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Coffea: The Application of Green Components in Cosmetics Formulation

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ABSTRACT

In recent years, the use of green components has attracted significant attention because of their safety, various pharmacological effects, various possible formulation applications, and renewable sources. Regarding its development, coffee is a potential candidate for alternatives of synthetic chemicals in cosmetic preparations because it contains active compounds including polyphenols, caffeine, chlorogenic acid, flavonoids, and alkaloids, which are effective for use on the skin as an antioxidant, anti-aging, sunscreen, moisturizer, anti-cellulite, and face brightener. The stratum corneum is the outer layer of skin that is so impenetrable that requires a formulation to help active compounds penetrate its deeper layers. The development of formulation, type, area of origin, part of the coffee used, and the extraction method affects the characteristics of obtained cosmetics.
Keywords: Coffea, Cosmetics, Formulation, Active compound

INTRODUCTION

Coffee had many pharmacological activities such as strong antioxidant (Sentkowska *et al.,* 2016; León and Galano, 2011; Shi *et al.,* 1991), anti-diabetic, body and liver fat reducing, and Parkinson's disease lowering activity (Bhupathiraju *et al.,* 2013; Cano-Marquina *et al.,* 2013). Green coffee contains 60% carbohydrates (stachyose, raffinose, sucrose, cellulose, arabinogalactan, galactomannan, arabinose, glucose, galactose, fructose, mannitol, mannose, xylose, and ribose), 8-18% proteins, lipids (triglyceride, stigmasterol, and sitosterol), fatty acids (oleic, linoleic, palmitic, linolenic, arachidic, stearic, behenic, and lignoceric), and polyphenols (caffeoylquinic, feruloyl quinic, cinnamoylquinic, and dicaffeoylquinic acids). The main amino acid constituents of coffee are asparagine, alanine, glutamic acid, lysine, and aspartic acid. Coffee is rich in caffeine, trigonelline, theophylline, and theobromine. The processing of coffee beans impacts their active compounds and pharmacological activity. Green coffee beans have better potential to be the source of those compounds than roasted coffee beans. The roasting process resulted in 8–10% degradation of chlorogenic acid in every 1% of dry matter (Clifford, 1999) and 11% -45% degradation of polyphenols (Budryn *et al.,* 2015). Several studies on the antioxidant capacity of coffee from various types of Arabica showed that the total phenol in roasted coffee was lower than in unroasted green coffee (Cheong *et al.,* 2013). Other parts of coffee that have pharmacological activity are its leaves, silverskins, and grounds. Related toits phytochemical constituents and biological properties, coffee beans were considered as a potential cosmetic ingredient (Amigoni *et al.,* 2017; Babova *et al.,* 2016).

Cosmetic referred to mixed ingredients which are then applied on the outer limbs such as skin epidermis of nails, hair, lips, teeth, etc. to increase attractiveness, protect, and repair for better appearance (Haynes *et al.,* 1997). The use of coffee in cosmetic were developing, mainly as anti-aging (Girsang *et al.,* 2020; Safrida *et al.,* 2017), antioxidant (Yanni *et al.,* 2018; Sunoqrot *et al.,* 2021; Zainol *et al*., 2020), sunscreen (Riberio *et al*., 2013; Rodrigues *et al*., 2016; Marto *et al*., 2016), moisturizer (Handayani *et al.,* 2020; Chaiyasut *et al.,* 2018), anti-cellulite (Herman *et al*, 2013), and face brightener (Kiattisin *et al.,* 2016; Seo *et al.,* 2019). The ethanol extract of arabica coffee beans had a very strong antioxidant is with an IC_{50} value of 12.43 ppm (DPPH assay)) (Ajhar and Meilani, 2020). Green arabica coffee beans had an IC_{50} value of 0.050 ± 0.01 mg / mL (DPPH assay), inhibiting 44.27 ± 0.01% of L-Tyrosinase: indicating facial brightening activity (Kiattisin *et al.,* 2016). The ethyl acetate fraction of coffee leaves were potential sunscreen with an SPF (UV-visible spectrophotometry) value of 19.82; % Te 10.96 and % Tp 18.14, and it belonged to the fast tanning sunscreen assessment category (Yuliawati *et al.,* 2019). The phenolic compounds in coffee are unstable and decompose easily when exposed to light, heat, and oxygen, so a formulation that can maintain the active compounds are required.

Several formulations that are applicable for cosmetics included serum preparations using various coffee extracts resulting in an IC_{50} value of

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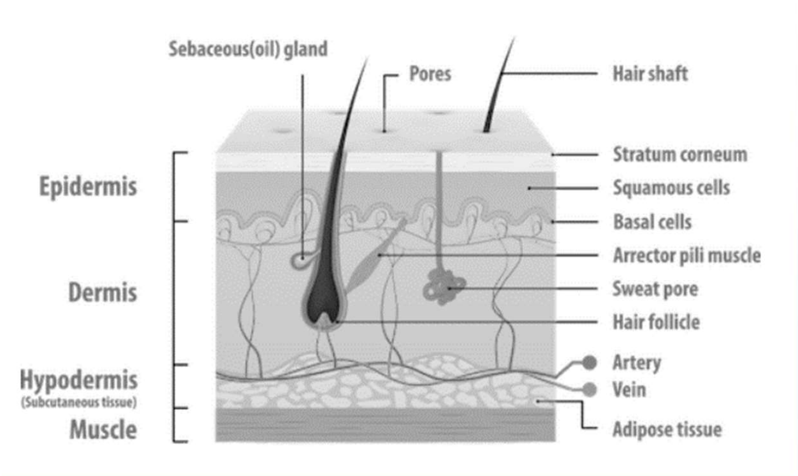

Figure 1. Skin Layer

68.89 µg / mL (DPPH assay), classified as a strong antioxidant (Yanni *et al.,* 2018); 2.5% of coffee silverskin extract was formulated in cream preparations with DPPH assay (mmol Trolox eq./g) and Folin (mg GAE eq./mL (Rodrigues *et al.,* 2016). The preparation formulation of green coffee oil microencapsulation was a promising antioxidant-rich cosmeceutical agent, and the skin creams containing coffee powder oil were proven to increase sebum levels (Page *et al*., 2017, Riberio *et al.,* 2013), as well as anti-aging (Girsang *et al.,* 2020). In addition, nano preparations in cosmetic formulations were applied, namely for coffee nanoparticles as antioxidants (Sunoqrot *et al.,* 2021) and cream preparations (Girsang *et al.,* 2020). Sunscreen formulations in the form of water-in-oil emulsions provided a sun protection factor (SPF) (Rodrigues *et al.,* 2016). Coffee was also used in the preparation of lip balm as a moisturizer (Handayani *et al.,* 2020), body lotion, and hand moisturizing cream (Chaiyasut *et al.,* 2018). In the future, coffee will have the potential to be developed as a cosmetic in a formulation with drug delivery systems such as SNEDDS (Pratiwi, 2021a; Pratiwi *et al.,* 2021b), Solid Lipid Nanoparticle (Dzulhi *et al.,* 2018), Gold nanoparticle (Potnikov *et al.,* 2017), Nanostructured Lipid Carrier (Almaeda *et al.,* 2013) and other deliveries.

