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Review

An overview on medicinally important plant: Jojoba (*Simmondsia chinensis* Link) Schneider

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Abstract

Simmondsia chinensis or Jojoba is the diaceous, perennial, slow growing and evergreen shrub and indigenous plant of California, United States and Mexico's Sonoran Desert. Jojoba comprises nitrile glycosides groups called simmondsin's compounds, stanols, sterols, toccopherols and flavonoids. The extracts of leaves, root and latex of jojoba possess anti-microbial, antiviral, anti-oxidant, anti-tumor properties. Various cosmetic formulation use jojoba as an important element of their product to enhance their moisturizing potential. Jojoba is applied for the treatment of psoriasis and acne-prone skin lesion. jojoba leaves and meal can be used as staple food and possess possible medicinal potentials. Jojoba oil is growing non-palatable oil, utilized as an unrefined substance for the production of biodiesel and development of the development of cleansers, plastics, environment friendly power and ointments. Its worldwide production is developing quickly and is supposed to arrive at 22,000 tons by 2022. This review focuses on the pharmacological medicinal and economic benefits of Jojoba.

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Introduction: *Simmondsia chinensis* (Link) Schneider (Syn. *Simmondsia californica* Nutt or Buxuschinensis Link.) is commonly known as jojoba but also called oat nut,deer nut, coffee berry andwild hazel. It belongs to the family simmondsiaceae [1]. Revered for its versatile applications and potent therapeutic properties, jojoba has become a focal point of research in the field of natural medicine. This article delves into the diverse medicinal benefits of jojoba, shedding light on its chemical composition, traditional uses, and contemporary applications in the realm of health and wellness.

Jojoba oil contains compounds with anti-inflammatory effects. Inflammation is implicated in various health conditions, including chronic diseases. Jojoba oil's antimicrobial and wound-healing properties have been recognized traditionally. It forms a protective barrier on the skin, which may help prevent infections and facilitate the healing of wounds. This could be beneficial in the context of skin infections. Research has shown that jojoba oil has the potential to inhibit the growth of certain pathogenic microorganisms, showcasing its antimicrobial efficacy. It often used in skincare products due to its similarity to human sebum. Individuals with dermatological conditions such as psoriasis, eczema, and acne may benefit from the moisturizing and soothing effects of jojoba oil. Its non-comedogenic nature makes it suitable for individuals with acne-prone skin. Jojoba oil contains antioxidants that can help combat oxidative stress. Antioxidants play a crucial role in neutralizing free radicals, which are implicated in various chronic diseases and the aging process. Regular use of jojoba oil may contribute to overall skin health and protection. Some studies suggest that jojoba oil may have hormonal regulatory effects. It could be explored in the context of oral health. This could include its potential use in oral care products to combat bacteria responsible for dental issues.

Summary Table of parts of plants:

Table 1 provides an overview of the key compounds found in different parts of the jojoba plant and their potential health benefits. It's important to note that the information presented here is based on existing research up to my knowledge cutoff in January 2022, and further studies may reveal additional compounds and benefits. Additionally, the potential health benefits mentioned are subject to ongoing research and may vary based on the specific context of use.

Phytochemical analysis and therapeutical effect of plant:

Alkaloids, tannins and saponins were found in all the extracts of root which is in accordance with the study of [11] who reported that plants comprise chemical ingredients which have anti-microbial potential. The extract of ethanol was affluant in these phytochemicals than both aqueous and hexane extracts. This could be because of the ethanol capability to bring out more components. Although, all the other extracts contain steroids in mild quantity except in hexane extract with no steroids present. While in latex glycosides are absent but slight alkaloids, saponins, steroids present and have high contents of tannin. Such preparateory phytochemicals screening might beneficial in detection of various chemical components in the polar or nonpolar solvents. [12]

The phytochemical detection of leaf extract by using the DPPH assay resulted in isolation and recognition of 10 flavonoids and 4 lignans.

