cosmetics

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Review

History of Natural Ingredients in Cosmetics

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Abstract: There has been interest in the history of cosmetics for the last several decades. In part, this renewed curiosity is probably due to the revolutionizing natural movement in the cosmetic industry. In this article, we provide an overview of the historical aspects of the use of natural ingredients in cosmetics, which mostly come from botanical and mineral sources. We begin with an introduction to the art and science of cosmetics in the ancient world, which includes accounts of Egyptian, Mesopotamian, Greek, and Roman cosmetics as well as Traditional Chinese Medicine and Ayurvedic Medicine. These dermatological and cosmetic practices, which were advanced for the time, paved the way for the current revolution of natural ingredients in cosmetic products. Without providing a comprehensive historical account, we surveyed selected cultures during different periods of time to provide some perspective of our current understanding of natural ingredients in cosmetics. Attention is also given to the rich contributions of body art by tribal societies to our knowledge base, especially in the areas of dyes and pigments. Finally, we offer some perspective of natural ingredient cosmetics in the Information Age.

Keywords: natural ingredients; cosmetics; history; botanicals; traditional Chinese medicine; Ayurvedic medicine; Egyptian cosmetics; Greek cosmetics; Roman cosmetics; body art

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1. Introduction

Dating back thousands of years, the use of cosmetic products has played an important role in humans' lives. They allowed for the enhancement of beauty, protection of the skin, care of the teeth, use of fragrance, and painting of the skin for cultural and religious purposes. Early in history, all cosmetic products were made of natural ingredients, mostly derived from plants, minerals, and animals. It was not until the twentieth century that synthetic and chemically modified ingredients became universally employed in cosmetics. Returning in the direction of early history, in the 1990s and early 2000s, the use of natural ingredients in cosmetic formulations started to become in vogue—a trend most likely set in motion by consumer demands and cosmetic manufacturers trying to distinguish themselves in the competitive marketplace. Initially, most of the natural ingredients were skin care actives, which elicited a biological response in the skin typically with the desired outcome of enhancing the structural integrity of the skin, providing solar protection, reducing chronic and photo-aging, and a host of other effects. Since then, there has been a much greater effort across many industries to produce more sustainable products. Materials and products characterized as sustainable should provide benefits to the consumer without harming the environment. This movement has led many companies in the cosmetics industry on a quest to find natural ingredients to replace their synthetic counterparts in formulation chassis. In this article, we provide a comprehensive review of the history of natural ingredients used in cosmetics with the hope that it will offer the reader some insight to developing novel natural-based products.

2. Egyptian Cosmetics

Cosmetics were an integral part of early Egyptian life, dating back to as early as 5000 BC [1–4]. Ahead of their time, the Egyptians were sophisticated cosmetic chemist formulators. Bathing was a part of their daily life, with most Egyptians bathing at home or in the river. Cleansing cream was made of animal fat or vegetable oil mixed with powdered lime and perfume. Oils and creams were used for protection against the harsh sun, wind, and dry climate. The lips and cheeks were treated with red ochre ground in water. People rubbed themselves daily with perfumed unguent oil that was soaked in scented wood. Perfumes were made of myrrh, thyme, marjoram, chamomile, lavender, lily, peppermint, rosemary, cedar, rose, aloe, olive oil, sesame oil, and almond oil [1]. The use of perfume had a very spiritual significance and was believed to optimize body function. Fingernails and the palms of the hands were treated with henna, producing an orange-red tone. In general, the variety of pigments based on natural minerals used by the ancient Egyptians for cosmetics is impressive [5,6].

One of the most distinctive cosmetic preparations used by the ancient Egyptians was kohl [7]. It is a dark cosmetic applied to the eyebrows, eyelashes, and perimeter of the eye. The wall painting displayed in Figure 1 clearly demonstrates the use of kohl by the ancient Egyptians. Analysis of samples from burial excavations provided evidence that green kohl was used in predynastic times (5000–3000 BC) with the principal ingredient being malachite ore (basic copper carbonate; $Cu_2(OH)_2CO_3$). In the Egyptian dynastic periods (3100–30 BC), kohl often contained galena ore (lead sulfide; PbS) as the most abundant ingredient, which provided a black color [8]. Throughout history, it was presumed that black kohl was predominantly made of stibnite (Sb_2S_3), a rarer mineral which gives a similar tone as galena ore. While stibnite has been found in excavated kohl samples, galena ore was more common. This misconception might stem from the use of the Latin word stibium for kohl or possibly the reference to stibnite in ancient Muslim texts as the proper ingredient for formulating kohl [9]. Often, minor components in kohl consisted of other lead-based compounds, such as phosgenite ($(PbCl)_2CO_3$) and laurionite (PbCl(OH)), which provided lighter tones to the resulting formula. Long chain fatty acids of animal origin were also found in kohl compositions. Although less prevalent, magnesium oxide (MnO_2) and brown ochre/iron oxide ($Fe_2O_3 \cdot nH_2O$) were also used as primary kohl ingredients. Later in history, kohl made from soot was more frequently used. See Figure 2 for an illustration for some of the minerals that were used in Egyptian cosmetic preparations.

Figure 1. Wall painting from Theban Tomb TT93. The tomb, located in the ancient Egyptian Theban Necropolis, is from the 18th Dynasty (1550–1292 BC). It belongs to Qenamun, who was the high steward for the pharaoh Amenhotep II. The use of kohl around the eyes is evident in the painting. The wall painting is on display at the Egyptian Museum of Barcelona. Image obtained by a license agreement with Alamy Ltd., Abingdon, Oxfordshire, UK.

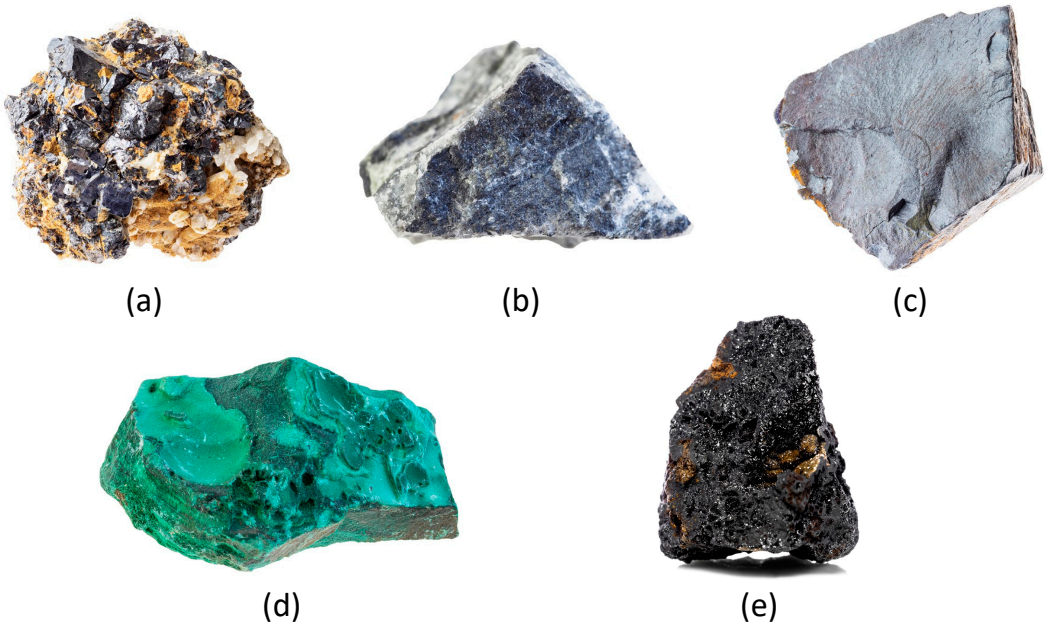


Figure 2. Minerals used in ancient Egypt for cosmetic preparations: (**a**) galena and sphalerite, (**b**) stibnite, (**c**) hematite, (**d**) malachite, and (**e**) manganese ore. Hematite is the primary ingredient in brown ochre. Photographs of the minerals by KrimKate were obtained through a license agreement with iStock (Getty Images), Calgary, Alberta, Canada.

Kohl was typically applied as a powder or paste (using a water-soluble gum) with a kohl stick. In addition to its cosmetic appeal, it was also applied as a salve to treat conditions and diseases of the eye. Today, kohl is still used in parts of Northern Africa and the Middle East. An analysis published in 2006 on the composition of modern-day Egyptian kohl products demonstrated that about 25% of the tested products were based on galena ore [8]. It should be noted that compounds containing lead are toxic and can enter the blood circulation by inhalation, ingestion, and percutaneous absorption. Lead compounds bioaccumulate in the body and are significantly more toxic to infants and children than to adults. They can cause intellectual disabilities, loss of hearing, and various other ailments. In the U.S., the Food and Drug Administration (FDA) does not approve the use of kohl products due to the presence of lead-based compounds. However, there are products that are labeled as kohl in the U.S., although in this case, kohl is a marketing term that is used to describe extremely dark shades of eyeliner.

Another important aspect of ancient Egyptian life was oral care [10]. Since the Egyptians used stone to grind wheat into flour, it is very likely that sand from the stones damaged enamel and other structural elements of the tooth [11]. Most archaeological evidence suggests that the Egyptians suffered from tooth decay, tooth loss, and dental abscesses. Interestingly, the earliest recorded dentist in the world was the Egyptian Hesy-Ra who lived during the Third Dynasty (First Dynasty of the Old Kingdom—2600 BC) [12]. Chewing sticks and wood have been used throughout history to clean the teeth. However, the ancient Egyptians are often credited for the first written recording of a toothpaste formula (ca. fourth century BC) containing a mixture of salt, pepper, mint leaves, and iris flowers [13]. Historically, salt and ash were used in dentifrices as abrasive ingredients serving a similar function as silica in today's modern-day preparations. Ironically, several commercial brands available on the market today contain salt as one of the principal ingredients. Most texts describe the first mints made by the Egyptians as containing frankincense, myrrh, and cinnamon, which were boiled with honey and shaped into pellets.

