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Review

A Comprehensive Review of Plant-Based Cosmetic Oils (Virgin Coconut Oil, Olive Oil, Argan Oil, and Jojoba Oil): Chemical and Biological Properties and Their Cosmeceutical Applications

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Cite This: *ACS Omega* 2024, 9, 44019–44032

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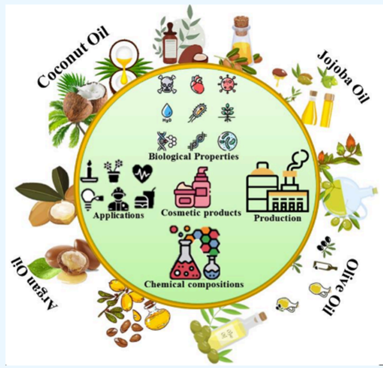
ABSTRACT: Plant-based oils, such as coconut, olive, argan, and jojoba, are abundant in natural emollients and vital fatty acids that hydrate and moisturize the skin. They shield the surface, stop moisture loss, and maintain suppleness of, the skin. They are rich in vitamins, nutrients, and antioxidants that nourish the skin. Virgin coconut oil (VCO) is used as a functional food due to its tremendous health benefits, and olive oil is well-known for its cosmetic and culinary applications. Argan oil contains many antioxidants, vital fatty acids, and vitamin E, while jojoba oil is an excellent moisturizer and conditioner. Plant-based oils can be extracted using various techniques including conventional and chemical extraction methods, and each will affect the yield and quality. Traditional methods like mechanical pressing are less efficient, whereas extraction methods such as pressurized liquid and supercritical fluid extraction may give higher yields and better quality. The chemical composition of olive oil primarily consists of saturated fatty acids (SFAs), polyunsaturated fatty acids (PUFAs), and monounsaturated fatty acids (MUFAs). Argan oil is rich in tocopherols, containing between 60 and 90 mg per 100 g, with only 19 g/100 g of argan oil's fatty acids saturated. Jojoba oil is liquid wax comprising over 98% triglyceride esters, pure waxes, vitamins, and sterols. This review focuses on the chemical and biological properties, production processes, and applications of natural cosmetic oils (virgin coconut oil, olive oil, argan oil, and jojoba oil), emphasizing their usage in skin care and cosmeceutical products.



1. INTRODUCTION

Plant-based oils obtained from various plant sources, such as nuts, seeds, flowers, and fruits, are sometimes referred to as plant-based or cosmetic oils. Since ancient times, these oils have been used in beauty and skincare regimens because of their advantageous qualities and versatility. They are widely incorporated into the compositions of products for skincare, hair care, and even makeup. The cosmetics industry prefers natural oils for their many benefits for hair, skin, and overall health. They are a great source of vital fatty acids, vitamins, and nutrients that hydrate and protect the skin and hair, antioxidants, and others. Various natural oils have different properties and compositions, enabling their use in cosmetics and other industries. Examples of cosmetic oils include virgin coconut oil, a commonly used ingredient in skincare and hair care products due to its well-known moisturizing and nourishing properties. It can support a healthy scalp, reduce inflammation, and moisturize the skin. Olive oil has anti-inflammatory, moisturizing, and antiaging properties because it contains antioxidants and healthy fatty acids. Moreover, argan oil is prized for its capacity to moisturize and nourish the skin, lessen aging symptoms, and enhance hair quality. Jojoba oil is used in skincare products because it has healing properties and soothes irritated skin.

Plant-based oils are appropriate for sensitive or problematic skin since they can help reduce itchiness, inflammation, and redness. They have essential natural polyphenols and are important bases in the formulation process of natural sunscreens. Several liquid oils from vegetable and fruit seeds are less occlusive, lighter, and viscous than hydrocarbon oils. In addition to their carotenoids, essential fatty acid content, and natural tocopherol, their penetrating and carrying properties make them highly beneficial.[1] The oils of avocado, almond, coconut, olive, cottonseed, peanut, soybean, and sesame have all reportedly been used as bases for natural sunscreen lotions and found to contain UV filters.[1] For instance, raspberry seed oil effectively inhibits UV-A and UV-B radiation.[2] Moreover, various oils have essential properties that contribute positively to the production of sunscreen; for example, olive oil helps avoid skin cancer, aloe vera oil is used for moisturizing, and coconut oil is used for antiaging. In general, vegetable oils have

Received: May 5, 2024
Revised: September 11, 2024
Accepted: September 18, 2024
Published: October 25, 2024

Table 1. Components of Different Oils

Oil	Physical properties	Fatty acids	Polyphenols	Refs
Extra virgin coconut oil	Relative density at 15 °C: 0.8690−0.8740 g/mL	Oleic acid	Methyl catechin	7−9, 18
	Iodine value: 6−9 g/100g	Lauric acid	Gallic acid	
		Caproic acid	Myricetin glycoside	
		Myristic acid	Quercetin	
		Stearic acid	Dihydrokaempferol	
		Caprylic acid	P-Coumaric acid	
		Palmitic acid	Ferulic acid	
			Vanillic acid	
			Syringic acid	
			Protocatechuic acid	
			Caffeic acid	
Olive oil	Density at 15 °C: 0.9140−0.9250 g/mL	Oleic acid	Tyrosol	10, 18
	Iodine value: 75−94 g/100g	Palmitic acid	Ligstroside	
		Linoleic acid	Hydroxytyrosol	
			Oleuropein	
Argan oil	Relative density at 15 °C: 0.9060−0.9190 g/mL	Stearic acid	6-Methyl- 3-hydroxypyridine	11−15, 18
	Iodine value: 92−102 g/100g	Palmitic acid	3-Hydroxypyridine (3-pyridinol)	
		Linoleic acid	Resorcinol	
		Oleic acid	Catechol	
		Palmitoleic acid	4-Hydroxybenzyl alcohol	
		Myristic acid	Epicatechin	
		Behenic acid	Vanillyl alcohol	
		Arachidic acid	Catechin	
			4-Hydroxy-3-methoxyphenethyl alcohol	
			Protocatechuic acid	
			Hydroxytyrosol	
			4-Hydroxyphenylacetic acid	
			3,4-Dihydroxybenzyl alcohol	
			Methyl 3,4-dihydroxybenzoate	
			Vanillin	
Jojoba oil	Relative density at 15 °C: 0.860−0.880 g/mL	Dodecanoic	Quercetin 3′ methyl ether	16, 17, 19
	Iodine value: 80.0−95.0 g/100g	Tetradecanoic	Quercetin	
		Pentadecanoic	Quercetin 3,3′-dimethyl ether	
		Hexadecenoic	Quercetin 3-methyl ether	
		Octadecanoic	Quercetin 3-O-glucoside	
		Nonadecanoic	Isorhamnetin 3-O-glucoside	
		Eicosanoic	Isorhamnetin 3-O-rutinoside	
		Docosanoic	Quercetin 3-O-rutinoside	
		Tricosenoic	Typhaneoside	

great spreadability and are readily absorbed when applied to the skin. The components (fatty acids, polyphenols) of plant-based oils, including coconut, olive, argan, and jojoba are tabulated in Table 1.

Plant-based oils can be extracted using a range of techniques, each of which has distinct advantages that affect the physicochemical and biological properties of the extracted oils.[3] For instance, organic solvent and expeller pressing extractions are prevalent processes for oil extraction in the food sector. However, both processes have considerable drawbacks, including environmental concerns associated with organic solvents and lower yields from expeller pressing.[4] Meanwhile, the conventional mechanical pressing method is thought to be inefficient due to its poor oil recovery rate, despite being simple and inexpensive.[5] Chemical methods of oil extraction are preferred because they yield higher economic gains and oil recovery.[5] However, the use of chemical solvents has been shown to have negative effects on the oil quality, human health, and the environment which has prompted the development of new technologies. Studies have demonstrated that the main drawbacks of the conventional method such as Soxhlet extraction can be successfully reduced by using techniques like pressurized liquid extraction, microwave-assisted extraction, ultrasound-assisted extraction, and supercritical fluid extraction, which were developed for the extraction of valuable components from plants and seed materials.[6] These include a reduction in solvent consumption, an increase in the yield of components that are extracted, a shorter extraction time, and improved extract quality.

