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Eastern Kentucky University

# In the Garden of Skincare: Exploring the Benefits and Regulations of Botanical Ingredients

Honors Thesis

Submitted

In Partial Fulfillment

Of The

Requirements of HON 420

Spring 2024

By

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## Abstract

In the Garden of Skincare: Exploring the Benefits and Regulations of Botanical Ingredients

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With the rising consumer demand for more natural skincare products, botanical ingredients have become more prevalent in skincare products. Skincare products with botanical properties are being preferred over those with chemical properties due to their biological origins. However, there are debates as to why botanical products are being used widespread and if they are safe to use. The safety of ingredients within cosmetics is observed by multiple regulatory systems throughout the world. These regulatory systems oversee making sure that each ingredient is extracted and purified before being incorporated into a cosmetic or skincare product. One goal of this project was to determine if botanical ingredients are safe to use and should be chosen over chemical ingredients. A literature review was conducted to gather information about the botanical ingredients commonly found in natural skincare products, the cultural usages of natural ingredients, the marketing behind natural cosmetic brands and products, the extraction and purification processes that natural ingredients undergo, and the regulatory systems that keep extraction and purification processes in check. The literature review concluded that botanical ingredients are safe to use when regulatory systems ensure that extraction and purification methods have been performed correctly, and when research has been conducted on the ingredients.

Keywords and phrases: *botanical ingredients*, *natural skincare*, *natural ingredients*, *extraction*, *purification*, *regulations*, *cosmetics*

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## Introduction

Skincare has evolved over the past centuries in various ways to adapt to consumer demand. According to Leong and others, “Skincare products are medicinal formulations prepared to be used on external parts of the human body to produce therapeutic topical effects and shield the deteriorated skin” (Leong et al., 2021). Within the past decade, using more “clean” and “natural” products has become trendy. To meet the demands of consumers, more skincare companies have created products with botanical ingredients. According to Ribeiro and other researchers (2015), the definition of a natural ingredient is “an ingredient that is produced by or found in nature and is directly extracted from plants or animal products”. Given the widespread use of botanical ingredients, or plant ingredients, used in skincare products, are natural ingredients safer than chemical ingredients? This question has led to many debates that bring up various points, such as if natural skincare products are safe and why more consumers are interested in natural products than chemical products.

Consumer demand for “clean” ingredients in cosmetics has led to an increase in botanical ingredients being placed in skincare products and are being used by many cultures. The botanical ingredients are safe to use in skincare products when regulatory systems ensure that safe extraction and purification processes were used, and that research has been performed on the ingredients. This literature review will examine botanical ingredients and their benefits, the cultural usage of botanical ingredients, the

marketing success of natural products, the differences between biosurfactants and chemical surfactants, and the regulatory systems that ensure cosmetic safety.

# Literature Review

## Overview of Skincare

Skincare has grown as an industry due to the importance of taking care of your skin. Skin is the human's largest organ that offers protection against harmful environmental conditions, such as sunlight exposure, and it keeps harmful chemicals out from our internal environment (Ribeiro et al., 2015). Our skin also serves as a barrier that holds in water, which increases skin hydration (Ribeiro et al., 2015). If humans don't take care of their skin properly, then their skin can be damaged by environmental conditions that can lead to consequences such as cancer, skin dehydration, and disease. Therefore, it is important to take care of our skin with products that help enhance our skin's health.

There are many products that have become available to consumers, due to their specific, yet various roles. Certain products are curated with surfactants that help various skin issues, such as acne prone skin, hyperpigmentation and skin aging (Leong et al., 2021). Surfactants are substances within products that help reduce surface tension of the skin (Karnwal et al., 2023). A major product in the skincare industry is skin creams. Skin care creams, also known as moisturizers, are oil and water mixtures that can moisturize any body part and help prevent water loss (Leong et al., 2021). Properties that help moisturizers prevent water loss include "fats, oils, humectants, emulsifiers and preservatives" (Kotnala et al., 2019). According to Kotnala and other researchers (2019), "Humectants help restore water content to the epidermis". Another important routine in skincare is sunscreen usage. Sunscreen products block UV-A and UV- B radiation in order to protect the skin and can be considered an anti-aging product due to the presence of oxybenzone, avobenzone, and octinoxate in the products (Kotnala et al., 2019).

However, sunscreens often contain photoallergies and phototoxic properties that may cause the presence of skin disorders (Khan and Alam, 2019). Some common sensitizers that can be found in sunscreen products include benzophenones and aminobenzoic acid, which can cause photo-allergic dermatitis (Khan and Alam, 2019). Sunscreens can also contain fragrances that could be carcinogenic, such as coumarins (Khan and Alam, 2019). However, cleansers are the most known skincare product as they create a thin cutaneous film with an odor that is produced by the sweat glands to attract microorganisms to the skin so they can clean it (Kotnala et al., 2019). Other skincare products include ointments, emulsions, powder solutions, and compacts (Sagbo and Mbeng, 2018).

**Botanical Ingredients and Their Properties**

Botanical ingredients have been incorporated into skincare products more frequently in the past decade due to their various properties and the idea of them having a biological makeup compared to chemical ingredients. The biological components and appeal of natural skincare products has led to more consumer demand, leading to an increase of production and regulatory expansion for the cosmetics industry. However, it is important to know which botanical ingredients are being incorporated in natural skincare products and their properties to understand why they must be regulated and put through extraction and purification processes.

Plant species are classified into different botanical families. While individual species often have unique properties, in many cases many plants in each family have the same chemical properties. Five botanical families that are significantly used in natural cosmetics are Asteraceae (the daisy family), Fabaceae (the legume family), Lamiaceae (the mint family), Poaceae (the grass family), and Rosaceae (the rose family) (Dorni et

al., 2017). Notable members of the Asteraceae family include *Achillea millefolium*, *Arnica montana*, *Calendula officinalis*, *Chrysanthemum indicum*, sunflower (*Helianthus annuus*), *Matricaria recutita*, and *Petasites japonicas* (Dorni et al., 2017). Important species members of the Fabaceae family include *Caesalpinia spinosa* and *Ceratonia siliqua* (Dorni et al., 2017). Some notable members of the Lamiaceae family include *Lavandula angustifolia*, *Mentha piperita*, *Ocimum basilicum*, *Rosmarinus officinalis*, *Salvia hispanica*, and *Thymus vulgaris* (Dorni et al., 2017). Some notable members of the Poaceae family include *Avena sativa*, *Oryza sativa*, *Saccharum officinarum*, and *Secale cereale* (Dorni et al., 2017). Some notable members of the Rosaceae family include *Prunus armeniaca*, *Prunus domestica*, *Prunus persica*, and *Rubus idaeus* (Dorni et al., 2017). Each of these families contain similar and different bioactive properties that help the skin with different issues (Table 1). In addition to the general floral extracts that most observe in natural skincare products, there are also consumable botanical ingredients that take place in natural skincare products (Table 1). However, if there are food ingredients placed in natural skincare products, they must meet certain criteria held by the USDA Natural Operations program to be certified (Dini and Laneri, 2021, p.2). The use of food ingredients in skincare has brought fame to the idea of nutricosmetics, which is the idea of using food supplements to improve beauty in various areas, such as hair and skincare and are available in multiple intake forms (Dini and Laneri, 2021, p.2).