Ointments and perfumes also played an important role in Egyptian life. Ointments, principally composed of animal fats and probably scented, were applied to the skin to protect it from the harsh elements and extremely arid environment. Perfume was applied to the

body and was important for funeral and temple rituals. Typical ingredients used in ancient Egyptian perfumes consisted of cardamon, cassia, cinnamon, and frankincense [14]. Other ingredients often described in the literature include myrrh, thyme, marjoram, chamomile, lavender, lily, peppermint, rosemary, cedar, rose, aloe, olive oil, sesame oil, and almond oil [1]. Perfumes from this period were fat-based, since modern techniques of preparation based on distillation were not discovered until later. Therefore, perfumes often contained animal fats or plant oils since they absorb and retain fragrance molecules [15]. Most of the historical analyses of ancient Egyptian perfumes only describe the base material as fat- or oil-based due to the limited advances in chemical analysis techniques in the early 1900s. Some of the ingredients that would have been locally available in the region at the time would have been plant-based oils such as sesame oil (*Sesamum indicum* L.), castor oil (*Ricinus communis* L.), Balanos oil (*Balanos aegyptiaca* L.), and moringa oil (*Moringa oleifera*). Other oils, such as olive oil (*Olea europea*) and almond oil (*Prunus amygdalus*), as well as animal fats (ox, sheep, and fowl fat) could have also been used [14].

Hair styling is another facet of the ancient Egyptian cosmetic palette. Recent archaeological evidence has shown that hair gels were employed in ancient Egypt [16]. Tombs of people who underwent a mummification process were compared to those of tombs that were naturally mummified by extremely arid conditions. Mummies from both groups were found to have fatty material (palmitic and stearic acid) applied to their styled hair. Therefore, this data suggests that the coating of hair with a fatty substance was not necessarily a part of the embalming procedure. However, it should also be pointed out that during the mummification procedure, hair was often treated with fat-based preparations.

It should also be noted that, in some cases, ancient Egyptians shaved their heads to cope with the extreme heat as well as for sanitary reasons. Wigs have been found in excavations of Egyptian tombs, and it is believed that wigs probably were worn on the shaved scalp [17]. Furthermore, archeologists suggest that wigs were placed on the heads of shaved mummies to prepare them for the afterlife. For example, Queen Nodjmet who was relatively old when she died in 1064 BC, was found to have a wig believed to help her look younger for the afterlife (see Figure 3).

Figure 3. Photograph of the mummy of Queen Nodjmet (death in 1064 BC) illustrating her elaborate wig made of human hair. She was buried at the ancient Egyptian city Thebes and is now held at the Egyptian Museum in Cairo. The photograph of the mummy was obtained through a license agreement with Science Photo Library, Ltd., London, UK.

The analysis of another ancient Egyptian wig from the 18th Dynasty (New Kingdom; buried at Thebes ca. 1400 BC) held in the British Museum indicated there was a coating present with a composition of about two-thirds beeswax and one-third resin [18]. Unfortunately, the resin was never properly analyzed; however, myrrh gum resin (*Commiphora myrrha*) was commonly used in ancient Egypt. There are several different species of *Commiphora* indigenous to the northeastern African continent. In addition to its antimicrobial properties, myrrh is a remedy for numerous ailments in herbal medicine [19].

While most of the cosmetic treatments in ancient Egypt used natural ingredients that provided effective results, there are examples in the literature of potions that probably were not very efficacious. For example, a remedy for gray hair was published in the Ebers Papyrus (ca. 1550 BC) that consisted of placing a donkey's liver in a pot and letting it sit until it becomes rotten [20]. The liver should then be cooked in water and mixed with lard prior to application to the scalp. More than likely, this treatment probably does not work, although there are not any studies to the authors' knowledge that disprove it. In general, herbal medicine was important in ancient Egypt. Some medical prescriptions in dermatology consisted of acacia (*Acacia nilotica*), Aloe vera, and turmeric (*Curcuma longa*) for treating skin diseases and burns as well as serving as wound healing agents [21].

The ancient Egyptians are also renowned for their technique and understanding of the conservation of the human body for the afterlife. Mummification was a process that took about 70 days and consisted of first removing all the internal organs (including the brain) except the heart, which was believed to carry all the good and bad deeds of a person and, therefore, to be necessary for the final judgement in the afterlife. After organ removal, the body would then be covered in salt (natron) and allowed to dry for 40 days. Perfumed oils and plant resins were then applied to the skin followed by a thick layer of resin, which was used to glue strips of linen to the body. It is believed that embalming ingredients consisted of plant oil (e.g., sesame), balsam-type plant or root extract (e.g., bullrush), plant-based gum (e.g., acacia), and conifer tree resin (e.g., pine) [22].

3. Traditional Chinese Medicine

Traditional Chinese Medicine has been practiced in China for over two millennia. It is a system of medicine based on maintaining the balance between the internal organs of the body and the external elements. Essentially, it is balanced harmony between the two opposing forces: yin and yang. Practitioners of Traditional Chinese Medicine may use acupuncture, acupressure, moxibustion (burning herbal leaves near the body), exercising (e.g., tai chi), cupping (placing hot cups on the body to increase blood flow to the skin), or herbal remedies. Qi describes the vital energy that flows by different channels throughout our body. A primary goal of Traditional Chinese Medicine is to maintain the flow of qi. Herbal preparations can often be composed of many different types of ingredients, plant- and animal-based, that are mixed before consumption.

Bencao Gangmu (本草綱目), also known as Compendium of Materia Medica, is an encyclopedic work written by the 16th-century Chinese doctor Li Shizhen that covers all aspects of Traditional Chinese Medicine. There is considerable interest in the cosmetic and dermatologic community to better understand the potential Traditional Chinese Medicine ingredients for skin care [23–26]. Most of the skin remedies in Traditional Chinese Medicine are decoctions (multi-ingredient) that are taken orally for several weeks. Topical preparations often consist of a single ingredient. Treatments for psoriasis, atopic dermatitis, eczema, and other skin ailments are described in Bencao Gangmu.

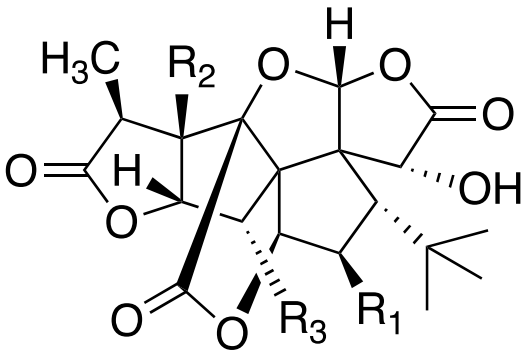
Herbal extracts are obtained by performing an extraction procedure on an indicated component of the plant (e.g., root, leaf, bark, etc.). Table 1 contains a list of several plant species that are used for the treatment of skin ailments in Traditional Chinese Medicine. *Carthami flos* is the floret of the safflower plant (*Carthamus tinctorius*), which belongs to the sunflower (*Asteraceae*) family. Mugwort has been used in traditional systems of medicine in different parts of the world. Nowadays, oral administration of mugwort is suggested for digestive problems, irregular menstruation, and high blood pressure. It also has properties

that make it useful as a sedative, laxative, and liver tonic. *Semen benincasae*, also referred to as Dong Gua Zi, is a melon whose seeds are crushed into a paste and then applied to skin. Taoren (*Semen persicae*) is the fruit kernel of peach (the kernel is the soft part of a seed). In general, there is renewed interest in understanding the history of skin care in China; however, there is not very much information available in the academic literature [27].

Table 1. Selected list of botanicals used in Traditional Chinese Medicine to treat skin [28].

Plant Species	Function	First Recorded Use
Carthami flos flower juice (*Carthamus tinctorius*)	Blush (Yan-Zhi) and skin softening agent	Shang Dynasty (16th–11th century BC)
Mugwort (*Artemisia stelleriana*)	Hair growth	Qin and Han Dynasties (221 BC–24 AD)
Chinese Waxgourd Seed (*Semen benincasae*)	Skin brightening and antiaging	Qin and Han Dynasties (221 BC–24 AD)
Taoren (*Semen persicae*) and Asian rice (*Oryza sativa*)	Facial cleanser for skin brightening	Tang Dynasty (618–907 AD)
Apricot seeds (*Semen armeniacae amarum*) and mica	Known as Yun-Mu cream and used to relieve black spots and acne	Song Dynasty (960–1279 AD)

The *Gingko biloba* tree is native to China and is the oldest living tree species. In western medicine, *Gingko* leaf extracts have been used for the last several decades to increase peripheral and cerebral blood flow as well as for the treatment of dementia. The extract of *Ginkgo biloba* leaves contains flavonoids and terpene tri-lactones. The flavonoids consist of flavone and flavonol glycosides, acylated flavonol glycosides, biflavonoids, flavane-3-ols, and proanthocyanidins. See Figure 4 for the structure of selected terpene tri-lactones (gingkolides) found in the *Gingko biloba* plant. *Gingko* seeds are used in Traditional Chinese Medicine to treat skin infections (topical antimicrobial). Present-day studies have shown that *Ginkgo* seed extracts protect against gram-positive skin pathogens: *Cutibacterium acnes*, *Staphylococcus aureus*, and *Streptococcus pyogenes* [29].