This review provides information on the chemical and biological properties of plant-based cosmetic oils (virgin coconut oil, olive oil, argan oil, and jojoba oil). The production processes of these oils and their applications in skincare and cosmeceutical products were discussed. Their benefits and drawbacks were also outlined in Table 2. This work serves as a stepping stone for the cosmeceutical industry sectors and those individuals who are interested in developing their knowledge about plant-based oils. It also provides a comprehensive overview of the cosmetic industry's views of plant-based

https://doi.org/10.1021/acsomega.4c04277
ACS Omega 2024, 9, 44019−44032

Table 2. Benefits, Drawbacks, and Cosmeceutical Applications of Oils

Oil	Benefits	Drawbacks	Cosmeceutical applications
Coconut oil	Rich in antioxidants	Highly comedogenic	Facial cleanser
	Antimicrobial properties	Solidifies at low temperatures	Moisturizers
	Promotes wound healing	Greasy texture	Lip balms
	Reduces inflammation	Potential for allergic reactions	Hair oil
			Hair masks
Olive oil	Rich in antioxidants	Comedogenic potential	Moisturizers
	Anti-inflammatory properties	Oxidation risk	Antiaging
	Antibacterial properties	Greasy texture	Products
		Potential skin sensitivity	Facial cleansers
			Hair oil
			Shampoo
			Shower gel
Argan oil	High in Vitamin E and fatty acids	Costly	Antiaging creams
	Promotes skin elasticity	Greasy feel	Skin serums
	Antiatherogenic properties	Potential for allergic reactions	Hair treatments
	Anti-inflammatory properties		Hair oil
			Shampoo
Jojoba oil	Rich in antioxidants	Costly	Moisturizers
	Moisturizing	Potential for allergies	Acne treatments
	Noncomedogenic	Greasy residue	Hair conditioners
	Conditioning agent		Hair oil
	Hypoallergenic		
	Oil control		

cosmetic oils (virgin coconut oil, olive oil, argan oil, and jojoba oil).

2. VIRGIN COCONUT OIL (VCO)

Coconut oil is an edible oil extracted from the kernel of the harvested and mature coconuts of the coconut palm. Tropical countries used coconuts from the *Cocos nucifera* tree, Family *Aracaceae* (palm family), as a staple of their nutrition and way of life for thousands of years.[20] The coconut palm has tremendous economic significance and is used in all its components. It is found on the majority of tropical islands and coasts throughout the world. It is also one of the most important commercial crops for many countries. It produces an ovoid fruit with meat (28%), water (15%), husk (35%), and shell (28%) as its main components.[21] Indonesia is the leader in the production of coconuts. The country's largest coconut production is in North Sulawesi. In the Philippines, the second-largest producer of coconuts in the world, coconuts are grown in abundance. India comes in third place worldwide in coconut production, followed by Sri Lanka, the fourth-largest producer of coconuts.[22] However, in 2014, India produces 21.7 billion, Indonesia 16.4 billion, and the Philippines 14.7 billion coconuts.[75] It is well acknowledged that coconuts provide several valuable resources to humans, such as juice, oil, milk, and coconut meat.

Recently, coconut oil has become a superstar in health foods. There are two varieties of coconut oil: virgin oil and refined oil. VCO can be defined as oil that is not chemically refined, bleached, or deodorized; its natural properties are preserved, and further processing is not necessary before humans may consume it.[20] VCO is produced by a cold press process of the liquid from the fresh part of coconut meat. It appears milky in texture. According to how it is prepared, VCO can be divided into two categories: fermentation method and cold compression method.[23]

2.1. Production.

VCO can be obtained by extracting it directly from coconut milk or fresh coconut (Figure 1). Wet or dry extraction methods can be used in the process. When using the dry method, the kernel is heated in a specific condition to eliminate moisture while preventing microbial invasion and scorching.[7] After grating the coconut meat and separating the thoroughly dried coconut copra, hydraulic extraction is performed at a low temperature (<50 °C). In contrast, the wet method does not include drying the kernel/coconut meat. The wet method can be further branched into fermentation, chilling, freezing, thawing, and enzymatic to destabilize the coconut milk emulsion. Producing VCO involves various processes, including centrifugation, hot processing, natural fermentation, and extraction from dried grading methods. The selection of suitable technology depends on different factors, including the degree of mechanization, the scale of operation, the market requirements, and the available investments.[24]

The modified hot process method for producing VCO uses controlled heating to keep the oil from turning yellow and to keep the moisture level below 0.2% to extend the shelf life. Two steps comprise the hot process: extracting or preparing

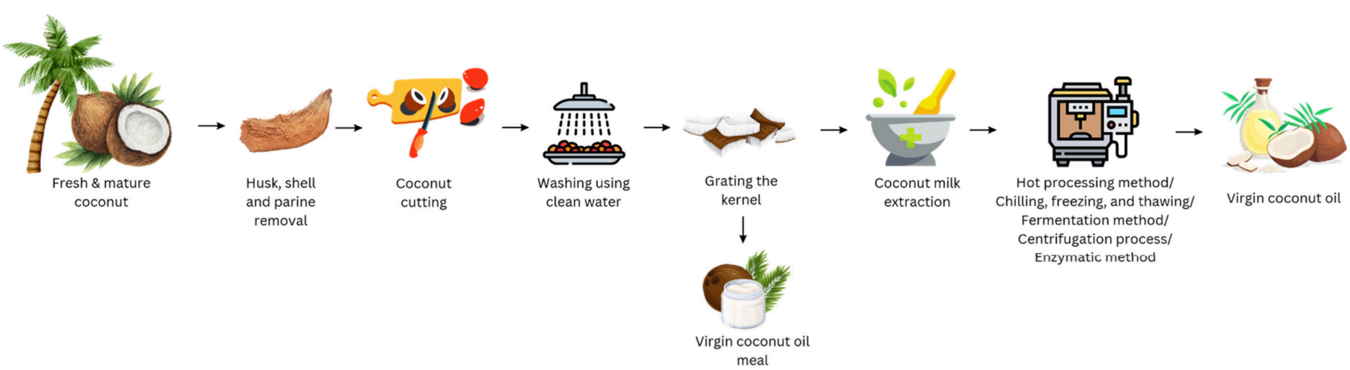


Figure 1. Flowchart of VCO production process. (Produced using Canva Pro.)

https://doi.org/10.1021/acsomega.4c04277
ACS Omega 2024, 9, 44019−44032

the coconut milk and boiling the milk to produce VCO. In the chilling, freezing, and thawing method, the coconut milk emulsion goes through a centrifugation process, then chilling and freezing at 10 and 4 °C, then thawing at 40 °C, bringing the coconut cream to room temperature. These processes would remove the insoluble solids and produce high-quality VCO.[7] Centrifugation can be used for oil recovery, and the coconut oil would be packed in globules during centrifugation to enable crystallization at a lower temperature. Another way of producing VCO is through the natural fermentation method. The fermentation process consists of two steps: extracting or preparing the coconut milk and then fermenting the milk to produce VCO. The oil is produced on a small scale using conventional kitchen utensils after extracting the coconut milk. In making VCO using the fermentation process, microorganisms are added to help in the process of separating the protein and oil components. Three layers will form during the fermentation process: pure oil at the top, blondo (protein) in the middle, and water at the bottom.[25] If the fermentation period is extended and the fermentation process parameters are not correctly regulated, the VCO generated may become sour. The fermentation process duration has an impact on the iodine number of the coconut oil. A longer fermentation process results in a lower iodine number.[26] Furthermore, one of the essential methods of producing VCO is the centrifugation method. In this process, hot water and coconut milk are added to a three-way centrifuge apparatus. The oil rises to the top during this procedure while the water and sludge drain out through other exits. This method produces high-quality oil with a delightful coconut scent; the finished VCO is clear. Lastly, the enzymatic method is also used in the production of VCO. Numerous enzymes engage in the extraction of VCO, including endoamylase, cellulose, viscozyme L, alcalase, and neutrase. To enhance oil extraction, these enzymes react with the coconut milk at different temperatures, concentrations, and pH levels. The oilseed's structural cell wall components are solubilized by the cell-wall degrading enzymes,[7] and last, the VCO is extracted by centrifugation.