The flavonoids recognised as [1] quercetin 3-O-rutinoside [13], [2] isorhamnetin (quercetin 3' - methyl ether) [14], [3] quercetin[14], [4] isorhamnetin 3-O-(2",6"-di-O-α-L-rhamnopyranosyl)- -d-glucopyranoside (typhaneoside) [15] ,(5)quercetin 3-O-glucoside[16], (6)quercetin 3-methylether [17], (7)isorhamnetin 3-O-glucoside,[18], (8)quercetin 3,3' -dimethyl ether, [17], (9) isorhamnetin 3-O-rutinoside [19], (10)isorhamnetin 3-O-(2",6"-di-O-α-L-rhamnopyranosyl)—dgalactopyranoside[20].

1. R1= Glc-rha, R2= H (figure 2)
2. R1= H, R2= CH3
3. R1= H, R2= H
4. R1= (2",6"-di-O-α-L-rhamnopyranosyl)-ß-D-glucopyranoside, R2= CH3
5. R1= Glc, R2= H
6. R1= CH3, R2= H
7. R1= Glc, R2= CH3
8. R1= CH3, R2= CH3
9. R1= Glc-rha, R2= CH3
10. R1= (2",6"-di-O-α-L-rhamnopyranosyl)-ß-D-galactopyranoside ,

R2= CH3

Four lignans

[11] (+)-lyoniresinol 4,9' -bis-O—d-glucopyranoside[21], [12] (+)-lyoniresinol 4,4'-bis-O—d-glucopyranoside[22]

[11]. R1= H, R2= Glc, R3= Glc,

[12]. R1= Glc, R2= Glc, R3= H

[13] (salvadoraside) 5,5' -dimethoxylariciresinol 4,4' -bis-O—d-glucopyranoside[23] and [14] (eleutheroside E) syringaresinoldiglucoside[24]. All spectral and physical data of these chemical constituents were in accordance with the study by [25].

Therapeutical effect of plant:

1. Seeds:

a) Liquid Wax Esters (C20–C22):

Mechanism: Resemble human sebum, providing a protective layer on the skin's surface, preventing moisture loss.

Therapeutic Indications: Excellent emollient for skin hydration, suitable for dry and sensitive skin. May help regulate sebum production.

b) Fatty Acids (e.g., Oleic Acid, Erucic Acid):

Mechanism: Contribute to the skin's lipid barrier, enhancing moisturization and promoting skin softness.

Therapeutic Indications: Effective for dry skin, helps in managing conditions like eczema. Supports overall skin health.

c) Tocopherols (Vitamin E):

Mechanism: Antioxidant activity scavenging free radicals, protecting skin cells from oxidative stress.

Therapeutic Indications: Anti-aging effects, reduction of oxidative damage, may contribute to skin repair and regeneration.

d) Phytosterols:

Mechanism: Potential anti-inflammatory effects, modulating immune responses in the skin.

Therapeutic Indications: Supporting skin health, especially in conditions with inflammation such as psoriasis or dermatitis.

2. Leaves:

a) Flavonoids:

Mechanism: Antioxidant activity, neutralizing free radicals.

Therapeutic Indications: Contributing to overall skin health, reducing oxidative stress.

b) Triterpenoids (e.g., Ursolic Acid):

Mechanism: Antioxidant activity, neutralizing free radicals.

Therapeutic Indications: Contributing to overall skin health, reducing oxidative stress.

3. Roots:

a) Simmondsin:

Mechanism: Used traditionally as an insecticide; specific mechanisms may involve disrupting insect metabolism.

Therapeutic Indications: Not typically used in direct human applications but has relevance in agriculture for pest control.

4. Whole Plant:

a) Polyphenols:

Mechanism: Antioxidant effects, protecting cells from oxidative damage.

Therapeutic Indications: Supporting overall skin health, potential anti-aging benefits.

b) Coumarins:

Mechanism: Potential anti-inflammatory effects, inhibiting inflammatory pathways.

Therapeutic Indications: Could contribute to formulations for conditions involving inflammation.

c) Lingams:

Mechanism: Antioxidant and anti-inflammatory properties.

Therapeutic Indications: Supporting skin health, potentially useful in managing conditions with inflammation.

d) Enzymes (e.g., Lipase):

Mechanism: Involved in the breakdown of lipids, potentially aiding digestion.

Therapeutic Indications: Limited direct application in skincare but may have relevance in food digestion and nutrition.

5. Latex (Gum):

a) Polysaccharides:

Mechanism: May have emulsifying properties, potentially contributing to the stability of cosmetic formulations.

