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Review

Health Effects of Dyes, Minerals, and Vitamins Used in Cosmetics

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Abstract: The average woman uses 12 different cosmetic products every day, but they can have a negative effect on human health. Therefore, in recent years, consumer preferences have changed towards buying natural or ecological cosmetics free from preservatives or unnecessary dyes. The aim of this work is to discuss the use of dyes, minerals, and vitamins in cosmetics in terms of their safety and impact on human health. These substances are very important in the cosmetics industry. Most of them are of natural origin. Some minerals used in the production of face masks or creams are recommended to work against inflammations such as ulcers and acne. Clay minerals have exceptional qualities, among others, low or no toxicity and high bio-compatibility. However, some of them may be harmful. For example, the safety of using talc has been widely debated in recent years. Cosmetic-grade talc cannot contain detectable fibrous asbestos minerals. Moreover, talc should not be applied to the skin when the epidermal barrier is missing or significantly disrupted. The use of talc in cosmetic products in the European Union is restricted. Vitamins are one of the most commonly used, biologically active, and easily accessible components in cosmetics. For example, provitamin B5 (D-panthenol) is a bioactive substance. In cosmetic preparations, it has a softening, repairing, and anti-inflammatory effect and is responsible for regulating sebum secretion. However, some vitamins may be harmful to human health. For example, the use of skin-whitening cosmetics containing vitamin C causes allergic contact dermatitis, whereas the most common adverse effect of topical use of vitamin A is skin irritation, erythema, and peeling. Dyes, which are used to color cosmetics, do not improve the condition of the skin, hair, or nails. Some of them may be harmful to human health. For example, the dye CI 60730 (Acid Violet 43) is prohibited for use in eye products and cosmetics that have contact with mucous membranes. In conclusion, some of the popular cosmetic ingredients discussed in this paper may exert a negative influence on human health, and many of these harmful effects have been discovered recently. Therefore, there is a need for further studies on the possible negative effects of dyes, minerals, and vitamins used in cosmetic products.

Keywords: cosmetics industry; beauty; natural ingredients; health

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1. Introduction

The cosmetics market of the European Union, as well as the world cosmetics market, develop strongly together with consumers' awareness. Producers and consumers are becoming more open to using natural cosmetics. A variety of natural raw materials is used by the cosmetics industry. Consumers more often choose natural or ecological cosmetics, free from preservatives, unnecessary dyes, fragrances, and contaminants. It forces cosmetic manufacturers to constantly improve the safety and quality of cosmetic products [1]. The human body and its proper functioning depend on several dozen chemical elements. The human skin requires about 30 elements for the proper course of its processes [2]. The body itself cannot synthesize them, so they should be taken with food. Today, scientists are

trying to find ways to provide these essential nutrients other than the food route. Therefore, more and more often, the elements become the active ingredients of creams, masks, and other cosmetic preparations. For example, cosmetics with minerals are part of a new trend in natural cosmetics [1]. The global mineral cosmetics market size was valued at USD 2.05 billion in 2021 and is expected to achieve USD 2.94 billion by 2026 [3]. Clay minerals have exceptional qualities, among others, high bio-compatibility and low or no toxicity. The history of the cosmetic usage of minerals dates back to ancient times [4]. As a result, the manufacturers have been introducing make-up products made of natural minerals, including zinc oxide, iron oxides, titanium dioxide, organic oils, and mica powder [3]. While many other cosmetic active agents experience their ups and downs, vitamins are one of the most commonly used active ingredients, and their role in skin care have been increasing [5]. They are essential components of natural and physiological cosmetics. Moreover, cosmeceuticals rich in vitamins are becoming more and more popular [6]. Vitamins have a positive effect on the condition of the skin and improve its health and appearance. They are invaluable in the fight against the effects of skin aging, support the normalization of disturbed skin balance, and stimulate tissue renewal. Dyes are essential ingredients of cosmetic products and have a long history of usage [7]. They influence consumer senses, increase the quality of cosmetics, and ensure their better functionality; however, many of them are presently considered as controversial cosmetic ingredients. Application of cosmetics compounds include dermal, oral, or ocular routes, depending on the form, physical–chemical properties, and intended use of the product [8]. There are three possible pathways for penetration of cosmetic ingredients through the skin [9]. These are transappendageal penetration through the hair follicle or via the sebaceous and/or sweat glands, intracellular (transcellular) permeation through the corneocytes, and intercellular through the lipid matrix. The intercellular route allows a straight path through the skin into the lower levels of the epidermis and the dermis. Taking into account the above facts, in this paper, we have discussed the use of dyes, minerals, and vitamins in cosmetics in terms of their safety and impact on human health. These substances of natural and/or artificial origin are used in a wide variety of conventional, as well as natural, organic, or vegan products.

