



INVITED REVIEW

Unconventional Oil Sources: Emerging Nutraceuticals for Integrated Health

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Abstract

Recent scientific research emphasizes the growing importance of functional foods as both nourishment and medicine, leading to the exploration of unconventional oils from plant sources like black seed, hibiscus, black cumin, and insect sources such as melon bug and cochineal. These oils are rich in bioactive compounds—including polyunsaturated fatty acids (PUFAs), antioxidants, phytosterols, and polyphenols—that contribute to anti-inflammatory, cardioprotective, neuroprotective, and immunomodulatory effects. Their unique nutritional profiles support the prevention and management of chronic diseases, metabolic disorders, oxidative stress, and gut microbiome imbalances, while also promoting mental health and longevity. Additionally, they show promise in dermatological applications, offering therapeutic benefits for skin and hair conditions. By integrating traditional knowledge with modern scientific validation, these oils represent a sustainable and innovative approach to holistic health and food product development. However, further research is needed to enhance their stability, bioavailability, and dosage accuracy to ensure clinical efficacy. As nutraceuticals and nutritional supplements, unconventional oils offer exciting potential for future applications in personalized nutrition and disease prevention strategies.

Keywords: Bioactive compounds, health, insect oil, nutraceuticals, unconventional oils.

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Introduction

Unconventional seed oils are oils extracted from the seeds of plants not commonly used for oil production, such as marula kernel oil, Moroccan argan oil, pumpkin seed oil, hibiscus seed oil, apricot kernel oil and insect oils. These oils are often rich in nutrients and beneficial compounds, making them healthy choices for cooking and cosmetics¹. Unconventional oils add a distinctive flavour to food and offer numerous health benefits. These oils are often cold pressed, contain unsaturated fatty acids that have a positive effect on metabolism.

Conventional vegetable oils are extracted from commonly used sources such as corn, olives, and sunflowers. In contrast, non-conventional vegetable oils are derived from less common sources or processed using different methods, such as fixed oils or oils not typically used in conventional cooking. Conventional oils are known for their diverse nutritional benefits and wide range of

applications, whereas non-traditional oils may vary in their nutritional composition, value, and physical properties².

Conventional and unconventional vegetable oils are distinguished by their source, scale of production, and typical applications. Conventional oils are from well-established crops and are mass-produced, while unconventional oils are sourced from a wider variety of plants or even other sources like insects and often have specialized uses (Table 1)³.

For thousands of years, human nutrition has been linked to the use and consumption of oils extracted from various types of plant seeds, in addition to margarine or “ghee” and butter extracted from animal milk and fats⁴. However, through experience and experimentation, humans discovered that the level of cholesterol in these animal derivatives is higher than in vegetable oils. After realizing that high undesirable kinds of cholesterol can lead to atherosclerosis, angina, and heart attacks, humans

turned to consumption of vegetable oils that are virtually cholesterol-free, such as sunflower oil, corn oil, olive oil, palm oil, and the like. These traditional oils have become a staple in human diets ⁵. There are unconventional oils that contain unsaturated acids that have a clear effect in lowering blood cholesterol levels (Table 2). Among these acids is oleic acid (Omega9), which is widely used in Mediterranean countries ⁶.

Unconventional oils have unique flavours and diverse nutrients, and may be more beneficial for some health conditions, but seem to be more expensive or less available than conventional oils. It is that they retain their obvious nutritional benefits.

This review aims to bring together scattered information on some unconventional oil sources for the benefit of researchers and specialists in the food and pharmaceutical industries. It also aims to stimulate further research and interest in unconventional oil sources to diversify the market and enhance the use of untapped plant species.

Methods

The review uses up-to-date data via manual screening of the titles and abstracts of retrieved articles using string foodborne diseases in Sudan and foodborne illnesses as keywords to obtain publications from the electronic databases; Science direct, PubMed, Scopus, and Google Scholar from the year 2000-2025 using the different searching tools, the databases were reviewed from June to September 2025.