Cosmetic

Cosmetic came from the Greek word which means to decorate and organize. Cosmetic referred to mixed ingredients which are then applied on the outer limbs such as skin epidermis, nails, hair, lips, teeth, etc. in order to increase attractiveness, protect, and repair for better appearance (Haynes *et al.,* 1997). The main applicable ingredients for cosmetics were basic ingredients that are efficacious and active and are added with other additives such as dyes, fragrances; the mixing of these ingredients had to meet the principles of making cosmetics in terms of various technological, chemical engineering, and other aspects (Wasitaatmaja, 1997). Cosmetics are used to enhance the appearance of both men and women. Cosmetics can be produced in natural and hypoallergenic forms as needed. The need for cosmetics is getting wider to keep the young and attractive. The developing cosmetics include creams, lipsticks, fragrances, eye shadows, nail polishes, hair showers, and face powders that make skin shine after applying basic cream. Lipsticks are made from ideal wax and cocoa butter. Creams, gels, and colognes are used consistently by women and men. Creams are usually used as a base for faces. A cosmetic cream serves as skin support for hard, and dry skin; it greases, reduces, and expels unwanted impurities from the skin. Some of the well-known fat creams used combine vaseline and lanolin. Dry creams are used in cleansing formulations, and gelatin is used as the base for the skin. Likewise, hair care has an essential potential for development in the beauty business. Many young people turned to oils and gels to style their hair so that products such as hair gels, oils, and moisturizers have been known in the market to treat hair loss and dandruff (Mohiuddin, 2019).

The skin consists of three primary layers: epidermis, dermis, and hypodermis. Each layer has certain characteristics and functions. The epidermis is the most superficial layer of the skin. This layer is very important in cosmetics because it gives skin texture and moisture, and contributes to skin tone. If the surface of the epidermis is dry or rough, the skin looks old. The most superficial layer of the epidermis was the stratum corneum or horny layer, which, on average, was about 15 cell layers thick (Christophers and Kligman, 1964; Rittie *et al.,* 2019; Blair, 1968). Keratinocytes in this layer are the most mature and have completed the keratinization process. Keratinocytes do not contain organelles, and their structure resembles a brick wall. The stratum corneum is a dead layer of cells because these cells do not show protein synthesis and are not responsive to cellular signaling. Horny layer functions as a skin protector, one of which is to prevent water loss in the transepidermal. Amino acids and metabolite compounds, which are byproducts formed from the breakdown of filaggrin, were natural moisturizers that work synergically with lipids in maintaining skin hydration, elasticity, and flexibility (Proksch and Jensen, 2008; Egelrud, 2000).

COFFEA AND ACTIVE COMPOUND

Effect of Coffee Beans Processing Process on Contained Active Compounds

The chemical composition of coffee varies on factors such as cultivation and processing conditions such as roasting and milling. Green coffee beans have better potential to be the source of these compounds than roasted coffee beans. In addition, it had was potential to be the natural source of polyphenols and antioxidants (Dziki *et al.,* 2015). Roasting coffee beans was an important step that affects the final quality (aroma, color, taste, and phytochemical content) of coffee (Belitz *et al.,* 2009). Green coffee contains 60% carbohydrates (stachyose, raffinose, sucrose, cellulose, arabinogalactan, galactomannan, arabinose, glucose, galactose, fructose, mannitol, mannose, xylose, and ribose), 8-18% proteins, lipids (triglyceride, stigmasterol, and sitosterol), fatty acids (oleic, linoleic, palmitic, linolenic, arachidic, stearic, behenic, and lignoceric), and polyphenols (caffeoylquinic, feruloylquinic, cinnamoylquinic, and dicaffeoylquinic acids). Asparagine, alanine, glutamic acid, lysine, and aspartic acid are the main amino acid constituents of coffee. In addition, coffee is rich in caffeine, trigonelline, theophylline, and theobromine. Green coffee bean metabolism is rich in compounds with well-known health-contributing effects, such as chlorogenic acid, trigonelline, and choline. Chlorogenic acid was the most important substance of coffee polyphenols (12%-18% dry weight in green coffee), and could be grouped into three main groups: caffeoylquinic acid, with 5-O-caffeoylquinic acid being the most abundant, feruloylquinic acid, and di- caffeoylquinic (Zhou *et al.,* 2013). Coffee roasting was a process that changes the color, taste, and smell of green coffee beans resulting in 8-10% degradation of chlorogenic acid in every 1% of dry matter (Clifford, 1999) and 11%-45% degradation of polyphenols (Budryn *et al.,* 2015). Several studies on the antioxidant capacity of coffee from various types of Arabica showed that the total phenol in roasted coffee was lower than in unroasted green coffee The lower levels of polyphenols in roasted coffee were due to polymerization, autoxidation, or degradation during roasting (Cammerer *et al.,* 2006). The antioxidant activity of 100% unroasted green arabica coffee extract was able to inhibit radicals by 89.55% ± 0.37, having a total phenol content of 77.54 μg / mL ± 15.36 and flavonoids of 1.74 μg / mL ± 0.03. (Hudáková *et al.*, 2016). The green coffee extract contained higher polyphenols and chlorogenic acid than instant coffee extract. The relatively low levels of total phenol were due to the degradation of these compounds during roasting (Singleton *et al.,* 1999). A study that compared the antioxidant and anti-tyrosinase activity of unroasted arabica coffee and roasted with extraction using n-hexane solvent and 95% ethanol for the dry extract that did not dissolve n-hexane revealed that the unroasted ethanol coffee bean extract had the highest antioxidant activity with an IC_{50} value of 0.050 mg / mL ± 0.01 (DPPH), 0.016 mg/mL ± 0.01 (ABTS), 1.246 mg/mL ± 0.85 (lipid peroxidase), with a total phenolic of 255.99 mg gallic acid/g extract ± 2.05. The antioxidant activity and content of phenolic compounds were much greater than that of unroasted and roasted n-hexane extract and on unroasted ethanol extract (Kiattisin *et al.,* 2016). Ethanolic extract showed higher antioxidant activity which is significantly different from hexane extract due to the presence of phenolic compounds, particularly chlorogenic acid, which could be extracted with more polar solvents (Prieto and Vázquez, 2014; Yashin *et al.,* 2013).

The Effect of Coffee Types on Antioxidant Activity and Contained Active Compounds

Nearly 60% of coffee production was dominated by Coffea arabica (Luwdig *et al.,* 2014). Arabica coffee was superior in aroma quality, while Robusta was rich in flavor, caffeine, and antioxidant activity (Farah, 2012). Antioxidant ability correlates with total phenol and flavonoid levels. Low levels of total phenols and flavonoids were found in instant coffee samples, which indicated a lower antioxidant capacity (Hudáková *et al.,* 2016). The study of Patay *et al.,* 2016 compared the content of coffee beans and pericarp of immature and ripe coffee of 3 coffee types:

Table Ia. Total Phenolic Content (TPC) on Several Types of Coffee

Coffee species	Plant parts	Origin	Extraction method	TPC (mg GAE)	Reference
Coffea arabica	Coffee beans	Thailand	Coffea machine	11.81 ± 0.86	Chaiyasut *et al*., 2018
Coffea arabica	Coffee beans	Thailand	Propylene glycol 80%	10.03 ± 1.75	Chaiyasut *et al*., 2018
Coffea arabica	Coffee beans	Spend coffea ground Roma	Ethanol 60%, air 40%	23.90 ± 0.22	Panusa *et al*., 2013
Coffea arabica	Coffee beans	Spend coffea ground Roma	Water 100%	17.43 ± 0.21	Panusa *et al*., 2013
Coffea arabica	Young coffee leaves	Indonesia	Methanol 70%	24.68 ± 1.50	Pristiana *et al*., 2017
Coffea arabica	Old coffee leaves	Indonesia	Methanol 70%	35.7 ± 2.83	Pristiana *et al*., 2017
Civet coffea	Coffee beans	Thailand	Coffea machine	10.34 ± 0.31	Panusa *et al*., 2013
Civet coffea	Coffee beans	Thailand	Propylene glycol 80%	10.67 ± 1.00	Panusa *et al*., 2013
Coffea arabica	Coffee beans	Thailand	Green, Hexane extract	Not detected	Kiattisin *et al*., 2016
Coffea arabica	Coffee beans	Thailand	Roasted, hexane extract	Not detected	Kiattisin *et al*., 2016
Coffea arabica	Coffee beans	Thailand	Green, ethanolic extract	255.99 ± 2.05	Kiattisin *et al*., 2016
Coffea arabica	Coffee beans	Thailand	Roasted, ethanolic extract	90.95 ±1.93	Kiattisin *et al*., 2016
Coffea arabica	Coffee beans	Slovak Republic	Roasted ground (gold) 100% coffee	73.64 ± 14.92	Hudakova *et al*., 2016
Coffea arabica	Coffee beans	Slovak Republic	Roasted ground (extra special) 100% coffee	55.7 ± 6.11	Hudakova *et al*., 2016
Coffea arabica	Coffee beans	Slovak Republic	Instan coffee 100% coffee	57.47 ± 11.24	Hudakova *et al*., 2016
Coffea arabica	Coffee beans	Slovak Republic	Crema gold	31.24 ±18.07	Hudakova *et al*., 2016
Coffea arabica	Coffee beans	Slovak Republic	Unroasted ground100% coffee	77.54 ± 15.36	Hudakova *et al*., 2016
Coffea canephora (Robusta)	Coffee beans	Spend coffea ground Roma	100% water	19.62 ± 0.02	Panusa *et al*., 2013
Coffea canephora (Robusta)	Coffee beans	Spend coffea ground Roma	60% ethanol, 40% water	28.26 ± 0.49	Panusa *et al*., 2013
Coffea canephora (Robusta)	Coffee beans	Slovak Republic	Roasted ground 100% coffee	51.37 ± 18.4	Hudakova *et al*., 2016

Table Ib. Total Phenolic Content (TPC) on Several Types of Coffee

Coffee species	Plant parts	Origin	Extraction method	TPC (mg GAE)	Reference
Coffea canephora (Robusta)	Coffee beans	Slovak Republic	Roasted ground	59.9 ± 11.03	Hudakova et al., 2016
Coffea canephora (Robusta)	Young coffee leaves	Indonesia	Methanol 70%	20.09 ± 0.26	Pristiana et al., 2017
Coffea canephora (Robusta)	Old coffee leaves	Indonesia	Methanol 70%	37.85 ± 1.54	Pristiana et al., 2017
Coffea liberica	Young coffee leaves	Indonesia	Methanol 70%	12.31 ± 1.73	Pristiana et al., 2017
Coffea liberica	Old coffee leaves	Indonesia	Methanol 70%	77.42 ± 3.87	Pristiana et al., 2017

Coffea arabica, Coffea benghalensis, and coffea liberica. The highest tannin content in immature liberica coffee beans was 1,164%, the highest total polyphenols in immature Arabica coffee beans was 4,146%, and the highest total phenolic content in immature liberica pericarp was 0.142% (Patay *et al.,* 2016).

Potential of Coffee Leaves as Antioxidant

Not only coffee beans, but the coffee leaves also have pharmacological activity. According to Pristiana *et al*., (2017), the antioxidant activity of young and old leaf extracts in Robusta (*Coffea canephora*) coffee is more or less the same, with the antioxidant activity values of young leaves and old leaves, respectively 33.67 + 110 and 382.75 + 183.8 mg eq. ascorbate/g extract. Coffee leaves (*Coffea canephora*) were extracted by maceration method using 70% ethanol solvent, fractionated by liquid-liquid extraction method with different solvents to obtain fractions of n-hexane, ethyl acetate, and methanol. Testing was carried out on all samples at concentrations of 50, 100 and 150 ppm including measurements of sun protection factor (SPF), %Te and %Tp using visible UV-visible spectrophotometry at 290 and 400 nm wavelengths. The test results showed that the ethyl acetate fraction with a concentration of 150 ppm had the highest potential as sunscreen compared to other samples with an SPF value of 19.82; % Te 10.96, % Tp 18.14 and included in fast tanning sunscreen (Yuliawati *et al*., 2019). Coffee leaves contain secondary metabolites such as flavonoids, alkaloids, saponins, caffeine, and polyphenols (Pristiana *et al*., 2017). Phenolic compounds have conjugated double bonds in the benzene core which will experience resonance due to the transfer of electrons when exposed to UV light. With this mechanism, phenolic compounds and compounds that act as sunscreens had the potential to act as photoprotection (Kusumanti *et al*., 2017). Flavonoids also have the potential because they have chromophore groups that act as aromatic conjugated double bonds able to absorb light at UV A and UV B wavelengths. Flavonoids play a role in protecting plants from UV radiation and in reducing free radicals formed due to exposure to UV rays. Therefore, flavonoids had three different photoprotection effect mechanisms, namely UV light absorption, direct and indirect antioxidants, and cell signaling pathways (Saewan *et al.,* 2013). Several studies suggested the possibility of using different extraction techniques and solvents to obtain extracts that show high antioxidant power (Mussatto *et al.,* 2011; Ludwig *et al.,* 2012; Bravo *et al*., 2013; Panusa *et al*., 2013; Ranic *et al*., 2014). This was inseparable from the role of chlorogenic acid and its derivatives (Kučera *et al*., 2016). These antioxidant molecules had great potential in medical and biomedical fields because of their ability to prevent and inhibit several chronic and degenerative diseases (Wadhawan and Anand, 2016; Vega *et al*., 2015). The highest phenol content in the old leaf extract of Liberika coffee was 77.42 ± 3.87 mg eq. US. error / g extract and the lowest was in young leaf extract of Liberica coffee which was 12.31 ± 1.73 mg eq/g extract (Pristiana *et al*., 2017).

Potential of Coffee Grounds as Cosmetics

In addition to the potential for coffee beans and coffee leaves. The use of coffee grounds is increasingly widespread. Coffee grounds are the best alternative source of renewable bioactive principles. Used coffee grounds contain kahweol, cafestol, trigonelline, caffeine, and polyphenols (gallic acid, protocratic acid, and chlorogenic acid) and show high antioxidant activity. The study shows that used coffee powder bioactive compounds are effective ingredients in cosmetic and pharmaceutical preparations (Acevedo *et al*., 2013; Choi *et al*., 2017). Several studies have revealed the antioxidant richness of raw and used coffee and its extracts (Kim *et al*., 2016; Nosaria *et al*., 2015; Page *et al*., 2017). Zainol *et al*., 2020 tested the antioxidant activity of coffee grounds for Robusta, Arabica, and Liberica types with DPPH, FTC, TBA, total phenolic content (TPC), and total phenolic content (TFC). The results showed that Robusta coffee had the highest DPPH inhibition (41.63 ± 0.04%), FTC (60.42 ± 0.03%), and TBA analysis (73.09 ± 0.08%). The highest total phenolic compounds were in Robusta coffee, while the highest total flavonoid content was in Arabica coffee (47.62 ± 0.05 to 56.20 ± 0.08 mg GAE/g sample) (Zainol *et al*., 2020).

