

# Citrus limon (Lemon) Phenomenon

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*Citrus limon* (lemon) is a species with valuable pharmaceutical, cosmetic and culinary (healthy food) properties. The valuable biological activity of *C. limon* is determined by its high content of phenolic compounds, mainly flavonoids (e.g., diosmin, hesperidin, limocitrin) and phenolic acids (e.g., ferulic, synapic, p-hydroxybenzoic acids). The essential oil is rich in bioactive monoterpenoids such as D-limonene,  $\beta$ -pinene,  $\gamma$ -terpinene. Recently scientifically proven therapeutic activities of *C. limon* include anti-inflammatory, antimicrobial, anticancer and antiparasitic activities. In view of beneficial properties *C. limon* is also used in the food industry and cosmetology. Attention should be pay on safety of use and potential phototoxicity of this raw materials.

Keywords: lemon ; chemical composition ; biological activity ; cosmetic applications ; phototoxicity ; biotechnological studies

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## 1. Introduction

*Citrus limon* (L.) Burm. f. is a tree with evergreen leaves and yellow edible fruits from the family *Rutaceae*. In some languages, *C. limon* is known as lemon (English), Zitrone (German), le citron (French), limón (Spanish), and níngmél, 檸檬 (Chinese).

The main raw material of *C. limon* is the fruit, particularly the essential oil and juice obtained from it. The *C. limon* fruit stands out as having well-known nutritional properties, but it is worth remarking that its valuable biological activities are underestimated in modern phytotherapy and cosmetology<sup>[1]</sup>.

By cold pressing fresh outer parts of the *C. limon* pericarp (lat. *exocarpium*) an essential oil is obtained – the lemon oil (lat. *Citrus limon aetheroleum*, *Limonis aetheroleum*, *Oleum Citri*). The oil is colourless or yellow, and has a characteristic, strong lemon scent<sup>[2]</sup>. It is considered a pharmacopoeial raw material. Its monographs, entitled '*Limonis aetheroleum*', are present in the European Pharmacopoeia 9<sup>th</sup><sup>[3]</sup>, American Pharmacopoeia<sup>[4]</sup>, and in the Ayurvedic Pharmacopoeia of India<sup>[5]</sup>. Another pharmacopoeial raw material obtained from *C. limon* is the outer part of the *mesocarp* – the *flavedo*. A monograph entitled '*Citrus limon flavedo*' can be found in older editions of the French Pharmacopoeia, for example, in its 10<sup>th</sup> edition from 1998<sup>[6]</sup>. The fresh fruit of *C. limon* is officially listed for use in phytotherapy and in homeopathy in Germany. According to the German Commission D Monographs for homeopathic medicines, *C. limon* fresh fruits can be used for treating gingival bleeding and debilitating diseases<sup>[7]</sup>. *C. limon* also has a positive opinion in the European Commission's Cosmetics Ingredients Database (CosIng) as a valuable plant for cosmetics production<sup>[8]</sup>. The European Food Safety Authority (EFSA) classified the pericarp, fruit, and leaves of *C. limon* as raw materials of plant origin in which there is presence of naturally occurring ingredients that may pose a threat to human health when used in the production of food and dietary supplements. EFSA has made a remark that the toxic substances in these raw materials are photosensitizing compounds belonging to the furanocoumarin group, including bergapten and oxypeucedanin<sup>[9]</sup>. In the American Food and Drug Administration (FDA) list, *C. limon* essential oil and extracts are classified as safe products<sup>[10]</sup>.