Examples of unconventional seed oils and their health properties.

Sclerocarya birrea (Marula)

Sclerocarya birrea (Marula) oil is an oil extracted from the seeds of the fruit of the African marula tree and is widely used in skin and hair care due to its cosmetic benefits. The marula tree is a wild African tree that grows in many African countries. Its components have numerous uses in food and traditional medicine. The fruit juice is richer in vitamin C than orange juice besides containing sesquiterpene hydrocarbons. The fruit seed is soft, white and rich in oil and protein. Oleic, palmitic, myristic, and stearic acids are the major fatty acids in the seed oil, whereas glutamic acid and arginine are the most important amino acids in marula protein. It contains important fatty acids such as oleic and linoleic acid, which help moisturize the skin and hair. Marula oil contains antioxidants that protect the skin from damage caused by free radicals. The tree extracts contain high level of phenolic compounds of high free radical scavenging capacity, and antioxidant activity. The tree has various medicinal uses for diabetes and inflammation, as well as for analgesic, antiparasitic, antimicrobial, and hypotensive purposes ^{7, 8}. Marula oil helps moisturize the skin, fight signs of aging, lighten scars, reduce inflammation, and treat some skin problems such as acne and dryness. It nourishes the hair, reduces breakage, adds shine and strength, and helps treat dry and

cracked scalps ⁹.

Black Mahlab Seed Oil

Black mahlab (*Monechma ciliatum*) is a species of the genus *Monechma* belonging to the family Acanthaceae. It is a well-known tropical medicinal herb, long used extensively in Africa for food and medicine. Also known as "black mahlab" among Sudanese people, due to its small, dark brown seeds. The plant is used in traditional dishes, medicinal treatments, and perfumes. The black mahlab seed contains good level of protein with appreciable amount of amino acids. The dry seeds contain different kinds of major elements (Ca, K, and Mg) and of minor elements (Al, Pb Ni, Mn, Cu, Cr, Co, and Fe) ¹⁰.

Black mahlab is used as a spice to add a distinctive flavour to dishes, especially baked goods and sweets. It is used in traditional medicine to treat digestive problems such as diarrhea and vomiting. Black mahlab seeds are used in traditional perfumery. in hair care as natural hair moisturizer where they help strengthen hair follicles, reduce hair loss, and stimulate new hair growth ¹¹. The oil yield of dried seed is about 13.1%, with dominant fatty acids of palmitic (4.5%), stearic (16.0%), oleic (47.3%), and linoleic (31.4%). This unconventional oil was found rich in tocopherols (45.2 mg/100 g) ¹².

The plant leave extract has a strong antioxidant effect based on its content of flavonoids, phenols, alkaloids and other metabolites. The black mahlab plant is used in Africa to treat body and liver pain, colds and diarrhea, and it is also traditionally used to treat infertility in women ¹⁰. Studies have shown that the antimicrobial activity of mahlab includes a wide spectrum of bacteria and fungi compared to known antibiotics ¹¹. Abdel Karim et al. ¹³ examined the antimicrobial activity of the seeds oil of *M. ciliatum* and reported that it has a significant effect on *Aspergillus niger*, *Candida albicans* fungi and *Staphylococcus aureus* bacteria. The oil was found to be partially active against *Escherichia coli* and *Pseudomonas aeruginosa*

Black cumin seed oil

Black cumin seed oil, also known as black cumin oil, is an oil extracted from the seeds of the plant "Nigella sativa" and has numerous health benefits and diverse uses. The oil is used in traditional medicine to treat a wide range of ailments, and in skin and hair care products ¹⁴. The seed oil contains bioactive compounds such as thymoquinone, which have anti-inflammatory properties. The use of the oil helps fight free radicals and protect cells from damage. It also help relieve symptoms of asthma and bronchitis, alleviate digestive problems such as bloating and gas, lower LDL cholesterol levels, and improve cardiovascular health ¹⁵. In addition to the previous properties, the seed oil can help improve nervous system health and treat certain neurological conditions such as Alzheimer's and Parkinson's diseases, as well as improving urinary tract health conditions such as cystitis and kidney inflammation ¹⁶.