2. Minerals

In the production of cosmetics, many mineral raw materials are used, such as bentonite, kaolin, illite, mica, talc, and others. Their application is directly related to their mineralogical and chemical composition. For example, clays containing high amounts of Si provide tissue hydration and mitigation of possible skin inflammatory processes. Moreover, they can be used in the reconstruction of skin tissues. Aluminum (Al) is another element found in high amounts in clays. Al is relevant in raw materials for cosmetics application due to its healing activity, hydration, dispersion of pigment, and adsorption of melanin. Clays, which contain Si, Al, Ca, Ti, Fe, and K, can be employed for bactericidal, antiseptic, and regenerative action, that contribute to cell renewal, invigoration of tissues, circulation activation, and adsorption of impurities [10]. Clay minerals and clays are extensively used for cosmetic purposes due to their high specific surface area, optimum rheological characteristics, and excellent ion exchange capability (CEC) [11]. Aluminum clays and minerals can be found in many skin care products, such as creams, but they can be also used separately for pimples and various types of skin rashes [12]. Because of their ion exchange capability, aluminum minerals are used as the active base in face masks. They are recommended for people who struggle with inflammatory skin conditions, such as ulcers and acne. Bentonite massage creams have the ability to open the pores of the skin and facilitate the penetration of active minerals (Cu, Zn, and Hg), which are responsible for the proper course of regenerative processes [13]. However, clay minerals can also have a negative effect on consumer health. For example, in case of inhalation for a very long time they can cause lung cancer, mesothelioma, or pneumoconiosis. The minerals toxicity is generally related to the presence of asbestos or quartz from mining operations [14]. Additionally,

heavy metals, such as Sb, As, Cd, Pb, Ni, and Tl, may be present in different minerals and thus cause a risk for human health. These metals are banned by the European Commission, whereas US Food and Drug Administration (FDA) and Canada have established strict limits on their maximum concentration in cosmetics. Face masks and eye cosmetics can facilitate the absorption of metals through the skin. Metals present in cosmetics can also accumulate in the skin. Allergic reactions [15] and internal organs damage (caused by Hg and Pb) were observed as a result of topical and systemic effects of the use of cosmetics containing heavy metals [16]. In general, the use of minerals (mainly in make-up products) is currently one of the basic tendencies when it comes to the use of natural and organic raw materials in the cosmetics industry [1,11,12,17].

2.1. Bentonite

Bentonites are composed mainly of minerals from the smectite group, accompanied by sanidine, biotite, quartz, volcanic glaze, and cristobalite opal [17]. Bentonite is characterized by significant specific surfaces with a tendency to adsorb water in the interlayer spaces in the skin. In general, in cosmetic products, bentonite is classified as an absorbent, bulking, emulsion-stabilizing, and viscosity-controlling agent [18–20]. For example, when used in concentrations from 0.5 to 5% (*w*/*w*), it is a suspending agent. It produces good flocculation in bismuth subnitrate suspensions [17]. Bentonites, similarly to other minerals used in cosmetics, must be free of heavy metals banned by the European Parliament [21]. Bentonite itself is probably no more toxic than any other mineral particulate and is not classified as a carcinogen; however, some bentonites may contain variable amounts of respirable crystalline silica, which is a recognized human carcinogen. The CIR Expert Panel concluded that bentonite is safe for use in cosmetic products [11,22].

Montmorillonite (MMT) is a clay material that is the basic component of bentonites (55–70%), kaolinite (10–21%), feldspars (10–16%), and silica (1–2%). It is also a mineral of volcanic origin [23]. It is a complex aluminum/magnesium silicate clay [24]. Montmorillonites, as the main composition of clay minerals, are recognized as good adsorbents owing to the existence of various active sites such as the surface- and ion-exchange sites. Montmorillonite is anti-acne and anti-inflammatory active. It supplies mineral elements, stimulates cell activity, discharges the toxic substances of cells, and helps cure acne and other skin diseases. Montomorillonite has a much larger cation exchange capacity (CEC) than kaolinite [11]. Montmorillonite eliminates inflammation of the skin and tightens the skin. It is used in masks, hair masks, creams, shower gels, soaps, and other products, and its concentration usually reaches up to several dozen percent [25,26]. The CIR Expert Panel concludes that montmorillonite is safe as used in cosmetic products [11].

