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A review of antioxidant and pharmacological properties of phenolic compounds in *Acacia confusa*

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ABSTRACT

In the present review article, the phytochemical, antioxidant and pharmacological studies are congregated and summarized concerning the current knowledge of the phenolic compounds of a traditional medical plant *Acacia confusa* in Taiwan. This plant is native to Taiwan and South-East Asia. It possesses major pharmacological activities, including antioxidant and radical scavenging activity, hepatoprotective effect, xanthine oxidase inhibition, semicarbazide-sensitive amine oxidase inhibition, angiotensin I converting enzyme inhibition, antihyperuricemic effect and anti-inflammatory activity. Phenolic compounds, especially flavonoids, flavonol glycoside and phenolic acid derivatives, are the main phytochemical compounds isolated from different plant parts of *A. confusa*. Recent interest in this species has focused on pharmacological investigations of the phytochemicals which exhibit potent antioxidant activity based on the multiple phenolic functionalities. The consequence of this review will further extend the potential applications of this plant and offer persuasive support to its future use in the fields of clinical medicine and health functional food.

1. Introduction

Acacia confusa Merr. (Leguminosae) is an endemic species of Taiwan and is one of the most widespread plants. *A. confusa* is a very adaptable and fast-growing plant suited to living in extreme conditions.[1] It can be found along the coast and river, slightly in from the high tide mark; up to the temperate forests of the higher mountains, but well below the freeze line. However, it usually tends to be more common below 1000 m elevation and temperatures in the range of 20–30 °C. In the wild, it can grow in the soils with poor nutritional value, such as hard clay, silt, dirt and rocky plain and hills. In southern Taiwan, where the winter months can be totally without rain and the summer months can have very heavy rain and typhoons, this plant is able to withstand and grow quite comfortably in a range of climates.[2] *A. confusa*, unlike many plant species of the Leguminosae family, forms a symbiotic association with rhizobia in which its root plays host to them. Many of the associations fix nitrogen from the atmosphere and eventually make it available to the plant and fertile to the surrounding soil.[3]

A. confusa is an evergreen plant (Fig. 1A). The stems and roots are incredibly hard and extremely strong. The sapwood is pale yellow and the heartwood is chocolate brown from the tannins. The barks are rough without ridge and spines. The leaves only appear on seedlings and young plants, and the phyllodes grow on mature plants (Fig. 1B). The phyllodes are dull green, 8–10 cm long and 10–15 mm wide, alternate, narrowly curved-shaped, slightly thickened, hairless, with 3–5 slim parallel veins from the base. The flower clusters of bright yellow balls roughly in 6–20 mm diameter emerge from the twigs (Fig. 1B). In Taiwan, flowering season is usually the coming summer, but, sometimes, it may occur year round. The fruits (pods) are narrow and flat, 5–10 cm long, 8–10 mm wide, dark brown, and split open. The seeds are beanlike, around 5 mm long, 4–8 pre pod, elliptical, dark brown, slightly flattened and shiny.[2]

In Taiwan, *A. confusa* was used as a traditional medicine. The aqueous extract of *A. confusa* leaves was applied to cure wounds and antiblood stasis.[1] The commercial and industrial uses of *A. confusa* were fire wood, charcoal-making, railroad tie, mining construction and mushroom cultivation.[4] For water and soil

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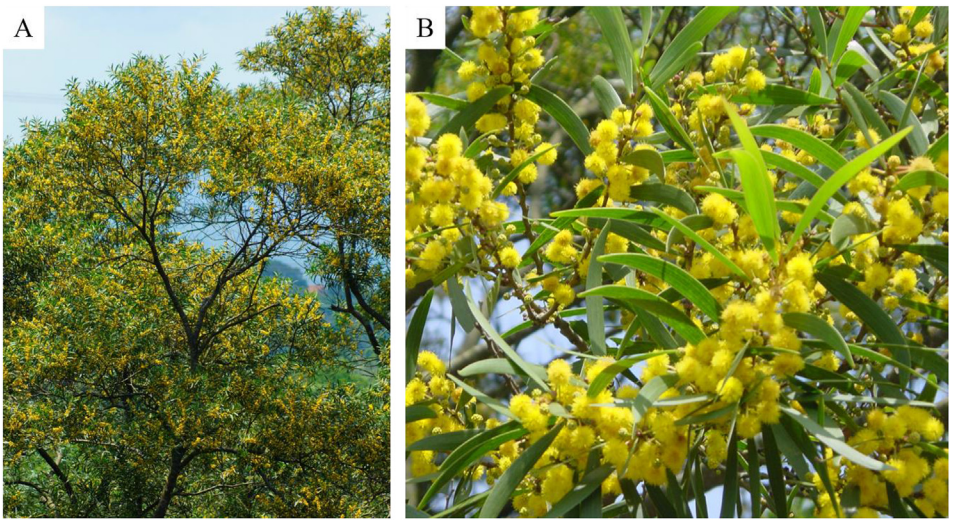