COFFEE IN COSMETIC FORMULATIONS

The application of coffee formulation as a cosmetic

Antioxidants act on the skin to reduce the effects of reactive oxygen species (ROS) due to exposure to ultraviolet (UV) rays. Antioxidants could stimulate the production of dermal collagen by increasing the production of tissue inhibitor of matrix metalloproteinase-I in the dermis which functions to inhibit the breakdown of collagen and elastin (Baumann, 2005). Matrix metalloproteinase is an enzyme that can cause a decrease in the collagen and elastin content in the skin; it results in aging. Photoaging is the aging caused by ultraviolet rays. In photoaging, the annual decrease in collagen was up to 59% per unit of skin area, whereas there was a decrease in the collagen of about 1% per unit of skin area in skin that was unexposed to UV (Uito *et al*., 2008; Griffits *et al*., 2009). The results showed that coffee silverskin was useful as an antioxidant. This is supported by Rodrigues' research showing that the 2.5% coffee silverskin extract formulated in cream for hands had antioxidant activity. Caffeine has been used in pharmaceutical and cosmetic preparations because it has many beneficial effects on the skin (Rubio *et al*., 2010). Hydro-alcohol extract of coffee, namely ethanol: water (1: 1) was added as an antioxidant in cosmetic preparations. A hand cream formulation was with components including water, cetostearyl alcohol, dimethicone, jojoba oil, lactic acid, glycerin, sodium lauret sulfate, triethanolamine, perfume, and preservatives. The cream base used an oil-in-water semi-solid emulsion system containing the same ingredients but without adding any extracts. The extract was added and dissolved in the mixture after reaching room temperature. This preparation was stable on storage for 6 months (Rodrigues *et al*., 2016). The dosage formulations of green coffee oil microencapsulation were promising antioxidant-rich cosmeceutical agents, and it was proven that skin creams containing coffee powder oil increase skin sebum levels (Page *et al*., 2017, Riberio *et al*., 2013). Green coffee (*Coffea canephora* var. Robusta) is developed into a topical serum cosmetic preparation as an antioxidant. Serum was preparation with high concentrations of active substances with low viscosity, delivering a thin film of active ingredients on the skin surface (Draelos, 2010). The serum is formulated with low viscosity and less clear (semi-transparent), which contains higher levels of active ingredients than topical preparations in general. The purpose of designing this preparation was the need for a topical preparation that penetrates quickly into the skin to protect the skin from cell damage caused by radicals (Yanni *et al.,* 2018). Optimization of the serum base was with a variety of gelling agents and obtained one selected base formula, namely Natrosol® 0.75%. The serum dosage formulations used variations of 0.5%, 0.8%, and 1.1% green coffee extract. Based on the results of physical evaluation analysis, namely organoleptic examination, homogeneity, measurement of pH, viscosity, and dispersion, all formulas showed stable serum preparations for 28 days; hedonic test results were favored by panelists, and antioxidant test results revealed IC50 value of 68.89 µg / mL, classified as strong antioxidants. The green coffee extract could be formulated in cosmetic serum preparations with the best formula containing 0.75% Natrosol® gelling agent and 0.5% green coffee extract and was proven to be effective as an antioxidant in vitro (Yanni *et al*., 2018). Compatible coffee extracts are formulated in nanoparticles. Arabica coffee beans were with varying degrees of roasting, namely green coffee without roasting, roasting to medium color, and black in various oxidizers: air, sodium meta periodate, and copper sulfate. Nanoparticle formation was verified by dynamic light scattering and transmission electron microscopy, resulting in nano-sized particles of various sizes and polydispersities. Unlike air oxidation, the addition of an oxidizer changed the particle size of the coffee nanoparticles. Among all tested groups, $CuSO_4$ oxidized green coffee extract produced the smallest nanoparticles with an average diameter of 44 nm, and the largest nanoparticles were obtained from the $NaIO_4$ and $CuSO_4$ oxidized dark coffee extracts (249 and 250 nm, respectively). In particular, the particle size for air-oxidized green coffee extracts significantly reduced from 121 to 73 nm and 44 nm after oxidation with NaIO4 and CuSO4. In medium roasting coffee, the particle size significantly reduced from 175 to 85 nm and 134 nm in the extracts oxidized by NaIO4 and CuSO4 (Sunoqrot *et al*., 2021). This finding can be attributed to the accelerated oxidative coupling reaction in the presence of an oxidizing agent, which allows more efficient oxidation of polyphenol groups. This reactive intermediary has been shown to mediate the formation of oligomeric with or without polymeric structures capable of forming nanoparticles (Xiang *et al.,* 2017; Sunoqrot *et al.,* 2019). The antioxidant activity of green extract and coffee extract from medium roasting with air antioxidants showed comparable antioxidant potential (EC_{50} = 75.5 and 68.5 µg·mL -1). The dark roasted coffee extract had a significantly lower antioxidant activity with EC50 149.7 µg·mL-1 (Sunoqrot *et al*., 2021). This was due to the roasting process, which has been shown to cause degradation of chlorogenic acid, the main constituent responsible for antioxidant activity (Cho *et al*., 2014). Coffee nanoparticles showed no antimicrobial activity against common strains of bacteria and fungi. Antioxidant nanoparticles could be explored for various applications such as drug delivery and cosmetics (Sunoqrot *et al*., 2021).

Coffee Formulation as Anti Aging

Aging is a process characterized by the loss of natural elasticity, resulting in thinner, saggier, and more brittle, skin and the appearance of wrinkles. Aging is caused by two genetic factors and UV rays. Endocrine and immune function are factors that cannot be avoided. Ultraviolet rays, weather changes, and environmental pollution could aggravate the natural aging process so that the use of several personal care products to treat aging was required (Xiang, 2015). Robusta coffee (*Coffea canephora*) has antioxidant compounds that can be used as a cosmetic ingredient. The high antioxidant activity was due to the caffeine content in coffee which makes skin healthier and younger looking by maintaining skin hydration, pigmentation, fine wrinkles, and treating skin infections such as acne and rosacea (Magnani *et al*., 2015). Apart from caffeine, polyphenols, alkaloids, tannins, and saponins found in Coffea canephora had high antioxidant activity (Chairgulprasert and Kittiya, 2017). The anti-aging effect of coffee extract can overcome photoaging problems. Cream with a coffee bean extract concentration of 2.5%, 5%, 7.5%, 10%, and control was divided into five groups and given exposure to UV A and B for five days; the cream was given twice a day for four weeks, and the changes were measured every one week. for four weeks with a skin analyzer. O/w type cream base consists of stearic acid, triethanolamine, glycerin, preservative sodium benzoate. The results showed that there was an increase in collagen levels, and the highest hydration level was 91.3% and in the administration of cream with 10% concentration of coffee extract the hydration level was 86.09%. The time of administration influenced the anti-aging effect and hydration levels (Girsang *et al.,* 2020). Aceh Arabica coffee extract also had the potential to improve skin quality in aging mice. The study was conducted in vivo using four treatments of a completely randomized design (CRD); each treatment contained five rats. The parameters observed were skin collagen levels, skin moisture content, and skin ribonucleic acid (RNA) levels. The results showed that the mean levels of skin collagen and skin RNA levels in premenopausal rats given coffee extract and ethinylestradiol were higher ($P < 0.05$) when compared to control rats. In contrast, the mean skin moisture content in premenopausal rats given coffee extract and ethinylestradiol was the same as the control rats. It was concluded that giving Aceh Arabica coffee extract could improve skin quality which is marked by an increase in collagen levels and skin RNA levels in aging mice (Safrida *et al*., 2017). Caffeine was a type of alkaloid found in coffee beans, tea leaves, and cocoa beans (Wilson, 2018). The main constituent of protein derivative compounds was called purine xanthine (Arwangga *et al*., 2016). Caffeine is increasingly being used in cosmetics due to its high biological activity and its ability to penetrate the skin barrier. A commercially available topical caffeine formulation contains 3% caffeine. Caffeine has strong antioxidant properties. This helps protect cells from UV radiation and slows down the photoaging process of the skin. In addition, the caffeine contained in cosmetics improves blood microcirculation in the skin and also stimulates hair growth through the inhibition of 5-reductase activity. The ability of active compounds from cosmetics or drugs to influence cell metabolism and other processes that occur in the skin highly depended on the capacity of these molecules to penetrate the skin barrier (Herman *et al.,* 2013).