Botanical ingredients are incorporated into certain skincare products due to their chemical properties. Beneficial properties that botanical ingredients may have include antioxidant, antifungal, anti-inflammatory, water-retaining, anti-aging, and moisturizing (Dini and Laneri, 2021; Dorni et al. 2017). However, it is important to know that

botanical ingredients are not limited to flowers but can also be fruits, stems, leaves, and roots. The most common properties of consumable botanical ingredients are antioxidant properties. Antioxidant properties help prevent oxidates, such as ultraviolet radiation, from damaging the skin (Dini and Laneri, 2021; Dorni et al. 2017). Consumable botanical ingredients that contain antioxidant properties include grapes, coffee, soybeans, and lemons (Dini and Laneri, 2021). Anti-inflammatory properties are another major skincare property that some botanical ingredients contain. Anti-inflammatory properties help prevent enzymes or other proteins that can cause inflammation of the skin. Inflammation of the skin can appear as acne, reactions due to allergens, or side effects of fungal infections (Leong et al., 2021). Botanical ingredients that contain anti-inflammatory properties include papaya, cocoa beans, coconut, and pomegranate (Dini and Laneri, 2021).

**Historic Skincare in Various Cultures**

Botanical ingredients are the foundation that allowed for cosmetic products to be as diverse as they are currently. In fact, the cosmetics that are present now did not exist until the late 1940s. The beginning of the cosmetics that we know of began during World War II, when camouflage paints and sunscreens became available to the public in the form of make-up creams (González-Minero and Bravo-Díaz, 2018). The popularity of cosmetics continued to bloom when television was able to be viewed in color. The ability to watch television in color meant that the actors and actresses had to wear color and products to appear healthy and beautiful for the screen (González-Minero and Bravo-Díaz, 2018).

However, others claim that the cosmetics that we know of began before World War II. Chaudri and Jain (2014) claim that lipsticks were created in 1915, while nail polish was created in 1932 by Revlon, sunscreen debuted in 1952, and mascara wands were created in 1958. It makes sense that most may consider the 1940s the peak creation of cosmetics though because of television. Chaudri and Jain (2014) further this point by mentioning pan-cake makeup, a type of makeup that was created to make actors and actresses look more natural on color film.

Despite the concept of natural cosmetics being recently new, prior to the advent of modern chemistry, the oldest skincare products were made with botanical ingredients. The Egyptians used plant ingredients for multiple reasons. During ancient times, Egyptians believed that healing plants had "spiritual essences that possessed supernatural powers" (González-Minero and Bravo-Díaz, 2018). Therefore, they created products that would protect their skin from the dry, windy climate using multiple plant ingredients such as myrrh (*Boswellia sacra*), thyme (*Thymus*), chamomile (*Matricaria*), lavender (*Lavandula sacra*), lily (Liliaceae), peppermint (*Mentha*), rosemary (*Rosmarinus officinalis*), rose (*Rosa*), and aloe (*Aloe barbadensis*) (González-Minero and Bravo-Díaz, 2018).

Cleanliness was also an important concept for the ancient Egyptians. According to Chaudri and Jain (2014), a cleansing cream made of "animal or vegetable oil", powdered lime and perfume was used to bathe instead of soap. The ancient Egyptians also rubbed themselves with perfumed oil that was soaked with scented wood (Chaudri and Jain, 2014). However, personal hygiene was not the only reason that the ancient Egyptians used plant ingredients. The Egyptians also used plant ingredients to complete

mummification (González-Minero and Bravo-Díaz, 2018). Coniferous resin (*Cedrus libani*), mastic (*Pistacia lentiscus*), myrrh, and arabic gum (*Acacia*) were some of the ingredients used to complete the mummification process (González-Minero and Bravo-Díaz, 2018).

**Current Skincare Usage in Developing Cultures**

Natural skincare products have been a part of various cultures for centuries. Natural skincare products may be used due to the accessibility of the ingredients, religious practice, excellent results, and the multiple uses of natural ingredients. Africa is known for having a long history of using natural skincare products. South Africa is a hotspot for floral biodiversity with eight protected areas that stretch from the Cape Peninsula to the heart of the Eastern Cape province (Ndhlala et al., 2022). The wide diversity in plants has allowed those facing socio-economic issues to be able to freely use the plants they find (Ndhlala et al., 2022). In South Africa, natural skincare products are preferred because of the belief that natural products can supply the body with nutrients (Sagbo and Mbeng, 2018). An aversion to synthetic chemicals is present due to philosophical position and cultural preference (Sagbo and Mbeng, 2018). Currently, the Xhosa community uses natural products made from vegetables and minerals to strengthen their health, beauty, and to indicate their social status (Sagbo and Mbeng, 2018).

Studies conducted in various countries show the continuous significance of botanical ingredients. In Eastern Cameroon, a study was conducted to determine the Gbaya tribe's knowledge on the local botanical ingredients (Fongnzossie et al., 2017). There were thirty-six species accounted for in the study, including *Carica papaya*, *Aloe vera*, *Citrus limon*, *Theobroma cacao*, *Cannabis sativa*, *Allium sativum*, and *Hibiscus*

*sabdariffa* (Fongnzossie et al., 2017). The researchers found that the botanical ingredients were used primarily for facial masks and scrubs, body creams, and hair creams (Fongnzossie et al., 2017). The botanical ingredients mentioned in the study were prepared in multiple ways. Fongnozzie and other researchers (2014) discovered that the botanical ingredients were prepared by "crushing (39.53%), maceration, which is the process of softening substances (37.21%), decoction, a process of obtaining concentrations by heating the botanical source (11.62%), infusion (3.10%), ashing, which is the process of heating up a botanical source that leaves behind ash residue (2.30%) and fermentation (1.55%)" while 4.65% of the ingredients were used "raw without any preparation" (Fongnzossie et al., 2017). The study concluded that the local ingredients were widely used in Eastern Cameroon and are in the best interests of users of cosmetics.