2.2. Chemical Compositions and Nutrients. Coconut oil and VCO have similar fatty acid compositions. Yet, VCO includes more biologically active substances, including tocols (4 mg/100 g), phenolic compounds (50 mg/100 g), and sterols (70 mg/100 g). VCO has significant health benefits compared to coconut oil due to its bioactive components. Most of the fatty acids in VCO are medium-chain ones, which have advantageous effects on the body. Numerous clinical investigations unequivocally demonstrate its beneficial effects on human skin, heart, liver, and brain. Additionally, coconut oil lowers the biological activity of numerous dangerous viruses and bacteria which are crucial for cancer prevention and treatment. As a result, VCO has various health-promoting and disease-preventing properties, such as antithrombotic effects, antidiabetic, and cardioprotective.[27]

The chemical composition of VCO[28] has been previously analyzed and studied. According to analysis, VCO consists of (>99%) triglycerides and contains a significant amount of medium-chain fatty acids. The fatty acid that is present in VCO in the highest concentrations (on average 46%–48%) is lauric acid (La; C12:0), followed by myristic acid (M; C14:0), which makes up 17% of the total amount as the second-highest fatty acid. Other fatty acids that are present in smaller amounts include caproic acid (0.5–0.7%), oleic acid (5%–7%), stearic acid (2%–4%), caprylic acid (7%–9%), and palmitic acid (8%–10%). In VCO samples, the main triglycerides were CLaLa (19%–21%), LaLaLa (22%–25%), CCLa (14%–16%), LaMM (7%–9%), and LaLaM (13%–15%). Studies have revealed that the medium-chain fatty acid and triglyceride content of VCO slightly vary from country to country.[7]

Some phenolic acids have been identified in the chemical composition of VCO, including protocatechuic acid, p-coumaric acid, vanillic acid, ferulic acid, syringic acid, and caffeic acid.[8] The primary phenolic acid in VCO is ferulic acid (5 mg/kg VCO). Moreover, several polyphenols are found in VCO, such as methyl catechin, gallic acid, myricetin glycoside, quercetin, and dihydrokaempferol. These polyphenols and phenolic acids may exhibit therapeutic benefits like anti-inflammatory, antibacterial, antioxidative, and wound healing.[9]

2.3. Biological Properties. Antioxidants prevent or delay the oxidation process by scavenging free radicals. Free radicals trigger oxidative stress and harm biomolecules such as lipids, DNA, and proteins. Numerous studies have been conducted to analyze the antioxidant properties of consumed vegetable oils, such as coconut oil. There have not been as many studies on the antioxidant activity of coconut oil as on other oils. However, VCO is becoming more recognized as an oil with increased antioxidant activity. A comparative study compared the total phenolic content and antioxidant potential of six regularly consumed vegetable oils: rice bran oil (RBO), sunflower oil (SFO), coconut oil (CNO), mustard oil (MO), groundnut oil (GNO), and sesame oil (SESO).[29] The study showed that RBO, CNO, and GNO had a higher potency against free radicals. Recent research has shown that unrefined VCO is preferred because of its remarkable health advantages. Hot extracted VCO and fermented VCO displayed the highest levels of radical scavenging and inhibitory activity among the different VCO preparations. VCO, in contrast to regular coconut oil, has also been demonstrated to have the ability to increase antioxidant enzymes and decrease the level of lipid peroxidation.[30]

VCO has also been shown to have anti-inflammatory and antioxidant properties. Numerous immune system functions are involved in inflammation; for instance, in chronic and acute inflammatory reactions, the immune system's component cells are activated in response to external antigenic or invader substances. According to some studies, VCO tends to boost antioxidant enzymes while lowering the expression of inflammatory genes. Additionally, a study was conducted to investigate the anti-inflammatory properties of dried and fermented processed VCO.[31] Using in vivo models, it has been found that F-VCO efficiently decreases acute inflammation; meanwhile, in chronic models, it is observed to be less effective.

VCO can be used as an ocular rewetting agent. A defect on the ocular surface or a lack of sufficient quantity or quality of tears can both contribute to dry eye symptoms. As a result, there will be discomfort, tear film instability, visual disturbance, increased tear film osmolality, and ocular surface inflammation, all of which may damage the ocular surface.[20] Artificial tears are the cornerstone of early dry eye patient treatment among all available therapeutic options. It is challenging to produce tears similar to those found in the human eye because of the complexity of the tear coating. Commercially accessible artificial tears come in various brands, including sodium hyaluronate, poly(vinyl alcohol), hydroxypropyl methylcellulose, and oil-based tears. According to a recent study, spraying the liposomal solution onto closed eyelids thickened the lipid

https://doi.org/10.1021/acsomega.4c04277
ACS Omega 2024, 9, 44019–44032

layer and significantly boosted the tear film's resilience. The Department of Optometry and Vision Science at Malaysian University examined the use of VCO in addition to tear film. A study examined the usefulness of VCO as an ocular rewetting agent on rabbit eyes. VCO was found safe for dry eyes, and its anti-inflammatory action's significant benefits in managing dry eyes were acknowledged.[20]

VCO has wound-healing properties. When an accident occurs, biological tissue or the skin repairs itself through a complex process known as wound healing. According to studies, the oil of *Cocos nucifera* is a potent wound-healing substance.[20] Nevin and Rajamohan (2010) studied how VCO affected the composition and antioxidant status dermal of the skin in terms of wound healing in young rats.[32] Twenty-four hours after the wound was first created, animals received VCO treatment for 10 days. VCO healing activity was determined by monitoring the time it took for the epithelium to form fully and other wound granulation tissue parameters. The study also examined collagen, granulation tissue's histology, and glycohydrolase activity's solubility pattern. Young rats who were given VCO showed much faster wound healing activity, as shown by a shorter time for complete epithelization and higher levels of various skin constituents. A considerable increase in glycohydrolase and collagen soluble in pepsin was also discovered, suggesting increased collagen turnover and cross-linking. These findings indicate that many physiologically active components of VCO may work together to promote wound healing.

Atopic dermatitis is a chronic skin disease associated with an inflamed cutaneous layer and damaged epidermal barrier. In this case, the stratum corneum's capacity to retain water was impaired, and the trans-epidermal water loss (TEWL) was reported to be elevated. Padilla Evangelista et al. (2014) used a randomized controlled trial design to assess the topical effects of VCO on skin capacitance and TEWL in 117 patients with mild to moderate pediatric atopic dermatitis who were examined at baseline, then again at 2, 4, and 8 weeks after the baseline evaluation.[33] The results demonstrated that VCO was more effective than mineral oil in pediatric patients with mild to moderate atopic dermatitis. Additionally, patients receiving VCO treatment displayed increased skin capacitance and a significant decrease in TEWL. To improve skin capacitance and hydration, prevent TEWL, and strengthen the defense against foreign substances, it was proposed that VCO could function as an occlusive agent that forms a film on the skin of atopic dermatitis patients.

2.4. Applications. One of the main nonedible uses for coconut oil is in the soap industry. Methyl esters of coconut fatty acids are a significant chemical derivative of coconut oil, created by treating coconut oil with methyl alcohol. Because they are easier to separate by fractional distillation and stable, these methyl esters serve as essential raw materials for the chemical industries. Additionally, diesel has been discovered to work well when mixed with coconut oil. Diesel cars perform very well on the road when this combination is used in a 30:70 ratio. Methyl esters of the fatty acids in coconut oil are also employed in the aviation sector as biodiesel and lubricants. Moreover, VCO can be used to prepare aromatherapy massage oils. It has been proven that the massage oil products of VCO were free of microbial contamination and considered safe for consumers.[21] Also, coconut oil is highly saturated because of the high saturation of saturated fatty acids. This high content of saturated fatty acids makes it very resistant to oxidative rancidity. As a result of the stable flavor and easy digestibility of coconut oil, it is used as an ingredient in infant milk powder. VCO has attracted much interest from the public and scientists in the food industry as a functional food oil. In addition, coconut oil is often a confectionary fat, especially for ice cream production. In replacement for cocoa butter, coconut oil and cocoa powder are used to imitate chocolate. Numerous other industrial applications for coconut oil exist in plastics, cosmetics, skincare, medicine, synthetic resins, and rubber substitutes.

2.4.1. Cosmeceutical Applications. VCO serves as the key ingredient in topical skin moisturizers (Table 2). VCO was reported to be a common ingredient in traditional skin care products, especially in Southeast Asia. Compared to conventional coconut oil, VCO has a higher phenolic content and antioxidant activity. It also has a higher level of fatty acids, particularly lauric acid. VCO can be utilized as an emollient in moisturizers and, in the correct concentrations, can also act as an occlusive agent. Previously, a study was conducted on the impact of VCO infused with solid lipid particles (SLPs) on the elasticity and hydration of the skin.[34] Skin evaluation was included in the study to compare the differences between lotions with and without (VCO-SLPs). From day 0 to day 28, it was discovered that moisturizing lotion combined with VCO-SLPs increased the hydration and elasticity of the skin by 24.8% and 2.60%, respectively. This showed that SLPs may deliver VCO to the dermis more effectively.