Coffee Formulation as Sunscreen

Sunscreen products have been recognized for their ability to overcome public health problems and are identified as a sun protection factor (SPF) (Ribeiro *et al*., 2013). Several things could be done do to prevent cell damage due to UV rays; they could be by avoiding sun exposure and covering skin or applying sunscreen with a high SPF. Sunscreens were usually made from synthetic chemicals with high capacities to absorb sunlight in the UVB (320–290 nm) and UVA (400–320 nm) spectra (Serpone *et al*., 2007). However, in addition to synthetic chemicals, natural ingredients have the potential as sunscreens.

Coffee grounds and green coffee beans have potential uses for cosmetic applications due to their safety and high lipid content as well as their attractive physicochemical properties. The sunscreen formulation in the form of a w/o emulsion provides a higher sun protection factor (SPF) than the o/w emulsion at the same concentration of sunscreen activity. An important factor in cosmetics is safety in use. This cream formulation was proven safe against keratinocytes and fibroblasts (Rodrigues *et al.,* 2016). The use of TiO2 and ZnO in the development of formulations using green coffee bean oil had an SPF value of 83.2% ± 10.5 and the formulation with coffee grounds oil had a value of 51.9% ± 5.55. High SPF values can protect against UVB and UVA. The green coffee bean oil formulation as a UV A filter was higher in value, namely 71.1% ± 10.1 compared to the coffee grounds oil formulation of 44.2% ± 5.2 (Marto et al., 2016). TiO2 particles were UV-B filters, which combine increased stability and high SPF properties (Wang and Tooley, 2011). ZnO ensures adequate UVA protection. In addition, ZnO particles have also been shown to be effective as antibacterial and antifungal agents (Singh *et al.,* 2012; Smijs and Pavel, 2011). Emulsion formulations containing 35% w / w fraction of spent coffee grounds are industrially scalable and suitable for topical use based on rheological, physical, and safety characteristics testing. The use of green coffee oil in the cosmetic industry has been shown to be effective in recycling and increasing the value of waste from the coffee industry (Marto *et al.,* 2016). Conney *et al.,* (2013) suggested that caffeine and sodium benzoate be useful as new inhibitors of sun-induced skin cancer. Caffeine and sodium benzoate coatings are more active as sunscreens than caffeine alone. In addition, they stimulated UVB-induced carcinogenesis apoptosis more than caffeine, and they were also very active in inhibiting carcinogenesis in high-risk mice that had been UVB pretreated.

Coffee Formulation as Face Brightener

In testing with L-tyrosinase, the ethanol extract of unroasted Arabica coffee had the highest value, namely 44.27 ± 0.01. In TLC and HPLC chromatograms, chlorogenic acids were only found in green coffee bean extract. The extract showed good stability and activity; it had good biological activity and was promising for further development of cosmeceutical or anti-aging products with a good stability profile (Kiattisin *et al*., 2016). The study used four coffee species (Colombia, Guatemala, Kenya, and Vietnam) and extraction procedures: focused high ultrasound (INEFU) and ultrasound extraction (EU), and water extraction (WE), to obtain cosmeceutical activity data on extraction yield and total polyphenols from the coffees. Under optimal extraction conditions, consisting of 1800W for 45 minutes (INEFU) and 500 W for 45 minutes (UE), the obtained highest extraction value and total polyphenol content were 10.4-19.5% and 8.2-16.2% (w/w). Face brightener activity using tyrosinase inhibition parameters was observed at 65.5% in INEFU extract, which is 26.5% higher than EU extract (51.8%) in Vietnamese coffee to reduce melanin production in Clone M-3 cells; 88.4% melanin production was observed after the addition of control, and 85.4% and 80.5% were found in UE and INEFU. High phenolic compounds could significantly improve the activity of coffee-based cosmeceutical ingredients (Seo *et al.,* 2019).

Coffee Formulation as Moisturizer and Skin Nutrition

Coffee extracts are used in cosmetic and pharmacological preparations. In arabica coffee formulation for a lip balm with a concentration of 3.6.9%, lip balm is more stable and has the highest effectiveness as an emollient at a concentration of 9%. All formulas are safe to use based on the results of the irritation test. The coffee extract was obtained by the soxhletation method using n-hexane as a solvent. The ingredients used in the lip balm formula were Cera alba, propylparaben, glycerin, butylated hydroxytoluene, vaseline album (Handayani *et al*., 2020). Research on body lotion and hand moisturizing cream is related to the development of a cosmetic formula based on Arabica and civet coffee extracts and the stability of the preparation. The coffee extract was prepared by mechanical pressing and solvent extraction methods. The total phenolic content of the extract was assessed by the Folin-Ciocalteu colorimetric method. Body lotion (BL) and hand moisturizing cream (H MC) were formulated, and the stability, heavy metal, and microbial contamination of the products were kept at different temperatures for three months. Body lotion and hand moisturizing cream were dark cream colors with a coffee aroma. The product was stable and did not change in color, odor, and texture for three months at 40 ° C. Body lotion was found to be uncontaminated with lead,

Table II. Application of Coffee in Cosmetic Formulations

Coffee	Formulation	Activity for cosmetics	Value	Reference
Silverskin coffee hydroalcoholic extract	Hand Cream	Antioxidant	IC_{50} 1296.25±55.16	Rodrigues *et al.*, 2016
Green coffee oil	Microencapsulation	Increase skin sebum levels	Effectively increase	Page *et al.*, 2017, Riberio *et al.*, 2013]
Robusta Green Coffee Extract	Serum	Antioxidant	IC_{50} 68.89 µg/ mL	Draelos, 2010
Arabica coffee extract	Nanoparticle	Antioxidant	EC_{50} 75.5 (green coffee) dan 68.5 µg/mL (medium roasted), 149.7 µg/mL (dark roasted)	Sunoqrot *et al.*, 2021
Robusta Coffee Extract	Cream	Anti-aging and hydration	Collagen levels and hydration levels were the highest, respectively 91.3%, and hydration levels of 86.09%	Girsang *et al.*, 2020
Coffee bean oil	Cream	Sunscreen	SPF 83.2% ± 10.5 UV A filter has a higher value, namely 71.1% ± 10.1	Marto *et al.*, 2016
Coffee grounds oil	Cream	Sunscreen	SPF 51.9%±5.55 filter UV A 44.2%± 5.2	Marto *et al.*, 2016
Green coffee bean ethanol extract (No roasting)	Potential as cosmetic	Facial brighteners	L-tyrosinase 44.27±0.01	Kiattisin *et al.*, 2016
High ultrasound Vietnam coffee extract	Potential as cosmetic	Facial brighteners	Tyrosinase inhibitory activity 65.5%	Seo *et al.*, 2019
Ultrasound Extraction Vietnam coffee	Potential as cosmetic	Facial brighteners	Tyrosinase inhibitory activity 51.8%	Seo *et al.*, 2019
N-hexane extract of arabica coffee	Lipbalm	Lip Moisturizer	Effectively moisturizes	Handayani *et al.*, 2020
Aceh arabica coffee	Cream	Anti-aging	Increased collagen levels and skin RNA levels in mice	Safrida *et al.*, 2017
Arabica coffee extract	Body lotion and hand moisturizing cream	Moisturizer	Has good stability	Chaiyasut *et al.*, 2018
Used coffee grounds	Encapsulation	Antioxidant	High encapsulation efficiency (63%)	Pettinato *et al.*, 2017
Coffee bean oil and green coffee bean water extract	Nanoemulsion	Anti-bacteria	Zone of inhibition 85%-100% against *Staphylococus aureus* and *Staphylococus epidermidis*, 88.79% inhibits *Eschericia Coli*	Buzanello *et al.*, 2020

whereas arsenic and mercury were found in negligible amounts and were shown to be safe free of pathogenic microbes. The coffee extracts in the product nourished and protected the skin and were suitable for topical applications (Chaiyasut *et al.*, 2018).