As previously mentioned, botanical ingredients were and are still heavily used in Egypt due to the belief that healing plants had "spiritual essences that possessed supernatural powers" and that cleanliness was an extremely important concept to the Egyptians (Chaudri and Jain, 2014; González-Minero and Bravo-Díaz, 2018). In Egypt, twenty-seven plant sources, that were studied by researchers, were formulated into oils and the plant organs that were used the most often were their leaves (Elansary et al., 2015). Elansary and other researchers (2015) also note that *Rosmarinus officinalis* L. and *Cinnamomum verum* L. had eight different cosmetic uses each. According to Elansary and the other researchers (2015), "The most important species according to their fidelity level, a consensus factor used for the metrics, were *Lawsonia inermis* L. (87%) and *Eruca sativa* L. (84%) in hair treatments, *Avena sativa* L. (63%) for beautification of women's faces, and *Jasminum grandiflorum* L. (46%) for skin treatments". The

researchers concluded that the local botanical ingredients were important to the Alexandria community for their cosmetic uses.

More recently, Sri Lanka has become a newer interest for natural ingredients for scientists because it possesses high levels of biodiversity and has had a traditional system of medicine (Nadeeshani Dilhara Gamagen et al., 2022). Sri Lanka has 3,771 flowering plant species, out of which 1,430 of them are considered medicinal plants and are mainly obtained from local sources or in the wild (Nadeeshani Dilhara Gamagen et al., 2022). Sixty-two plants were observed for potential beautifying properties, and it was found that five plant species had the potential to be used for developing photoprotective cosmetic products and five other plant species had the potential to help treat various skin disorders by analyzing enzyme inhibitory and antioxidant activities (Nadeeshani Dilhara Gamagen et al., 2022). Researchers noticed in a different study that out of the 58 families that were observed, the most dominant family that contained medicinal plants was the Fabaceae family and that they are commonly used in skincare, hair care, and oral care (Nadeeshani Dilhara Gamagen et al., 2022). It was also noted that *Ocimum tenuiflorum*, *Chrysopogon zizanioides*, *Citrus hystrix*, and *Curcuma zedoaria* are fragrant agents that could be used in the perfume industry (Nadeeshani Dilhara Gamagen et al., 2022).

**Marketing of Natural Skincare in Modern Western Cultures**

Skincare companies always need to appeal to customers regardless of the source of their ingredients. The question is, how do these companies design and promote their brands that reflect their products? Do they have an ecological impact, do they give back to the community, or do they help inspire others? There are several strategies employed by competing brands that are used to distinguish them from similar competitors.

First, it is important to understand the monetary value of the natural skincare industry and why natural skincare has become widespread throughout the world. According to the "Organic Skincare Global Market Report" (2023), the organic skincare market was worth $10.91 billion in 2023 compared to its $9.83 billion worth in 2022. The organic skincare market is expected to continue growing with an expected $16.1 billion value in 2027 ("Organic", 2023). With the organic skincare market growing, more brands have been created since the start of organic skincare brands such as Burt's Bees, Lush Cosmetics, and The Body Shop. Newer natural skincare brands include Jurlique, L'occitane, La M.er, Smooth E, Arthistry, Elmis, Tropicana, and Dermatologica (Sripatthanawatt and Nelson, 2014).

One goal of every brand is to attract the desired consumers. Brands attract customers by appealing to their senses through their brand image. Four variables that were examined in a study to see university students' purchase intentions were brand association, brand awareness, brand loyalty, and perceived quality (Lee et al., 2019). Brand awareness is when a buyer could potentially recognize the brand based on the products it carries (Lee et al., 2019). Meanwhile brand association refers to how a brand represents itself based on elements that it could be identified with, which can be positive or negative based on how the consumers perceive the brand (Lee et al., 2019). It is also noted that perceived quality is defined as the consumers viewpoint towards the entirety of the brand, whereas brand loyalty is the process of consumers switching or staying with a certain brand due to various factors (Lee et al., 2019). The researchers concluded that all four of the variables influenced university students' purchase intentions, but the most

common variable was perceived quality (Lee et al., 2019). Because of studies like these, brands are always improving their products and image, but how?

To be successful as a business in a competitive market, the brand needs to have something that makes it stand out. Natural beauty brands including Burt's Bees, The Body Shop, and Tom's of Maine are known for their natural and organic products that attract consumers who want to better their skin health and better their product use (Todd, 2004). Burt's Bees and Tom's of Maine are both companies that do not operate out of stand-alone stores, while The Body Shop is a large retail chain (Todd, 2004). Despite natural skincare brands being sold in big retail stores, the reason why these brands may feel the need to not operate out of their own stores is because operating out of a retail outlet may seem unconnected to ethical "green" standards, whereas choosing not to operate out of retail outlets may show a sense of connection to nature. Despite these differences, each companies' products are sold in many stores and share their values with their customers (Todd, 2004). So why are consumers attracted to buy "green" products from these companies?

Todd et al. (2004) unveils multiple reasons why people are tempted to shop from "green" beauty brands. First, the companies have an environmental aesthetic that incorporates an ethical sense of beauty (Todd, 2004). Organic beauty brands achieve this aesthetic by intimate participation and engagement with their customers as the performance of their products is derived from the product's properties and its sense of environmental sustainability (Todd, 2004). Organic beauty brands must also have a perceived ecological aesthetic to convince customers that the brand cares about the ecosystem and that they should too (Todd, 2004).

Another important detail for an organic beauty brand is natural involvement in products (Todd, 2004). Tom's of Maine promises the preservation of ecosystems using natural ingredients that are made without synthetic additives, while also promising that the products are created to work for customers and communities (Todd, 2004). Meanwhile, The Body Shop has made their focus on making products that not only make humans look good, but also to make them feel good and do good for humans too (Todd, 2004). The Body Shop's message conveys to their customers as a reminder that you reflect nature and become inspired by nature when focusing on your appearance (Todd, 2004).