Therapeutic Indications: In skincare, contributes to the texture and stability of formulations. This in-depth exploration underscores the multifaceted nature of jojoba's bioactive compounds and their potential therapeutic applications in skincare. The combination of emollient properties, anti-inflammatory effects, and antioxidant activity makes jojoba a valuable natural ingredient in various cosmetic and medicinal formulations.

Pharmacological activities

Antibacterial activity: A study published in the "International Journal of Molecular Sciences" (2017) investigated the antimicrobial activity of jojoba oil. The findings suggested that jojoba oil exhibited significant antimicrobial effects against various bacterial and fungal strains. Thousands of medicinal plants were being investigated for the cure of various infectious diseases [6]. The extracts of root and latex of jojoba possess potent antibacterial activity by inhibiting growth of investigated bacteria (based on clearance zones). Hexane extract of root exhibit antibacterial against *Staphylococcus aureus, Bacillus cereus*, Ethanolic and aqueous extracts of root were sensitive against *Bacillus cereus, Salmonella typhimurium* and *Staphylococcus aureus, Escherichia coli* and *Clostridium perfringens* [7]. Jojoba oil showed antibacterial potential against *Proteus vulgaris, Staphylococcus aureus, Bacillus subtilis, andproteus mirabilis. E. coli, Salmonella typhimurium* and *Pseudomonas aeruginosa* were resistant [8].

Anti-fungal: The aqueous and ethanolic extract of jojoba did not affected *Candida albicans* against but hexane extract inhibited its growth. The Ethanol extract and the latex screening reduced the mycelia growth of *Aspergillus flavus* [7]. Jojoba oil showed no activity against fungi and yeast [7]. The Jojoba wax ability to hinder the growth of *Malassezia furfur* was determined by Alamar Blue assay. The wax used upto 850 µg/mL but no anti-fungal activity was observed. Insignificant anti-fungal action of the wax was previously found in two disease causing fungal species (*Asperigillus flavus* and *Candida albicans* [26] recommending that the wax of Jojoba may not have anti-fungal activity. Simultaneously, in other uses as an emollient in spa treatment, Jojoba may be superficially applied on skin, so that its bioactive ingredients mask in high concentration. In this manner, it can't be avoided that the low potential revealed by others might in any case exhibit clinical significance [27, 28].

Anti-oxidant: Research published in "Food Chemistry" (2017) evaluated the antioxidant activity of jojoba seed extract. The study found that the extract exhibited antioxidant properties, indicating its potential role in combating oxidative stress. There are several phytochemicals including terpenes, flavonoids and polyphenols that exhibit an antioxidant potential. The extracts of ethanol and methanol Jojoba seeds and leaves exhibit antioxidant action depending on scavenging [28]. The leaf extract was investigated for the phytochemical guided by using DPPH method [9] lead to segregation and recognition of several phenolic constituents comprising quercetin, isorhamnetin and quercetin like flavonoids as in aglycone and glycosides along with lignoid glycosides. Flavonoid aglycones reveal greater lipoxygenase inhibitory and antioxidant activities as compare to the glycoside compouns. Lignoid glycosides exhibit moderate to weak lipoxygenase inhibitory and antioxidant activities [9].

Phytosterols and Cholesterol Regulation: A study in "Lipids in Health and Disease" (2012) explored the cholesterol-lowering effects of jojoba meal (residue after oil extraction) in rats. The results suggested that jojoba meal consumption had a positive impact on lipid metabolism and cholesterol levels.

Anti-cancer activity: The extracts from various parts of jojoba showed antitumor activity against several types of human neoplastic cell line. Jojoba oil (hexane extract & cold pressing extract) is more effective as compare to other parts of plant, against the human melanoma (MV 3) and

human colorectal (HCT 116). Jojoba extracts showed cytotoxicity that is dose-dependent [29].

