The lasiodiplodan production by *Lasiodiplodia theobromae* CCT 3966 from Sugarcane bagasse (SCB), a significant residue of lignocellulosic agriculture, has been investigated. The highest SCB-based lasiodiplodan output has been reported that *L. theobromae*, a microbial cell factory, has proven the viability of producing lasiodiplodan sustainably from renewable biomass feedstock (Ascencio et al. 2021).

The separation of polysaccharides from Almond Shells (AS) and their solid residue (ASR) following autohydrolysis was studied using a two-step alkaline extraction without and in combination with a quick ultrasonic treatment. The yield, chemical makeup, structural characteristics, and antioxidant activity of the water-soluble preparations evaluated were used to characterize the produced polysaccharide preparations. According to the findings, the traditional method extracted most hemicelluloses using ultrasound using a 5% NaOH solution in 10 minutes instead of 60 minutes. The water-soluble component of these materials' AOA ranged from 48 to 80%, demonstrating their potential as antioxidants. Both AS and ASR xylan polymers could be used as biopolymer sources in their natural form or subsequently targeted modification to produce polysaccharide-based antioxidants and value-added substances for use in cosmetics, food, and other applications (Ebringerova et al. 2008).

Tyrosinase is a copper-containing enzyme that is required for melanin synthesis. Hyperpigmentation and neurodegenerative diseases are caused by melanin overproduction and abnormal accumulation. As a result, tyrosinase appears to be promising for use in medicine and cosmetics. It has been discovered that cysteine-containing dipeptides that directly block the vigorous site of tyrosinase are vastly effective inhibitors; in particular, N-terminal cysteine-containing dipeptides outperform C-terminal cysteine-comprising dipeptides (Tseng et al. 2015).

Because of their distinctive structural proteins, the oleosins, oleosomes are recognized to be helpful in cosmetics and other emulsion applications. It was looked into if intact oleosomes could be fractionated to create soybean oil using organic solvents. Investigations were done on the process variables, including centrifugation, filtration, cell lysis, and enzyme treatment. The crucial procedures were multiple residue extractions, the deletion of the filtration stage, ultrasonication or pressurization of soybean flour before enzyme treatment and enzyme treatment of the residue. The results were considered valuable for creating large-scale and effective oleosome extraction techniques from soybean (Kapchie et al. 2008).

The disposal of rice husk ash, a vast and messy by-product of rice milling, is a significant environmental concern. In light of this, silica nanoparticles were extracted from rice husk ash utilizing the sol-gel method and green technology. The sodium silicate solution was produced by hydrothermal activation of rice husk ash rather than commercially available expensive and occasionally poisonous raw ingredients. Because of this, the recommended ecologically friendly approach created nearly ultra-pure ~98.9% amorphous nano silica particles at lower temperatures, which could be employed in a variety of industrial applications (Mor et al. 2017).

In order to improve the quality, effectiveness, and shelf life of cosmetic, beauty, and personal care products, a vast range of chemical substances are now being added to the manufacturing process as preservatives, additives, perfumes, stabilizers, stains, surfactants, and shines. However, given the literature review on cosmetics and the findings, it is unsurprising to learn that some of the substances are environmentally determined, bioactive, and show probable bioaccumulation. As a result of widespread, indiscriminate, and prolonged exposure, these substances can seriously threaten the environment and human health. Using cosmetics linked to environmental issues should not be prohibited, as this is not a practical solution. To solve this issue, several innovative approaches are needed. Although the management and authorities in charge of cosmetic regulation around the world are very concerned about the situation, they should be more rigorous and careful when combining new substances or ingredients that pose a health risk into the production of cosmetics in order to avoid unfavorable effects on the human health and environment. Further thorough research should be conducted on these very concerning pollutants' acute or chronic poisoning to enable a more precise monitoring and detailed examination of the actual ecological and health concerns. Last but not least, including information on cosmetic products'effects on the environment and human health on their packaging will reassure customers and promote more responsible use of these items (Bilal et al. 2020). Table 1.3 summarizes agricultural residue as a source of bioactive ingredients in cosmetics.