**Korean Skincare**

Some of the trending "natural" skincare products currently are Korean skincare products. For the longest time, Korean skincare was not sold in the United States. However, in 2011, BB cream, a lightweight cosmetic that evens out skin tone and can contain sunscreen, became the first Korean skincare product to be exported to the United States and it immediately became a giant success (Nguyen et al., 2020). After the growing demand for BB cream products, more Korean skincare products, including face masks and skin serums, started to be imported into the United States (Nguyen et al., 2020). In terms of monetary value, export costs of Korean beauty increased from $1 billion dollars to $2.6 billion dollars from 2012 to 2015 and increased by 389% in the United States from 2013 to 2017 (Nguyen et al., 2020).

Korean skincare products have been successful because they involve natural ingredients in the formulations, which are advertised to produce results of healthy, youthful skin. Some natural ingredients found in Korean beauty products include animal-

derived such as starfish powder, snail mucin, bee venom, and various plant materials (Nguyen et al., 2020). Some of the many common botanical ingredients found in Korean beauty products include aloe vera, chamomile, cherry blossom, ginseng, green tea, and turmeric (Nguyen et al., 2020). These botanical ingredients promise consumers various benefits including moisturized skin, cleared acne, cancer prevention, and healed wounds (Nguyen et al., 2020). Despite these wonderful benefits that plant ingredients found in Korean beauty can provide, how can botanical ingredients be safe enough for humans to use on their skin?

**Biosurfactants vs. Chemical Surfactants**

Beauty products from major cosmetic and skincare brands often are manufactured in warehouses with exposure to many chemicals inside the products and in the production environment. Surfactants are substances that help reduce surface tension of water to release tension caused by the products (Karnwal et al., 2023). Chemical surfactants are surfactants that contain a chemical origin (Karnwal et al., 2023). Chemical surfactants can cause skin irritation and allergies depending on the chemicals present in the product (Karnwal et al., 2023). To ensure care for the skin, the largest organ in the body, scientists have recommended replacing chemical surfactants with biosurfactants (Karnwal et al., 2023).

Biosurfactants are agents of biological origin mainly produced by bacteria and other secondary metabolites (Adu et al., 2020). Separation processes like extraction and distillation are used to separate the biosurfactants from the secondary metabolites without the addition of organic synthesis (Adu et al., 2023). Besides being “naturally derived”,

biosurfactants are also biodegradable, non-toxic, and environmentally friendly, which makes them safer for the environment too (Karnwal et al., 2023).

Despite the claims by Karnwal and other researchers (2023) that biosurfactants are great alternatives for chemical surfactants, they do list reasons why some people may prefer to use chemical surfactants. One reason why people may continue to use products with chemical surfactants is because there is a wider availability of products in the market containing chemical surfactants (Karnwal et al., 2023). Some commonly used chemical surfactants found in cosmetics include sodium-lauryl-sulfate and sodium-dodecyl-sulfate (Karnwal et al., 2023). Another reason why people may be drawn to use chemical surfactants is because of their ability to remove dirt from the skin, condition hair, and moisturize the skin (Karnwal et al., 2023). However, there is not a clear answer as to which mechanisms trigger the potential harmful consequences of chemical surfactants (Karnwal et al., 2023). These consequences include allergies, skin inflammation, and abnormalities in the skin (Karnwal et al., 2023). If chemical surfactants are commonly used in commercialized beauty products, then why are biosurfactants replacing them?

Biosurfactants are more beneficial to include in commercialized beauty products as they have a biological origin that can help the human skin in several ways (Karnwal et al., 2023). Biosurfactants can act as moisturizers for the skin (Karnwal et al., 2023). The researchers created an anti-dandruff shampoo that contained a mixture of biosurfactants and antidandruff properties, which was found to improve the shampoo’s anti-dandruff properties (Karnwal et al., 2023).

Given the benefits that biosurfactants have, there are also some complications that they have compared to chemical surfactants. One of the downsides of biosurfactants is

that large-scale production of biosurfactants is harder to achieve due to them being naturally derived (Adu et al., 2023). Meanwhile, chemical surfactants are easier to produce in large amounts because there is organic synthesis involved in their production. However, scientists have been creating ways to allow for larger-scale productions of biosurfactants. Some ways that scientists have been able to create larger amounts of biosurfactants include metabolic engineering and the usage of microbial enzymes in products (Adu et al., 2023).

Another reason why biosurfactants can have disadvantages is because they are usually made with a mixture of congeners instead of just one compound (Adu et al., 2023). Congeners are variants with similar structures, which is a problem for biosurfactants because each congener has different bioactivities and when being mixed, it is hard to determine how each congener is prepped for the mixture (Adu et al., 2023). These congener mixtures can cause allergies and sensitivities in natural skincare products (Adu et al., 2023).

**Extraction and Purification of Botanical Ingredients**

In order to obtain the specific ingredients needed for skincare products, the botanical source of the ingredient is run through different extraction and purification processes for only the ingredients they need. The extraction processes help extract the specific ingredient needed for skincare products by separating the specific ingredient from other ingredients that source of the desired compound may have. Meanwhile, the purification processes help rid the extracted ingredient of any imperfections.

The polysaccharides within plants hold medicinal properties that promote healthier skin (Yao and Xu, 2022). For example, cyanobacteria have become an

increasingly popular ingredient to include in natural products because of its compounds which resist UV radiation and heat (Yao and Xu, 2022). *Nostoc,* a genus of cyanobacteria, has been studied by multiple researchers who have concluded that it has allergen-inflammation suppressing properties, as well as properties that help delay aging (Yao and Xu, 2022). Bacterial polysaccharides have become a favorable alternative to other naturally sourced polysaccharides because their production is not strongly affected by seasonal conditions and because they do not need to undergo chemical reactions or extreme temperature changes (Albuquerque et al., 2022). Despite the favorable conditions of bacterial polysaccharides, scientists still use plant polysaccharides due to their high starch content and cell wall components (Albuquerque et al., 2022).

Prior to modern extraction practices due to advanced technologies, botanical ingredients were extracted and purified without the use of advanced technology. Botanical ingredients were prepared to be used in skincare products using multiple methods including crushing, maceration, decoction, infusion, ashing, and fermentation (Fongnzossie et al., 2017). Some of the botanical ingredients were used raw without any preparation (Fongnzossie et al., 2017). Thanks to technology improvements, botanical ingredients are extracted and purified at quicker rates.