2.2. Kaolin

About 99% of kaolin is a mixture of aluminosilicates, mainly kaolinite and illite, with a small amount of feldspar and quartz [27–29]. Kaolin clay is used in cosmetology because of its beneficial effect on dry and sensitive skin, as this type of skin tends to delaminate and form wrinkles and furrows. In the cosmetics industry, kaolin is added to powders, creams, soaps, dusting powders, cleansing milk, toothpaste, and shampoos [30]. Kaolin is widespread. For example, it is present in the composition of cosmetically used mud from the Dead Sea [29,30]. It has cleansing, remineralizing, stimulating blood circulation, anti-aging properties, and influence on the oxygen exchange [30]. Mineral clays such as green or white clay are only characterized (and commercialized) based on their color [27]. Green clays, which are composed of interstratified illite/smectite, illite, and chlorites, with considerable amounts of Ni and Sr, while the other green samples are composed of illite only and are enriched in As. Green clay is a good sorbent, which helps to remove impurities from the skin and regulates excessive oil produced by the skin. It also has a bactericidal effect [30]. In cosmetics, it is classified as absorbent, bulking, emulsion stabilizing, viscosity controlling agent, and as light stabilizer [24]. White clay, similarly to green clay, can absorb toxic substances and nourish the skin [20,28]. This variant consists mainly of aluminum

and silicon ions, and to a lesser extent, of magnesium, potassium, sodium, and calcium [20]. White clay extracts show greater antioxidant properties because white clay has a lower adsorption capacity than, for example, blue clay. The ability of aluminum (present in clays) to penetrate through the skin may have a negative effect on human health since Al may exert toxic effects due to reaching the circulatory system and accumulation in various organs [25,31]. Due to prolonged exposure to aluminum and its accumulation in the bones, this metal may cause osteomalacia. In general, the SCCS Scientific Committee confirmed the safety of aluminum compounds in antiperspirants (inhalation exposure) as well as other types of cosmetics (skin exposure) in the following maximum concentrations (as aluminum): 10.60% in spray deodorants and spray antiperspirants, 6.25% in non-spray deodorants and non-spray antiperspirants, 2.65% in toothpaste, and 0.77% in lipsticks [32]. Mattioli and co-authors [27] showed that among the studied clays, the white clay was the most potentially hazardous clay for human health since it has the highest content of Zn, As, Ba, and Pb. The CIR Expert Panel concluded that kaolin is safe for use in cosmetic products [11].

2.3. Illite

Illite is an aluminum soil mineral. When illite is used as clay, it has exfoliating properties. It has a similar structure to montmorillonite and does not swell when exposed to water [33]. It helps remove oils, impurities and toxic substances from the skin, as well as exfoliate and lead to the skin detoxification process. It is used in soaps, body, and foot powders in concentrations up to 100%. In cosmetics, it is used as an abrasive, absorbent, anticaking, and swelling agent [34].

2.4. Charcoal Powder

Activated charcoal powder is highly absorptive as it has numerous small pores allowing it to adsorb chemical substances such as impurities and oil from the skin and hair. Charcoal powder acts as an anti-inflammatory, antimicrobial, and anti-pollution agent. It has abrasive, absorbent, and opacifying functions and helps in the removal of heavy metals [35]. It finds application in formulating moisturizing, hair care, body care, and facial skin care products. The concentration of charcoal powder in cosmetics ranges from 0.001% (skin care) to even 10% (mainly make-up cosmetics—mascaras). As a powder, it can irritate the eyes. Brooks and co-authors [36] showed that there are insufficient clinical and laboratory data to substantiate the safety and efficacy claims of charcoal and charcoal-based dentifrices.

2.5. Silica and Hydrated Silica

Silica (SiO_2) is a common inorganic oxide on earth [37]. Silica is a component of certain plant species, for example, *Equisetum arvense* (field horsetail), used in cosmetology [38]. The safety of the use of silica depends on its form and application. For example, respiratory exposure to crystalline silica may cause serious health hazards, such as allergies, cancer, or organ system toxicity. It was stated that products (containing crystalline silica) that may be aerosolized could cause cancer; however, topical application has no known hazards. Contrary to crystalline SiO_2, SAS silica (the synthetic amorphous silica) does not have negative and lasting health effects, hence its wide range of applications as an additive to cosmetics, food, and everyday use items [39]. Organic silica is used in the treatment of lipodystrophy [40] and in the fight against stretch marks [41]. According to 2019 VCRP data, silica has over 8200 uses. It is mainly used in leave-on make-up preparations (foundations, face powders, lipsticks, and eye make-up) [42,43]. Silica is used in preparations for mesotherapy treatments [44]. Silica with a size from 120 to 1000 nm penetrates into the hair follicles [45]. Hydrated silica has over 460 uses (mostly in rinse-off personal cleanliness and oral hygiene products) [42]. In general, in cosmetics, hydrated silica plays abrasive, absorbent, anticaking, bulking, opacifying, and viscosity-controlling functions [46]. Silica and hydrated silica may be used in products that come into contact with mucous membranes