	R_1	R_2	R_3
Gingkolide A	H	OH	H
Gingkolide B	H	OH	OH
Gingkolide C	OH	OH	OH

Figure 4. Molecular structure of selected terpene tri-lactones (gingkolides) isolated from the Gingko biloba plant.

Pearl powder has been used in Traditional Chinese Medicine since the early part of the Common Era as a health, cosmetic, and nutrient supplement. The empress Wu Zetian (625–705 AD) consumed pearl powder and applied it to her face for its brightening/lightening properties. Calcium carbonate ($CaCO_3$) is the most abundant ingredient in pearls. The organic matrix contains proteins, glycoproteins, and polysaccharides. Pearls also contain silica, calcium phosphate ($Ca_3(PO_4)_2$), aluminum oxide, and iron oxide as well as trace elements (sodium, manganese, selenium, aluminum, and copper). Recent studies have shown the potential of pearl powder to treat wounds and atopic dermatitis as well as to stimulate fibroblast proliferation and collagen synthesis [30].

Nail polish was introduced in China around 3000 BC. Nail polish formulations consisted of beeswax, egg whites, and gelatin with orchids or roses. Initially, red and black tones were preferred, and nail polish was reserved for the higher echelon of society [31]. During the Zhou Dynasty (1050–221 BC), women of all classes could wear nail polish. Higher social ranking individuals painted their nails and covered them with silver and gold dust. Average Chinese women were allowed to wear neutral colors (e.g., pink). Not abiding to these norms could result in punishment and even the death penalty. During the same period, the early Egyptians also painted their nails (mostly with henna). Cleopatra is known for wearing a henna-based red nail polish. Berries were also used to stain the nails. Nail painting was also carried out during the era of the Babylonian empire.

4. Ayurvedic Medicine

India has a deep-rooted tradition of herbal medicine that has been facilitated through several systems of medicine, namely Ayurveda, Unani, Siddha, naturopathy, and homeopathy. In recent years, there has been great interest in understanding the scientific mechanisms responsible for many of the phytochemicals used in these different medical modalities, especially from an herbal cosmetics perspective [32–36]. For the sake of brevity, we only touch upon certain aspects of Ayurvedic medicine and the treatment of skin.

Developed in India, Ayurveda has been practiced for more than 3000 years. Literally translated, Ayurveda comes from the Sanskrit words ayur (life) and veda (science or knowledge). It is an herbal medicine system deeply rooted in the philosophy of healthy living and maintaining proper balance in our physiological and psychological being. Illness is treated using natural ingredients which target the disease with the intent to restore proper balance. India is one of the most biodiverse regions in the world, offering a variety of plant sources for the many treatment modalities of Ayurveda.

Skin care is an important part of Ayurveda [37,38]. Diet and water are believed to play an important role in the overall health state of the skin. In general, Ayurvedic treatments focus on skin beauty as well as treating skin disorders, such as acne vulgaris, aging skin, eczema, psoriasis, and vitiligo. Sesame oil, which contains lignan compounds (sesamin and sesamolin) is used as a base in many Ayurvedic cosmetic preparations. Face mask preparations traditionally contain buttermilk and goat milk powder—rich in vitamin A, B6, B12, and E—providing emollient properties to the skin. A popular shampoo ingredient is the herb shikakai, which comes from the shikakai pods and nuts of the *Acacia concinna* shrub. The pods contain saponins, which acts as mild detergents [39].

Some examples of botanical ingredients used in ayurveda for the treatment of skin are provided in Table 2. Aloe vera has been used by some of the ancient cultures for millennia, including China, Greece, Egypt, India, and Mexico. Mucopolysaccharides in Aloe vera bind water and help maintain moisture levels of the skin. Aloe vera contains numerous vitamins (vitamin C, vitamin E, and beta-carotene), enzymes (anti-inflammatory and metabolism of sugars and fats), minerals (to promote enzyme activity), anthraquinones (laxatives), and hormones [40].

Calendula officinialis (marigold) has reported wound healing properties, especially during the inflammation stage of wound healing and production of granulation tissue [41]. *Curcuma longa* (Curcumin) is the yellow pigment obtained from the rhizome of the perennial herb turmeric. It has received a lot of interest in recent years as a skin treatment due to anti-inflammatory, antimicrobial, antioxidant, and anti-neoplastic properties [42].

Table 2. Selected list of botanical ingredients used in Ayurvedic Medicine for skin care.

Medicinal Plant	Botanical Name	Function	Reference
Aloe vera	*Aloe barbadensis miller*	Moisturizing; antiseptic	[40]
Marigold	*Calendula officinialis*	Wound healing	[41]
Curcumin (turmeric)	*Curcuma longa* L.	Improve complexion; antiseptic; treatment of eczema and acne	[43]
Coco grass; purple nutsedge; java grass; nut grass	*Cyperus rotundus* L.	Hair growth regulation; anti-inflammatory; antibacterial agent	[44]
Gotu kola	*Centella asiatica*	Wound healing; burns; psoriasis; scleroderma	[45]

In many instances, botanicals used in Ayurveda may not be readily available. Therefore, practitioners of Ayurveda often use substitute ingredients (due to limited availability), which should have similar pharmacological activity to the original botanical ingredient. One example is Ativisha (*Aconitum heterophyllum*), which is used for treating a variety of ailments, but has limited availability [46]. Coco grass (a substitute for Ativisha) is considered one of the world's worst weeds, known for infecting crops and other plants. In addition to its role as an alternative for Ativisha, coco grass was also shown to regulate hair growth, which was suggested to result from the activity of flavonoids on the androgenic activity of the hair follicle [44].

Gotu kola (*Centella asiatica*) is an herbaceous plant that has been used to treat a host of ailments in Ayurveda and other traditional medicines. The principal active ingredients are saponins (triterpenoids), which are surface active glycosides. Gotu kola is used to treat wounds, eczema, psoriasis, and many other skin ailments [47]. In wound healing, its mechanism of action is believed to result from the proliferation of fibroblasts leading to an increase in collagen synthesis, elevated levels of fibronectin in the extracellular matrix, and a reduction of inflammation [45].

5. Color Cosmetics on the Indian Subcontinent

Historically, India has a very rich cosmetic cultural tradition, although it can be very diverse from region to region. Some of these traditions extend beyond present-day India into Pakistan, Sri Lanka, Bangladesh, and other neighboring countries. Many customs are associated with religious ceremonies or social status. In the paragraphs that follow, we provide a few examples of natural ingredients used in Indian color cosmetics [48].

5.1. Kumkum

Kumkum, also known as kumkuma, is an important color cosmetic powder traditionally made from lime water and turmeric. Lime water—also referred to as slaked lime—is a saturated solution of calcium hydroxide, which is produced when calcium oxide is mixed with water. Calcium oxide (quicklime), which is caustic and alkaline, results from the thermal decomposition of limestone and seashells. Curcumin, the principal ingredient of turmeric, is responsible for its yellow color, which becomes red with increasing pH (see Figures 5 and 6). Early in history, lime was used as a plaster agent, fertilizer, hair dye, and soap ingredient.

Figure 5. Photograph of (**a**) turmeric and (**b**) kumkum. The image by Akash Kharvi was obtained through a license agreement with Alamy Ltd., Abingdon, Oxfordshire, UK.

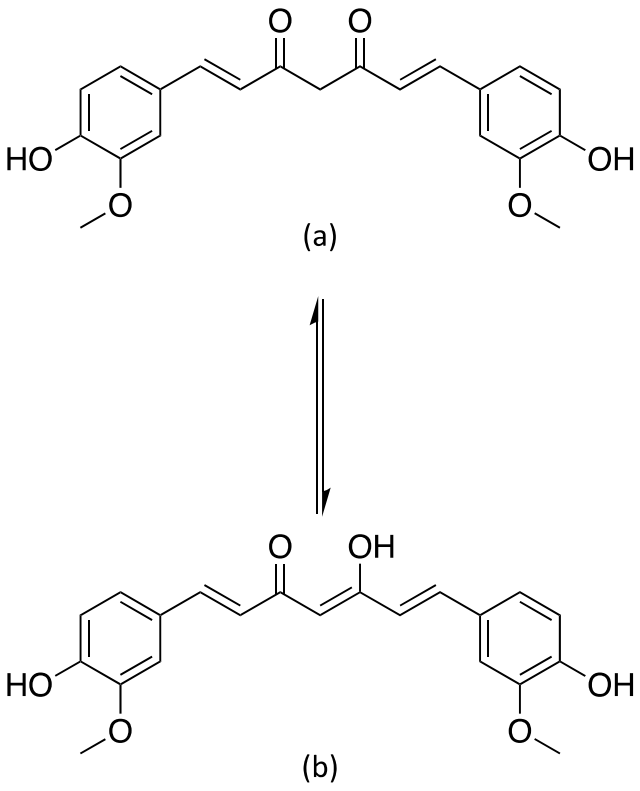


Figure 6. Molecular structure of curcumin, the chief component of turmeric. At low pH, it primarily exists in the (**a**) keto form, which tautomerizes to the (**b**) enol form at higher pH.

Kumkum is still commonly used today for social and religious rituals in India. For example, one of its popular uses is for puja, which is a ritual offering to gods in Hinduism. In addition, married Indian women part their hair and apply kumkum daily at the part line at the top of the forehead. This application is often referred to as vermilion (sindoor in Hindi). In some cases, kumkum is applied as a dot (known as bindi) to the forehead of

women as part of the religious tradition of Hinduism, Buddhism, Jainism, and Sikhism. Although, nowadays it is more common to use a sticker or some other type of material.