Extraction methods are required to be performed before purifying the ingredients, to separate the botanical extracts from their sources. Plant cell walls help provide support for the plant, but they also contain primary and secondary compounds (Keegstra, 2010). The primary wall contains many primary compounds including hemicellulosic polysaccharides, glycoproteins, and lignin, which allow reorganization of cellular components within the plant during growth (Keegstra, 2010). On the other hand,

secondary compounds include cellulose and large amounts of lignin (Keegstra, 2010). Because polysaccharides have large, hydrophilic, polar molecules, water is used as the solvent for extraction most times (Albuquerque et al., 2022). Using water as the solvent is beneficial because there is no reagent pollution, it makes the process simpler and safer, and allows for “an improved polysaccharide solubility” (Albuquerque et al., 2022). However, there are also cons for using water as the solvent, including low production, high energy consumption, and long processing time (Albuquerque et al., 2022). Hot water extraction has been successful in extracting polysaccharides from red ginseng, which is a botanical ingredient used to prevent skin aging (Yao and Xu, 2022).

Acidic and alkaline extraction methods are also used to acquire compounds for cosmetics. Acidic extraction destroys the cell wall of plants, which allows the polysaccharides to be released (Albuquerque et al., 2022). Acidic extractions have high extraction rates but are also known to modify the polysaccharide structure (Albuquerque et al., 2022). Alkaline extractions are another extraction method similar to acidic extractions but are performed with alkalines instead of acids. Alkaline extractions are sometimes used instead of acidic extractions because they produce large concentrations of extracts and have shorter extraction times, but they also have a disadvantage (Albuquerque et al., 2022). If high amounts of alkali are used in the extraction process, hydrolysis could destroy the polysaccharides' structure (Albuquerque et al., 2022).

Enzymolysis (breaking substances down with enzymes) is another extraction method used for botanical ingredients. Enzymes are proteins that facilitate and speed up chemical reactions. Enzymolysis is primarily used to facilitate the breakdown of plant cell walls (Albuquerque et al., 2022). Because the enzymes expose and promote the

dissolution of active ingredients that were within the cell wall more quickly, enzymolysis is preferred over other extraction methods (Albuquerque et al., 2022). Enzymolysis is also preferred over other extraction methods because there is a reduced use of chemical reagents, it is a simple process, and it has improved extraction efficiency (Albuquerque et al., 2022). Despite the preference for enzymolysis, it also has disadvantages. Disadvantages when using enzymolysis include the pricing of enzymes and "limiting factors, such as enzyme mass concentration, temperature, and pH levels associated with large-scale application" (Albuquerque et al., 2022).

Ultrasonic extraction is also used to break down polysaccharides. Ultrasonic extraction allows the breakdown and acceleration of the dissolution of organics within cells, which allows for higher concentrations of polysaccharides to be present (Albuquerque et al., 2022). Ultrasonic extraction can be combined with water extraction or enzymolysis to increase extraction concentrations whenever the ultrasonic extraction does not produce high concentrations by itself (Albuquerque et al., 2022). "UE has the advantages of high extraction efficiency, short time, and low energy required to work effectively, while the main disadvantage is the difficulty to reach the best frequency, solid-liquid ratio, and temperature conditions" (Albuquerque et al., 2022).

Because each of the extraction methods listed have disadvantages that do not always allow for the best extraction concentrations to collect, scientists have been investigating new extraction methods to use for botanical ingredients. An extraction method that scientists have been testing for extracting natural ingredients is the supercritical carbon dioxide extraction method (Albuquerque et al., 2022). Supercritical carbon dioxide extraction could be successful in extracting natural ingredients because of

the carbon dioxide's supercritical fluid, which is a compressed liquid made up of gas and liquid properties (Albuquerque et al., 2022). Supercritical carbon dioxide extraction is an ideal method for natural ingredients is because "the supercritical fluid of carbon dioxide can be safe, non-toxic, not easy to burn, and leaves no solvent residue, in addition to presenting strong selectivity, low temperature, and the ability to maintain the activity of the components" (Albuquerque et al., 2022).

New extraction methods have also been created due to beneficial polysaccharides being found in new botanical sources. The *Dendrobium* orchid is a flower that is rich in bioactive polysaccharides with bioactivities, but most of the plant was not able to be used due to the lack of successful extraction for commercial use (Yao and Xu, 2022). This led scientists to create an eco-friendly extraction method to use green solvents to extract polysaccharides from the *Dendrobium* flowers, which proved that *Dendrobium* flowers can be effective in cosmetic products due to its skin moisturizing properties (Yao and Xu, 2022). The extraction method allows for the flower part of the orchid to be used in cosmetic formulation, in addition to stem polysaccharides that were previously used in cosmetics (Yao and Xu, 2022).

Once polysaccharides have been extracted from the plant, they have to go through a purification process to get rid of any impurities that may still be present. Purification processes also allow scientists to learn about each compound's properties as opposed to learning about multiple properties after extraction (Albuquerque et al., 2022).

Before purification methods can take place, the polysaccharides go through denaturation and centrifugation processes. Denaturation, the process of breaking up proteins, occurs before purification, allowing the maximum number of denatured proteins

to be removed prior to the purification processes (Albuquerque et al., 2022). Centrifugation processes separate molecules based on their individual densities and properties (Albuquerque et al., 2022). However, it is difficult to reach good purity when using these methods by themselves, so they are combined with enzymatic methods for improved purification (Albuquerque et al., 2022).

Pigments in ingredients also need to be removed because they can oxidize the polysaccharides and affect the identification of the polymers (Albuquerque et al., 2022). To decolorize the pigments, microporous resins and hydrogen peroxide solutions are used instead of activated carbon (Albuquerque et al., 2022). Activated carbon was originally used to decolorize pigments because it allowed for suitable large-scale production, but had many restrictive factors, such as low yield for purification (Albuquerque et al., 2022). Once the pigments in the ingredients have become decolorized, the ingredients are then sent through purification processes. However, some plants contain more polysaccharide than others. For example, *Anadenanthera colubrina* is a tree that has polysaccharide concentrations with high pigment abundancy, but also contains properties that maintain skin hydration (Yao and Xu, 2022). Because the abundant pigments made it difficult to easily de-pigmentize the tree extracts, researchers had to develop a pigment-free agent that contained *A. colubrina* polysaccharide-rich dermo-cosmetic preparation (Yao and Xu, 2022).

Because impurities can still exist in an ingredient after it has been through an extraction process, a purification process needs to occur. There are three main categories of purification processes: physical separation, chemical precipitation, and chromatographic purification (Albuquerque et al., 2022). Physical separation is a

purification process that separates membranes and uses ultracentrifugation (Albuquerque et al., 2022).

