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A COMPREHENSIVE REVIEW ON PHYTO-PHARMACOLOGY OF *FORTUNELLA JAPONICA*

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ABSTRACT

Fortunella japonica, commonly known as kumquat, is a small citrus fruit renowned for its nutritional and medicinal properties. This review aims to provide an in-depth analysis of the pharmacological actions of *Fortunella japonica*, including its phytochemical composition, antioxidant, anti-ageing, antimicrobial, and antidiabetic activities. The review also explores the potential mechanisms underlying these effects and discusses the current research gaps and future directions.

Keywords: *Fortunella japonica*, phytoconstituents, pharmacology, antimicrobial, antidiabetic

INTRODUCTION

Fortunella japonica, a member of the Rutaceae family, is extensively cultivated in East Asia. Kumquats have been traditionally employed in a variety of cultural remedies due to their sweet and piquant flavour **[1]**. This small, oval fruit is ingested in its entirety, including its skin, which is abundant in aromatic compounds and essential oils. Due to its adaptability and economic value, it has been introduced and cultivated in other

regions of the globe, with a primary focus on East Asia. Its geographical distribution is extensive **[2, 3]**. Kumquat has been traditionally employed in folk medicine to alleviate a wide range of maladies, such as inflammatory conditions, digestive problems, and respiratory disorders. The fruit is highly regarded for its health benefits, which are substantiated by both historical use and emerging scientific evidence, in addition to its culinary applications.

Botanical Classification

- **Kingdom:** Plantae
- **Clade:** Angiosperms
- **Clade:** Eudicots
- **Clade:** Rosids
- **Order:** Sapindales
- **Family:** Rutaceae
- **Genus:** Fortunella
- **Species:** F. japonica

Vernacular names

- Bulgarian - Kymkyat.
- Chinese - Jin gan, Yuan jin gan, Jin ju, Shan ju, chin chü.
- Croatia - Kumkvat.
- Dutch - Dwerg sinaasappelboom.s
- French - Kumquat rond, Kumquat a fruits ronds.
- German - Rundkumquat, Marumikumquat, Rundfrüchtiger kumquat, Zwergpomeranzenbaum.
- Hungarian - Japan kumkvat.
- Italian - Kumquat a frutto tondo.
- Japanese - Maru kinkan, Marumi kinkan.
- Korean - Dung geun, Geum gam, Geum gyul la mu, Dong gul gyul.
- Portuguese - Cunquato-marumi, Kumquat, Tanngerineira-ana, Tangerineira-do-japao.
- Romanian - Morgani kumquat.
- Slovene - Kumkvati.
- Spanish - Kumquat redondo, Naranjita japonesa, Quinoto.
- Turkis - Kumkuat.

Figure 1: Fruit bearing plant of *Fortunella japonica*

Phytoconstituents

Hydrodistillation of *C. japonica* peel and kernel produced a yellow coloured oil **[4, 5]**. The major constituents identified in peel oil were limonene, germacrene D and β-myrcene, β-phellandrene, (+)- carvone, α-pinene, δ-cadinene, germacrene b, γ-cadinene, γ-elemene, geranyl acetate, (+)- carvone and myristicin. Linolenic (ω-3), linoleic acids (ω-6), γ-muurolene, (E)-dihydrofarnesol, pentadecene-1, dodecanol-1, nonene-4-methyl-5, undecene- 4- methyl-5, decene-2(Z) and tetradecene-7(E) were also detected in the essential oil. β-sitosterol, umbelliferone, isopimpenellin, xanthotoxin, apigenin-7-O-β-D-glucopyranoside, apigenin-7-O-β-rhamno-glucoside and cirsimaritin have been isolated from the leaves of petroleum ether and ethyl acetate soluble extracts of *F. japonica* **[6]**. The fresh peels of the fruit of *F. japonica* was extracted with methanol to obtain α-tocopherol, lupenone, ß-amyrin, α-amyrin, ß-sitosterol, Glucose-ß-sitosteryl 3-O-glucopyranoside, Kaempferide-3-O-rhamnopyranoside, Acacetin-7-O-Neohesperidose, Acacetin-8-C-Neohesperidose and 3',5'-Di-C-glucopyranosylphloretin **[7]**. In another study, the essential oil obtained from the fresh leaves and fruit peels of *F. japonica* was found to contain n-decanal, ß-Pinene, d-limonene, linalool, trans-ocimene, α-pinene, myrcene and geranyl acetate **[8]**. From the fruit peelings of *F. japonica* flavonoids 6,8-di-C-glucosylapigenin, 3,6-di-C-glucosylacacetin, 2"-O-oc-L-rhamnosyl-4'-O-methyl-vitexin, 2"-O-oc-L-rhamnosyl-4' -O-methylisovitexin, 2"-O-oc-L-rhamnosylvitexin, 2"-O-oc-L-rhamnosylorientin, 2"-O-oc-L-rhamnosyl-4'-O-methylorientin and ponicilin have been isolated **[9]**. In a study the fresh peels (pericarp) of three species of kumquat yielded essential oil in 1.5% v/w yield. The GC-MS analysis of the oil revealed a total of 53 phytoconstituents in these three species with 12 volatile components in *F. japonica*. New components like δ-elemene, β-elemene, β-gurjunene, γ-elemene, α-humulene, β-selinene, valencene, elemol, α-eudesmol and viridiflorol were reported **[10]**. The structures of some prominent constituents of the oil is presented in **Figure 2**.