3. OLIVE OIL

Olive oil may be obtained from the fleshy constituents of the fruit of olive trees (*Olea europaea* L.). Olive oil comes in assorted colors, from pure yellow to golden; some types derived from unripe fruit have a faint undertone of green. Extra virgin olive oil (EVOO), virgin olive oil (VOO), refined olive oil (ROO), and pomace oil are the standard categories of olive oil that are now available in the market, as reported by the International Olive Council (IOC) and the United States Department of Agriculture (USDA). The degree of processing or the free acidity of the oil determines the standard grade.[35] Almost every country that cultivates olives produces oils with varied qualities and characteristics; the differences depend on the region and fruit ripeness. Between 15 and 40 kg of olives are produced annually by each olive tree, which is then used to make olive oil. Approximately 750 million active olive trees, most of which are in the Mediterranean region, contributed to the global production of almost 2.5 million tonnes of olive oil.[36] In particular, there are roughly 25,000 olive mills in the entire world. Outside the Mediterranean region, olives are grown in the United States of America, the Middle East, South America, Australia, and Argentina.[36] It was reported that the top four countries known for olive oil production were Spain, Italy, Greece, and Turkey, with a generation of 0.9, 0.6, 0.4, and 0.2 million tonnes of olive oil in 2002, respectively), and Tunisia, Portugal, Morocco, and Algeria coming in second.[36] Rapa et al. (2022) stated that olive oil is produced most abundantly in Europe with 67% of global production and four million hectares under cultivation.[37] It has long been acknowledged that Italy, Greece, and Spain are the top producers of olive oil.[37]

3.1. Production. The production of olive oil has tended to increase over the past decades because it is one of the most essential global dietary trends. It is an important source of fatty acids and antioxidants for the human diet. The basic

https://doi.org/10.1021/acsomega.4c04277
ACS Omega 2024, 9, 44019−44032

Figure 2. Flowchart of the olive oil extraction process. (Produced using Canva Pro.)

procedures for making olive oil have not evolved much since ancient times: gather the olives at the right time, make a paste out of them, separate the liquid from the solid parts, and then further separate the vegetable water from the oil. The extraction method significantly impacts the final flavor and quality of the olive oil. The extraction systems of olive oil could be divided into two main categories: the traditional pressing method, and the centrifugal processes, which include two centrifugation systems known as the two- and three-phase systems. Numerous modifications and improvements to the mechanical process have improved quality and productivity.

In the traditional press system, olives are usually ground and crushed in stone mills, with the paste then being put into fiber diaphragms, which are then placed in a press on top of one another (Figure 2). The solid phase of the olive paste is compacted, and the liquid phases (vegetable water and oil) are percolated due to hydraulic pressure being applied to the discs. To enhance percolation, which aids in separating the liquid phase, water is poured down the edges of the discs. The discs were traditionally made of hemp or coconut fiber, but modern discs are composed of synthetic fibers for more straightforward servicing and maintenance.[38] The press system produces an emulsion that includes the water phase, olive oil, and a solid component known as olive husks or kernels. Finally, vertical centrifugation or decantation separates the remaining effluent from the olive oil. The olive oil produced using the traditional method is relatively high quality. However, other safety precautions should be taken, such as thoroughly cleaning the discs and quick treatment of the paste to stop fermentation. Modern continuous centrifugal extraction has replaced conventional pressure mills because of the requirement to process vast quantities of olives and produce more olive oil.

In the centrifugal extraction of olive oil, after washing, crushing, and malaxation procedures, mechanical oil extraction is often carried out using a continuous method that utilizes centrifugation with a decanter. The decanter centrifuge's rotating bowl and screw conveyer allow it to manage large amounts of olives in a short time. Two-phase and three-phase centrifugation are the two types of centrifugal decanters currently in use. In the 1970s, the continuous three-phase centrifugation method was developed to improve extraction yield, decrease labor demand, and enhance processing capacity.[36] During the three-phase centrifugation, hot water must be added to wash the oil. The process produces three phases: the oil phase, the solid residue of olive cake (olive stones and pulp), and the wastewater from the olive mill. In the decanter, the two phases are separated from the solid residue. Vertical centrifugation separates the olive oil and mill wastewater from the liquid phases. One of the disadvantages of this process is the significant amount of wastewater produced because of the high-water consumption. The centrifugal extraction process requires a 1.25−1.75-fold greater quantity of water than the traditional press extraction process.[39]

3.2. Chemical Composition and Nutrients. Over 200 distinct compounds including major, minor, and essential are typically found in olive oil. In general, olive oil is known to have a high nutritional value. Nevertheless, the concentration of each chemical might vary depending on the environment and the variety of olives. Complex multivariate interactions between endogenous and external variables determine its nutritional composition. Also, various environmental factors, processing systems, and agronomics have a significant impact. Across all grades of olive oil, the physiological characteristics, nutritional value, and primary component types are essentially the same. Polyunsaturated fatty acids (PUFAs), monounsaturated fatty acids (MUFAs), and saturated fatty acids (SFAs) in the form of glycerol esters make up the majority of the chemical makeup of olive oil. In addition to being high in lipids, olives also contain significant levels of vitamins and minerals, including vitamins K and E, calcium, potassium, iron, and sodium. Since the main tocopherol in olives is alpha-tocopherol, which has the highest biological activity of all tocopherols, olives are a significant source of vitamin E. As significant liposoluble antioxidants found in nature, tocopherols (vitamin E) strongly inhibit the lipid peroxidation of lipoproteins and cellular membranes.

Olive oil is one of the best sources of fatty acids. Considering their benefits to human health, their nutritional qualities are widely regarded. Monounsaturated fatty acids (MUFAs) are present in extra virgin olive oil, with oleic acid accounting for the majority of these fatty acids (55−83%). Fatty acids included in the oil are palmitic acid (7.5−20%) and linoleic acid (3.5−21%). Additionally, smaller quantities of eicosenoic and palmitoleic acids are also found in other MUFAs.[40] In comparison to other edible oils like soybean, corn, and sunflower oils, olive oil has a greater MUFA concentration. SFA content in olive oil is about 14%, which is lower than that of other edible oils such as palm oil, sunflower oil, and soybean oil. Olive oil is known to have low PUFA content. Each edible vegetable oil has different health advantages because of these composition variations.[41] The main MUFA, SFA, and PUFA in olive oil are oleic acid, palmitic acid, and linoleic acid.

There are very few secondary metabolites found in olive oil. These secondary metabolites contain phenolic chemicals in copious quantities. Each type of olive should be harvested at the ideal moment to yield oil with the highest phenolic content. The intricate multivariate interactions between endogenous and external variables also influence the phenolic content. The environmental and intrinsic genotypic potential of olive, processing systems, and agronomic can all profoundly affect the content and composition of phenols. The range of total phenol concentration is 196 to 500 mg/kg.[10] EVOO has a

https://doi.org/10.1021/acsomega.4c04277
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phenol content that ranges from 250.77 to 925.75 mg/kg, which is the highest due to minimum processing and mechanical.[42] In contrast, phenols are significantly reduced in olive oil that has been refined to remove the odor, flavor, and color components. At least 36 structurally different phenolic compounds have been found in the phenolic fraction of olive oil, making it heterogeneous. Tyrosol, ligstroside, hydroxytyrosol, and oleuropein are major phenols that comprise around 90% of the phenol content in virgin olive oil (VOO).[35]

Furthermore, the existence of hydrocarbons, phenolic compounds, carotenoids, and chlorophylls contributes to a high content of MUFA within olive oil. Strong antioxidant properties can be seen in these compounds. Phenols are essential in determining the quality of olive oil due to their considerable impact on the finished product's organoleptic evaluation and nutritional value.[43] Several variables, including the type of plant, the environment, the time of harvest, the mineral content of the soil and the plant, and the extraction methods influence the number of antioxidants present in plants.[35] The ecological and physiological significance of antioxidants for plants makes them the most significant bioactive molecules in plants. Antioxidants and other chemical compositions within olive oil allow it to be involved in different valuable applications.