Anti-viral: A study in the "Journal of Ethnopharmacology" (2019) assessed the wound-healing potential of jojoba oil in rats. The results suggested that jojoba oil accelerated the wound-healing process, possibly due to its moisturizing and antimicrobial properties. Vero cells inoculated with the 0.1 m.o.i. of the herpes viruses and analysed after treatment with 50µg/ml of aqueous extract of the plant *S. chinesis* for different points before, at the time or after infection. When treatment was given at the time or after infection inhibition results were greatest. It was analysed that pre-treatment of cells was not significant in lower or inhibiting the induction of infection. Although, treating cells after infection resulted in limited inhibition. The extracts of plant are considered to apply their inhibitory activity at a beginning phase in the viral disease cycle for example infection adsorption onto as well as entrance into the host cell [30].

Then, the Jojoba wax ability to lessen the arrangement of plaques formed by HSV-1 was researched in Vero cells. Vero cell feasibility was not entirely evaluated by a MTT assay to rule out direct wax cytotoxicity. However, Jojoba wax at 850 µg/mL was very much endured by the vero cells (host cells), four Jojoba wax products with similar concentrations restricted the development of HSV-1 plaque approx. 35-55%[31].

Dermatology and skin care: A clinical trial published in the "Journal of Dermatological Treatment" (2019) investigated the effects of a jojoba based skin care product on skin hydration and elasticity. The study concluded that the product improved skin hydration and elasticity, highlighting the potential cosmetic and dermatological benefits of jojoba oil.

1. Natural Moisturizer: Jojoba oil closely resembles the natural sebum produced by the skin. This similarity allows it to act as an effective moisturizer without clogging pores. It helps balance skin oil production and is suitable for all skin types, including oily and acne-prone skin.

2. Hydrating Properties: The liquid wax esters in jojoba oil provide long-lasting hydration. It forms a protective barrier on the skin, preventing moisture loss and keeping the skin supple and hydrated.

3. Anti-Inflammatory Effects: Jojoba oil contains compounds with anti-inflammatory properties, making it beneficial for soothing irritated or inflamed skin. It may assist in calming conditions such as eczema, psoriasis, and other inflammatory skin issues.

4. Acne Management: Despite being an oil, jojoba oil is non-comedogenic, meaning it doesn't clog pores. This property makes it suitable for individuals with acne-prone skin. Jojoba oil helps regulate sebum production, reducing the likelihood of breakouts.

5. Wound Healing: Jojoba oil has been traditionally used for wound healing. Its antimicrobial properties may protect wounds from infections, and its moisturizing effect may contribute to faster healing. It forms a natural barrier that shields the skin during the healing process.

6. Anti-Aging Properties: Jojoba oil is rich in antioxidants, including vitamin E. Antioxidants help combat free radicals that contribute to premature aging. Regular use of jojoba oil may reduce the appearance of fine lines and wrinkles, promoting a more youthful complexion.

7. Hair and Scalp Care: Jojoba oil is beneficial for hair and scalp health. It conditions the hair, reduces frizz, and promotes a healthy scalp. Its molecular structure is similar to the natural oils produced by the scalp, making it an excellent choice for nourishing the hair and preventing dryness.

8. Sunburn Relief: Jojoba oil may provide relief from sunburn due to its soothing and moisturizing properties. Applying jojoba oil to sun-exposed skin may help alleviate discomfort and promote healing. Moreover, the tocopherol and anti-oxidant components of jojoba referenced above might be utilized to diminish oxidative stress related to skin [34]. Various cosmetic formulation use jojoba as an important element of their product and until this point, very nearly 200 International Nomenclature of Cosmetic Ingredients (INCI) sections recorded jojoba and subsidiaries. A few clinical trials examined the characteristics of dermal applications of *Simmondsia chinensis*. For example, it has been accounted for that the application of its hydrolyzed ester in salves could upgrade dermal hydration by decrease of water loss trans-epidermaly (TEWL)[38].jojoba application stimulate collagen union in fibroblasts. Ca2+ subordinate mechanisms that need contribution of the PI3K-Akt-mTOR pathway and ERK1/2 and p38 has been proposed by its author.