and eyes or can be incidentally ingested. The content of silica in neck and face products is up to 82%, whereas in lipsticks and mascaras up to 50% [47]. The content of hydrated silica in oral hygiene products achieves up to 33.8%, whereas in leave-on skin care products up to 10%. Moreover, these ingredients are used in spray products (e.g., up to 0.84% in deodorants and up to 2% in hair sprays) [43]. The studies show [48,49] that in practice, in the case of final product formulations, which are a mixture of ingredients, from 95% to 99% of the droplets or particles released from sprays and incidentally inhaled would not enter the lungs to any appreciable amount due to deposition in the nasopharyngeal and bronchial regions. The particles are not respirable due to their diameter (>10 μm). Silica is also used in powders (e.g., up to 66% in face powders), which could possibly be inhaled [46]. Strict estimates of inhalation exposures to respirable particles of loose powder cosmetic products are from 400-fold to 1000-fold less than legal limits for inert airborne respirable particles in the workplace [50,51]. Silica and hydrated silica are not restricted from use in cosmetics by the European Commission [21].

2.6. Mica

Mica is a silicate mineral present, among others, in crystals and granite. It may contain traces of heavy metals, including Pb, As, and Hg [52,53]. Mica, both natural and synthetic, is used in the cosmetics industry to give cosmetics a metallic and shiny appearance, and it gives color cosmetics a shine. It is used as a pigment in varnishes. Mica is also used in such products as eyeliners, mascaras, lipsticks, lip glosses, and eye shadows [54]. Pigment concentrations differ per product, starting at 1% (e.g., in liquid soap) up to 60% (in pressed powders) [55]. Daily use of mica in skin care products should not cause harmful side effects. However, in the case of sensitive people, mica may have the immediate effect of irritating the skin and eyes, causing itching and redness. Mica irritates the mucous membranes lining the lungs; therefore, inhaling mica may result in coughing, shortness of breath, and wheezing [42,56]. Natural mica, such as other minerals, can contain heavy metals. In order to avoid dangerous trace minerals, many cosmetic companies have started using synthetic mica, which is composed of magnesium aluminum silicate sheets bound with potassium. It seems that synthetic mica has no negative impact on skin; however, some dyes used to color the product may be a health hazard [57].

2.7. Alumina and Aluminum Hydroxide

Alumina (aluminum oxide) and aluminum hydroxide, which are cosmetic ingredients, are stable, oxidized aluminum compounds. They differ substantially from aluminum (elemental or metallic) in physical and chemical properties, as well as in functions and toxicity potential. Alumina functions as an abrasive, absorbent, bulking, anticaking, and opacifying agent, whereas aluminum hydroxide is a corrosion inhibitor, buffering agent, and pH adjuster [58]. Dermabrasion and micro-cuts use alumina particles to peel/damage the stratum corneum [59]. The Cosmetic Ingredient Review (CIR) Expert Panel stated that both alumina and aluminum hydroxide are safe in specified practices of use and concentration described in the safety assessment [58]. The cases of incidental inhalation exposure to alumina and aluminum hydroxide present in cosmetic powders and fragrance preparations were also discussed as these ingredients are reportedly used at concentrations up to 6% in cosmetic sprays and up to 5% in other products that may become airborne. The Expert Panel stated that from 95% to 99% of droplets or particles would not be respirable in appreciable amounts and the concentrations used are safe [58].

2.8. Talc

Talc in cosmetics is used as an abrasive, absorbent, and anticaking agent, filler, and opacifying protective ingredient [60]. Talc is a material with a grain diameter not exceeding 30 μm, and it can be characterized as a coherent and very fine Geldart powder [61]. It is very difficult to fluidize it. In cosmetology, talc is used as magnesium silicate ($2MgO \times 4SiO_3 \times H_2O$). In nature, it occurs in the form of the soapstone mineral. After grinding, it is a lamellar, very

soft, white or greenish powder. Crushed, it is the basis of drying powders and poorly absorbs water [62]. Talc is used in over 3400 cosmetic products reaching up to 100%. It is present in almost every type of cosmetics, including cosmetic powders and sprays. For example, talc is reported to be used in aerosol deodorants at up to 30%, in aerosol make-up bases at up to 35%, in baby powders at 99%, and in face powders at 100% [63]. Case studies showed severe respiratory distress in infants who inhaled baby powder containing talc [42,64]. The use of intimate hygiene cosmetics containing talc is now recognized as an additional risk factor for malignant neoplasms of the ovary in genetically burdened people [65]. Increased risk of endometrial cancer was observed among postmenopausal women as a result of talc use for the care of the genital organs. For all women, the risk may increase with frequency of use, although this remains contended [42]. The safety of using talc has been widely debated in recent years. Cosmetic-grade talc cannot contain detectable fibrous asbestos minerals. Moreover, talc should not be applied to the skin when the epidermal barrier is missing or significantly disrupted [66]. The use of talc in cosmetic products in the European Union is restricted [21].