Over the last several decades, numerous commercial kumkum products have become available to the consumer in the form of powders, liquids, and pastes. Many of these formulations contain conventional synthetic or natural ingredients that have been processed. Possibly, this could be the reason for studies in the literature, which report contact dermatitis resulting from the use of kumkum [49,50]. Nowadays, some of the products that claim to be organic and/or natural kumkum use borax (sodium borate salt), alum (hydrated sulfated salt of aluminum), lemon/lime juice, plant powders, and plant oils (e.g., sesame, jojoba, almond). The salts provide the necessary caustic conditions for curcumin to change its color from yellow to red.

5.2. Kajal

Like the ancient Egyptians, people residing on the Indian subcontinent used to apply (and still do) a dark eyeliner known as kajal. Essentially, it was the same composition as kohl (already discussed in the section Egyptian Cosmetics) where the mineral galena was the primary ingredient. Its use stems from the perceived protective effect of the eye from UV radiation and for religious reasons. Even today, in the medical community there is significant concern of its use, especially by the younger generation [51]. In addition to lead sulfide (PbS) found in galena, commercial formulations have been reported to contain minium (Pb_3O4), amorphous carbon, magnetite (Fe_3O_4), and zincite (ZnO) [52]. Carbon black has become a more common modern-day version of kajal, which circumvents any issues that could be associated with lead poisoning from traditional kajal. It should be pointed out that some scientists distinguish between the chemical composition of kohl and kajal [48].

5.3. Henna

Henna comes from the plant *Lawsonia inermis* and is a traditional ingredient with a long history of use which dates to the ancient civilizations. In Ayurveda, it is recommended for various ailments including some skin diseases and scabies. It is most well-known for its hair dyeing properties, especially in the regions of present-day India, Pakistan, and Iran. Lawsone (see Figure 7) is the principal dye molecule component responsible for its characteristic orange-red color. Henna is also the primary dye component used in the body art Mehndi, which has been practiced since the 4th or 5th century BC and is still common today in India and surrounding regions. Mehndi is typically administered on the hands and/or legs and is especially popular for traditional Hindu weddings.

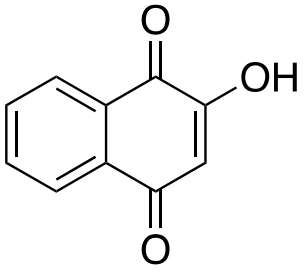


Figure 7. Molecular structure of lawsone, the principal dye molecule in henna.

Modern-day hair dyes based on henna often contain other dyes in addition to henna as well as metallic salts [53]. The preparation and application of henna hair formulations is a more time-consuming process than conventional hair dye systems. In addition, the colorfastness of conventional commercial hair systems is greater than natural henna dyes.

6. Cosmetics in Ancient Mesopotamia

Often referred to as the cradle of civilization, Mesopotamia (today known as the Middle East) developed in the region bound by the Tigris and Euphrates rivers in Southwest Asia. The Sumer civilization played an important role in developing culture, commerce, and infrastructure. The Sumerians were the first people to develop cities in this area dating back to approximately 3000 BC. Later, Babylon and Sumer became two important cities in this region. Cosmetic chemistry was not as well developed in Mesopotamia as it was in ancient Egypt; however, cosmetic practices by its inhabitants were later adopted by the Ancient Greeks, Romans, and other civilizations in the Mediterranean region [54,55].

Much of what is known about Mesopotamian cosmetics comes from ancient texts written in cuneiform as well as archaeological expeditions of burial sites, which have revealed a variety of cosmetic containers. Fragrance and incense were very important to the Sumerians and even represented a mode of connecting with the deities. Herbs, oils, and wood were used to create many of the incense varieties. Different colors of pigments were applied to the face as a form of color cosmetics. Eye cosmetics were an important aspect of color cosmetics and primarily consisted of antimony paste, which could be applied using an object shaped like a needle [56]. The use of eye cosmetics was very similar to the customs in Egypt—essentially another form of kohl. Lotion and unguent formulations were devised to care for the skin and protect it from the powerful UV radiation and dry climate in the region.

7. Cosmetics and Dermatology in Ancient Greece and Rome

According to ancient Greek literary and archeological evidence, cosmetic use in Greece did not appear until the bronze age (3200–1100 BC). Fragrances and unguents were applied for their cosmetic and medicinal properties and at times used for rituals [57]. There was a noteworthy Egyptian influence on the development of Greek cosmetics. Some of the cosmetic ingredients used during that time for color cosmetic applications included chalk (limestone), lapis-lazuli (a deep blue metamorphic rock), and malachite (discussed in the section Egyptian Cosmetics) [58]. During the archaic period (800–490 BC), women started to treat their skin with lead-based creams that provided a whitening effect. The use of such lead-based formulas to make the skin appear whiter persisted until the 18th century in Europe.

Cosmetics in Rome evolved from the Greek tradition and continued to play an important role in people's lives. Most of what we know about Roman cosmetics comes from the scientific writings of Pliny the Elder and Cornelius Celsus [59]. Other information comes from literature and poetry (e.g., the poet Ovid). Some of the beauty attributes during this period include pale skin, joining of the two eyebrows by a patch of hair (monobrow), and blonde or auburn (reddish-brown) hair. Skin lightening became increasingly important since Roman women spent more time outside of the house than their Greek predecessors. While cosmetics were used by all echelons of society, for women with a higher standing in society, cosmetics were typically applied in a small room with the help of female slaves known as cosmetae.

In addition to color cosmetics, skin care and dermatology were also important in ancient Rome. Table 3 contains a selection of different treatments that were included in the works of Pliny the Elder and Cornelius Celsus and summarized by Ursin et al. [60]. Rather than an exhaustive list, selected ingredients are discussed. The first ingredient in the table is *Alcyonium*—the soft coral genus (sponge-type) from the Mediterranean Sea—which, according to ancient legends, served as the nest for the halcyon, a bird nowadays that is identified as the kingfisher. While there is certainly a fair amount of literature describing different ingredients in *Alcyonium*, to the authors' knowledge there are not any published studies focused on its efficacy in the treatment of the skin.

Table 3. Ingredients used to treat certain ailments of the skin as described by Pliny the Elder and Cornelius Celsus [60]. Many of the ingredients are used in combination with other ingredients for treatment.

Ingredient	Botanical Name	Pliny the Elder	Cornelius Celsus
Soft coral	*Alcyonium*	Removes lichens, leprous sores, and freckles	Treat vitiligo †
Bulb of narcissus (daffodil)	*Narcissus tazetta*	Removes blemishes and softens skin	Erodent that exfoliates skin
Honey	*Mel*	An emollient and used to remove pimples	Used to prevent pimples, freckles, and moles
Myrrh	*Commiphora myrrha*	Made into a tisane; cures sores on the head and face	Erodent that removes cicatrices
Orris root	*Iris germanica* or *Iris pallida*	Used for ointments; remedy for skin conditions and freckles	Cleanser

† Vitiligo in ancient times is distinct from modern-day vitiligo.

The second ingredient in Table 3 is narcissus, which is a genus of perennial plant that is commonly known as the daffodil. There are two published studies (by the same group) that demonstrate its efficacy in the prevention of chronological skin aging—it was proposed that a decrease in cell turnover time produces this effect [61,62]. In another study looking at cell proliferation and dermal structural components, an increase in the production of growth factors, signaling molecules, structural biomarkers, and oxidative stress indicators was observed for a blend of *Narcissus tazetta* bulb extract and *Schisandra chinensis* fruit extract [63].

According to Pliny the Elder and Cornelius Celsus, honey was used in ancient Rome for its emollient properties and to treat pimples, freckles, and moles. In recent decades, there has been a significant amount of interest in the therapeutic properties of honey for treatment of the skin [64,65]. In addition to simple carbohydrates (fructose and glucose), honey contains enzymes, vitamins, minerals, and other molecules with bioactivity. Furthermore, honey has antimicrobial properties, which has led to interest in its use against pathogenic microorganisms that mitigate the skin [66,67]. More than likely, its potential as a wound healing agent stems from its antimicrobial activity [68–70]. Moreover, the immunomodulating properties of honey should provide additional support for wound healing and the treatment of other skin disorders [71].

Myrrh has been used to treat ailments of the skin since antiquity. It is obtained from the sap that is secreted as an exudate from the *Commiphora myrrha* tree. Myrrh is considered a natural remedy for wounds, infections, and acne and is also used as a perfume agent. The antiseptic, anesthetic, and antitumor properties of myrrh are attributed to the terpenoids (isoprenoids), especially the furanosesquiterpenes [72]. See Figure 8 for a representative example of a molecule from the furanosesquiterpenes class. Surprisingly, there have not been many studies aimed at better understanding the potential of myrrh in skin care [73,74]. There has been concern about potential skin sensitizers in myrrh due to the high degree of variability in the sources of myrrh and the complex nature of the myrrh exudate [75].

Orris root (*Rhizoma iridis*) is the root from the plant *Iris germanica* or *Iris pallida*. Traditionally, it was used as a skin treatment in folk medicine in several different cultures. Nowadays, it is an important fragrance and perfume ingredient [76]. There are many bioactive molecules present in orris root including benzoquinones, flavonoids, sterols, and triterpenes [77]. Irones (see Figure 9) are the key molecules that provide the typical orris root scent and are commercially important in the fragrance industry [78]. In a recent study, there was interest about the potential of orris root to impede the activity of the stress hormone, cortisol, in skin [79].