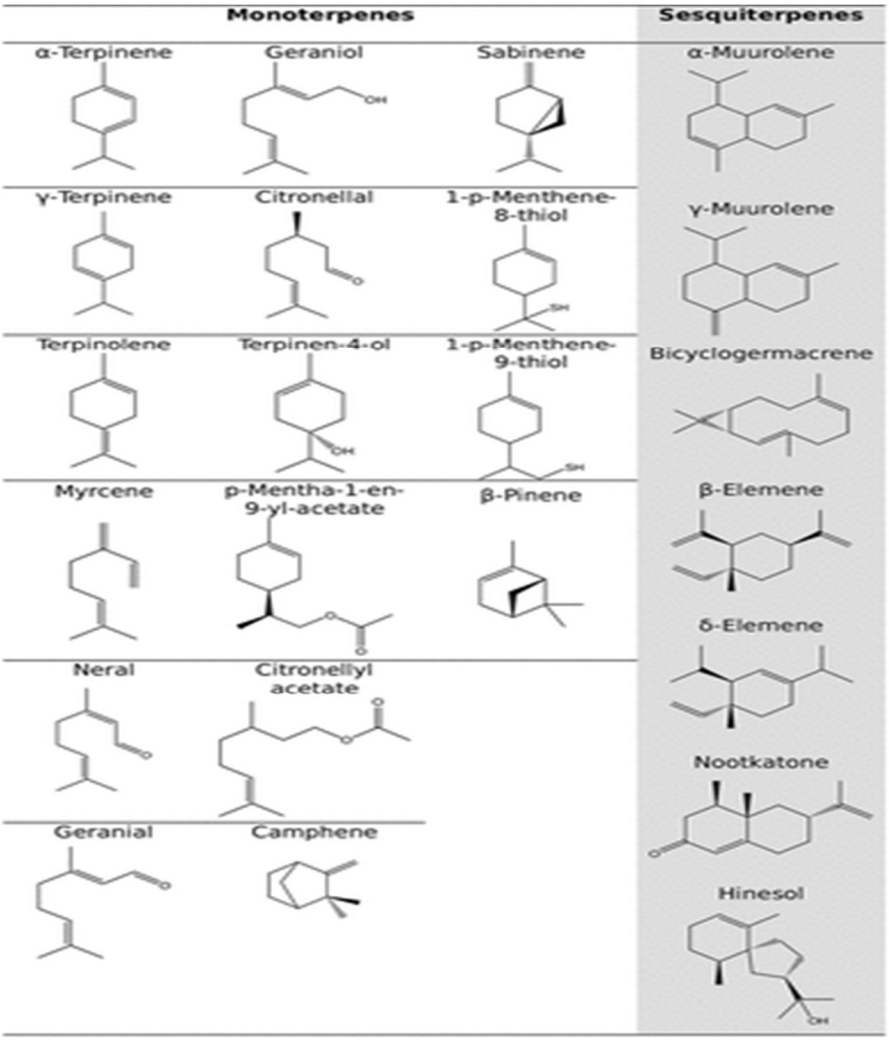

Figure 2: Few prominent phytoconstituents from Kumquat essential oil

Traditional Uses

Respiratory Disorders

Traditionally, kumquat has been employed in East Asian cultures to ameliorate the symptoms of respiratory disorders, including colds, coughs, and sore throats. The fruit is frequently used to create syrups or teas, and it is believed to alleviate phlegm production and soothe the throat. The essential oils in kumquat peel, which contain compounds such as limonene and myrcene, are believed to possess expectorant and anti-inflammatory properties, which may contribute to respiratory ease **[11]**.

Digestive Health

Kumquat is employed in traditional medicine to promote digestive health. The fruit's high fibre content facilitates digestion and prevents constipation. Furthermore, it is hypothesized that the essential compounds in the peel enhance the secretion of digestive enzymes,

thereby enhancing the overall digestion and nutrient absorption **[12]**.

Anti-inflammatory and Antioxidant Uses

Kumquat has been employed for its antioxidant and anti-inflammatory properties. Kumquat is frequently employed in traditional remedies to alleviate inflammation and oxidative stress in the body, either as part of a diet or in infusions. The antioxidant properties of kumquat are a result of its high concentration of flavonoids and vitamin C, which safeguard cells from the harm caused by free radicals **[13]**.

Other cultural uses

Kumquat is classified as a warming substance that aids in the displacement of cold and dampness from the body in Traditional Chinese Medicine (TCM). It is referred to as "jinju" in TCM. It is frequently employed in the treatment of colds and congestion, frequently in conjunction with ginger or honey to optimize its therapeutic properties. Kumquat is also employed to alleviate stagnation in the digestive tract and stimulate the passage of qi (vital energy) **[14]**. In Japan, kumquat, which is referred to as "kinkan," is traditionally ingested to alleviate the symptoms of colds and flu and to support immune function. During the winter months, the fruit is frequently candied or transformed into marmalade and ingested as a preventive measure against respiratory infections. Kumquat is also employed in Japanese folk remedies for its capacity to alleviate fever and its soothing effects on the pharynx **[15]**.