2.9. Zinc Oxide and Titanium Dioxide

Zinc oxide (ZnO) and titanium dioxide (TiO_2) are classified as inorganic filters. Zinc oxide has antibacterial properties. It protects against UVA1, UVA2, and UVB radiation; however, the scope of protection against UV radiation is low compared to other organic UV filters. Zinc oxide is one of the most widely used nanoparticles (NPs) and can be present not only in sunscreen lotions but in many skin care products such as creams. Zinc oxide and titanium dioxide do not penetrate deep into the skin; therefore, their use is safe. Despite this, a number of in vitro studies have shown strong cytotoxicity of zinc oxide nanoparticles, including genotoxicity, irradiation-induced cytotoxicity, oxidative stress, apoptosis, and necrosis induction [67–69]. Potential routes of exposure to nanoparticles present in *cosmetics* include inhalation, dermal, oral, or ocular routes, depending on the form and intended use of the product. Concerning dermal penetration, NPs may be absorbed by the skin via different pathways, depending on their physical–chemical properties [9]. The International Agency for Research on Cancer designated TiO_2 as a carcinogen, mostly due to the increased number of cases of lung cancers observed after inhalation exposure in animals. Findings show that TiO_2 particles smaller than 100 nm are more harmful than traditional larger particles of TiO_2 [42]. In order to reduce the accumulation of pigment particles and facilitate distribution on the skin surface, ZnO and TiO_2 are often covered with silicones, alumina, or fatty acids [70]. The bioactive compounds used in practice, containing, in addition to (or instead of) silver copper, zinc or titanium dioxide, have various effects on typical bacteria and fungi. For example, zinc oxide nanoparticles show bacteriostatic activity against *Aspergillus* and *Staphylococcus* bacteria, while they practically do not inhibit the growth of the widespread *E. coli* bacteria [71]. Maximum safe concentration of titanium dioxide in ready for use preparation is 25% [21].

3. Vitamins

Vitamins are organic chemical compounds divided into two groups: water-soluble (hydrophilic) and fat-soluble (lipophylic) [72]. The first group includes vitamins B, F, and H, and the second group includes fat-soluble vitamins A, D, E, and K, which are readily absorbed through the skin. The intake and absorption of vitamins and antioxidants with food is of key importance for human health. In the human body, vitamins perform regulatory functions and also affect the health and physical performance of the body. Most of the vitamins are not synthesized in the body; therefore, they must be supplied with food. Besides free vitamins, their derivatives (compounds of vitamins with other substances; acid esters, such as palmitic acid and acetic acid) or provitamins (pre-stages of vitamins) are also assimilated. Thanks to their unique functions, vitamins are used in prophylaxis and in local and systemic treatment of photoaging, as well as chronological skin aging [73]. The antioxidant properties of vitamins are used in cosmetics for skin, hair, and nails. Water-

soluble vitamins are the largest group, and among them, vitamins B, C, and others are the most commonly used in cosmetics [5,6]. In the cosmetics industry, natural vitamins come from raw materials of plant origin, which are used more and more often. Plants contain a number of other biologically active and easily accessible ingredients, such as antioxidants, oils, and others [74]. Vitamins need to be replenished constantly as they use up when they fulfill their respective functions in the human body. This applies not only to the organism as a whole but to the skin in particular.

3.1. Ascorbic Acid

In cosmetics, the main functions of the water-soluble vitamin C (ascorbic acid) are product protection (antioxidant), deactivation of free radicals, and keratolytic effects of free, concentrated ascorbic acid at a low pH level analogous to the alpha hydroxy acids (AHA) [5,75]. Vitamin C derivatives play a role in the prevention of skin hyperpigmentation and stimulation of collagen formation. Deficiencies of vitamin C in the body may disturb the dynamics of DNA methylation and demethylation, as well as histones contributing to phenotypic changes [76]. Vitamin C functions in the water compartment of the cell, and its action is based on the donation of an electron, neutralization of free radicals and protection of the intracellular structure against oxidative stress [77]. Vitamin C is used on the skin after treatments but also on a daily basis by mature people due to a decrease in collagen synthesis with age. The majority of creams contain ascorbic acid with a concentration of 8–20%. In eye creams, it is 3–5%, although it is believed that the most active are creams with a content of 15% [78]. Vitamin C soothes irritations; therefore, it is a component of dermo-cosmetics used for the care of sensitive skin. It is used in products intended for skin prone to capillaries and rosacea. Ascorbic acid improves wound healing and acts as an anti-inflammatory component. Vitamin C is added to cosmetics that protect against the negative effects of UV radiation and remove shallow wrinkles. In combination with vitamin E, it is a synergistic antioxidant [79]. Apart from positive effects, some cases of allergic contact dermatitis due to the use of skin-whitening cosmetics containing vitamin C were noted [80]; a positive reaction to 3-o-ethyl-ascorbic acid (1% aq.) was observed.