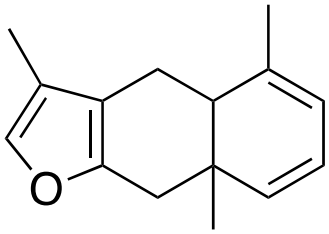


Figure 8. Molecular structure of furanoeudesma-1,3-diene, one of the furanosesquiterpenes, which contributes to providing myrrh with its unique fragrance characteristic.

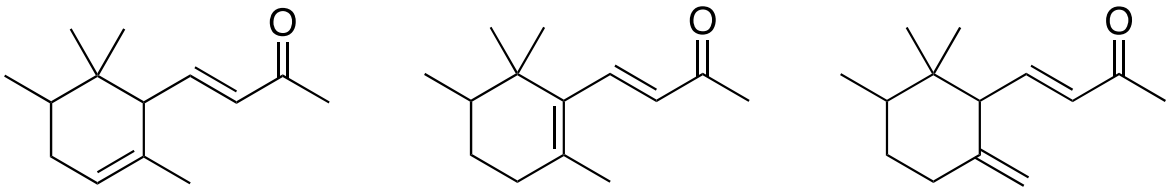


Figure 9. Molecular structure of (**a**) α-, (**b**) β-, and (**c**) γ-irones which are responsible for the characteristic fragrance odor of orris root oil.

8. Cosmetics in Europe during the Renaissance and Modern Era

The Renaissance was a cultural movement in Western Europe (born in Florence, Italy) resulting in a rebirth of the arts, sciences, and humanities. The Renaissance period (15th and 16th centuries) was a transition from the Middle Ages to the Modern Era, which began around 1500 AD. Keeping in mind the influence of the Roman Catholic Church on society during the Middle Ages, it is not surprising that the use of cosmetics, or more specifically makeup, was frowned upon and often viewed as a defiance of God's natural creation.

8.1. Venetian Ceruse

One of the hallmark cosmetic treatments of the Renaissance and early Modern Era was a concoction based on lead carbonate ($2PbCO_3 \cdot Pb(OH)_2$), which was applied to the face to give women a lighter appearance. Light skin symbolized youth and fertility. While this was not the first time in history that such treatments were applied to skin (the ancient Egyptians, Greeks, Romans, and Chinese also used lead carbonate in cosmetics), it is the most notorious period probably due to its widespread use among the aristocracy and its display in artistic portraits [80]. Ceruse was typically prepared with water, vinegar, and lead carbonate. Venetian ceruse refers to a particular type of ceruse that was of the highest quality, probably due to the purity of white lead.

Queen Elizabeth I of England (see Figure 10) is probably one of the most well-known historical figures that used Venetian ceruse to whiten her face. As a child, she had smallpox, which in sixteenth-century Europe had a mortality rate of 30%, leaving her deeply scarred for life. For this reason, she used ceruse and other preparations, giving her an almost clown-like appearance. Maria Coventry, Countess of Coventry (1733–1760 AD) and London society hostess, was another known figure during this period who was afflicted with the negative consequences of using lead carbonate-based cosmetics. At the age of 28, the Countess of Coventry died from lead poisoning [81]. Often, the use of ceruse led to the formation of eruptions on the skin, which women tried to cover up by applying more ceruse, thereby creating a vicious cycle.

Figure 10. Portrait of Queen Elizabeth I of England and Ireland ca. 1588 AD by George Gower. The photograph by Ann Ronan Pictures was obtained through a license agreement with Getty Images, Seattle, WA, USA. Elizabeth I ruled from 1558 to 1603 AD and was the last monarch from the house of Tudor. The original painting is held at the National Portrait Gallery, London, UK.

The symptoms of lead poisoning consist of abdominal pain, constipation, hearing loss, irritability, learning disorders, seizures, and vomiting. In a recent study, it was suggested that many post-Renaissance artists (e.g., Francisco Goya, Caravaggio, Michelangelo) were afflicted by this disease, often referred to as saturnism, due to exposure to lead in paints [82]. Today, exposure to heavy metals in face paint is still a concern for Chinese opera actors [83].

8.2. Cinnabar

Queen Elizabeth I was also known for wearing lipstick containing cinnabar as well as applying cinnabar to the cheeks to obtain a rouge effect. Cinnabar is a mercury sulfide mineral (Figure 11). It is the most common ore used to obtain refined elemental mercury. Overexposure to mercury leads to neurotoxicity, which affects the body's nervous system. Cinnabar has been used in Traditional Chinese Medicine and Ayurveda for thousands of years; however, in today's health-conscious environment, there certainly are concerns about its toxicity [84]. Nowadays, some commercial color cosmetics (e.g., lipstick) brands use the word cinnabar as a description of the makeup color.

8.3. Perfumed Gloves

During the Elizabethan period (1558–1603 AD), perfumed gloves were also a popular item for members of the upper strata of the social scale. They were often hung on the belt as an indication of a woman's status. A recommended procedure for producing the perfumed glove is as follows: Add clove powder, ambergris, musk, *Lignum aloes*, and *Acorus calamus* to a mixture of angelica and rose water. Boil until half of the liquid vaporizes, then strain it. Immerse the gloves in the liquid and allow them to hang dry. Repeat this procedure two times [85].

Angelica (*Angelica archangelica*) is an herb, which, according to folklore, is named for the archangel Michael who appeared to a monk in his dream during one of the plagues in Europe. The angel led the monk to the *Angelica archangelica* plant, which cured people with the disease. Angelica water is made by boiling the angelica root in water, while rose water is prepared by placing rose pedals in boiling water. Cloves are flower buds from the

tree *Syzygium aromaticum*, which is native to the Maluku Islands in Indonesia. Ambergris is a substance produced by the sperm whale (*Physeter macrocephalus*). Much of the whale's diet consists of squid and cuttlefish, which contain indigestible components. Over a long period of time, they form a solid mass known as ambergris, which is secreted by the whale. Used for millennia, ambergris is a rare and expensive ingredient that is highly sought after in the perfume market [86].

Figure 11. Photograph of cinnabar illustrating its red color and dull luster. The photograph by Bjoern Wylezich was obtained through a license agreement with Shutterstock, Inc., New York, NY, USA.

Musk has been used in perfumery for many years. It is the glandular secretion from several different species of animals (e.g., the musk deer, muskrat, etc.). Some plants (e.g., *Angelica archangelica*) also produce compounds that have a characteristic musk smell. Natural animal musk is no longer used due to ethical reasons; however, plant-based as well synthetic musk has been used in the fragrance industry.

Lignum aloes (agarwood) come from the heartwood of Aquilaria trees that are native to Southeast Asia and have been used since antiquity in incense and perfumes [87]. The aroma of the essential oil is extremely sought after, especially in the Arab world, and is extremely expensive (agarwood is the most expensive wood in the world) [88]. Stress to the tree caused by a fungus induces the formation of the aroma. The aromatic and medicinal properties of agarwood are thought to arise from about 150 identified compounds that include sesquiterpenoids, chromones, and volatile aromatic compounds [89].

Acorus calamus (sweet flag) is an herbaceous plant that contains psychoactive chemicals. If ingested, it can be toxic, which is why its commercial sale is banned in the United States. Methyl isoeugenol and cyclohexanone are two major components of the essential oil, which has antimicrobial activity against a range of microorganisms including *Propionibacterium acne* [90].

9. The Perfume Industry in France

Perfumes played an almost essential role in most of the ancient civilizations [91]. During the crusades, many scents were brought back to Europe from the Eastern Mediterranean. The crusades were a series of wars (ca. 1096–1291 AD) between the European Christians and Muslims to take control of the Holy Land, located in modern-day Israel. In the Renaissance period, perfume was mostly worn by royalty and the upper echelon of society to mask body odor. During the reign of Louis XV (18th century AD), his court became known as *la cour perfume* due to their excessive use of perfume. Madame Pompadour (mistress of Louis XV), Marie Antoinette (18th century AD; last queen of France before the French Revolution), and Duchesse d'Aumont (18th–19th century AD) are well-known figures in French history who were perfume enthusiasts. The nobility did not practice very good

personal hygiene primarily due to their fear of water and the belief that most diseases were transmitted through water.

It is not surprising that France converted into the perfume capital of the world. As early as the 14th century, the cultivation of perfume-bearing plants began in the south of France [92]. Grasse, a small village just north of the French Riviera, became the center of the perfume industry. Some of the plant species harvested in the south of France consisted of jasmine (*Jasminum grandiflorum*), lavender (*Lavandula*), marjoram (*Origanum majorana*), mimosa (*Acacia dealbata*), rosemary (*Salvia rosmarinus*), savory (*Satureja hortensis*), and thyme (*Thymus*). Figure 12 contains a photograph of a blooming lavender field in Grasse, France.

Figure 12. Field of lavender in Grasse, France. The photograph by Remedios was obtained through a license agreement with iStockphoto (Getty Images), Calgary, Alberta, Canada.

10. Traditional Japanese Customs

Cosmetics in Japan evolved from face painting (with red pigment) during the Kofun period (300–538 AD) to some of the most advanced products in today's market. Early cosmetics in Japan (ca. 6th century AD) were influenced by China and Korea, which later transitioned into its own distinct form. Historical hallmarks of Japanese cosmetics include whitening the face, applying beni to the lips, and blackening the teeth—treatments which provided an almost mask-like appearance [93]. The white powder applied to the face and known as oshiroi contained lead carbonate, with the same composition as ceruse, which was applied in Europe during the Renaissance and Modern era. Beni (lipstick) was formulated by making a pulp of the safflower plant (*Carthamus tinctorius* L.) and then extracting the red and yellow dyes. Beni was normally placed in small bowl and became red when moistened. Komachi beni—made from pure high-quality safflower—dates as far back as the Edo period (1603–1867 AD) in Japan. Two principal dye components in the safflower plant are carthamidin (yellow) and carthamin (red), whose molecular structures are provided in Figure 13 [94,95]. Carthamin is not soluble in water while carthamidin is water soluble. Nowadays, carthamin (Natural red 26) is used as a color additive in food

and cosmetic products. The safflower plant contains many molecules of pharmacological importance [96].