Argan Oil

The Argan tree, *Argania spinosa*, is a natural plant that grows abundantly in Southern Morocco, Southwest Algeria, Mexico, and USA, although the plant bears no fruits with the latter two countries. This tree has lived for millions of years and has a tremendous ability to resist drought and combat desertification¹⁷.

There are two types of Argan oil: Food-grade, which is commonly used in food preparation and is the main ingredient in amlou, is dark brown in colour with a strong flavour¹⁸ due to the roasting of Argan tree nuts before extracting the oil. The second type is golden yellow in colour, as the oil is extracted from the almonds of the Argan tree without roasting. It is used as a skin moisturizer and as an important ingredient in high-end cosmetics. It is more expensive than the food grade one due to its high demand¹⁸. Argan oil contains 42.8% oleic acid (Omega 9), 36.8% linoleic acid (Omega 6), 6.0% stearic acid, 12.0% palmitic acid, and less than 0.5% linolenic acid (Omega 3). In addition to these fatty acids, it contains tocopherol, squalene, steroids, carotenes, and phenols. The oil is usually prepared using cold pressing as an optimal method for preserving the nutrients and vitamins in the product intended for cosmetic use. Such oil, being rich in vitamin A and fatty acids, and distinguished by its golden yellow colour and distinctive, light aroma, is more expensive, and has moisturizing and nourishing benefits for hair and skin¹⁹. Amazigh women in Morocco have used this oil since ancient times as a moisturizer for dry skin and as an anti-wrinkle agent, due to its essential fatty acids, omega-6, omega-9, and antioxidants content. In cosmetics, Argan oil is used as an anti-acne, anti-psoriasis, and anti-redness agent²⁰. It is easily absorbed and leaves no trace. It moisturizes the skin, softens and smooths it, and treats dryness, cracks, and roughness^{20,21}. Argan oil is useful in cleansing the skin of acne scars and impurities, leaving it soft and radiant, and it's particularly beneficial for treating stretch marks and cracks. The oil is also known to nourish the hair and scalp, eliminate dandruff, and gives the hair a lustrous, shiny, and silky texture²². The Argan oil helps prevent and treat stretch marks on the abdominal skin. It restores overall freshness and vitality to the skin within just a few days of use by stimulating the vital functions of skin cells²³.

Pumpkin seed oil

Pumpkin seed oil is a vegetable oil extracted from pumpkin seeds. It is rich in unsaturated fatty acids, including the Omega6 linoleic acid (52%), the Omega9 oleic acid (18%), in addition to vitamins, minerals, and antioxidants^{24,25}. Pumpkin seed oil has many benefits for skin, hair, and seems to help improve heart and prostate health²⁶.

The bioactive compounds, such as gamma tocopherol and linoleic acid, in pumpkin seed oil contribute to a balanced immune response, reducing the risk of inflammatory and chronic diseases²⁷. It helps reduce internal inflammation that weakens the immune system, through its anti-inflammatory and tissue-soothing properties²⁸. Vitamin E in pumpkin seed oil helps protect immune cells from

damage, enhances their strength, and ensures their continued efficient functioning. The seed oil was found rich in powerful antioxidants that combat free radicals, naturally and safely boosting the immune system's response to various infections and diseases^{29,30}. The oil contains zinc, essential for the function of immune cells, enhancing the body's natural defenses and increasing its ability to resist infections and viruses³¹. More of these studies showed that pumpkin seed oil is beneficial in treating benign prostatic hyperplasia, as it stops the enlargement of the prostate caused by testosterone hormone. Consuming such oil for more than three months confirmed treatment and alleviation of the symptoms of benign prostatic hyperplasia (BPH), including reduction of inflammation and the urge to urinate, thereby improving the patient's quality of life. Furthermore, the oil was found to prevent the conversion of testosterone to Dihydro-testosterone (DHT) and hence avoiding the negative effects on the prostate. Consumption of pumpkin seed oil has no side effects, making its long-term use safe and largely effective^{32,33}.