The biological potential of *C. limon* is determined by its rich chemical composition. It has been determined not only for the whole fruit but also separately for the pericarp, juice, pomace, leaves, seeds and essential oil<sup>[11][12][13][14][15]</sup>. The most important group of bioactive compounds in both *C. limon* fruit and its juice, determining their biological activity, are flavonoids such as: flavonones – eriodictyol, hesperidin, hesperetin, naringin; flavones – apigenin, diosmin; flavonols – quercetin; and their derivatives. In the whole fruit, other flavonoids are additionally detected: flavonols – limocitrin and spinacetin, and flavones – orientin and vitexin<sup>[11][12][14]</sup>. Phenolic acids were found both in the juice and fruit. There are mainly two such compounds in the juice – ferulic acid and synapic acid, and their derivatives. In contrast, the presence of p-hydroxybenzoic acid has been confirmed in the fruit. In the fruit, there are also coumarin compounds, carboxylic acids, carbohydrates, as well as amino acids, a complex of B vitamins, and what is particularly important – vitamin C (ascorbic acid)<sup>[11][12][14]</sup>. Another interesting group of compounds that are found in *C. limon* fruits are limonoids - limonin and nomilin. They mainly occur in citrus fruits, including lemons, in which they are found mainly in the seeds, pulp, and

peel<sup>[16]</sup>. The main components of the essential oil are monoterpenoids e.g. D-limonene (69.9%),  $\beta$ -pinene (11.2%),  $\gamma$ -terpinene (8.21%), geranial (E-citral, 2.9%), neral (Z-citral, 1.5%), linalool (1.41%). In addition to terpenoids, the essential oil also contains linear furanocoumarins (psoralens) and polymethoxylated flavones<sup>[17][18][19]</sup>.

## 2. Influence and application

*C. limon* fruit juice (lemon juice) has traditionally been used as a remedy for scurvy before the discovery of vitamin C<sup>[20]</sup> [20]. This common use of *C. limon*, known since ancient times, has nowadays been supported by numerous scientific studies. Other uses for lemon juice, known from traditional medicine (e.g. Romanian, Trinidad, Indian) include treatment of high blood pressure, common cold, sore throats, fevers, rheumatism and irregular menstruation. Moreover, the essential oil of *C. limon* is a known remedy for coughs<sup>[21][22][23][24]</sup>.

Currently, valuable scientific publications focus on the ever wider pharmacological actions of *C. limon* fruit extract, juice and essential oil. They include studies of, for example, anticancer, antioxidant, anti-inflammatory, antibacterial, antifungal, antiviral, anti-allergic, anti-obesity and hepatoregenerative activities. Additionally researches proved the significant role of *C. limon* in the prevention of diabetes and treatment of its symptoms, functioning on the cardiovascular, nervous, respiratory and skeletal systems and moreover in the treatment of menstrual disorders<sup>[25][26][27][28][29][30][31][32][33][34][35]</sup>.

*C. limon* fruit and other lemon-derived raw materials, they find application in the food industry and food processing. The lemon fruit is used mainly as a fresh fruit, but it is also processed to make juices, jams, jellies, molasses, etc.<sup>[36][37]</sup>. The essential oil from lemon, i.e. pure isolated linalol and citral, is used mainly as a flavouring and natural preservative due to its functional properties (antimicrobial, antifungal, etc.)<sup>[38][39]</sup>.

*C. limon* fruit extracts and essential oil, as well as the active compounds isolated from these raw materials are proving the possibilities of their use in cosmetology. Lemon-derived products have a positive effect on acne-prone skin that is easily affected by sunburn or mycosis. Scientific studies have shown a significant antioxidant and anti-aging effects of *C. limon* fruit extracts<sup>[26][40]</sup>. According to the CosIng database (Cosmetic Ingredient Database), *C. limon* can be used in twenty-three forms, e.g. oils obtained from various organs, in the form of extracts, hydrolates, powdered parts of the plant, wax and juice<sup>[8]</sup>. The most common activity defined by CosIng for the raw material of this species is to keep the skin in good condition, and to be used as corrigent<sup>[8]</sup>.

Moreover, there has been some biotechnological research aimed at developing effective *in vitro* micropropagation protocols for *C. limon*<sup>[41][42]</sup>.

The publication "*Citrus limon* (lemon) phenomenon – a review of the chemistry, pharmacological properties, applications in the modern pharmaceutical, food, and cosmetics industries, and biotechnological studies" can be found here: <https://www.mdpi.com/2223-7747/9/1/119>

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