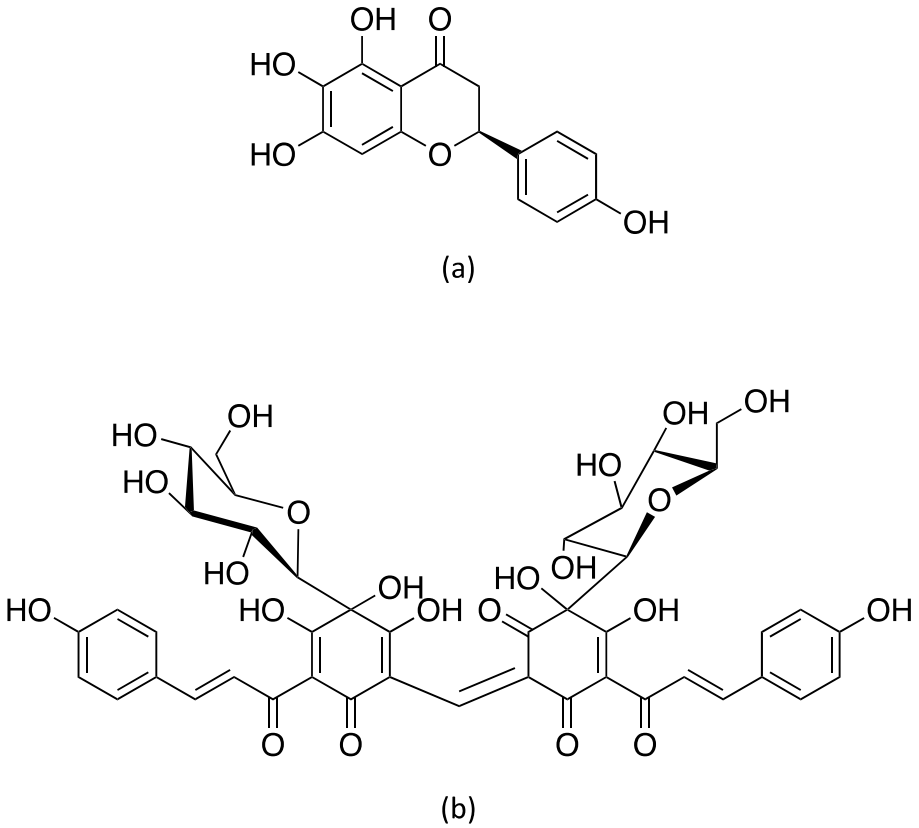


Figure 13. Molecular structures of (**a**) carthamidin and (**b**) carthamin, the yellow and red dye molecules, respectively, found in safflower.

Staining the teeth black (o-haguro) dates back thousands of years ago in Japan. Dark objects were considered beautiful in Japanese culture. Kanemizu solution was made by mixing ferric acetate (from iron filings) with vinegar and tannins (from tea or vegetables). Traditionally, tooth darkening indicated a person was at the beginning of adulthood. Later, aristocrats and nobles stained their teeth daily. These customs were also adopted by the geisha in which case a maiko would stain her teeth black when graduating to become a geisha.

11. Body Art in Tribal Cultures

Body art has been practiced by humans since prehistoric times and is still common among many indigenous and tribal cultures worldwide. It serves to express identity, prepare for battle, attract the opposite sex (e.g., courtship), and perform rituals (honor the gods and other spiritual motives) among many other reasons. We will discuss body art that is still practiced today by societies in Africa and South America as well as provide some historical perspective of the body painting customs of indigenous tribes in North America and Mesoamerica. A variety of natural ingredients have been used to paint the body and face throughout history including several types of ochre, minerals, and botanical preparations. Typically, black, white, red, and yellow have been the principal colors used by most ancient and present-day tribal societies. Most of the ingredients used to obtain these colors require minimal processing (e.g., simple grinding to a powder) and are mixed with a binder material.

11.1. Body Painting by African Tribes

Let us begin our journey in the African continent where the art of body painting is still in full force today. The text entitled *Painted Bodies: African Body Painting, Tattoos, and Scarification* by Carol Beckwith and Angela Fisher is highly recommended for readers who wish to learn more about the body painting customs in Africa [97]. Beckwith and Fisher spent many years traveling across Africa photographically documenting the customs of many of its inhabitants. In the paragraphs that follow, we summarize some of their findings in relation to the art of body painting.

Chalk and red ochre are two of the most common ingredients used to adorn the skin. In many areas in Africa, they are easily obtained at riverbanks where they are exposed due to erosion. Both materials are ground into a fine powder and then mixed with either animal fat (e.g., to make an unguent) or water (to make a paste). Chalk (limestone) is a soft, porous material composed primarily of calcium carbonate ($CaCO_3$). Ochre is a natural clay pigment that can range in color from yellow to orange, red, and violet. Ochres contain various types of iron oxides such as hematite and goethite as well as white pigments (e.g., aluminosilicate, quartz, and calcium minerals) [98]. Red ochre has been one of the most used pigments worldwide throughout history and contains the mineral hematite, which gives it is characteristic reddish hue [99]. In general, clays have been used to treat dermatological diseases, clean the skin, provide moisturization, and provide UV protection [100,101].

The Surma and Karo tribes in Ethiopia are known for their use of chalk and red ochre in body paint. Chalk can be applied to the entire body, and designs can be made using the fingers, providing a stark contrast with the dark skin of the subject. Alternatively, a natural paintbrush can be used to apply the chalk, creating various patterns on the skin. Figure 14 contains a photograph of a Surma man with facial and body painting demonstrating the use of chalk.

Figure 14. Photograph of a Surma man with facial and body painting using chalk. The photograph was obtained in Kibish, Omo River Valley, Ethiopia. Image obtained by a license agreement with Alamy Ltd., Abingdon, Oxfordshire, UK.

The Masai people in the Great Rift Valley in Kenya and Tanzania also use red ochre quite extensively. Every 7–12 years during the eunoto ceremony, young warriors paint themselves with red ochre to mark their transition into elderhood. The Masai are renowned for the intense hue of their red ochre as compared to other African tribes. Herbs or plant extracts are often added to the red ochre formulation.

The Himba people live in the northwest corner of Namibia (near the Namib desert) and are also renowned for their use of red ochre in the form of paste called otjize, which contains red ochre, fat, herbs, and powdered bark. Similar to other indigenous societies, red ochre symbolizes blood. The Himba apply otjize every day, which provides protection against the harmful ultraviolet rays of the sun and the arid conditions of the desert. Figure 15 contains a photograph of a young Himba woman with otjize applied to the skin and hair giving it a reddish hue. The hair arrangement is typical for Himba women styled into thick lustrous braids that symbolize their fertility.

Figure 15. Photograph of a young Himba woman taken in Opuwo, Namibia, demonstrating the reddish hue provided by red ochre on the skin and hair. The photograph by Jim Zuckerman was obtained by a license agreement with Alamy Ltd., Abingdon, Oxfordshire, UK.

The Wodaabe nomads in Niger make tattoos on their body by creating incisions and applying charcoal, which results in a bluish hue. Typically, these tattoos are situated near the mouth and eyes as it is believed that evil spirits can enter the body though the orifices. Mothers start tattooing their children as infants to protect them from the spirits. Interestingly, in the early 1990s, the body of Ötzi the Iceman (estimated to have lived ca. 3250 BC during the Copper Age) was found preserved in an Alpine glacier on the boarder of Austria and Italy with approximately 61 tattoos in the form of lines and crosses also made with charcoal [102]. The tattoos appeared to be located along acupuncture and pressure points, suggesting that they were for therapeutic reasons and not for cosmetic adornment.

Voodoo is a major religion in West Africa. During voodoo ceremonies, a white kaolin paste, ash, and palm oil are applied all over the body and represent a food offering to the

gods. Kaolinite ($Al_2Si_2O_5(OH)_4$) is the principal clay mineral found in kaolin, which has a white to gray characteristic color. In central Africa, the Dinka men from South Sudan apply the ash from cattle dung fires all over their body each night to provide protection against mosquitoes and other insects. They also bleach their hair with cattle urine.

11.2. Ingredients Used in Native American Body Art

Native Americans have a deep-rooted tradition of adorning themselves with dyes and pigments. Face and body painting were conducted for a variety of reasons including battle (war paint), spiritual reasons, mourning, attracting the opposite sex, and many other motives. Each color had a meaning. For example, in many tribes, red was for war while white was for peace and purity. In some tribes, only men painted their skin, while in others, the women also painted themselves. Some tribes practiced body painting on special occasions for rituals while others applied pigments to their skin on a daily basis. The Plains Indians (indigenous people of the Great Plains and Canadian Prairie) were particularly known for painting themselves in relation to their achievements in battle [103]. Much of what we know about the cosmetic painting customs of Native Americans comes from the work of George Catlin who painted portraits and provided a historical account of their customs and practices.

The Native American tradition of body painting in North America was very diverse due to the number of different tribes spread across a large landscape. Today, the United States government recognizes 574 tribes in the 48 contiguous states and Alaska. Like mainly places in the world, red ochre was a principal ingredient of the Native American palette. In many instances, it was applied over the entire body. For this reason, Caucasians who migrated from Europe probably mistakenly identified Native Americans as having red skin. Figure 16 provides an example of the very subtle use of red ochre by a member of the Ojibbeway Nation.