Hibiscus (*Hibiscus sabdarifa*) is a plant widely grown in tropical regions and today, over 300 species of hibiscus are found worldwide. The oil content in hibiscus seeds ranges between 20% and 24% of the dry seed weight. The oil is considered a fixed oil suitable for human consumption and is characterized by its low saturated fatty acid content³⁴. The seed oil was reported rich in some fatty acids such as oleic, linoleic, palmitic, and stearic as well as antioxidants. Its high level of unsaturated fatty acids makes it useful for use in cosmetics, skin care, and hair care industries³⁵. Some studies suggest that hibiscus seed oil seems to help lower blood pressure, reducing the risk of heart disease³⁶. It also helps protect the liver from damage and promotes its health. The oil has anti-inflammatory properties, which help reduce inflammation in the body³⁷. The oil also help improve digestion, alleviate some digestive disorders and help lower harmful cholesterol levels in the blood³⁸.

Further work on this oil found it to revitalize dormant hair follicles, stimulate new hair growth, strengthen hair roots, and prevent hair loss. It acts as a natural conditioner, making it softer and shinier and hence helps maintain natural hair colour and prevent premature graying³⁹.

Regular use of hibiscus seed oil improves the health of the scalp and its follicles, helps combat dandruff, and nourishes the scalp and follicles, which support healthy hair growth⁴⁰. Hibiscus seed oil helps moisturize the skin, make it more radiant, tighten the skin, and improve its elasticity. It can be used to even out skin tone and eliminate dark spots. The oil possesses antibacterial properties that may help fight acne⁴¹.

Both conventional and non-conventional vegetable oils are analyzed concerning their safety, toxicity, allergenicity, and clinical evidence. High monounsaturated (MUFA) and polyunsaturated fatty acids (PUFA) in vegetable oils may offer health benefits, such as lower cancer risk, yet evidence remains uncertain⁴². Toxicity issues arise from refined oils, containing harmful chemicals like polycyclic aromatic hydrocarbons (PAHs), trans fats, and metals, particularly with reused oil leading to lipid peroxidation risks. High omega-6 oil consumption can increase inflammation, while

some oils may adversely affect gut health ⁴³. Generally, highly refined oils pose low allergy risks, unlike unrefined oils which retain more proteins. Sustainability is crucial in oil production, as high-impact palm oil alternatives could worsen environmental issues. Non-conventional oils lack solid safety data and may have higher allergic reaction risks due to residual proteins. Scalability challenges stem from geographical limitations and expensive extraction processes, while scaling could lead to new environmental concerns ⁴⁴.

Insect oils, such as those derived from watermelon bug, sorghum bugs, and black soldier fly larvae, show promise as safe protein sources in animal diets, with potential health benefits noted in some studies. However, concerns exist regarding microbial contamination and allergenicity, particularly for individuals with existing allergies ⁴⁵. In contrast, plant oils, while generally low-risk, can pose safety issues when unrefined. The production of insect oils offers significant sustainability advantages, requiring less land, water, and feed, and can utilize waste materials. Conversely, conventional plant oils face increasing environmental challenges despite established safety profiles. Overall, while insect oils may provide nutritional and environmental benefits, their scalability and allergenic risks necessitate further research before broad adoption ⁴⁶.

Watermelon seed oil

Watermelon (*Citrullus vulgaris*) is grown in most tropical, subtropical, and arid regions of the world. It is a cash crop that serves as a source of water during the long summer season for both animals and humans ⁴⁷. Watermelon seeds are an important agricultural crop in many countries. They are collected from certain watermelon varieties and known for their high protein content and quality. Watermelon seeds contain 18–22% protein, 18–28% oil, 38–47% fiber, 7–8% carbohydrates, moisture 4–5% and 557 calories in 100 grams ⁴⁸.