On the other hand, chemical precipitation is “performed with organic reagents and salt solutions” (Albuquerque et al., 2022). The two most common reagents used in precipitation processes are ethanol and methanol, which separate polysaccharides that have large solubility and molecular weight differences (Albuquerque et al., 2022). However, methanol and ethanol use are minimized due to their toxicity (Albuquerque et al., 2022). Meanwhile, salt solutions that contain sodium or potassium are used in chemical precipitation purification processes to isolate acidic polysaccharides (Albuquerque et al., 2022).

The third common purification process is column chromatography (Albuquerque et al., 2022). Chromatography is a process that allows for mixtures to be separated by passing the mixture through a medium to purify compounds (Albuquerque et al., 2022). Column chromatography separates targeted ingredients with the help of stationary and mobile phases (Albuquerque et al., 2022). There are three types of column chromatography: affinity column chromatography, gel filtration chromatography, and ion exchange column chromatography (Albuquerque et al., 2022). These different types of chromatography are commonly used together because they are more effective separating polysaccharides with a high viscosity and a tendency to aggregate (Albuquerque et al., 2022).

Despite these purification methods being able to perform by themselves, scientists combine multiple processes for higher yields (Albuquerque et al., 2022).

**Regulatory Systems**

How do we know that natural skincare products are safe to use? To ensure that the skincare products are safe to use, they must be checked by regulatory systems. Regulatory systems follow guidelines set to ensure human safety when using certain products. To promote innovation and limit trade restrictions, a couple of international organizations have been founded to achieve these goals (Ferreira et al., 2022). Three organizations that have put efforts towards these goals are the International Cooperation on Cosmetics Regulation, the Organization for Economic Co-operation and Development, and the International Organization for Standardization (Ferreira et al., 2022). These organizations have met annually to discuss cosmetic safety and regulations. Despite these efforts, some countries have their own regulations and opinions that differ from the international organizations' opinions. Therefore, the regulatory systems and guidelines vary differently for each country.

In the United States, cosmetics are regulated by the Food and Drug Administration (FDA). The FDA defines cosmetics as products that are "intended to cleanse, beautify, enhance attractiveness, or change appearance" (Pratiwi et al., 2022). The Food and Drug Administration (FDA) has enforced both the Federal Food, Drug and Cosmetic Act (FD&C Act) and the Fair Packaging and Labeling Act (FPLA) in the 1900s with few changes being made since (Ferreira et al., 2022). The FD&C Act does not give a definition for cosmetics (Vaishampayan and Rane, 2022). The FDA has restricted and/or prohibited bithionol, chloroform, and mercury in cosmetics (Pratiwi et al., 2022). These ingredients have been banned or restricted in cosmetic use because they have caused harm to human health. For example, bithionol is banned in the United States and the

European Union because it has caused photosensitization in many consumers (Pratiwi et al., 2022).

Currently “eight out of the fifty states (California, Hawaii, Illinois, Maine, Maryland, Nevada, New Jersey and Virginia) in the United States have banned animal testing” (Ferreira et al., 2022). However, the rest of states have not banned animal testing because “even though the FD&C Act does not specifically require the use of animals in safety cosmetic studies, and while the FDA supports the use of alternative methods for the refinement, reduction and replacement of animal testing, it is the manufacturers’ responsibility to employ whatever tests are deemed necessary to sustain the safety of their products” (Ferreira et al., 2022; Pratiwi et al., 2022).

On the other hand, the European Union (EU), an organization of participating European countries, has banned animal testing (Ferreira et al., 2022). To ensure that the EU is not marketing products that have been animal tested, a cosmetic product safety report has a product information file (PIF) filled with important information about the product (Ferreira et al., 2022). The PIF is divided into two categories: cosmetic product safety information and cosmetic product safety assessment (Ferreira et al., 2022). The cosmetic product safety information contains the product’s “quantitative and qualitative composition, physical/chemical characteristics and stability, microbiological quality, impurities, traces and information about the packaging material, normal and reasonably foreseeable use, exposure to the cosmetic product, exposure to the substances, toxicological profile of the substances, undesirable effects and serious undesirable effect, and information on the cosmetic product” (Ferreira et al., 2022). On the other hand, the cosmetic product safety assessment section contains information about the “assessment

conclusion, labeled warning and instruction of use, reasoning, and the assessor's credentials and approval (Ferreira et al., 2022). The PIF also contains "the manufacturing method and a statement of compliance with good manufacturing processes; proof of the effect claimed for the cosmetic product and data on any animal testing performed by the manufacturer, his agents or suppliers, relating to the development or safety assessment of the cosmetic product or its ingredients, including any animal testing performed to meet the legislative or regulatory requirements of third countries" (Ferreira et al., 2022).

Because animal testing is banned by the EU, they use different testing methods to ensure that ingredients are safe to use. The EU uses toxicokinetic models, topical toxicity tests, and systemic toxicity tests as alternatives for animal testing (Almeida et al., 2017). Toxicokinetics is the amount of time that it takes for toxicants to clear the human body (Almeida et al., 2017). Toxicokinetic models are used to assess the toxicology of an ingredient and are significantly improving as testing methods (Almeida et al., 2017). Despite improved toxicokinetic testing, only one model has been approved for cosmetic use to evaluate ingredient absorption properties by using human skin static or flow-through diffusion cell models (Almeida et al., 2017). On the other hand, various topical toxicity tests have been used to assess toxicity associated with eye-irritation, skin irritation and corrosion, and skin sensitization (Almeida et al., 2017). Systemic toxicity tests include phototoxicity, carcinogenicity, genotoxicity, and endocrine system toxicity tests (Almeida et al., 2017).

Unlike the United States, the European Union is stricter with regulations regarding cosmetics. The EU defines cosmetics as substances intended to "be placed in contact with the external parts of the human body or with the teeth and the mucous

membranes of the oral cavity in order to clean them, perfume them, changing their appearance, protect them, keep them in good condition, or to correct body odors" (Pratiwi et al., 2022). Cosmetic regulation performed in the EU is covered by the following guidelines: EU Cosmetics Directive 76/768/ EEC (Vaishampayan and Rane, 2022). These guidelines help ensure proper packaging of cosmetics, ensure that necessary constraints are set for ingredients, and provide accessible information for inspections done by enforcement authorities (Vaishampayan and Rane, 2022). The EU has a regulatory framework that is responsible for cosmetic legislation and allows each member state to have a regulatory harmonization (Ferreira et al., 2022). The EU also has a regulatory list called Annex II of the Cosmetic Products Regulation, which prohibits certain substances from being placed in cosmetic products (Pratiwi et al., 2022). Not all ingredients listed in Annex II have been placed in cosmetics but are prohibited from being placed in them due to safety concerns. Annex II of the Cosmetic Products Regulation lists at least 1,600 ingredients including formaldehyde, chloroform, cadmium, and furocoumarin (Pratiwi et al., 2022). For example, cadmium was prohibited from being used in cosmetic products because it is a known human carcinogen and can be absorbed through the kidney and liver if a product with the ingredient was used (Khan and Alam, 2019). Cadmium can also lead to kidney damage and cause damage to the human bones, making them weak or deforming them (Khan and Alam, 2019).