Coffee Formulation as Anti-Cellulite

Cellulite is an abnormal distribution of body fat, combined with a change in the endemic-fibrous nature of the subcutaneous tissue. This disease occurs in 65-70% of women, and the first changes may appear as early as adolescence. Cellulite was most often located on stomach, hips, thighs and buttocks (Konopacka-Brud, Brud, 1999; Lenart 2011; Noszczyk 2010). Caffeine can be used as a cosmetic, which is an active compound in anti-cellulite products because it prevents excessive fat accumulation in cells. These alkaloids could stimulate fat degradation during lipolysis through inhibition of phosphodiesterase activity (Herman *et al*, 2013).

Future Development of Coffee Preparation Formulations

Used coffee grounds are good raw materials that contain bioactive compounds. Used coffee extract is rich in antioxidants, especially chlorogenic acid (5-caffeoylquinic acid) (CGA) and melanoidin, which can prevent serious neurodegenerative and cardiovascular diseases. To maintain the activity of this compound, encapsulation with spray drying is used for the formulation. In this study, an extract rich in phenolic compounds from used coffee grounds was obtained by extraction using a 54:46 (v/v) ethanol: water mixture as solvent, at a temperature of 150 °C, an extraction time of 90 minutes. The encapsulation process, using inulin and maltodextrin as a coating agent, applied experimental design and response surface methodology. The results showed that a high encapsulation efficiency (63%) could be achieved using inulin as a carrier, leading to the production of polyphenol-rich micro-capsule dry powders which have potential industrial applications in the food and cosmetics fields (Pettinato *et al*., 2017). The subsequent development showed that coffee with oil extracts and green coffee water extracts has antioxidant and antimicrobial effects in nanoemulsion preparations. The nanoemulsion was designed with a spontaneous emulsion method using various concentrations of oil and extract components to optimize the preparation of the formulation. The nanoemulsion formula provides size characteristics and tentative concentrations that are more suitable for the investigation of its antioxidant and antibacterial activity. In testing the strains of *Staphylococcus aureus*, *Staphylococcus epidermidis,* and *Escherichia coli* at different nanoemulsion concentrations were proven to be able to inhibit free radicals and showed excellent antibacterial activity, namely having an inhibition zone of 85% - 100% against *Staphylococcus aureus* and *Staphylococcus epidermidis*, and could inhibit 88.79% *Escherichia coli*. The results showed the potential of coffee in cosmetic and therapeutic applications (Buzanello *et al*, 2020).

CONCLUSION

Coffee involving its coffee beans, leaves, coffee silverskin, and even coffee grounds as a green component has the potential to be applied as an active ingredient in cosmetic formulation. Coffee contains active compounds in the form of phenolics, flavonoids, tannins, and caffeine, which have an effect on improving skin quality. The location of the coffee origin extraction method, the formulation, and the coffee processing can affect the contained active compounds and the penetration capacity through the skin layer. The locations where coffee is taken show the number of active compounds and different activities. Likewise in coffee processing, green coffee without roasting and green coffee in medium roasting can maintain the content of active compounds. The maceration extraction method with ethanol gave the highest total phenolic. The different formulations, preparations, bases used, emulsion types, surfactants, and other additives are the parameters that determine the penetration of the active compound through the skin and its effectiveness as a cosmetic.

REFERENCES

Acevedo, F., Rubilar, M., Scheuermann, E., Cancino, B., Uquiche, E., Garces, M., *et al*., 2013, 'Spent coffee grounds as a renewable source of bioactivecompounds', *J Biobased Mater Bio*. 7,1-9.

Ajhar, N., and Meilani, D., 2020, 'Phytochemical Screening and Antioxidant Activity Test of Ethanol Extract of Arabica Coffee Beans (*Coffea arabica*) Growing in Gayo Area Using the DPPH Method', *Pharma Xplore*. 5 (1), 34-40.

Allan, H., Conney., Lu, Y., Lou, Y.R., Kawasumi, M., and Nghiem, P., 2013, 'Mechanisms of Caffeine-Induced Inhibition of UVB Carcinogenesis Cancer moleculer targets and therapeutic', *Front Oncol*. 3, 1-11.

Almeida., Mandelli, M., Chacra, B., Nádia, A., Conte., *et al*., 2013, 'Evaluation of Physical and Chemical Stability of Nanostructured Lipid Carries Containing Ursolic Acid in Cosmetic Formulation', *Journal of Applied Pharmaceutical Science*, 3 (1): 005-008.

Amigoni., Stuknyte, M., Ciaramelli, C., Magoni, C., Bruni, I., *et al*., 2017, 'Green coffee extract enhances oxidative stress resistance and delays aging in Caenorhabditis elegans Loredana', *Journal of Functional Foods*. 33, 297-306.

Arwangga, A.F., Asih, I.A., and Sudiarta, I.W., 2016, 'Analysis of Caffeine in Coffee in Sesaot Narmada Village Using UV-Vis Spectrophotometry', *Journal of Chemistry*. 10 (1):110-114.

Babova, O., Occhipinti, A., Massimo, E., and Maffei., 2016, 'Chemical partitioning and antioxidant capacity of green coffee (*Coffea arabica* and *Coffea canephora*) of different geographical origin', *Phytochemistry*. 123, 33–39.

Baumann, L., 2005, 'How to Prevent Photoaging?', *Journal of Investigative Dermatology*. 125, 1-2.

Belitz, H.D., Grosch, M., and Schieberle, P., 2009, *Food Chemistry*, 4th ed. Springer-Verlag, Berlin.

Bhupathiraju, S.N., Pan, A., Malik, V.S., Manson, J.E., Willett, W.C., Van, D.R., *et al*., 2013, 'Caffeinated and caffeine-free beverages and risk of type 2 diabetes', *Am J Clin Nutr*. 97,155–166.

Blair, C., 1968, 'Morphology and thickness of the human stratum corneum', *Br J Dermatol*. 80, 430.

Bravo, J., Monente, C., Juániz, I., De Peña, M.P., and Cid, C., 2013, 'Influence of extraction process on antioxidant capacity of spent coffee', *Food Research International*. 50, 610-616.

Brud, K., and Brud, W.S., 1999, 'Essential oils as active ingredients for the treatment of cellulite', *Drugstore*. 1, 12-20.

Budryn, G., Nebesny, E., and Oracz, J., 2015. 'Correlation between the stability of chlorogenic acids, antioxidant activity and acrylamide content in coffee beans roasted in different conditions', *Int. J. Food Prop*. 18 (2), 290-302.

Buzanello, E.B., Machado, G.T., Kuhnen., Mazzarino, L., and Maraschin, M., 2020, 'Nanoemulsions containing oil and aqueous extract of green coffee beans with antioxidant and antimicrobial activities', *Nano Express*. 1, 1-14.

Cammerer, B., and Kroh, L.W., 2006, 'Antioxidant activity of coffee brews. European Food Research and Technology'. 223, 469-474.

Cano-Marquina, A., Tarín, J.J., and Cano, A., 2013, 'The impact of coffee on health', *Maturitas*. 75, 7–21.

Chairgulprasert, V., and Kittiya, K., 2017, 'Preliminary Phytochemical Screening and Antioxidant Activity of Robusta Coffee Blossom', *Thammasat International Journal of Science and Technology*. 22 (1), 1-8.

Chaiyasut, C., Sivamruthi, B.S., Makhamruerang, N., Sirithunyalug, J., Peerajan, S., *et al*., 2018, 'Formulation and Stability Assesment of Arabica and Civet Coffee Extract Based Cosmetic Preparation', *Asian J Pharm Clin Res*. 11 (6), 425-429.