Figure 16. Painting of Boy Chief, Ojibbeway (1843) by George Catlin held at the National Gallery of Art, Washington, DC, USA. The subtle use of several pigments (e.g., red ochre) on the subject's face in the painting is evident. Image obtained by a license agreement with Alamy Ltd., Abingdon, Oxfordshire, UK.

Some examples of pigments used by selected Native American tribes, located in present day California, are provided in Table 4. While charcoal had various uses, in

some Native American societies, a charcoal preparation was painted around the eyes and oftentimes even on the eyelids to prevent sun glare from decreasing visibility and damaging the eye.

Table 4. Pigments used by tribes in the California region [104].

Ingredient	Use	Tribe
Charcoal and red ochre	Prevent sunburn and protect the eyes	Modoc
Soapstone (steatite)	Thin layer on the skin of babies to provide solar protection	Kumeyaay
Chalk mixed with saliva	Warriors paint the face white and create designs using fingers or a brush (negative painting)	Modoc
Red ochre	Prevent sunburn	Chumash
Kaolin	Paint the legs white to increase the speed of runners	Juaneño and Luiseño
Red ochre	Apply to chafed buttocks of the baby	Paiute

11.3. Cosmetic Practices in South America and Mesoamerica

In pre-Columbian America, archaeological evidence demonstrates that applying colorants to the skin was a common practice in many societies and civilizations that inhabited these lands. Cosmetics were used to decorate the dead for funerary rituals and to adorn the alive. Just like in many other societies in Africa, North America, Asia, and Australia, the people of South America and Mesoamerica utilized basic ingredients from the Earth for their painting rituals. For example, black hues were obtained from charcoal (burnt wood), charred bone (burnt animal bone), and manganese compounds (e.g., manganese oxide). On the other hand, white pigments typically came from natural earth clays (e.g., kaolin), limestone (one of the principal minerals is calcite, which is calcium carbonate ($CaCO_3$)), and gypsum (calcium sulfate). Red ochre and its derivatives provided reddish hues to the South American and Mesoamerican palette. Body painting in the Americas was also accomplished with botanical ingredients.

Table 5 provides a list of several ingredients that were popular in pre-Columbian Mesoamerica. Carmine is a bright red dye that is obtained by extracting carminic acid from the cochineal insect and mixing with aluminum or calcium salts. Nowadays, carmine (also known as C.I. Natural red 4 or C.I. 75470) is a popular dye ingredient in cosmetics and food products (see Figure 17). It can be found in color cosmetic preparations, such as lipstick and some selected foundations. Carminic acid itself is a dye as well as several of its derivatives such as carmine. In the western hemisphere, carminic acid is obtained from the *Dactylopius coccus* species of cochineal. However, carminic acid can also be obtained from the *Porphyrophora hamelii* (Armenia) and *Porphyrophora polonica* (north-central Europe) species.

Table 5. Selected list of some botanical ingredients used in Mesoamerica as skin colorants [105].

Ingredient	Source	Application
Carmine	Extract from cochineal (*Dactylopius coccus*)	Red dye
Annatto	*Bixa orellana* (achiote) seed pods	Red dye
Axin	Grease obtained by crushing the insect *Coccus axin* or *Llaveia axin*	Ointment and medicinal treatment for skin conditions; also a base for pigments.
Palo de campeche (*Haemotoxylum campechianum*)	Dye is obtained from the heartwood of the tree	Black dye

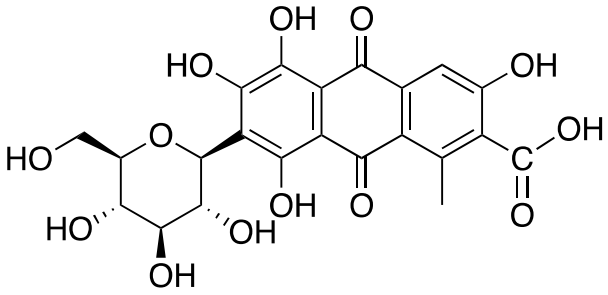


Figure 17. Molecular structure of carminic acid (Natural red 4; C.I. 75470).

The achiote shrub, sometimes referred to as the lipstick tree, produces a hairy fruit (similar in appearance to the lychee) that contains seed pods. Red body paint can be made by grinding the seeds into a paste producing a red-orange color substance called annatto. Today, annatto is used in food products, cosmetics, and pharmaceuticals. Bixin (an apocaretonoid) is the principal ingredient providing annatto with its characteristic color (see Figure 18).

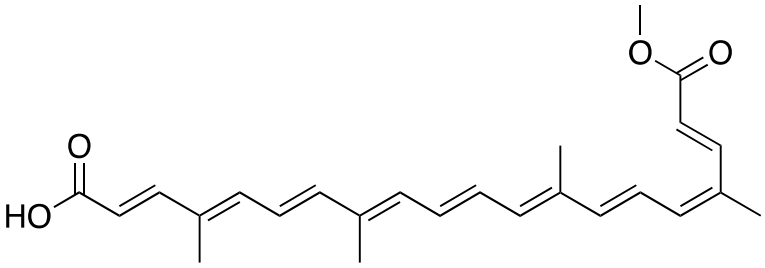


Figure 18. Molecular structure of bixin, the primary apocarotenoid found in annatto.

Boiled extracts of mealy bugs, *Coccus axin*, had many applications in traditional ancient Mexican culture including ointment, lacquer, and perfume. It was applied to skin as a treatment for ailments and burns as well as an anti-inflammatory agent [106].

Finally, the last item in Table 5 is palo de campeche, a member of the legume family, which is also known as the blackwood, longwood, or bloodwood tree. A black dye, obtained from the red heartwood, was traditionally used as face paint in Mesoamerican tribes. Later, the Europeans used it as a textile dye in the 17th–19th centuries.

The Kayapó are a tribe known for their body art skills from the Amazonian region of Brazil. In recent years, the Kayapó people have been protagonists in Brazil's struggle with balancing economic development and protecting the Amazon Forest. Much debate arose during the construction of the Belo Monte Dam on the Xingu River, which was completed in 2019.

Typically, women and children of Kayapó society paint themselves with patterns that demonstrate their harmony with the insects and bees—a belief that stems from their ancestral heritage. Figure 19 contains a photograph of several young Kayapó women where one can observe such patterns. Typical ingredients used by the Kayapó as body paint include crushed seeds from the achiote shrub (red hues), liquid from the *Genipa americana* fruit (black color), and charcoal (dark hues). Interestingly, the liquid obtained from the *Genipa americana* fruit becomes black upon oxidation. After application to the skin, it remains in the upper levels of the epidermis for a couple of weeks.

Figure 19. Group of young women from the Kayapó tribe in Brazil. This photograph was taken in the city of Palmas in the Amazon jungle state of Tocantins during the first World Indigenous Games in 2015. The photograph by MaestroBooks was obtained through a licensing agreement with Getty Images, Seattle, WA, USA.

11.4. Cosmetic Traditions in Oceania

Rich in tradition and rituals, tribal societies in the Oceania region often use pigments to color their bodies and faces. In addition, animal and plant derived raw materials are commonly employed for cutaneous remedies. Many of the present-day practices of skin care and body painting by the indigenous population of Oceania have a long history. Oceania is typically categorized by anthropologists as containing four distinct regions: Australasia, Melanesia, Micronesia, and Polynesia. In modern-day Australia, the two principal indigenous groups (those people whose heritage precedes the era of British colonization) are the Aboriginal and Torres Strait Islander people. The Aboriginals predominantly live in mainland Australia, while the Torres Straight Islanders, who are Melanesian, hail from the sea region between Papua New Guinea and Queensland.

Tribes in Melanesia (i.e., New Guinea and surrounding areas) are well known for utilizing body paint and tattoos to reinvent their body and express their emotions as well as their social status. Red ochre or white clay are the most common colorants, although plant-based pigments are also employed. Functional skin care cosmetics have also been developed. In the Asaro and Jale tribes, anti-wrinkle formulations contain grinded Cyperus (*Cyperus neoguinensis*) tubers and wild banana flowers. For skin renewal, Betel (*Piper betle*) leaf extract is often combined with eucalyptus leaves. As a hydrating treatment, a formula containing boiled sago palm (*Metroxylon sagu*) leaves, which generate a creamy texture, can be combined with macerated pandan (*Pandanus amaryllifolius*) flowers. In the Abelam and Asmat tribes, it is interesting to note the use of a combination of mangroves, rhus, and acacia tree bark derived powders as astringents to reduce and absorb sebum in oily skin.

In New Zealand, facial tattoos are one of the most distinct traits of the Māori tribes, but functional cosmetics using indigenous plants are also a common practice. Kūmara tubers (a New Zealand Sweet Potato) are cooked in water to create a creamy texture that, when applied on the face, provides smoother and softer skin. As a hydrating formula, a combination of ground fern leaves with beech fruits (the seed oil is known to have anti-

wrinkle properties) is used. *Eucalyptus* leaf and *Helichrysum* flower extracts are also often used as cutaneous remedies.

Australian Aboriginals from the coastal Yulengor tribes do not tattoo themselves but color their entire bodies using red or white ochre as well as white clay. The colors are often associated with specific ceremonies (see Figure 20). Given the high sun exposure in Australia, dry skin is very common. Therefore, formulations are prepared to address dryness by using tubers from different plants from the jungle, while astringent preparation is derived from eucalyptus and acacia bark. Preparations based on eucalyptus and white/red cedar leaves are used for wound healing.