3.3. Biological Properties. Extra virgin olive oil (EVOO)-rich diets have been demonstrated to reduce the incidence of several cancers, including prostate, breast, and digestive system cancers.[44] Abdel-Gayoum et al. (2015) reported that 2 mL/kg/day of EVOO decreased the nephrotoxicity symptoms in rats exposed to lithopone (150 mg/kg/day) and enhanced health status and antioxidants.[45] In accordance with several investigations, animals with kidney-related disorders could be treated with dietary VOO or its derivative products. Additionally, olive oil polyphenols alter the immune system by increasing the synthesis of white blood cells, cytokines, and other molecules that improve immunological resistance.[44] Also, high levels of phenols within olive oil have potent antibacterial and antioxidant properties that can inhibit the growth and spread of various bacteria. The polyphenolic content of olive extract has been linked to a remarkable antibacterial response.[46] Moreover, the increase in body weight and a broad spectrum of obesity-related disorders are usually caused by the overuse of oils in dietary products. It has been demonstrated that olive oil can help avoid diseases connected to obesity.[47]

In the Mediterranean diet, olive oil is the primary fat source. Comparing individuals who follow this diet to those who follow other diets, it appears that those who follow it have a longer life expectancy, including a lower risk of dying from cardiovascular diseases (CVD). Santangelo et al. (2017) evaluated the number of cardiovascular events among those who followed a Mediterranean diet, which includes either a low-fat diet, nuts, or olive oil.[48] A decreased incidence of cardiovascular disease was observed in people who followed the Mediterranean diet, whether it included olive oil or nuts. Tressera-Rimbau et al. (2017) stated that polyphenols that exist in EVOO may protect against CVD, stroke, atherosclerosis, cancer, and brain dysfunction.[49] The European Food Safety Authority and the Food and Drug Administration (FDA) advise taking about 20 g (g) or two tablespoons of EVOO daily to lower the risk of cardiovascular disease and inflammation.[48]

The inflammation of the digestive tract is thought to be caused by inflammatory bowel disease (IBD). The IBD instances include Crohn's illness and ulcerative colitis. The effects of olive oil's bisphenol on IBD were investigated in a previous study.[50] In accordance with the study's findings, the phenols in olive oil boost intestinal immunity and gut health by altering the microbes in the gut. For patients with colitis and other IBD types, this might be advantageous. However, it is concluded that additional research is needed in the future to support these findings.

3.4. Applications. Olive oil is one of the three primary food sources utilized in Mediterranean cuisine and a key component of cooking in the countries surrounding the Mediterranean basin. Due to its high concentration of oleic acid compounds and phytochemicals like sterol and phenolic compounds, olive oil is regarded as a functional food. The significant number of phenolic compounds of olive oil has proven its durability and organoleptic properties.[51] Additionally, VOO has recently been used as a significant food ingredient because of its high concentration of functional and nutraceutical components. VOO has been linked to a lower cancer risk and cardiovascular disease.[51] The most common application for EVOO is as a salad dressing or a component of salad dressings. It has an intense taste and flavor if it is not heated and added to cold food preparations. Additionally, pure olive oil is utilized to preserve food, mainly canned fish. Furthermore, it is used to make high-quality castile soap in the textile business to comb wool, in the pharmaceutical sector as a lubricant, and in manufacturing cosmetics and toiletries.

3.4.1. Cosmeceutical Applications. Ancient Romans and Egyptians utilized olive oil in numerous ways, including cooking, as cosmetics, as salves for wound treatment, and for anointing. Ancient Greeks used olive oil in their baths. Atopic dermatitis, psoriasis, eczema, seborrhea, contact dermatitis, different inflammations, pruritus, and burns have all been reported to respond well to olive oil treatment (Table 2).[52] Olive oil can serve as a second skin barrier for dry and cracked skin in the winter. It is an excellent skin moisturizer, mainly when applied to wet skin when the pores are open. The anti-inflammatory and antioxidant properties of olive oil are two more significant advantages. According to dermatologists, triterpenes, which are anti-inflammatory components present in olive oil, help wound healing by accelerating collagen formation and shortening the time it takes for wound closure. Vitamin E in olive oil promotes healthy skin by treating acne, dryness, itchiness, and inflammation. Additionally, it increases the elasticity and regenerative properties of the skin. Minerals, healthy fats, and antioxidants combat free radicals and support healthy and fuller skin.

In a recent study, researchers assessed the ability of extra virgin olive oil (EVOO) to inhibit reactive oxygen species and skin tumors brought on by exposure to ultraviolet (UV) light. Skin tumors developed more slowly in hairless mice treated with oil before or after repeated exposure to UVB radiation than in control animals. The differences between the control mice and those that had received an olive oil pretreatment began to vanish with increased UVB exposure. Interestingly, mice treated with olive oil had significantly fewer tumors than mice in the control group when they were exposed to UVB afterward. Therefore, topical olive oil administration after UVB exposure helped prevent or delay the occurrence of mouse skin tumors.[53]

https://doi.org/10.1021/acsomega.4c04277
ACS Omega 2024, 9, 44019−44032

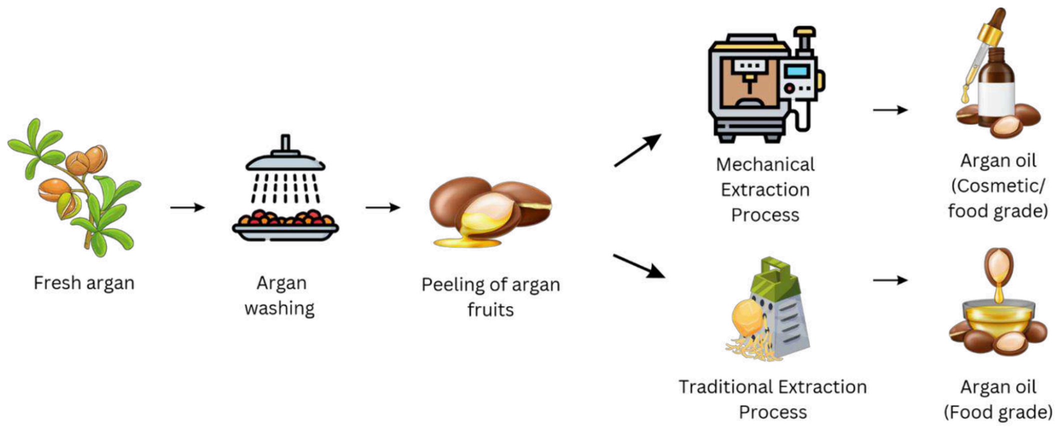

Figure 3. Flowchart of argan oil extraction process. (Produced using Canva Pro.)

Researchers recently evaluated the stability and the cutaneous effects of hemp-seed oil and olive oil against oxidation. These two unsaturated fatty acids were reported to be beneficial with xerosis and other aging-related symptoms. Researchers found that EVOO had stronger photostability than hemp-seed oil and higher stability against peroxidation than hemp-seed oil.[52] They hypothesized this might be because EVOO contains more antioxidants than hemp seed oil. After making emulsions with olive oil and hemp seed oil, it was reported that some of the gel-emulsion formulations were suitable for spraying on the skin. It is important to note that the polyphenolic antioxidant components oleuropein and hydroxytyrosol have been implicated in the exceptional stability and intense flavor of EVOO.[54] These olive oil components have also been proven to have more potent antioxidant properties than vitamin E.[54]

4. ARGAN OIL

Argan oil, a type of unrefined vegetable oil, is made from the argan tree seeds [*Argania Spinosa* (L.) Skeels], an endemic plant from southwest Morocco. Despite being distributed globally by several business enterprises in Europe and North America, argan oil is regarded as a relatively internationally exported product from Morocco. Over the past two decades, argan oil has gained popularity as a haute cuisine and cosmetic ingredient. Chemists and Pharmacists have been looking into the traditional argan oil health claims because of their potential economic value. They are also investigating the undiscovered beneficial properties of the oil and other argan products. From a social and financial perspective, the argan tree is a significant forest species. Argan oil has quickly gained recognition as a substantial product that can boost communities' income. It is also vital for environmental conservation because of its ability to prevent the spread of desert progression. Women's cooperatives in Morocco introduced a semi-industrial mechanical extraction technique producing high-quality argan oil.[12]

4.1. Production. There are several steps in the traditional extraction method of producing argan oil, including fruit picking, fruit peeling, nut cracking, kernel roasting, kernel grinding, malaxing, and oil extraction (Figure 3). The fruits are manually collected and placed under the sun until thoroughly dried. According to Harhar et al. (2010), a two-week fruit drying period is optimal for producing high-quality argan oil. The dried peel of fruits is removed after drying, producing argan nuts.[55] Then, the nuts are cracked open, and the kernels are selected and collected for the roasting process, which will take place on clay plates. Roasting 1 kg of kernels takes around 30 to 40 min.[12] The roasted kernels are ground using a millstone, followed by manual-malaxing the resulting greasy dough for a few minutes while adding tiny amounts of water. Argan oil is extracted from the released emulsion as the dough gradually solidifies. In terms of traceability, bacteriological safety, and oxidative stability, traditional extraction is often done in unhygienic settings.[12] Alternatively, a change was made to enhance the traceability and quality of argan oil by upgrading its extraction technology.