The regulatory systems and their guidelines also vary depending on the origin of the product and whether the products are natural or non-natural. In the United States, the Food and Drug Administration does not have "organic" or "natural" as terms for cosmetics and their regulations (Franca and Ueno, 2020). Meanwhile the EU defines

conventional cosmetics, which are cosmetics made with synthetic chemicals, but does not mention organic or natural cosmetics (Franca and Ueno, 2020). Despite organic and natural cosmetics not being mentioned in the regulation systems that are widely used, there are certification systems used specifically to determine if a product could be determined as natural. Certification systems are systems that "verify the ingredients, processes, production, storage of raw materials, packaging, labeling, energy use, waste management and labeling of producers" (Franca and Ueno, 2020). Products that have been certified have many benefits including "the control and track of the raw material supply chain, increased confidence in the product brand, recognition and differentiation of the product in the market" (Fonseca-Santos *et al.*, 2015; Franca and Ueno, 2020). Green certification systems are starting to make their appearance in many countries including, "Bundesverband Der Industrie-und Handelsunternehmen (Germany), Ecocert (France), Instituto Biodinâmico de Certificações (Brazil), Istituto per la Certificazione Etica e Ambientale (Italy) and Natrue (Belgium)" (Franca and Ueno, 2020). In order to be certified as an organic or natural product, the product must contain a minimum percentage of natural or organic ingredients. The percentage requirements vary depending on the certification system being used. For example, IBD requires a 15% organic material makeup for its "natural cosmetics with organic portions" label, while Ecocert requires a 95% for Ecocert's "natural cosmetic" label (Franca and Ueno, 2020).

The United States Department of Agriculture (USDA) has created four different labels to signify that products contain organic ingredients, depending on the organic concentrations (Fonseca-Santos et al., 2015). Organic labels were originally created for consumables but can now be applied to cosmetics if they meet the criteria of the labels

(Fonseca-Santos et al., 2015). The “100% organic” and “organic” labels require the products to only contain organic ingredients and require the ingredients to be processed in organic methods, as well as labeling each ingredient as on the information panel as a part of the ingredient name or having a symbol to signify that the ingredient is organic (Fonseca-Santos et al., 2015). Products with a "Made with Organic" label must contain at least 70% of its ingredient makeup with organic ingredients and cannot be processed with ionizing radiation or excluded methods (Fonseca-Santos et al., 2015). Lastly, the “Less than 70% Organic” label given by the USDA requires the products to omit the term “organic” anywhere on the display panel, but the products can have ingredients that are organically produced, and USDA certified as “organically produced” on the information panel (Fonseca-Santos et al., 2015).

**New Botanical Ingredients Being Tested in Skincare**

With the evolution of natural skincare comes the need to experiment with new botanical ingredients to combat new or previously existing skin issues. Testing new ingredients in natural skincare products could result in new alternatives for people who may be allergic to a specific botanical ingredient and could lead to new cosmeceutical discoveries.

An experimental study took place to see if there was an ingredient that could reduce skin aging while also possessing other bioactivities that could help other skin issues (Susano et al., 2022). *Saccorhiza polyschides*, also known as brown seaweed, was chosen as the botanical ingredient to be tested on because of its bioactive potential according to previous studies (Susano et al., 2022).

The researchers observed the antioxidant, anti-enzymatic, antimicrobial, anti-inflammatory, and photoprotective properties of the seaweed species to determine if the plant ingredient was successful in aiding skin health or not (Susano et al., 2022). Antioxidant properties of *S. polyschides* were run 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity, ferric reducing antioxidant power, and oxygen radical absorbance capacity assays (Susano et al., 2022). The results of the assays were compared to a reference compound, butylhydroxytoluene (Susano et al., 2022). Anti-enzymatic properties were examined through collagenase, hyaluronidase, elastase, and tyrosine activity, with tyrosine having the highest inhibited activity (Susano et al., 2022). Tyrosinase is an important enzyme that helps prevent skin discoloration (Thibane et al., 2018). It has been found that a reduction of tyrosinase enzyme activity can cause skin discoloration and dark spots to form (Thibane et al., 2019).

The antimicrobial activity of *S. polyschides* was measured by the growth of *S. epidermidis*, *C. acnes* and *M. furfur*. The strongest antimicrobial effect was on *C. acnes* (Susano et al., 2022). Anti-inflammatory properties were measured by the concentration of pro-inflammatory cytokines and anti-inflammatory cytokines in *S. polyschides*, which resulted in pro-inflammatory cytokines having a stronger presence than anti-inflammatory cytokines, which had no stimulated production. Meanwhile, the photo-protective properties of *S. polyschides* were observed due to the lack of cytotoxicity present (Susano et al., 2022). Photo-protective effects measure the sun protection factor which is the ratio of ultraviolet (UV) radiation required to produce a minimal erythema dose (MED) in protected skin to unprotected skin (Thibane et al., 2019). The MED is the amount of UV radiation that will produce minimal sunburn on unprotected skin, so it is

important to purchase products with higher SPF values for more protection from developing a sunburn (Thibane et al., 2019).

The only *S. polyschides* fraction that had photoreceptive abilities was the ethyl acetate fraction (Susano et al., 2022). Overall, *S. polyschides* was described as a potential natural ingredient to be added to natural skincare products. However, the study does mention that more research and experimentation is needed to ensure that *S. polyschides* extracts are entirely safe to include in natural skincare products.