3.2. Vitamin B1 (Thiamin)

Vitamin B1, one of the B vitamins, is found in large amounts, for example, in seaweeds [81]. Vitamin B1 plays a major role in indirect carbon metabolism and is essential for several enzymes such as pyruvate dehydrogenase, pyruvate decarboxylate, and transketolase [72,73]. Thiamine pyrophosphate, which is a biologically active form, combined with specific proteins, acts as a co-enzyme of many enzymes involved in the intermediate metabolism of carbohydrates. In cosmetic applications, it is used as hydrochloride and is frequently combined with other B-vitamins (the so-called vitamin B complex) for the treatment of compromised skin. B-vitamins are hydrophilic and, as a rule, easily penetrate into the skin, hair, and nail plates. Thiamin has an antipruritic effect and is used in the treatment of seborrheic diseases as well as rosacea [82]. To the best of our knowledge, no negative effects of thiamin, present in cosmetic products, on human health have been observed.

3.3. Vitamin B2 (Riboflavin)

Vitamin B2 has an anti-inflammatory effect and, like vitamin B1, is used in the treatment of seborrheic diseases and rosacea [72,73,82]. Vitamin B2 is thermally stable. It can be found in many different food products and natural sources, including wild-grown plants [83]. Its small amounts are also found in honey, which is a component of many cosmetic preparations [84]. Vitamin B2 used in cosmetic products delays the appearance of wrinkles, especially around the mouth. It also is used in food and cosmetic products as a yellow coloring agent (E 101) [72,82]. To the best of our knowledge, no negative effects of riboflavin present in cosmetic products on human health have been observed.

3.4. Vitamin B3 (Niacin)

Niacin occurs in the form of a derivative, either as nicotinamide or nicotinic acid. It is well soluble in water and easily absorbed by the skin [85]. Vitamin B3 has a beneficial effect in the treatment of chloasma and discoloration [86,87]. It also increases collagen production, which can improve skin elasticity and reduce fine lines. All of these effects can help reverse some of the signs of skin aging. For this purpose, the vitamin is used in cosmeceutical products in concentrations from 3.5% to 5% [87,88]. In 2005, the CIR Expert Panel stated that niacinamide and niacin are safe in the and concentration (0.0001–3%) in cosmetic products [89].

3.5. Vitamin B5 (Pantothenic Acid)

Provitamin B5, also known as D-panthenol, is a bioactive adjuvant for topical application in the form of a cosmetic preparation. It is responsible for regulating sebum, has softening, repairing, moisturizing, and anti-inflammatory effects [90]. It is part of the formulations dedicated to products for sunbathing and after sunbathing, intimate hygiene, hand, foot, and nail care, after epilation and shaving. The vitamin is present in products for the care of baby and atopic skin [91]. This vitamin plays a major role in hair care, actively participates in the synthesis of proteins and lipids, stimulates hair growth, and affects its color [92]. It is used in hair care preparations that prevent split ends, give the hair strength, elasticity, shine, and a healthy appearance, optically thicken and improve detangling [93]. The concentration of D-panthenol in rinse-off shampoos and conditioners is 1%, and in leave-on preparations, it is 0.5% [94].

3.6. Vitamin B7 (Biotin, Vitamin H)

Vitamin H (biotin) is a water-soluble coenzyme covalently bound for carboxylases. It is used in metabolic reactions of cells, including the synthesis of fatty acids and the metabolism of glucose and amino acids [95]. Biotin strengthens the hair, which is proved by its active participation in the process of keratin formation. Hair conditioners and masks containing biotin hold the hair cuticles together [96]. The reported maximum leave-on concentration of use and concentration of use in the eye area are both 0.1%. The CIR Expert Panel stated that biotin is safe as used in cosmetic formulations [97]. Moreover, it could be used in cosmetics at concentrations as high as 1%.

3.7. Vitamin F

Essential fatty acids (EFAs) are called vitamin F. These acids include linolenic acid, oleic acid, linoleic acid, and saturated acids (palmitic and stearic). Linoleic acid (PUFA) is most commonly consumed by humans. It acts as a structural component that maintains a certain level of fluidity of the transdermal water barrier of the epidermis [98]. Pomegranate seed oil, which is a rich source of vitamin F, is used in the production of cosmetics with a renewing, nourishing, moisturizing, and refreshing effect on the skin [99,100]. The concentrations of EFAs in cosmetics vary [101]. For example, linoleic acid is used at up to 3.4% in face, neck, hand, and body skin care products and at up to 21.8% in rinse-off skin cleansing products. Stearic acid is used at up to 37.4% in rinse-off products (detergents and bath soaps) and at up to 21% in leave-on products (eyebrow pencil). The CIR Expert Panel stated that vitamin F is safe in the present practices of use and concentration described in the safety assessment when formulated to be non-irritating and non-sensitizing.