The fruits are mechanically peeled using the mechanical extraction method for producing argan oil, and press extraction is used to extract the oil. In this process, the roasting step has been enhanced, and the water used for extraction has been eliminated. In this method, argan oil can become an "extra virgin argan oil", and this technology maintains all of argan oil's known benefits. Food-grade and cosmetic-grade argan oil can both be manufactured mechanically.[12] The cosmetic-grade argan oil is made from unroasted kernels, whereas food-grade argan oil is made by cold-pressing kernels that have been mildly roasted for a few minutes.[12] There are six steps in extracting food argan oil: fruit gathering, sun-drying, dehulling, kernel collection (nut breaking), roasting, and cold pressing (Figure 3). Oil decantation and filtration are also added to get rid of a lot of gums and waxes. Cosmetic oil is produced when the roasting stage is skipped. Argan oil used in food is copper-colored, whereas argan oil used in cosmetics is gold-colored. Each processing stage dramatically influences the quality and quantity of the resultant oil.

4.2. Chemical Composition and Nutrients. Fatty acids are the essential components of vegetable oils. It is noted that the fatty acid composition significantly impacts the nutritional value, stability, and properties of specific vegetable oils.[56] Only 19 g/100 g of argan oil's fatty acids are saturated, making up around 80% of its total fatty acid composition. Linoleic acid and oleic acid make up most of the unsaturated fatty acids in argan oil (29−37 and 43−49 g/100 g, respectively).[12] Additionally, linoleic acid is a highly oxidizable molecule found in extremely small abundances, typically less than 0.3 g/100 g. This trace amount of linolenic acid can be used to determine whether argan oil has been contaminated with other linolenic acid-rich vegetable oils, such as soybean and rapeseed oils. The key saturated fatty acids palmitic acid (11.70−11.75 g/100 g) and stearic acid (3.14−3.28 g/100 g) are also found in argan oil. Other fatty acids with a low concentration include

https://doi.org/10.1021/acsomega.4c04277
ACS Omega 2024, 9, 44019−44032

arachidic acid (C20:0), behenic acid (C22:0), palmitoleic acid (C16:1), and myristic acid (C14:0).[13]

The final aroma of argan oil results from the participation of several distinct groups of chemical compounds, including ketones, hydrocarbons, aldehydes, and furans.[57] In accordance with reports, roughly eight prominent families are represented in the volatile portion of virgin argan oils: alcohols, acids, aldehydes, esters, ketones, furans, terpenes, and N-heterocycles.[57] Yet, argan oil made from goat-peeled fruit contains more volatile chemicals. The roasting procedure significantly impacts the volatile components of cold-pressed argan oil, primarily used to create food-grade argan oil. An aroma is made during roasting and kept in the oil during extraction. The Maillard reaction and oil oxidation are the two main processes that produce flavor when roasting argan kernels.[58] The volatile compounds of argan oil extracted from unroasted kernels are obtained by the oil oxidation products including pentanal, hexanal, 2-pentyl-furan, as well as N-heterocycles like 2,6-dimethyl pyrazine, alcohols (2,3-butanediol, 1-hexanol, and 2-methyl-1 propanol), 1-methyl-1-pyrrole, acetic acid, and ketones (acetoin).[57] The quantity of Millard reaction products, such as 2- and 3-methyl butanal, the Strecker aldehydes 2-methyl propanal, 2,6-dimethyl pyrazine, 3-ethyl-2,5-dimethyl pyrazine, furfural, and trimethyl pyrazine, can distinguish the volatile profile of food-grade argan oil.

The composition of compounds containing tocopherols is a significant aspect of argan oil. The tocopherol content is directly associated with nutritional qualities, stability, and cosmetics and can be utilized to identify adulterations in argan oil.[59] Argan oil is abundant in tocopherols, containing between 60 and 90 mg per 100 g. Argan oil contains γ-tocopherol (81–92 g/100 g), δ-tocopherol (6.2–12.8 g/100 g), α-tocopherol (2.4–6.5 g/100 g), and β-tocopherol (0.1–0.3 g/100 g) as its primary tocopherols.[14] Tyrosol and other antioxidants like ferulic, syringic, and vanillic acids have also been found in argan oil. Vanillin and *p*-hydroxybenzoic acid are also discovered in minor amounts. Argan oil contains additional bioactive substances with significant antioxidant potential, including melatonin, polyphenols, and coenzyme Q10.

The phenolic content of argan oil is high. Gas chromatography-mass spectrometry (GC-MS) analysis of cosmetic and alimentary argan oil identifies nine phenols, including 6-methyl-3-hydroxypyridine, 3-hydroxypyridine (3-pyridinol), resorcinol, catechol, 4-hydroxybenzyl alcohol, epicatechin, vanillyl alcohol, catechin, and 4-hydroxy-3-methoxyphenethyl alcohol. Six novel phenols that are not found in oils were discovered during the study of the press cake of argan oil, including protocatechuic acid, hydroxytyrosol, 4-hydroxyphenylacetic acid, 3,4-dihydroxybenzyl alcohol, methyl 3,4-dihydroxybenzoate, and vanillin.[15] Argan oil's total polyphenol content ranged from 6.07 to 152.04 mg GAE/kg. Comparatively, virgin argan oil has more polyphenols than other edible oils.[15]

The second class of compounds in argan oil is sterols, also known as phytosterols. Argan oil contains up to 220 mg of phytosterols per 100 g.[60] Since they resemble an argan oil fingerprint, they are frequently used to demonstrate authenticity. Stigmasta-8-22-dien-3β-ol (3.2–5.7 g/100 g), Δ7-avenasterol (4.0–7.0 g/100 g), spinasterol (34.0–44.0 g/100 g), and schotenol (44.0–49.0 g/100 g) are the primary sterols present in argan oil.[14] Although campesterol is present in extremely small amounts, it is interesting to determine the authenticity of argan oil. Although the squalene content of argan oil is high, it is lower than olive oil and significantly higher than sunflower oil.[61] In addition to being essential substances with strong biological capabilities, sterols also play a vital role in human health due to their antioxidant activity.

4.3. Biological Properties. Rheumatology uses argan oil, which is applied to the affected area as a skin lotion. Argan oil is traditionally advised as a hepatoprotective agent, as well as in cases of atherosclerosis or hypercholesterolemia, and is taken by mouth.[15] Argan oil has several health advantages, including suppressing prostate cancer, lowering plasma cholesterol, boosting prostaglandin production, and having anti-inflammatory effects. Argan oil is also known to have antidiabetic and antiatherogenic properties, as well as to reduce hypertension. A small abundance of fatty acids, including linoleic acid in argan oil, contribute to the production of prostaglandins vital for the immune and circulatory systems. Prostaglandins help with cardiovascular and rheumatoid arthritis problems. The impact of argan oil on risk factors for CVD, such as high blood pressure, high lipid levels, and high cholesterol, makes this field of study fascinating. This interest was triggered by a study by El Abbassi et al. (2014) highlighting the presence of tocopherols, polyunsaturated fatty acids, and monounsaturated fatty acids in argan oil.[15]

4.4. Applications. The argan tree provides the Indigenous Berber population of southern Morocco with various valuable products, including wood for building and carpentry, charcoal for heating and cooking, animal feed, and oil for food, cosmetics, and medicine. Argan oil has been used for cosmetic and culinary reasons since the beginning of humanity. It plays a big part in Moroccan culture and has an exciting history. Argan oil is widely used to prepare traditional Moroccan dishes like tagine and couscous. In addition, a delectable spread known as Amlou is used, which is made by combining it with chopped almonds, honey, and butter. The flavor of amlou is comparable to peanut butter; when combined with oats, it is regarded as a nutritious meal for kids and infants. Argan oil is by far the most used for nutritional purposes. Additionally, argan oil is used to treat dry hair and improve the protection and softness of all hair types. Its application to the skin has demonstrated that it is not harmful in chronic or acute form.