Cheong, M.W., Tong, K.H., Ong, J.J., Liu, S.Q., Curran, P., and Yu, B., 2013, 'Volatile composition and antioxidant capacity of Arabica coffee', *Food Research International*. 51, 388-396.

Cho, A.R., Park, K.W., Kim, K.M., Kim, S.Y., and Han, J., 2014, 'Influence of roasting conditions on the antioxidant characteristics of Colombian coffee (*Coffea arabica* L.) beans', *J. Food Biochem*. 38, 271-280.

Choi, B., and Koh, E., 2017, 'Spent coffee as a rich source of antioxidative compounds', *Food Sci Biotechnol*. 26, 921-927.

Christophers, E., and Kligman, A.M., 1964, 'Visualization of the cell layers of the stratum corneum', *J Invest Dermatol*. 42, 407.

Clifford, M.N., 1999, 'Chlorogenic acids and other cinnamates–nature, occurrence and dietary burden', *J. Sci. Food Agri*. 79, 362-372.

Draelos, Z.D., 2010, *Cosmetic Dermatology Products and Procedures*, Blackwell Publishing, Ltd, USA.

Dziki, D., Dziki, G.U., Pecio, L., Różyło, R., S´wieca, M., *et al*., 2015, 'Ground green coffee beans as a functional food supplement–Preliminary study', *LWT-Food Sci. Technol*. 63 (1), 691-699.

Dzulhi, S., Anwar, E., and Nurhayati, T., 2018, 'Formulation, Characterization and *In Vitro* Skin Penetration of Green Tea (*Camellia sinensis* L.) Leaves Extract-Loaded Solid Lipid Nanoparticle', *JAPS*. 8 (8), 57-62.

Egelrud, T., and Desquamation., 2000, *Dry Skin and Moisturizers*, 1st ed. Boca Raton, FL: CRC Press.

Farah, A., 2012, 'Coffee constituents, Coffee: Emerging Health Effects and Disease Prevention', 1sted, Blackwell Publishing Ltd, USA.

Girsang, L.C., Fachrial, E., and Listerc, I.N., 2020, 'Effectiveness Test of Robusta Coffee (*Coffea cenephora*) Extract from North Sumatra in Collagen and Hydration Skin Level of Female Wistar Rattus norvegicus', *American Scientific Research Journal for Engineering, Technology and Sciences*. 65 (1), 108-115.

Griffits, C., Russman, A.N., Majmudar, G., and Singer, R.S., 1993. 'Restoration of collagen

Formation in photodamage Human Skin by Tretinoin', *New England Journal of Medicine*. 329 (8), 530-535.

Handayani, R., Srarumtias, F.F., Sofwan, S.S., 2020, 'Lipbalm preparation formulation from arabica coffee bean extract (*Coffea arabica* L.) Java Preanger as emollient', *JIF Farmasyifa*. 4(1), 105-111.

Haynes, A., 1997, 'Behind a Beautiful Face: Facts About The Benefits And Risks Of Cosmetics', Indonesian Consumers Foundation, Jakarta.

Herman., and Herman, A.P., 2013, 'Caffeine's Mechanisms of Action and Its Cosmetic Use', *Skin Pharmacol Physiol*. 26, 8-14.

Hudáková, J., Marcinčáková, D., and Legáth, J., 2016, 'Study of Antioxidant Effects of Selected Types of Coffee', *Folia Veterinaria*. 60 (3), 34-38.

Kiattisin, K., Nantarat, T., and Leelapornpisid, P., 2016, 'Evaluation of antioxidant and anti-tyrosinase activities as well as stability of green and roasted coffee bean extracts from Coffea arabica and Coffea canephora grown in Thailand', *Journal of Pharmacognosy and Phytotherapy*. 8(10), 182-192.

Kim, J.H., Ahn, D.U., Eun, J.B., and Moon, S.H., 2016, 'Antioxidant effect of extracts from the coffee residue in raw and cooked meat', *Antioxidants (Basel)*. 5 (3), 1-10.

Kučera, L., Papoušek, R., Kurka, O., Barták, P., and Bednář, P., 2016, 'Study of composition of espresso coffee prepared from various roast degrees of *Coffea arabica* L. coffee beans', *Food Chemistry*.199, 727-735.

Kusumanti, D.P., Sayuti, N.A., and Indarto, A.S., 2017, 'Sunscreen Activity with Javanese Cold Powder Formula', *Indones J Pharm Sci Technol*. 1(1), 1-7.

León, C.J.R., and Galano, A., 2011, 'Is Caffeine a Good Scavenger of Oxygenated Free Radicals?. *J. Phys. Chem. B*.115, 4538-4546.

Lenart, D., 2011, 'Cellulit or cellulitis?', *Magazine Pharmacy*. 2 (91), 72-73.

Ludwig, I., Sanchez, L., Caemmerer, B., Kroh, L.W., De Peña, M.P., and Cid, C. 2012, 'Extraction of coffee antioxidants: Impact of brewing time and method', *Food Research International*. 48, 57-64.

Marto, L.F., Gouveia, B.G., Chiari, A., Paiva, V., Isaac, P., *et al*., 2016, 'The green generation of sunscreens: Using coffee industrial sub-products', *Industrial Crops and Products*. (80), 93-100.

Magnani, C., Thais, S.O., Vera, L.I., Marcos, A.C., and Herida, R.S., 2015, 'Validation of Caffeic Acid in Emulsion by UV-Spectrophotometric Method', *Journal Physical Chemistry*. 5(1),16-22.

Mohiuddin, A.K., 2019, 'Cosmetics in use: a pharmacological review', *J Dermat Cosmetol*. 3(2), 50-67.

Mussatto, S.I, Ballesteros, L.F., Martins, S., and Teixeira, J.A., 2011, 'Extraction of antioxidant phenolic compounds from spent coffee grounds', *Separation and Purification Technology*. 83, 173-179.

Noszczyk, M., 2010, *Lipodystrophy-Cellulit, Nursing and Therapeutic Cosmetology*, PZWL Publishing House, Warsaw.

Nosaria, A.B., Lima, J.F., Serra, O.A., and Freitas, L.A., 2015, 'Improved green coffee oil antioxidant activity for cosmetical purpose by spray drying microencapsulation', *Rev Bras Farm*. 25, 307-311.

Page, J.C., Arruda, N.P., and Freitas, S.P., 2017,'Crude ethanolic extract from spent coffee grounds: Volatile and functional properties', *Waste Manag*. 69, 463-469.

Panusa, A., Zuorro, A., Lavecchia, R., Marrosu, G., and Petrucci, R., 2013, 'Recovery of Natural Antioxidants from Spent Coffee Grounds', *Journal of Agricultural and Food Chemistry*. 61, 4162-4168.

Patay, E.B., Bencsik, T., and Papp, N., 2016, 'Phytochemical overview and medicinal importance of Coffea species from the past until now', *Asian Pasific Journal of Tropical Medicine*. 9 (12), 1127-1135.

Pettinato, M., Aliakbarian, B., Casazza, A.A., and Perego, P., 2017, 'Encapsulation of Antioxidants from Spent Coffee Ground Extracts by Spray Drying', *Chemical Engineering Transtions*. 57, 1219-1224.

Pratiwi, L., 2021, 'Novel antimicrobial activities of self-nanoemulsifying drug delivery system ethyl acetate fraction from *Garcinia mangostana* L. peels against *Staphylococcus epidermidis*: Design, optimization, and *in vitro* studies', *Journal of Applied Pharmaceutical Science*. 11(03), 162-171.

Pratiwi, L., Sari, R., and Apridamayanti, P., 2021, 'Design and Characterization of Nanospray With Self-Nanoemulsifying Drug Delivery System Using Sinergistic Combination of *Melastoma malabathricum* L. Fraction and Gentamicin', *Int J App Pharm*. 13 (2), 254-263.

