Chemical and biological progress of *Podocarpus nagi*

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**Abstract**

*Podocarpus nagi* is a tree belonging to the family of Podocarpaceae, which has ever been used for treatment of trauma, stop-bleeding, fractures, knife wounds, gunshot wounds, body odor, eye diseases, colds and rheumatoid arthritis in clinic. Some compounds have been isolated and their biological activities were also evaluated. This review briefly describes the progress of the chemical components and biological activities of *podocarpus nagi*; for providing a reference for the researchers.

**Introduction**

*Podocarpus nagi* (named Zhubai in Chinese) is a tree belonging to the family of Podocarpaceae, widely distributed in the South District of the Yangtse River, such as Jiangxi, Zhejiang, Fujian, Hunan, Guangxi and Guangdong, etc. In Nanping, Sanming and Zhangzhou of Fujian Province, there are small-scaled natural communities or artificial enclosure planting of *Podocarpus nagi*, which is a native tree species of local place. The branches of *Podocarpus nagi* are excellent materials for building, furniture and craft. The oil content of its seeds is higher and can be used for edible after being refined or directly used industrially [1]. Some compounds and biological activities have been studied. In this mini-review, we briefly describe the progress of the chemical components and biological activities of *podocarpus nagi*.

**Chemical components of ** *Podocarpus nagi**

According to the reported literatures, there are many active components in the branches, leaves and seeds of *Podocarpus nagi*, which include volatile oils, terpenoids, cypress lactones, flavonoids, lignin and cyclic peptides. The main components of essential oil in the leaves of *Podocarpus nagi* are elemene, cadinene, β-palindolene, pinene and caryophyllene.

**Volatile oils**

Yang Rongbin et al. [2] extracted the volatile oil from the leaves of *Podocarpus nagi* grown in Guangzhou, Guangdong Province, and identified the components and contents by GC-MS. The results showed that the main components are (-)-α-pinene (5.59%), β-elemene (9.57%), (10.04%), 4-isopropenylidene-1-vinylmenthene (53.82%); He Daohang et al. [3] extracted volatile oil from the leaves of *Podocarpus nagi* grown in Zengcheng district of Guangdong Province, and identified the components and contents by GC-MS. The results showed that the main components are spathulenol, cadinenol, α-cadinol, α-pinene, 3-thujene, β-elemene, γ-elemene, β-cadinene, aromadendrene, germacrene D, γ-muurolene, α-caryophyllene, δ-cadinene, β-caryophyllene, β-cadinene, viridiflorene. The authors also extracted the volatile oil from the branches of *Podocarpus nagi* and identified the components and contents by GC-MS. The results showed that the main components are 1-hepten-3-ol, α-pinene, 3-thujene, caryophyllene, β-cadinene, α-caryophyllene, germacrene B, eremophilene, α-amorphene, γ-cadinene, δ-cadinene. By comparison the results reported by Yang Rongbin and He Daohang [2,3], there are much difference between the components and contents of volatile oil, the reasons can be due to the *Podocarpus nagi* growing the different places; Liao Zeyong et al. [5] extracted volatile oil from the peel and nutshell of *Podocarpus nagi* fruits and identified the components and contents by GC-MS, respectively. The results showed that the volatile oil is very low in peel, while the volatile oil is higher in nutshell.

From the results reported above, we can know that the main components of the volatile oil are terpenes.

**Flavonoids**

It was reported that the seeds of *Podocarpus nagi* contained biflavonoids: sciadopitysin and amentoflavone -4', 4', 7', tetramethylether [6]. Wang Qiuxiang et al. [7] isolated the amentoflavone, bilobetin, podocarpusflavone A, quercetin, (-)-catechin from the leaves of *Podocarpus nagi*. Xu Yaming et al. [8] isolated isoginkgetin from the leaves of *Podocarpus nagi*. The structures of flavonoids listed in figure 1.

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**Key words**: Podocarpus nagi, chemical components, biological activities

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**Steroids**

Wang Qiuxiang et al. [7] obtained 5α,6β-sitosterol from the leaves of *Podocarpus nagi*, which widely exists in many kinds of plant.

**Sugar and glycosides**

It was reported that the seeds of *Podocarpus nagi* contain polysaccharide compounds such as nagilactone A-1-β-D-glucoside, ethyl-β-D-glucopyranoside, nagilactone glycoside A and sucrose [6,9].

**Lactone compounds**

It was reported [6,7,9] that the seeds of *Podocarpus nagi* contain nagilactone A,B,C, 15-hydroxynagilactone D, 15-methoxy-carbonylnagilactone D, 1-deoxy-2α-hydroxynagilactone A, 3β-hydroxynagilactone A, 1-deoxy-2β,3β-epoxynagilactone A. *Podocarpus nagi* stem bark contains 16-hydroxypodolide, 2,3-dihydro-16-hydroxypodolide, 2β,3β-epoxypodolide, 2,3-dihydrotripolide, 2,3-dehydro-16-hydroxynagilactone F, nagilactone I, 16-hydroxynagilactone E, 2α-hydroxynagilactone F, nagilactone E, 1-deoxy-2,3-dehydronagilactone A, 1-deoxynagilactone A, 1-deoxy-2,3-dehydronagilactone A, stem bark contains nagilactone C,D,I,J, 16-hydroxynagilactone E. The structures of representative nagilactones showed in figure 2.