3.8. Vitamin A (Retinol)

Vitamin A is a group of unsaturated nutritional organic compounds that includes retinol, retinal, and several provitamin A carotenoids (e.g., beta-carotene). Retinol, retinal, retinoic acid, and provitamin A show the biological activity of vitamin A [102]. Vitamin A is included in many preparations used on the skin. The local use of retinoids consists in affecting specific receptors that regulate the processes of keratinization and differentiation of keratinocytes, reduce adhesion, facilitate the exfoliation of corneocytes, and activate

collagen synthesis and angiogenesis [73]. Vitamin A is designed to smooth and elasticize the skin, eliminate fine wrinkles, reduce discoloration, stimulate activity, and increase the number of fibroblasts and the production of collagen fibers. As a result of the improvement of the structure of the stratum corneum, the protective function of the epidermis is enhanced, and the transepidermal water loss (TEWL) is reduced [103]. Retinoids are applied topically to treat acne. The most common retinoid used in cosmetics is retinol. It is used in low concentrations (0.01–0.08%) due to the risk of irritation [104]. However, it was shown that products containing a higher dose (0.1%) of retinol promoted the proliferation of keratinocytes, strengthened the skin, and reduced the signs of aging, with no significant side effects [105]. Retinoids are used in the treatment of, among others, atopic dermatitis, psoriasis, acne, and photoaging [101]. Vitamin A deficiency may cause increased hair dryness and, in some cases, even hair loss. Preparations containing vitamin A influence hair styling. It has anti-dandruff properties, facilitates styling, reduces brittleness, and gives shine. It is effectively used as an additive to hair care preparations [106]. Cosmetics with vitamin A accelerate the synthesis of collagen and elastin, activate the production of natural moisturizing factors and increase the level of glycosaminoglycan, due to which fine wrinkles are smoothed out. They stimulate the production of fibrillin, which determines the proper cross-linking of the supporting proteins of the dermis. Vitamin A reduces the activity of enzymes that degrade collagen and elastin. Retinoids can cause irritations, such as erythema [107]. Due to the sensitivity of retinoids to atmospheric oxygen, cosmetic preparations which contain retinoids should not be applied at the daytime in the blazing sun [5,107]. Moreover, retinyl palmitate and retinoic acid, in combination with sunlight, may increase skin cancer risk. All-trans retinoic acid and retinol/retinyl esters were identified as toxicants [42].

3.9. Vitamin E

Vitamin E, known as the "elixir of youth", has a strong antioxidant effect [79]. It does not dissolve in water, but it dissolves in fats, alcohol, ether, and acetone. It is found naturally in products such as wheat germ oil, soybean oil, rapeseed oil, hazelnuts, walnuts, olives, butter, and raw spinach [48]. Vitamin E as alpha-tocopherol or tocopherol acetate is used in over-the-counter topical products in concentrations ranging from 1% to 5% [74]. The most beneficial effect of the preparations occurs when its content is 1.5–3%. The vitamin is able to neutralize free radicals, and also has a regulatory function in gene expression, stabilizes cell membranes and has anti-inflammatory properties [108]. Tocopherols are often used in cosmetics with UV filters due to the increase in their protective factors [5]. They protect epidermal lipids, collagen, and elastin fibers against oxidation, which ensures skin elasticity. Vitamin E soothes sunburn and burns. It has anti-inflammatory and anti-swelling properties. Tocopherol derivatives are often used in cosmetics. Linoleate and tocopherol acetate are clearly incorporated into epidermal lipids, giving an uninterrupted moisturizing and sunscreen effect. In cosmetic products, a mixture of α, β, γ, δ-tocopherols with different percentages is regularly used. Tocopherols can be found, among others, in lipsticks, sunscreens, hair and nail cosmetics, body lotions, and anti-wrinkle creams. Tocopherols used in low concentrations show a protective effect in relation to other ingredients of the preparation. In cosmetics containing polyunsaturated fatty acids, vitamin E is used as a strong antioxidant [5,109]. It seems that vitamin E is a relatively rare contact allergen, but single cases of people who had allergic contact dermatitis from α-tocopherol and worsening rosacea were observed [110,111]. The most common adverse effect of topical use of vitamin A is skin irritation, erythema, and peeling [107].

Penetration of vitamins through the skin depends on their solubility and molecular structure [5]. The higher the solubility in fat, the better the vitamins can be absorbed and retained. For example, free vitamin C in the form of a polar molecule only has superficial effects on the skin or may be used as an antioxidant in skin care products. Substantial effects can only be achieved by derivatives in combination with penetration-enhancing substances such as nanodispersions (lipophilic) or liposomes (hydrophilic). In cosmetics,

the provitamin (D-panthenol), which is easily penetrating through the skin and is oxidized in the skin into pantothenic acid, is preferred to calcium salt (Calcium Pantothenate).