4.4.1. Cosmeceutical Applications. Argan oil has a high fatty acid and antioxidant content that improves the texture and appearance of hair and skin while moisturizing, nourishing, and softening without any greasy residue left (Table 2). By increasing elasticity and minimizing the appearance of wrinkles, argan oil leaves the skin feeling and appearing firmer, softer, and smoother. Argan oil is usually recommended to treat all skin pimples, specifically chicken pox pustules and juvenile acne.[15] Argan oil balances the moisture and oil production of the skin, reduces the appearance of scars, and soothes inflammation and irritation in acne-prone skin. In addition, stretch marks can be reduced with an argan carrier oil since it encourages new skin development while improving the existing suppleness of the skin. Argan oil has a high concentration of polyphenols believed to protect the skin by repairing and moisturizing it. Polyphenols are known to be effective in preventing photoaging and UV-B-induced wrinkle formation that is caused by inflammatory responses and collagen destruction.[62]

5. JOJOBA OIL

The Jojoba plant (*Simmondsia chinensis*)[63] is found in the deserts of North and Central America and is very adaptable to

https://doi.org/10.1021/acsomega.4c04277
ACS Omega 2024, 9, 44019−44032

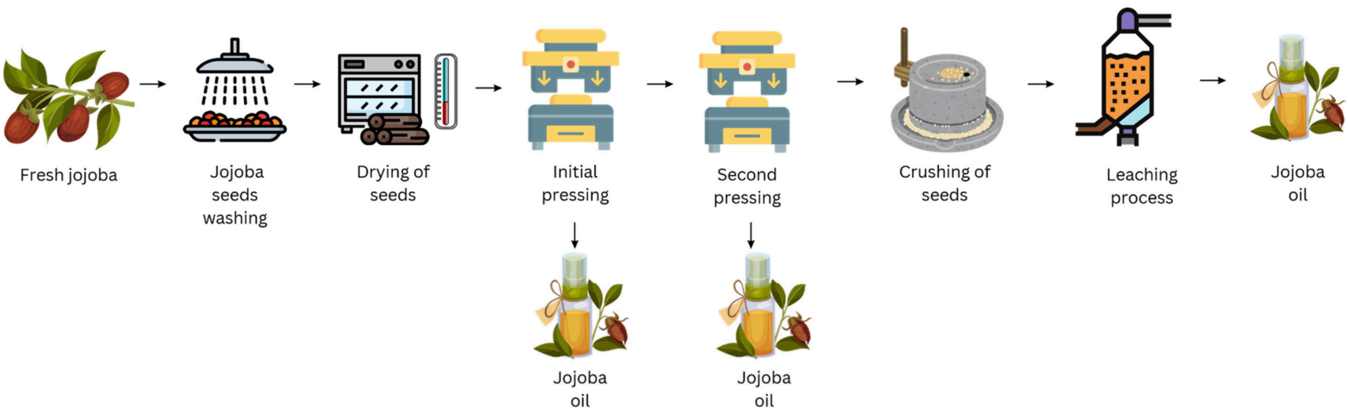

Figure 4. Flowchart of jojoba oil extraction process. (Produced using Canva Pro.)

various environments. Jojoba, for instance, might be cultivated in Mexico, Chile, India, Egypt, South Africa, and Argentina. Native Americans in the Sonora Desert of California frequently used jojoba as a food item in the form of roasted fruits and as a remedy for several illnesses, such as obesity, cancer treatment, renal disease, sore throat, and parturition.[16] Jojoba, jatropha, and camelina are three of the most significant nonedible oils currently used.[64] Jojoba oil is obtained from the smashed bean of the jojoba plant shrub. The oil yield of the jojoba plant is roughly 1818 kg/ha, slightly less than the jatropha plant (1900−2500 kg/ha) but greater than camelina (800−1200 kg/ha).[64] Because of this, certain places in India have employed this plant to prevent desertification, indicating that it might have both an economic and an environmental purpose.

5.1. Production. A proper oil extraction machine or full assembly line is needed to collect oil from jojoba seeds. Jojoba oil makes up around 50% of the total weight of the jojoba seed.[65] It has a lengthy lifespan because it contains alcohol, monoesters of long-chain fatty acids, and triglycerides. For producing jojoba oil, a hydraulic press type is manually operated to press jojoba seeds to extract the oil. A cylindrical container is filled with jojoba seeds for each run before being kept under the press load. The weight of the oil extracted from the seeds is calculated based on the amount of oil collected after each press. Some samples may undergo a second pressing by being removed from the cylindrical container. After the initial press, the disklike residue is broken and placed back into the cylindrical container. The initial and second pressing are to be performed at room temperature.

Jojoba seeds have a thick center and a tough outer shell, so extracting all the oil in a single pressing is challenging. In the initial pressing, part of the oil is released (35.4%) and the seed material is broken down. Then the second pressing maximizes yield and improves process efficiency, by ensuring that the residual oil is removed (8.4%).[65] Furthermore, first and second pressings are performed on the jojoba seeds, after which the sample is removed from the cylindrical container and crushed. Using a Soxhlet extractor, the crushed sample undergoes a leaching process using organic solvent. Oil collected from the first and second pressing processes and the leaching process is added to determine the total amount of oil removed (Figure 4). A Soxhlet extractor is to be used to perform the leaching process. The Soxhlet extractor will be charged with crushed jojoba seeds for each run, along with the organic solvent. Some of the organic solvents that can be employed in the leaching process include petroleum ether, hexane, benzene, isopropanol, chloroform, and toluene. Leaching is done at each solvent's boiling point until a clear liquid is recovered from the jojoba. The oil and solvent from the extracted phase are then separated using two distillation stages. Simple distillation will be used in the first stage, followed by a rota-vapor apparatus in the second stage. The jojoba oil produced using this approach has been compared to pure pressed oil by measuring their characteristics.[65]

5.2. Chemical Composition and Nutrients. Jojoba oil is known as liquid wax rather than fat or oil because it contains over 98% pure waxes (primarily wax esters, free fatty acids, hydrocarbons, and alcohols), sterols, triglyceride esters, and vitamins.[16] The various parts of the jojoba plant have been investigated to reveal wax content, and it was discovered that the seeds had most of the wax inside the plant, making up around 50−52% of the seed weight.[16] The main component of jojoba wax is esters, which contain smaller amounts of free alcohol, free acids, and hydrocarbons. Long straight-chain or higher molecular weight monohydric alcohols are joined with long straight-chain fatty acids to form esters.[66] Additionally, small triglyceride esters are also present.

The primary constituents of wax esters are eicosenyl eicosenoate, docosenyl eicosenoate, docosenyl docosenoate, eicosenyl docosenoate, docosenyl oleate, and eicosenyl oleate.[16] In addition, additional wax esters, free fatty acids, and minute quantities of alcohol are present. In accordance with reports, jojoba oil has small amounts of free alcohols (1.11%) and fatty acids (0.96%).[16] Free alcohols including hexadecanol, heptadec-8-enol, octadecanol, octadec-9-enol, octadec-11-enol, eicosanol, eicos-11-enol, hecos-12-enol, docosanol, docos-12-enol, tetracos-15-enol, and hexacosenol.[16] Moreover, free fatty acids include dodecanoic acid, tetradecanoic acid, pentadecanoic acid, hexadecenoic acid, octadecanoic acid, nonadecanoic acid, eicosanoic acid, docosanoic acid, and tricosenoic acid.[16]

There are several reports addressing the content of jojoba oils' sterols. The majority of the sterols fraction is campesterol (16.9%), stigmasterol (6.7%), isofucosterol (4.1%), cholesterol (0.8%), fucosterol (0.6%), and β-sitosterol (0.6%).[17] Moreover, the most prevalent secondary metabolites in nature are phenolic chemicals, and jojoba oil only constitutes a small part of them. Ten flavonoids that have been found within the jojoba oil include quercetin 3′ methyl ether, quercetin, quercetin 3,3′-dimethyl ether, quercetin 3-methyl ether, quercetin 3-O-glucoside, isorhamnetin 3-O-glucoside, isorhamnetin 3-O-rutinoside, quercetin 3-O-rutinoside, and typhaneoside.[16]

https://doi.org/10.1021/acsomega.4c04277
ACS Omega 2024, 9, 44019−44032

Add to that, the primary cyanogenic glycosides within jojoba oil are simmondisin, simmonosides A, B, and 4,5-dimethyl-4-O-alpha-D-glucopyranoslysimmondsin. There are also several lignans present in jojoba oil such as salvadoraside, (+)-lyonir-esinol 4,4′-bis-O-β-D-glucopyranoside, and eleutheroside E.[67] Jojoba oil contains vitamin D and other fat-soluble vitamins such as vitamin A.[17] Also, α, δ, and γ tocopherol were quantitively assessed and isolated from the jojoba oil, where γ-tocopherol makes up around 79% of these compounds.