Watermelon seeds represent between 4% and 6% of the annual crop production in Sudan and are mainly used as snacks for local consumption and export. The seed oil was reported to be used in a variety of industries, including cosmetics, food, and pharmaceuticals ^{49,50}. The seed oil is rich in essential fatty acids such as linoleic acid, as well as vitamins and minerals that make it an effective moisturizer and nourisher for the skin and hair ⁵¹.

The oil helps hydrate the skin and prevent moisture loss, making it beneficial for dry skin. It contains antioxidants that help fight free radicals and reduce signs of aging such as wrinkles and fine lines. It also moisturizes hair, protecting it from breakage and damage, and helps increase its shine and softness ⁵². It helps cleanse pores and reduce the appearance of acne, especially for oily and blemish-prone skin. The oil has anti-inflammatory properties, making it useful in soothing irritated skin ⁵³.

Watermelon seed oil was found effective as diuretics, helping to purify the body of toxins and eliminate excess fluids and salts, which helps regulate blood pressure ⁵⁴. Watermelon seed oil plays a major role in strengthening the immune system, due to its high vitamin E content.

This enhances the body's ability to fight free radicals, thanks to its antioxidant properties, which reduce the risk of chronic diseases ⁵⁵. The seed oil was found important for liver health. It helps enhance its vital functions and protect it from cirrhosis, as it contains nutrients that contribute to reducing its enzymes in the blood ⁵⁶. Watermelon seed oil is characterized by its content of fatty acids, such as palmitic and oleic acids, which work to reduce levels of harmful cholesterol in the blood, LDL, and increase good cholesterol, HDL, which helps prevent heart diseases, such as atherosclerosis ⁵⁰. Massaging the body with watermelon seed oil helps relieve stress and anxiety, calm the nerves, relax the muscles, and improve sleep. The seed oil can be used as a natural skin cleaner, to remove the dirt and grime that accumulates on the skin's surface. It also provides fatty acids that maintain moisture and protect it from dryness. Applying the oil to the skin is an effective way to reduce the risk of certain conditions, such as psoriasis and eczema ⁵¹.

Watermelon seed oil helps reduce oily skin secretions, which clog pores and lead to acne. The oil also delays the appearance of signs of aging on the skin, such as wrinkles and fine lines, because it reduces oxidative stress that threatens skin cells with damage. The oil was found an effective treatment for dry and frizzy hair, as it moisturizes it and makes it soft and shine ⁵².

Insect oils

Edible insects are rich sources of protein, dietary fiber, fatty acids, minerals, and vitamins. Their most important characteristic is their low carbon footprint, and their production and farming require less land, water, and food resources than livestock. Insect oils are extracted from insects, although they are not as common as those extracted from plants ⁵⁷. Examples include cochineal oil (carmine oil), which is used as a food colouring ⁵⁸.

Cochineal dye is a natural red dye extracted from the cochineal insect, also known as carmine. This dye is used in many applications, including food colouring, cosmetics, and medicines. The cochineal insect is a scale insect that lives on cactus plants, especially in tropical and subtropical regions. Carmine dye is extracted from dried and ground female cochineal insects. It contains carminic acid, which is red in colour. Carmine dye is used to colour variety of foods and beverages, such as desserts, ice cream, soft drinks, processed meats, sauces, and much more. The dye is also used in lipstick, eye shadow, blush, and many other beauty products, and is used in some medications to impart the colour. Cochineal oil is a natural oil extracted from the cochineal insect and used as a natural red dye in food, cosmetics, and medicines. This oil is also known as carmine and assigned E120 as certified additive ^{59,60}.