Plotnikov, E., Zhuravkov, S., Gapeyev, A., Plotnikov, V., Martemianova, I., and Martemianov, D., 2017, 'Comparative Study of Genotoxicity of Silver and Gold Nanoparticles Prepared by the Electric Spark Dispersion Method', *Journal of Applied Pharmaceutical Science*, 7 (7), 35-39.

Prieto, M.A., and Vázquez, J.A., 2014, 'In vitro determination of the lipophilic and hydrophilic antioxidant capacity of unroasted coffee bean extracts and their synergistic and antagonistic effects', *Food Res. Int*. 62, 1183-1196.

Pristiana, D.Y., Susanti, S., and Nurwantoro, N., 2017, 'Antioxidant Activity and Phenol Levels of Various Coffee Leaf Extracts (Coffea sp.): Potential Applications of Natural Ingredients for Food Fortification', *J Apl Teknol Pangan*. 6(2), 89-92.

Proksch, E., and Jensen, J., 2008, *Skin as an organ of protection*. Dermatology in General Medicine, 7th New York, NY: McGraw-Hill.

Ranic, M., Nikolic, M., Pavlovic, M., Buntic, A., and Marinkovic, S., *et al*., 2014, 'Optimization of microwave-assisted extraction of natural antioxidants from spent espresso coffee grounds by response surface methodology', *Journal of Cleaner Production*. 80, 69-79.

Ribeiro, H., Marto, J., Raposo, S., Agapito, M., Isaac, V., Chiari, B.G., *et al*., 2013, 'From coffee industry waste materials to skin-friendly products with improved skin fat levels', *Eur J Lipid Sci Technol*.115, 330-336.

Rittié, L., Athanasopoulos, T., Garcia, M.C., Davies, M.L., Dow, D.J., Howe, S.J., *et al*., 2019, 'The Landscape of Early Clinical Gene Therapies outside of Oncology Molecular Therapy', *The American Society of Gene and Cell Therapy*. 27 (10), 1706-1717.

Rubio, L., Alonso, C., Coderch, L., Parra, J.L., Martí, M., Cebrián, J., *et al*., 2010, 'Skin delivery of caffeine contained in biofunctional textiles', *Text Res J*. 80, 1214-1221.

Sentkowska, A., Skowron, M.J., and Pyrzynska, K., 2016, 'Comparative studies on the antioxidant properties of different Green coffee extracts', *MOJ Food Process Technol*. 3(2), 296-302.

Seo, S.N., and Kim, Y.M., 2019, 'Implications for Beneficial Effects on Cosmetic Activity by Optimizing the 4 Coffee Variety Extraction Process', *Natural Product Communications*. 5, 1-5.

Rodrigues, F., Gaspar, C., Oliveira, A.P., Sarmento, B., Amaral, M.H.M., and Oliveira, B.P., 2016, 'Application of Coffee Silverskin in cosmetic formulations: physical/antioxidant stability studies and cytotoxicity effects', Drug Dev Ind Pharm. 42(1), 99-106.

Saewan, N., and Jimtaisong, A., 2013, 'Photoprotection of natural flavonoids', *J Appl Pharm Sci*, 3(9), 129-141.

Safrida, S., and Sabri, M., 2017, 'Potential of Aceh Coffee Extract (*Coffea arabica* L.) in Rejuvenation of Aging Skin in Rat', *Journal of Veterinary Medicine*. 11(3),101-103.

Serpone, N., Dondi, D., Albini, A., 2007, 'Inorganic and organic UV filters: Their role and efficacy in sunscreens and suncare products', *Inorganica Chimica Acta*. 360: 794–802.

Shi, X., Dalal, N.S., Jain, A.C., 1991, 'Antioxidant behaviour of caffeine: Efficient scavenging of hydroxyl radicals. Food Chem', *Toxicol*. 29, 1-6.

Singh, G., Joyce, E.M., Beddow, J., and Mason, T.J., 2012, 'Evaluation of antibacterial activity of ZnO nanoparticles coated sonochemically onto textile fabrics', *J. Microbiol. Biotechnol. Food Sci,* 2, 106-20.

Singleton, V.I., Ortofer, R., and Raventos, R.M., 1999, *Analysis of total phenols and other oxidation substances and antioxidants by means of Folin-Ciocalteu reagent*. In Packer, L. (Ed.): Methods in Enzymology. Academic Press.

Smijs, T.G., and Pavel, S., 2011, 'Titanium dioxide and zinc oxide nanoparticles in sunscreens: focus on their safety and effectiveness', *Nanotechnol Sci Appl*. 13 (4), 95-112.

Sunoqrot, S., Al-Shalabi, E., Ibrahim, H.L., and Zalloum, H., 2019, 'Nature-inspired polymerization of quercetin to produce antioxidant nanoparticles with controlled size and skin tone-matching colors', *Molecules*. 24, 1-12.

Sunoqrot, S., Al-Shalabi, E., Al-Bakri, A.G., Zalloum, H., Abu-Irmaileh, B., et al., 2021, 'Coffee Bean Polyphenols Can Form Biocompatible Template-free Antioxidant Nanoparticles with Various Sizes and Distinct Colors', *ACS Omega*. 6, 2767-2776.

Vega, R.C., Piña, G.L., Hayde, A., Castañeda, V., and Oomah, D., 2015, 'Spent coffee grounds: A review on current research and future prospects', *Trends in Food Science & Technology*. 45, 24-36.

Wadhawan, M., and Anand, A.C., 2016, 'Coffee and Liver Disease. Journal of Clinical and Experimental Hepatology, 2016; 6: 40-46.

Wang, S.Q., and Tooley, R., 2011, 'Photoprotection in the era of nanotechnology', *Semin. Cutan. Med. Surg. J*. 30, 210-213.

Wasitaatmaja. 1997. Medical Cosmetics Science Guide, Unversitas Indonesia Press.

Wilson, C., 2018, 'The clinical toxicology of caffeine: A review and case study. Toxicology Reports, 2018; 5:1140-52.

Uito, J., Chu, M., Gallo, R., and Eizen, A.Z., 2008, Collagen, Elastic fibers and Extracellular Matrix of the Dermis.

Xiang, L., 2015, 'Anti-aging cosmetics and its efficacy assessment methods', *Global Conference on Polymer and Composite Materials*. 87, 1-5.

Yanni, D., Mardhiani, Yulianti, H., Azhary, D.P., and Rusdian, T., 2017, 'Formulation and Stability of Serum From Green Coffee Extract (*Coffea canephora* var. Robusta) As Antioxidants', *Indonesia Natural Research Pharmaceutical Journal*. 2 (2), 19-33.

Yashin, A., Yashin, Y., Wang, J.Y., and Nemzer, B., 2013, 'Antioxidant and Antiradical Activity of Coffee', *Antioxidants*. 2: 230-45.

Yuliawati, K.M., Sadiyah, E.R., Solehati, R., and Elgiawan, A., 2019, 'Sunscreen Activity Testing of Robusta Coffee (*Coffea cenephora* ex Froehner) Leave Extract and Fractions', *Indonesian Journal of Pharmaceutical Science and Technology*.1(1), 24-29.

Zainol, M.K., Subri, I., Zamri, A.I., Zin, Z., Fisal, A., *et al*., 2020, 'Antioxidative properties and proximate analysis of spent coffee ground (SCG) extracted using ultrasonic-methanol assisted technique as a potential functional food ingredient', *H. Food Research*. 4(3), 636-644.

Zhou, J., Zhou, S., Zeng, S., Jiyin, Z., and Shengya, Z., 2013, 'Experimental diabetes treated with trigonelline: effect on β cell and pancreatic oxidative parameters', *Fundam Clin Pharmacol*. 27(3), 279-287.