4. Dyes

Colors play a decisive role in the marketing of cosmetic products. Thousands of substances are used to color the product itself or to color a body part (hair, skin, eyelashes, and nails). Synthetic dyes are the most widespread in the cosmetics industry. Dyes act on the principle of absorbing and reflecting sunlight [112]. Colorants are divided into two categories in terms of solubility: dyes and pigments. Dyes are made up of synthetic organic compounds and are hydro or oil-soluble. They may be present in skin care products and toiletries. Pigments, on the other hand, are insoluble and remain in particulate form. They are found mainly in toothpaste and decorative make-up [113]. Dyes can be classified according to chemical structure in five main groups: azoic, triarylmethane, xanthenes, indigoid, and quinoline. Each coloring agent used in the cosmetics industry is marked with the symbol C.I. (Color Index) followed by the number of the given dye. There are a number of dyes that are restricted or banned in the European Union [21] and cannot be used in products applied on mucous membranes or eye products. The maximum concentration of many dyes in ready-for-use preparations may not exceed a few percent.

Some of the dyes present in cosmetic products can cause negative health effects. Dermal contact, with special attention to areas close to mucous membranes, is the main route of human exposure to dyes present in cosmetics. For example, the dye CI 17200, which is identified by the FDA code as red No. 33 and assigned to the nitrogen chromophore group [114], can release amines, which are considered to be carcinogenic [115]. The dye CI 19140 (Yellow No. 5, tetrazine), which belongs to the azo chromophore group [113,114], has been limited in the European Union in products for children, because it causes them to be hyperactive, and in hair dye products [21,116]. Tetrazine can also lead to dermatitis, anaphylaxis, and itching of the lips and tongue [117]. CI 47005 (Yellow No. 10) is assigned to the quinoline chromophore group [114]. This dye can be genotoxic when absorbed through the skin [118]. The dye CI 16255 (red code 4R) belongs to the azo chromophore group [114] and can cause sensitization by itself or in combination with sunset yellow [119]. CI 15985 (Yellow No. 6, orange–yellow), assigned to the azo chromophore group [114,120], can cause concentration disorders and hyperactivity in children, as well as urticaria, Quincki's edema and allergic reactions that may lead to anaphylaxis [121]. CI 14720 (the trade name Azorubine, according to the Color Index—Food Red3, Acid Red 13) is an azo dye with hepatotoxic properties. It does not exhibit carcinogenic properties but is an inducer of DNA chain damage [122]. The dye CI 16185 (Amaranth [123]) affects the hormonal balance, which is associated with adverse health effects [124,125]. The dye CI 75810 is assigned to the chlorophyll group and defined by the FDA code as chlorophyllin [114]. This dye is used mostly in the food industry but is also used in the cosmetics industry for its antioxidant, anti-inflammatory, and wound-healing effects. It is used in photoprotective preparations because it influences the treatment of photo damage [126]. CI 77891 (White Color No. 6) belongs to the chemical class TiO_2 Azocompound [127]. It is used in the production of toothpaste as a whitening agent. The dye improperly ground in cosmetics causes whitening of the skin and is susceptible to abrasion, which is not conducive to providing protection against harmful factors of ultraviolet radiation. Its too small fragmentation causes the deeper penetration of the product with this dye into the skin, thus increasing the toxicity of the preparations [70]. The dye CI 60730 (Acid Violet 43) is prohibited for use in eye products and in cosmetics that come into contact with mucous membranes [21,112]. The dye CI 45100 (acid red, or Acid Red 33) is mildly allergic [128].

5. Conclusions

In this paper, we discussed the human health effects of the chosen popular dyes, minerals, and vitamins used in the cosmetics industry. In general, they have a long history of use and are increasingly used in cosmetics, especially in the more and more popular

natural cosmetics and cosmeceuticals. Therefore, their safety of usage is very important. There are many other important substances used in cosmetics, for example, bioactive kinetin, zeatin, and others, which do not come under the category of vitamins but are considered as either indirect antioxidants, direct antioxidants, or mild stress-inducing hormetins [129]. Our work shows that some minerals used in cosmetics may negatively affect human health, for example, due to the content of heavy metals, which presence in cosmetics is not banned in many countries. In recent years, the safety of using talcum powder and mica in cosmetics and care products has been particularly discussed. Most minerals and vitamins are beneficial when it comes to the improvement of the condition of the skin, hair or nails, and as they are mostly safe for use, they are valued raw materials and cosmetic ingredients. Dyes and pigments, due to the potential negative impact on human health of many of them, are often controversial components of cosmetic preparations. The constantly growing awareness of consumers makes cosmetics manufacturers strive to eliminate potentially harmful substances and use safe raw materials and ingredients of natural origin. Therefore, there is a need for further studies on possible negative effects of dyes, minerals and vitamins used in cosmetic products, as well as updating the legal provisions on their use.

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