**Other components isolated from *Podocarpus nagi***

Wang Qiuxiang et al. [7] isolated prinsepiol from the leaves of *Podocarpus nagi*. According to the literatures reported, there are organic acids in the oil of the seeds of *Podocarpus nagi*, the nutmeg acid, palmitic acid, stearic acid, oleic acid, 9,12-linoleic acid, paullinic acid, eicosadienoic acid, carbonium are included [8,10]. We also extracted the oil of the seeds of *Podocarpus nagi* planted in Yangli town of Fujian province and analyzed its components, and palmitic acid, palmitic acid, octanoic acid, stearic acid, oleic acid, linoleic acid, peanut acid, arachidonic acid, α-linolenic acid, arachidonic acid, behenic acid, lignoceric acid are detected.

**Biological activities**

It was reported that the leaves and bark of *Podocarpus nagi* can emit the odor similar to clove, which can repel the mosquitoes. In addition, as a kind of traditional Chinese herbal medicine, *Podocarpus nagi* exhibits hemostasis, bone setting and detumescentce. As a kind of folk medicine of Yao nationality, *Podocarpus nagi* can also be used to treat trauma, stop-bleeding, fractures, knife wounds, gunshot wounds, body odor, eye diseases and colds, etc. The fresh barks or roots of *Podocarpus nagi* were also used to treat the rheumatoid arthritis [5,6,11].

*Figure 1. Representative structures of flavonoids isolated from Podocarpus nagi*

- Sciadopitysin
- Amentoflavone -4', 4', 7, 7'-tetramethylether
- Amentoflavone
- Bilobetin
- Quercetin
- Catechin
- Podocarpusflavone A

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**Figure 2.** The structures of representative nagilactones

**Figure 3.** Podolactones isolated from *Podocarpus nagi* with anti-inflammatory activity
Anticancer activity

Xu Yaming et al. [7] reported that mgilactone A, 1-deoxy-2β,3β-epoxynagilactone A and 1-deoxy-2α,4β-dioxynagilactone towards the leukemia, the results showed that these compounds exhibited cytotoxicity against P388 cell lines, and the inhibitions of these three compounds against P388 cell lines are 73, 88.5 and 97.4% respectively at the concentration of 10 μg/mL. While the inhibition of mgilactone B towards P388 cell lines is 98.6% [9]. Lee et al. [12] reported that amentoflavone exhibited higher inhibition to phospholipase C. Liao Ze Yong et al. studied the volatile oil from the peel and shell of Podocarpus nagi fruit towards nasopharyngeal carcinoma line CNE. The results showed that the inhibitions of volatile oil from the pericarp towards nasopharyngeal carcinoma line CNE are (22.62 ± 0.54)%, (52.55 ± 2.83)%, (73.24 ± 1.79)% (84.18 ± 3.37)% at the concentrations of 20,40,80,100, 120μg/mL respectively, while the inhibitions of volatile oil from shell towards nasopharyngeal carcinoma line CNE are (18.37 ± 1.13)%, (23.74 ± 0.52)%, (38.55 ± 1.04)%, (42.96 ± 2.15)%, (68.14 ± 2.06)% at the concentrations of 20,40,80,100, 120 μg/mL respectively.

Anti-bacterial activity

Kubo tested the 2α-hydroxyagilactone F against saccharomyces beer yeast and the result showed that it exhibited stronger inhibitory activity against saccharomyces beer yeast and its MIC was 800 μg/mL. Nagilactone C, nagilactone D, nagilactone E also exhibited inhibitory effects on fungi. Tartalol exhibited stronger inhibitory activity against staphylococcus aureus, while tartalol and totarol exhibited peculiar inhibitory activity against Gram-positive bacteria, and norderpenoid dilactone showed peculiar activity against saccharomyces cerevisiae, blastomyces albicans and pityrosporum (Malassezia) ovale [13-18].

Antiviral and other activities

Matsuki et al reported that bilobetin exhibited potent antiviral activity against Epstein-Barr virus, and also stronger against carcinogen than that of vitamin A acid [19]. Feng Zheling et al. isolated some podolactones from Podocarpus nagi and evaluated their anti-inflammatory effect. The results showed that compounds 1 and 2 (Figure 3) significantly inhibited Nitric Oxide (NO) production on LPS-stimulated RAW264.7 macrophages, with IC50 values of 0.18 ± 0.04 and (Figure 3) significantly inhibited Nitric Oxide (NO) production on LPS-isolated some podolactones from and evaluated their carcinogen than that of vitamin A acid [19]. Feng Zheling et al. studied the volatile oil from the peel and shell of Podocarpus nagi fruit towards nasopharyngeal carcinoma line CNE. The results showed that the inhibitions of volatile oil from the pericarp towards nasopharyngeal carcinoma line CNE are (22.62 ± 0.54)%, (52.55 ± 2.83)%, (73.24 ± 1.79)% (84.18 ± 3.37)% at the concentrations of 20,40,80,100, 120μg/mL respectively, while the inhibitions of volatile oil from shell towards nasopharyngeal carcinoma line CNE are (18.37 ± 1.13)%, (23.74 ± 0.52)%, (38.55 ± 1.04)%, (42.96 ± 2.15)%, (68.14 ± 2.06)% at the concentrations of 20,40,80,100, 120 μg/mL respectively.

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