Figure 20. Aboriginal man wearing white body paint and playing the digeridoo. The photograph was taken in Cairns, Queensland, Australia. Image obtained by a license agreement with Alamy Ltd., Abingdon, Oxfordshire, UK.

Tribes from the Fiji Islands in Melanesia have the tradition to drink crushed kava (*Piper methysticum*) roots strained in water during gatherings. The drink induces a state of euphoria, since kava root contains kavalactones, which are associated with its psychotropic effects. Interestingly, kava roots have been used in cosmetic preparations, often in combination with the dried bark of wild hibiscus (Fiji's most common flower) for skin regeneration. A composition of dried frangipani-like flowers (local name ceviga) added to warm coconut oil can be used to condition hair and as a body and face lotion.

Monoï oil is one of the most common cosmetic ingredients of the Tahitian tribes in Polynesia and is used predominantly to enhance the shine and gloss of hair as well as moisturize the skin and protect it from the sun. The petals of Tahitian gardenias (tiaré flowers) are allowed to soak in coconut oil, in direct sunlight, for approximately three weeks to produce the popular monoï oil. To combat dry skin, inland tribes use a mask composition based on macerated leaves of the mountain fern (*Gleichenia dichotoma*). As a skin astringent, a sumac (*Rhus taitensis*) bark decoction has been used in topical applications. To treat pimples and skin eruptions, a decoction of Tahiti chestnut (*Inocarpus edulis*) fruits—or, as an alternative, a mixture of banana and manioca paste—can be applied to the skin. Tribal societies from Bora Bora and Morrea have made bark decoctions with giant taro (*Alocasia macrorryza*), also known as ape, for dermatosis and to combat skin aging.

Information in this section was garnered from a previously published source [107].

12. Urotherapy in Folklore Medicine

Urine therapy dates to antiquity. It is believed to have originated in India and later practiced by the Egyptians, Greeks, and Romans [108]. Its use continued in the Middle Ages and into the Renaissance period. Urine predominately consists of water (95% *w/w*), urea (2%), creatine (<1%), uric acid (<1%), and ions (<1%). Figure 21 contains the molecular structure of urea. Interestingly, urea is one of the components of the natural moisturizing factor (NMF) of skin. It is used as a moisturizing agent and to treat atopic dermatitis, ichthyosis, psoriasis, and xerosis [109]. Topical treatment of skin with urea provides moisturization at concentrations less than 10% (*w/w*) and acts as a keratolytic agent (exfoliant) at concentrations greater than 10% (*w/w*) [110].

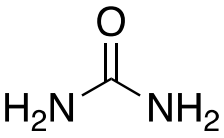


Figure 21. Molecular structure of urea.

Urine-based therapeutics have played an important role in Spanish folklore medicine. It is prescribed to treat various skin diseases such as eczema, chloasma, and alopecia in addition to its role as a therapeutic for burns, chapped skin, wounds, and venomous bites [111]. In recent years, urotherapy (or pee facials) has become increasingly popular [112].

13. Essential Oils

Essential oils are present in flowers, leaves, stems, roots, seeds, barks, resins, and fruit rinds and often provide them with their fragrant odors [113]. They are volatile substances that are obtained by distillation of the plant. Essential oils have been used in medicine, pharmacology, and cosmetics for centuries due to their antibacterial, antiviral, and antifungal properties [114]. They are rich in antioxidants and usually contain terpenes and terpenoids as well as a variety of phenolic compounds [115]. The use of essential oils for their medicinal properties is known as aromatherapy.

The benefits of essential oils for the skin have been known for quite some time. For example, chamomile essential oil has been used for centuries as an anti-inflammatory agent and for the treatment of eczema and dermatitis [116]. As another example, the broad-spectrum antimicrobial activity of tea tree oil protects against bacterial, viral, fungal, and protozoal infections of the skin [117]. There are many cases in the literature highlighting the beneficial effects that essential oils provide to the skin [118,119]. Due to the properties of essential oils already discussed, they also offer promise as wound healing agents [120].

There have been a significant number of studies investigating the permeation-enhancing properties of essential oils for the transdermal delivery of drugs and other agents [121]. It is believed that essential oils function as good permeation enhancers due to their ability to compromise the lipid phase of the stratum corneum due to interactions they have with stratum corneum proteins that might undergo conformational changes and weaken the skin's barrier properties. While many essential oils have been found to be effective permeation enhancers, it is not certain to what extent this was ever really put into commercial practice in the dermatological world.

Essential oils have also been reported for insect repellent activity [122,123]. The plant families most cited as having insect repellent properties are *Cymbopogon* spp. (lemon grass), *Ocimum* spp., and *Eucalyptus* spp. The presence of monoterpenes and sesquiterpenes (see Figure 22), such as α-pinene, camphor, citronellal, citronellol, and thymol has been noted [124].

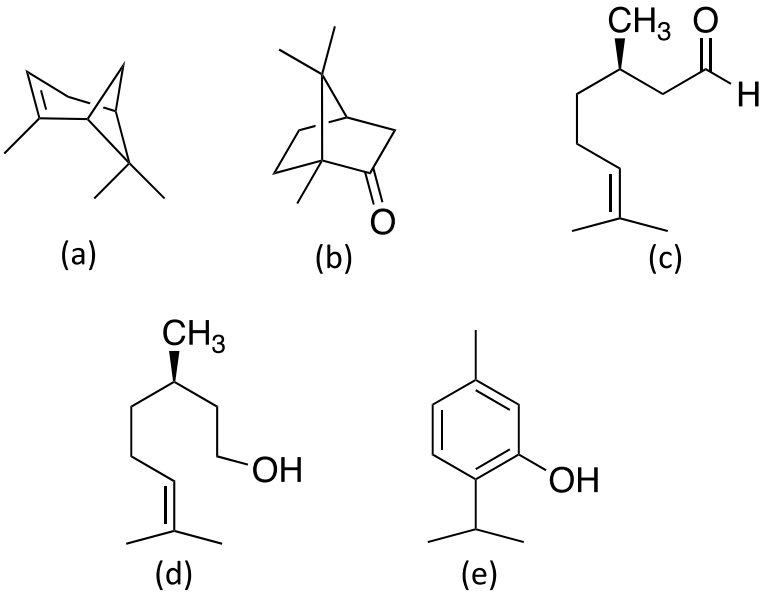


Figure 22. Molecular structures of monoterpenes and sesquiterpenes found in some essential oils, which have insect repellant properties: (**a**) α-pinene, (**b**) camphor, (**c**) citronellal, (**d**) citronellol, and (**e**) thymol.

14. Natural Ingredients in the Information Age

The late 20th and early 21st century have witnessed an explosion of activity in the cosmetic industry regarding the development of sustainable products based on natural ingredients [125–131]. This movement began with products based on naturally derived polysaccharides from cellulose, guar gum, starch, and many other ingredients. These are functional biopolymers in the formulation that serve as rheology modifiers, binding agents, emulsifiers, and film formers.

In more recent years, great efforts were made in the skin care active ingredient arena. This falls under the realm of cosmeceuticals and typically involves the intervention of peptides and botanical ingredients in the viable epidermis and dermis. Successful treatments ultimately lead to improvements in the reduction of skin aging or improvements in skin whitening and skin hydration.

Antioxidants found in botanical ingredients has also been a vast area of skin care technology that has greatly advanced in the last two decades [132]. Today, almost every skin care formulation contains some form of antioxidant, either to be delivered to the skin so that it can biochemically exert its action or to help prevent oxidation in the cosmetic formula.

Consumer products companies in the personal care industry are under increasing pressure to develop sustainable products that do not harm the environment. As a result, product development programs increasingly require that a large percentage of the formula's ingredients come from natural sources. However, there are many challenges when trying to meet the same level of efficacy that is provided by conventional ingredients. There is still a lot of activity in the personal care product development arena in the quest to develop green preservatives, surfactants, hair styling agents, sunscreens, and many other ingredients.

15. Understanding the Safety of Natural Ingredients in Modern-Day Cosmetics

In recent years, there has been some concern about the toxicity of natural ingredients in personal care products [133,134]. Many of today's product labels contain claims that the product is free of parabens, sulfates, PEGs, silicones, phthalates, and a growing list of chemicals that have become blacklisted in cosmetics. However, much less attention has been given to the potential toxicity of natural ingredients. A major concern is that labeling requirements of personal care products does not guarantee that a consumer will be aware of potentially hazardous ingredients. For example, many plant oils contain limonene, citral,

citronellol, linalool, and other fragrance allergens. According to INCI requirements, only the Latin name of the botanical extract should appear on the label, which provides no indication of individual molecules that might create a hazardous condition.

In addition, there is also concern that the harvesting and use of toxic natural ingredients in personal care products can lead to contamination of our waterways, ultimately leading to human exposure [135]. For example, in a grassland field, it was shown that isoflavone production (phytoestrogens) can reach up to 220 kg per hectare per year [136]. The harvesting of an increasing number and variety of plants for use in cosmetics could likely result in elevated levels of some toxic natural compounds, which could contaminate our waterways and soil. In addition, cosmetic ingredients that are washed from our skin and hair during showering and bathing could also accumulate in our waterways.

16. Concluding Remarks

The natural ingredients movement in cosmetics and personal care are revolutionizing the cosmetic industry. Looking back to distant times provides us with insight of some of the ingredients still in use today. It also makes us keenly aware of the need to conduct rigorous efficacy and toxicological testing. Not all natural ingredients are necessarily safe. In any event, we hope you enjoyed this journey to near and distant lands and have gained an appreciation for the sophistication of past and present-day cosmetic technological innovations.

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