Watermelon bug oil

The watermelon bug (*Aspongopus viduatus*) is found worldwide, infecting plants of the cucurbit family, cucumber, cantaloupe and mainly watermelon, and other plants, for example vegetables, c, and wheat. It is called the melon bug, or the shield bug. It resembles the green bug in

size and shape, except that its colour is brown with a bluish tinge, and the basal parts of the wings are dark red ⁶¹.

The adult stage of melon bug has been used in a powdered form after drying and grinding as appetizer with different meals. Watermelon bug oil contains a range of fatty acids, including oleic, palmitic, linoleic, and linolenic acids. The insect's protein also contains approximately 16 known amino acids, including all essential amino acids making the bugs good and suitable source of edible oil and protein. The proximate analysis of the dry matter of adult watermelon bugs revealed a moisture content of 8.3%, crude protein of 27%, fat of 54.2%, and ash of 3.5%. Watermelon bug oil was proved to be suitable for cooking and biofuel production ⁶².

Edible insects are rich in minerals and vitamins. They provide the human body with fat- and water-soluble vitamins A, B1 and B12, C, D, E, and K which are required for normal growth, health and recovering the deficiencies resulted from improper intake of mineral and vitamins ⁶⁰. Melon bug fats are composed of saturated and unsaturated fatty acids, with a total saturated fatty acid content of 37.87%, including myristic acid (0.34%), palmitic acid (31.33%), and stearic acid (3.47%). The total monounsaturated fatty acid content, based on dry weight, is 56.78%, including palmitoleic acid (10.62%) and oleic acid (45.53%) ⁶³.

Camel herders in some Sudanese regions make the tar smear by burning dried bugs and then using it to treat some skin diseases in their animals. The effect of crude bug oil and oil stripped of phenolic compounds on a range of bacterial species was studied. Both oils exhibited high antibacterial activity against some of the tested bacteria, while the oil purified by a silicic acid column showed no antibacterial activity. This study suggests the use of bug oil as a food preservative ⁶⁴.

Sorghum bug oil

Sorghum bug is one of the insect pests that feed on Sorghum plants and many other crops. It is one of the main pests of this crop in Sudan. The bug is mechanically controlled by collection and burying. In nomadic Botana regions, Sudan, people use tar smear received from notably heated bugs for their camels to treat dermatological infections ⁶⁵.

Mariod, ⁶⁶ determined the oil content of dried ground sorghum bug adults and found it 60%, almost higher than in commercial oil seeds such as groundnut, soybean, sunflower or rapeseed. Further analysis showed that the main fatty acids in sorghum bug oil are palmitic, stearic, oleic, and linoleic acids with lower content of saturated fatty acids (20.8%) and higher content of unsaturated fatty acids (77.8%).

Research Gaps

Future directions for traditional vegetable oils focus on improving sustainability, nutritional value, and processing efficiency. Researchers are exploring precision breeding and gene-editing technologies like CRISPR to develop oilseed

crops with enhanced fatty acid profiles and resilience to climate stress ⁶⁷. Innovations in green extraction methods aim to reduce energy use and chemical solvents, while circular agriculture practices seek to repurpose oilseed byproducts for food, feed, and bioenergy. Additionally, reformulating oils to meet specific dietary needs—such as increasing omega-3 content—is gaining traction, alongside efforts to integrate digital tools for better crop and supply chain management ⁶⁸.

Future directions for insect oils as unconventional oils focus on enhancing sustainable production, expanding applications, and improving consumer acceptance. Advances in eco-friendly extraction methods and bioreactor technologies aim to boost yield and purity, while research explores their use in functional foods, aquafeed, cosmetics, and pharmaceuticals due to favorable lipid profiles and antimicrobial properties ⁶⁹. Efforts to blend insect oils with conventional oils and develop hybrid formulations are gaining traction, alongside initiatives to establish safety regulations and educate consumers to overcome cultural barriers. These developments position insect oils as a promising alternative in the quest for sustainable and versatile lipid sources ⁷⁰.

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