Anti-inflammatory: Research in the "Journal of Ethnopharmacology" (2017) explored the anti-inflammatory effects of jojoba liquid wax in a rat model of carrageenan-induced paw edema. Intraplate infusion of carrageenan to rodents brought about extreme perceptible inflammation and critical expansion in the mean volume of the tested paw contrasted with that of the untreated paws (162.3% of the untreated paws). Pretreatment of rodents with JLW in dosages of 5 and 10 ml kg−1 altogether repressed the carrageenin-prompted expansion in the oedema volume of the paws by 26.4 and 34%, separately. Also, indomethacin-treated set showed huge antioedema impact (43.4% of the initiated paws). Carrageenin challenge brought about more than five-overlay expansion in PGE2 focus in inflammatory exudates in rodents of group 2 contrasted with unchallenged group 1 animal. individual getting JLW showed critical decrease of the PGE2 focus in exudates that was natural portion (decrease by 58.15 and 77.4% of the carrageenin-treated creatures, separately). The higher portion of JLW too as indomethacin could bring down PGE2 level in carrageenin-tested creatures moving toward typical levels [44].

Metabolic syndrome and metabolism: Metabolic syndrome refer to be multiple metabolic irregularities like non-alcoholic hepatic steatosis, glucose intolerance, weight, insulin resistance and type 2 diabetes. A new report by shown that consolidation of seeds of jojoba for the eating routine of rodents could diminish the malicious impacts of high fructose and fat eating routine [45] In their review, treatment group showed an obvious decrease in renal complications, fat mass and insulin resistance. These discoveries were joined by decrease in the rodent weight, and consequently the author presumed this anorexic effect

as the primary driver of the jojoba remedy. Their outcomes are additionally according to past studies exhibiting that extract of jojoba leaf might lessen body weight in rodents [46]

Simmondsin present in leaves and jojoba oil, has previously been displayed to diminish food ingestion in rodents, proposing that the effect of this plant jojoba for craving is intervened because of this particular molecule [47]. Moreover, an immediate impact of simmondsin has been seen in beta-cells of pancreas, proposing its activity on various sites by this chemical [45].

Conclusion: In conclusion, jojoba (*Simmondsia chinensis* Link) Schneider stands as a versatile and valuable ally in skincare, offering a myriad of medicinal benefits. Its unique composition, resembling the skin's natural sebum, makes it an effective moisturizer with applications ranging from hydration and anti-inflammatory relief to wound healing and acne management. Jojoba's antioxidant properties contribute to anti-aging effects, while its soothing nature provides relief from sunburn. As a natural makeup remover and scar reduction agent, jojoba oil showcases its adaptability in various skincare formulations. From dermatitis to hair care, jojoba plays a vital role in promoting overall skin health. Incorporating jojoba into skincare routines can harness its diverse medicinal aspects, contributing to radiant and nourished skin.

Conflict of Interest

The authors have no conflict of interest.

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Table 1. Summary Table of parts of plants

Plant Part	Key Compounds	Potential Health Benefits
Seeds	Liquid Wax Esters (C20–C22)	- Emollient properties for skin hydration
	Fatty Acids (e.g., Oleic Acid, Erucic Acid)	- Skin conditioning
	Tocopherols (Vitamin E)	- Antioxidant activity
	Phytosterols	- Potential anti-inflammatory effects
	Proteins	- Nutrient source for skin and hair
Leaves	Triterpenoids (e.g., Ursolic Acid)	- Anti-inflammatory properties
	Flavonoids	- Antioxidant activity
Roots	Simmondsin	- Insecticidal properties (used as a natural insecticide)
Whole Plant	Polyphenols	- Antioxidant effects
	Coumarins	- Potential anti-inflammatory effects
	Lignans	- Antioxidant and anti-inflammatory properties
	Enzymes (e.g., Lipase)	- Involved in the breakdown of lipids, potentially aiding digestion
Latex (Gum)	Polysaccharides	- May have emulsifying properties

Figure 1. [10]

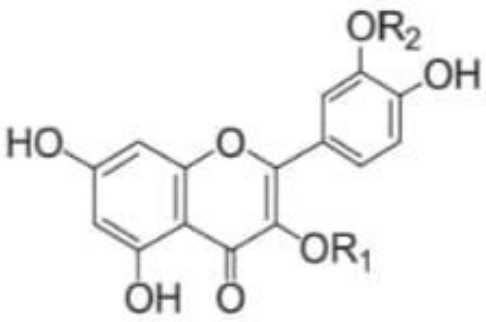

Figure 2. R1= Glc-rha, R2= H