Table 1.3 Agricultural residue as a source of bioactive ingredients in cosmetics

Plant	Part used	Chemical constituent	Cosmetics use	Reference
• *Passiflora edulis* f. flavicarpa • Apple pomace • Citrus albedo • Beet pulp	Peel extracts, isolate	Pectin	Gelling agent and stabilizer	Liew et al. (2014)
• Passion fruit pomace				
Viticulture—Muscat of Hambourg	Extract leaves and cans	Polyphenols	Antioxidant	Karsheva and Kirova (2014)
Rice	Rice bran	De-oiled rice bran	Moisturizers	Dechprasittichok et al. (2015)
		Rice bran fermentation	Anti-aging, melanin synthesis inhibition, whitening, moisturizing	Chen et al. (2018)
Nannochloropsis oculata and *Dunaliella salina*	Microalgae extracts	A protein-rich extract	Thickening agents, water-binding agents, antioxidants, collagen I synthesis, wrinkles, and protects the skin	Stolz and Obermayer (2005)
Citrus reticulate L.	Rag, peel, and seeds	Polyphenol	Antioxidants	Lu et al. (2021), Sagar et al. (2017)
The hemp fibers	Fractions, extraction of hemp fibers	Microcrystalline cellulose	Rheology control agent	Barbash et al. (2016), Dale Vonbehren et al. (2010)
Centella asiatica (CA)	*Centella asiatica* (CA) leaves. Petioles stem, and runners extract, synthesis of silver nanoparticles (SNPs)	Triterpenoids, and saponins, synthesis of silver nanoparticles (SNPs)	Antioxidant	Venkatasubbaiah et al. (2021)
Rice straw and *Crotalaria juncea* fibers	Extract	Levulinic acid	Preservative	Papageorgiou et al. (2010), Santos et al. (2021)

Cocoa	Extract/fraction of bean shell, pod husk, and pulp	Enzymes, polysaccharides, flavonoids, terpenoid-derived metabolites	Antioxidant, inhibition of collagenase	Karim et al. (2014), Vásquez et al. (2019)
Apple (*Rosaceae*)	Apple pomace extracts	Phenolic compounds and pectin	Antioxidant, anti-inflammatory, antibacterial, antifungal, and anticancer properties	Gołębiewska and Kalinowska (2021), Magyar et al. (2016), Messinese et al. (2023)
Grapes (Vitaceae)	Pomace, marc including seeds, pulp, skins, stems, and leaves	Phenolic acid, flavanols, catechins, anthocyanins, resveratrol, fatty acid	Antioxidant, anti-inflammatory, anti-proliferative activity	Biniari et al. (2020), Fontana et al. (2013), Nadeeshani Dilhara Gamage et al. (2022), Oleszek et al. (2023)
Banana (Musaceae)	Peels, rotting fruit, leaves, stems, flower, pseudoparts	Phenolic acid (ellagic ferulic), flavonols, flavanones, catechins	Antioxidant, antimicrobial, platelet aggregation inhibitory, antihyperglycemic activity, bio fungicide, corrosion inhibitors, colorant	
Tomato (Solanaceae)	Peels, seeds, pulp, leaves, stems	Phenolic acid, flavonols, flavanones, isoflavones, resveratrol, carotenoids	Antioxidants, food additives, natural colorants	Oleszek et al. (2023), Savatović et al. (2011)
Soybean (Fabaceae)	Pod pericarp, twigs, okara, leaves	Phenolic acid, flavanols, flavons, isoflavons, lecithin, catechin, saponins	Antioxidant, antimicrobial, anticancer, anti-estrogenic, cardiovascular activity, food supplement	Oleszek et al. (2023), Pabich et al. (2021)
Potato (Solanaceae)	Peels	Phenolic acid, flavanols, anthocyanins, glycoalcaloids	Antioxidant, hepatoprotective, anti-inflammatory, antiobesity, precursor for hormones	Fritsch et al. (2017), Oleszek et al. (2023)
Maize (Poaceae)	Husk, cobs, tassel, pollen, silk, fiber, stigma	Phenolic acid, flavonols, anthocyanins,	Antioxidant, antimicrobial, antidiabetic, anticancer, preservatives, stabilizers, emulsifiers, coloring	Oleszek et al. (2023), Žilić et al. (2014)

(continued)

Table 1.3 (continued)

Plant	Part used	Chemical constituent	Cosmetics use	Reference
Sugarcane (Poaceae)	Bagasse	Gallic, coumaric, caffeic, chlorogenic, cinnamic acids, isoflavones, quercetin	Antioxidant, antimicrobial, antihyperglycemic, reducing agent	Juttuporn et al. (2018), Oleszek et al. (2023)
Olives (Oleaceae)	Pomace, olive mill wastewater, leaves	Phenolic acids, secoiridoids, flavonoids	Antioxidant, antitumor, antimicrobial, nutraceutical additive	da Silva and Rodrigues (2014), Obied et al. (2007), Oleszek et al. (2023)
Kiwi (Actinidiaceae)	Leaves, stems, roots, flowers	Phenolic compounds, volatile compounds, vitamins, minerals, dietary fiber, etc.	Antioxidant, anti-inflammatory or antimicrobial activities. Applications in the food (pectins, softeners, milk coagulants, and colorants), cosmetic (ecological pigments) and pharmaceutical industry (fortified, functional, nutraceutical, or prebiotic foods)	Chamorro et al. (2022)