5.3. Biological Properties. Traditionally, jojoba oil has been used in various medical applications, including cancer remedies, liver function improvement, curing suppression of urine, increasing body immunity, promoting hair growth, and weight loss.[16] Numerous pharmacological and biological research using jojoba oil and its derivatives show that these medicines have a broad spectrum of biological activity when used topically or ingested. The chemical structure of the various wax esters may be related to these activities. The main biological activities of jojoba oil include antioxidant activity, hepatoprotective activity, anti-inflammatory, antiacne, antiviral, antimicrobial, antipyretic, antipsoriasis, and antihyperglycemia activities.[16] Jojoba oil has unique properties which allow it to be utilized in a wide range of industries. For instance, pharmaceuticals, cosmetics, heating insulators, high-pressure lubricants, foam control agents, heating oil, fire retardants, plasticizers, and transformer oils.[68]

5.4. Applications. Jojoba oil provides excellent lubricity in single-phase and emulsion systems without feeling greasy or oily like other lipids, especially petrolatum and lanolin. Additionally, it might make it easier for the skin to regulate how much water transpires, reducing evaporation without obstructing the movement of gases and water vapor. This feature prevents excessive epidermal cell flaking and smoothing dry skin due to its low viscosity, high molecular weight, and structural similarity to skin sebum.[16] In accordance with skin indentation tests, jojoba oil enhanced skin suppleness in a manner that is similar to the lanolin effect. Jojoba oil demonstrated a keratoplastic impact and seemed to restore the natural sheen of the skin.[16]

5.4.1. Cosmeceutical Applications. The emollient qualities of jojoba oil have generated claims of its use as a conditioning agent (Table 2). Hair fiber was positively influenced when jojoba oil was added to thioglycolate-based straightening emulsions by improving the breakage resistance, allowing tiny protein loss, and protecting hair thread.[16] To take advantage of the chemical foundation of jojoba oil, Touitou and Godin (2008) developed sunscreens that do not penetrate the skin as novel photoprotection against UV radiation.[69] The goal is to create new filters by combining jojoba oil and UV sunscreen molecules (methoxycinnamate). The designed nonpenetrating sunscreens had high skin substantivity, which reduced the requirement for repeated application and prevented in vitro methoxycinnamate-nonpenetrating sunscreen penetration across the skin for 1 day.

Moreover, jojoba was added to topical formulations to increase the effectiveness of medications used to treat skin diseases. A prior study showed that lycopene, a significant antioxidant with low solubility in oil and water, could dissolve in jojoba oil. The increased solubility makes it possible to formulate lycopene into transparent, liquid solutions for medicinal applications.[16] Shevachman et al. (2004) employed jojoba wax as the oily phase in a productive microemulsion preparation where the quantity of jojoba oil determined the change from the water-in-oil to bicontinuous and oil-in-water structures.[70]

Jojoba oil's historical use by Mexican Indians to cure wounds has recently brought attention to its potential to treat psoriasis and acne. Thomas K. Miwa (1984) conducted a clinical examination of the jojoba wax on acne vulgaris patients and provided scientific proof of its effectiveness as an antiacne treatment.[71] The findings suggested that jojoba oil may effectively treat specific conditions. Its qualities as a liquid wax make it possible to dissolve skin sebum deposits in hair follicles since it can get inside the follicles and separate the come dome, cleaning and purifying the skin as it does so.

6. CONCLUSION AND OUR PERSPECTIVES

In conclusion, virgin coconut, olive, argan, and jojoba oil are precious plant-based oils in the cosmetics industry. Generally, they provide the skin with several benefits, including antiaging properties, nourishment, moisturization, and protection properties. They are valuable ingredients in various cosmetic products because of their natural composition, benefits, and wide range of properties. These oils provide a holistic and natural approach to beauty and skincare, whether it is to improve the appearance of the skin, boost the health of the hair, or offer therapeutic advantages. The market for these cosmetic oils will increase due to the expanding demand for cosmetic products.

In accordance with Global Industry Insight (2022),[72] the cosmetic oil industry was worth about USD 4.8 billion in 2020. From 2021 to 2027, it is anticipated to expand at a compound annual growth rate (CAGR) of over 5.5%. The rising demand for organic goods and the expanding use of vegetable oils in the cosmetics sector are credited with this growth. Several aspects are considered while evaluating the economic feasibility of coconut oil, olive oil, argan oil, and jojoba oil. These aspects are accessibility, cost, production expenses, and market demand. Factors including the rising customer preference for natural and organic goods, advancements in extraction procedures, and sustainable sourcing practices can influence the economic viability of these oils in the cosmetics sector. Among these, coconut oil has the most significant market share, primarily due to its rising use in cosmetics for the skin and hair. The South Asian olive oil market is projected to grow at a compound annual growth rate (CAGR) of roughly 5% between 2021 and 2026.[73] The critical market forces influencing the olive oil market are rising disposable incomes, population expansion, and increasing demand from the food and beverage, cosmetics and beauty, and pharmaceutical industries. In addition, jojoba oil possesses strong lubricity and causes no long-term environmental risk, but its main current drawbacks are its high price and restricted supply.[74] A low-cost, high-volume jojoba oil is needed instead of the current high-cost and low-volume commodity. In 2020, 16,840 tonnes of jojoba oil were sold worldwide; between 2021 and 2026, the market is projected to increase at a compound annual growth rate (CAGR) of 7.6%, reaching 26,107 tonnes.[73] The main jojoba oil industry drivers are health awareness growth, increasing disposable income, rising focus on aesthetics and appearance, use of oil transformers and lubricants, cosmetic industry, and rising retail sector. Vegetable oil consumption has expanded dramatically as a result of the expanding trend toward natural and organic certifications in cosmetics, which is fueling the expansion of the entire industry. The growing innovation of cosmetic goods employing diverse

https://doi.org/10.1021/acsomega.4c04277
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vegetable oils will speed up the development of the cosmetic oil business even more. Despite some drawbacks, Jojoba and argan oils are relatively expensive compared to coconut and olive oils. Also, coconut and olive oils are comedogenic when used for cosmetic applications. As it may clog pores and lead to breakout of acne for those individuals having sensitive skin. Moreover, one of the drawbacks of coconut oil is that it can be greasy at low temperatures and may fully solidify, therefore, it might not absorb well into the skin. Olive oil needs to be stored carefully as it is susceptible to oxidation.

Synthetic oils consist of chemical compounds. Using plant-based oils in industries will eliminate and reduce the need for synthetic oils, positively affecting the environment. This impact aligns with the 12 Principles of Green Chemistry and SDG 12, where zero chemical waste management is required. Also, plant-based oils are preferred over synthetic oils because they promote good health and well-being since they are from natural sources, are environmentally friendly, and have no harmful effects on human health upon use. This impact is in line with SDG 3, where we should ensure healthy lives and promote well-being for all ages.

■ ASSOCIATED CONTENT

Data Availability Statement

Data are available in the manuscript.

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All authors reviewed and approved the final version of the manuscript for publication.

Notes

The authors declare no competing financial interest.

■ ACKNOWLEDGMENTS

This work was supported by the Fundamental Research Grant Scheme (FRGS) (Grant FRGS/1/2020/STG01/SYUC/02/1) awarded by the Ministry of Higher Education Malaysia (MOHE). The authors would like to acknowledge the Sunway Postgraduate Research Scholarship which was granted to Sarah Abdalla Eltayib Adam by Sunway University, Malaysia.

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https://doi.org/10.1021/acsomega.4c04277
ACS Omega 2024, 9, 44019−44032