Another experiment was conducted by Klimaszewska and other researchers (2021) to determine if blue honeysuckle would be an effective natural ingredient in large-scale production, as it is a relatively new natural ingredient to use in natural skincare. The researchers chose to use a face mask as the skincare product of choice because face masks usually contain a high content of active ingredients and come in different types (Klimaszewska et al., 2021). Blue honeysuckle (*Lonicera caerulea*) was chosen as the newer botanical ingredient to experiment with for many reasons. Blue honeysuckle is referred to by the native Ainu people of Hokkaido, Japan as, “elixir of life”, due to its many properties. The berries from blue honeysuckle are known to have “antioxidant, moisturizing, and anti-inflammatory properties”, as well as a high nutritional value (Klimaszewska et al., 2021). Blue honeysuckle was also an ideal choice for the researchers because blue honeysuckle is not difficult to cultivate and is highly resistant to pests, disease, and unfavorable weather conditions (Klimaszewska et al., 2021). Blue honeysuckle is also rich in phenolic compounds, polyphenols, anthocyanins, vitamins, and acids (Klimaszewska et al., 2021). The blue honeysuckle masks were created from scratch using plants and other ingredients, including the blue honeysuckle itself.

The blue honeysuckle face masks underwent various tests to find the product's stability, dynamic viscosity, yield point, texture analysis, and color parameters (Klimaszewska et al., 2021). Skin hydration was tested on skin on a person's forearm, with their consent, to determine which concentrations of blue honeysuckle promoted the most skin hydration (Klimaszewska et al., 2021). There were five different concentrations of blue honeysuckle formulated into the masks and a control tested on forearm skin (Klimaszewska et al., 2021). Face masks with 0.7% and 0.9% concentrations of blue honeysuckle promoted the highest results of skin hydration, leading to the conclusion that higher concentrations of blue honeysuckle powder will lead to increasing levels of skin hydration (Klimaszewska et al., 2021). The researchers concluded that the blue honeysuckle did not change the stability of the formulations, higher blue honeysuckle concentrations allowed for the product to be spread across the skin easier, and that face masks that contained the blue honeysuckle improved the skin's hydration (Klimaszewska et al., 2021). Given the success of the blue honeysuckle being incorporated into the face masks, it sheds light for more botanical ingredients to be incorporated into skincare products.

**Conclusion**

Despite knowing more about botanical ingredients and how they can be safe in natural cosmetics, there is not enough performed on each botanical ingredient to confidently say it is safe to use in skincare products. Therefore, more studies and research is needed to deem any botanical ingredient as "safe" for skin care usage. However, when research is done properly and multiple studies have been conducted to prove that the

ingredient is worth being skincare products, then it is worth incorporating the ingredient into natural skincare products.

In conclusion, botanical ingredients are safe to use in natural skincare products. Botanical ingredients can be deemed safe when regulatory systems ensure that safe extraction and purification processes were used, and that research has been performed on the ingredients.

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# Appendix A

Table 1. Botanical Ingredients and Their Cosmetic Purposes (Dini and Laneri, 2021; Dorni et al., 2017)

- (Dini and Laneri, 2021) is represented by *
- (Dorni et al., 2017) is represented by +

Table 1. Botanical Ingredients and Their Cosmetic Purposes (Dini and Laneri, 2021; Dorni et al., 2017)

| Key for Source | Scientific Name | Common Name | Bioactive Properties and Mechanism of Action of Ingredients |
|---|---|---|---|
| + | *Helianthus annuus* | Common sunflower | Moisture retention and skin softening |
| + | *Calendula officinalis* | Common marigold | UV protector, moisturizer, improves skin tone and texture |
| + | *Achillea millefolium* | Yarrow | Reduces oxidative stress |
| + | *Arnica montana* | Wolf's bane: Mountain tobacco | Moisturizer, soothing, and nourishing |
| + | *Chrysanthemum indicum* | Indian chrysanthemum | Free radical scavenger, reduces cellulite appearance, moisturizer, skin burn protector |
| + | *Matricaria recutita* | Chamomile | Soothing and lenitive |
| + | *Petasites japonicas* | Cardusmarianus | ounters irritation effects |
| + | *Caesalpinia spinosa* | Tara | Anti-wrinkle and moisturizer |
| + | *Ceratonia siliqua* | Carob tree; Locust bean | Moisturizing, repairing, antioxidant |
| + | *Lavandula angustifolia* | Common lavender | Antioxidant, anti-apoptotic, collagen stimulating activity |
| + | *Mentha piperita* | Peppermint; Mentha | Antimicrobial |
| + | *Ocimum basilicum* | Basil | Anti-hair loss activity and skin nourishing |

Table 1. Botanical Ingredients and Their Cosmetic Purposes (Dini and Laneri, 2021; Dorni et al., 2017)

| Key for Source | Scientific Name | Common Name | Bioactive Properties and Mechanism of Action of Ingredients |
|---|---|---|---|
| + | *Rosmarinus officinalis* | Rosemary | Antioxidant, protects skin collagen and elastic fibers, soothes skin, enhances elastin and hyaluronic acid production |
| + | *Salvia hispanica* | Chia | Contains antioxidative properties and collagen synthesis |
| + | *Thymus vulgaris* | Common thyme | A natural preservative for skincare products |
| + | *Avena sativa* | Oat | Soothes and moisturizes skin |
| + | *Oryza sativa* | Rice | Moisturizes and is anti-alopecia |
| + | *Saccharum officinarum* | Sugar cane | Cell renewing, soothing, and firming |
| + | *Secale cereale* | Rye | Provides skin with tensor effect |
| + | *Prunus armeniaca* | Ansu apricot; Siberian aprico; Armenian plum | Moisturizer and revitalizer |
| + | *Prunus domestica* | Plum | Causes keratinocytes to stop eating melanin, preventing uneven skin tone |
| + | *Prunus persica* | Peach; Nectarine | Anti-aging, exfoliating and regenerating |
| + | *Rubus idaeus* | Red Raspberry | Antioxidant, collagen synthesis and skin elasticity |
| * | *Aloe barbadensis* | Aloe vera | Antioxidant, anti-inflammatory, and water-retention properties |
| * | *Vitis viniferia* | Common grape vine | Contains antioxidant properties |
| * | *Coffea arabica* | Coffee | Contains antioxidant properties |
| * | *Glycine max* | Soybean | Contains antioxidant properties |
| * | *Citrus limon* | Lemon | Contains antioxidant properties |
| * | *Carica papaya* | Papaya | Contains scavenging effects and anti-inflammatory properties |
| * | *Theobroma cacao* | Cocoa beans | Contains antioxidant and anti-inflammatory properties |
| * | *Cocos nucifera* | Coconut | Contains antioxidant and anti-inflammatory properties |
| * | *Punica granatum* | Pomegranate | Contains antioxidant, antifungal, and anti-inflammatory properties |

End of Table 1