Pharmacological Potential of *Fortunella japonica*

Hypotensive

Crude flavonoids were obtained from the hot water extract of kinkan peel and purified by gel filtration and column chromatography. The eight flavonoids were examined for depressive effects on brood pressure. Of the 8 isolates, four exhibited strong depressive effect on systolic pressure 30 min post intravenous administration **[9]**.

Neuroprotective

Crude ethanol extract of *F. japonica* fruit, carrot seeds ethanol and petroleum ether extracts have been studied for protection against brain aging induced by D-galactose in rats. The extracts suppressed the reduction in CAT and the elevation in MDA suggesting applicability as potent protective agents against the brain ageing **[16]**.

Antioxidant, Antidiabetic and antihyperlipidemic

Whole kumquat powder had been found to be improve thyroid levels (T4, Thyroxine and T3, Triiodothyronine) and serum glucose level in diabetic rats fed with high fat cholesterol diet. The glucose lowering was

hypothesized to be due to stimulation of insulin release by the powder **[17]**. The powder also exhibited good antioxidant action in DPPH scavenging assay and FRAP assay.

The essential oil from peels of Kumquat, rich in limonene displayed good antioxidant action in (ABTS•+) scavenging activity and ferric reducing antioxidant power (FRAP) assay with value of of 25.29±0.17mM Trolox equivalent (mM TE)/g dry weight and 6.25±0.15 mM TE/g dry weight respectively **[18]**.

The phytophenolic isolated from ethanolic extract of F. japonica leaves displayed hypoglycemic, hypotriglyceridemic and antioxidant effects in STZ-induced diabetic rats. A significant enhancement in GSH and SOD levels in the liver of diabetic rats along with a reduction in LDL-c levels, thereby enhancing nitric oxide production **[6]**.

The peel and pulp of Kumquat was extracted with water, ethanol and methanol and assessed for antioxidant action by DPPH radical scavenging and ORAC assay. A direct relationship between the flavonoid content in extract and antioxidant action of the extract was obtained **[19]**.

The whole plant extract of Kumquat has been reported to improve the total lipid, total cholesterol and LDL ratios by 27.51%, 28.25% and 40.77% compared with a positive control group. The levels of serum triglyceride, serum total cholesterol, serum total lipid, high-density lipoprotein (HDL) cholesterol and atherogenic indices (AC, CRR, AI) were also improved implying that hypocholesterolemic effects of 5% whole kumquat were partly attributed to the reduced absorption of lipid and cholesterol **[20]**.

Hepatoprotective

In a study, the whole plant extract of Kumquat was able to exhibit protection against liver damage induced by injection of carbon tetrachloride in rats. Pretreatment with the extract led to a complete protection against hepatic damage as no histological alterations were visible in the liver tissue sections **[21]**.

Antimicrobial

Pure peel oil from Kumquat was evaluated for antimicrobial potential against Bacillus subtilis, Staphylococcus aureus, Klebsiella pneumonia, Pseudomonas aeruginosa and Proteus mirabilis. The MIC of the oil was found to be 5 mg/mL against Bacillus subtilis and 10 mg/mL against the remaining bacterial species studied **[19]**.

In a study volatiles of different aerial parts of three kumquat species (*Fortunella margarita* Swingle–Nagami, *Fortunella japonica* Swingle–Marumi, and *Fortunella crassifolia* Swingle–Meiwa) showed weak antimicrobial activity, respectively, against Gram-positive

and Gram-negative bacterial strains and pathogenic fungi. The essential oil from the flower of *F. crassifolia* Swingle (Meiwa) showed a stronger effect (MIC values 3.5–7.48 mg/mL) against all the assayed microorganisms **[10]**.

CONCLUSION

Fortunella japonica is a plant that is both alluring and versatile, providing both aesthetic and practical benefits. Its adaptability to various growing conditions and its multifarious uses in culinary and medicinal applications render it a valuable addition to orchards and gardens. *Fortunella japonica 's* adaptability and economic significance are illustrated by its geographical distribution. Kumquat has evolved into a valuable fruit crop with profound cultural, culinary, and medicinal applications, extending from its native regions in China and Japan to its introduced ranges in North America, Europe, and Australia. *Fortunella japonica 's* potential therapeutic benefits and its significance in folk medicine are underscored by its traditional applications in a variety of cultural remedies. The fruit's diverse pharmacological properties are demonstrated by its application in the treatment of respiratory disorders, the promotion of digestive health, and the reduction of inflammation and oxidative stress. These traditional practices are being increasingly substantiated by scientific research, which is continuing to uncover the mechanisms behind the health benefits of kumquat. The fruit's rich phytochemical composition demonstrates a diverse array of pharmacological actions, such as antioxidant, antimicrobial, antidiabetic, and antiaging effects. These characteristics emphasize its potential as a therapeutic agent and functional sustenance.

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