Fig. 1. Plants (A), flowers and phyllodes (B) of *Acacia confusa*.

conservation, this plant is planted in the wilderness for a long time because its root system is extremely strong and can grow extensively and deeply into the ground. Recently, this plant has shown great potential for air pollution prevention because of its remarkable carbon dioxide sequestration ability and foliar dust retention.[5] The bark and wood of *A. confusa*, like many other *Acacia* species, are rich in tannins which are used to dye and stain clothes and tan leather. Due to the high content of tannins and phenolic compounds, many studies have focused on the phytochemistry of *A. confusa* extract in recent years.[6] The aim of this contribution is to review the current literatures on the bioactivities and active compounds of *A. confusa*.

2. Phytochemistry

Secondary metabolite researches have been carried out on *A. confusa* and have led to the isolation of phenolic acid derivatives and flavonoids from its different plant parts. There have been 55 compounds, including 13 phenolic acid derivatives, 3 caffeic acid derivatives, 21 flavonoids, 13 flavonol glycosides, 1 lignan and 4 alkaloids, isolated from the extracts of different plant parts of *A. confusa*. The heartwood extract and the root extract contain flavonoids and phenolic acid derivatives. The bark extract is almost phenolic acid derivatives and caffeic acid derivatives. The extracts of the leaves, branches, twigs, flowers and buds contain flavonol glycosides, some flavonoids and phenolic acid derivatives. The flavonoids in the heartwood and the root extract contain 7,8-dihydroxyflavonoids rather than the usual 5,7-dihydroxyflavonoids in other parts. The following section collected the chemical names of the isolated compounds, and their chemical structures are shown in Fig. 2.

2.1. Constituents in the wood

Ethanol (70%) was used to extract the heartwood. For phenolic acid derivatives, like 3,4-dihydroxybenzoic acid (**3**), 3,4-dihydroxybenzoic acid methyl ester (**4**), 3,4-dihydroxybenzoic acid ethyl ester (**5**) and 3-hydroxy-4-methoxybenzoic acid (**7**) were isolated.[7,8]

Thirteen flavonoids, including 3 flavanols, 1 flavanone, 1 flavanonol, 2 flavones, 5 flavonols and 1 chalcone, were isolated.[7–9] Three flavanols are melacacidin (**18**), 4-*O*-methylmelacacidin (**20**) and 4′-*O*-methylmelacacidin (**21**). One flavanone is 7,8,3′,4′-tetrahydroxyflavanone (**22**). One flavanonol is *trans*-3,7,8,3′,4′-pentahydroxyflavanone (**24**). Two flavones are 7,3′,4′-trihydroxyflavone (**25**) and 7,8,3′,4′-tetrahydroxyflavone (**26**). Five flavonols are 7,3′,4′-trihydroxy-3-*O*-methylflavonol (**27**), melanoxetin (**28**), transilitin (**29**), 4′-*O*-methylmelanoxetin (**30**) and 4′-*O*-methyltransilitin (**31**). One chalcone is okanin (**32**).

2.2. Constituents of the root

Fourteen compounds, including 1 phenolic acid, 11 flavonoids and 2 alkaloids were isolated from 95% ethanolic root extract. These compounds are 3,4-dihydroxybenzoic acid (**3**), melacacidin (**18**), isomelacacidin (**19**), 4-*O*-methylmelacacidin (**20**), 4′-*O*-methylmelacacidin (**21**), *cis*-3,7,8,3′,4′-pentahydroxyflavanone (**23**), *trans*-3,7,8,3′,4′-pentahydroxyflavanone (**24**), melanoxetin (**28**), transilitin (**29**), okanin (**32**), (+)-catechin (**33**), (-)-epicatechin (**34**), *N*-methyltryptamine (**52**) and *N*,*N*-dimethyltryptamine (**53**).[10,11] Flavonoids are the main constituents of the heartwood and the root, however, the constituents of the root contain alkaloids not found in heartwood.

2.3. Constituents of the bark

Phenolic acid derivatives are the most abundant constituents in the 70% ethanolic bark extract. Fifteen phenolic acid derivatives, including 4-hydroxybenzoic acid (**1**), 4-hydroxybenzoic acid ethyl ester (**2**), 3,4-dihydroxybenzoic acid (**3**), 3,4-dihydroxybenzoic acid methyl ester (**4**), 3,4-dihydroxybenzoic acid ethyl ester (**5**), 3,4-dihydroxybenzoic acid butyl ester (**6**), 3-hydroxy-4-methoxybenzoic acid (**7**), 4-hydroxy-3-methoxybenzoic acid (**8**), 4-hydroxy-3,5-dimethoxybenzoic acid (**9**), 4-hydroxy-3,5-dimethoxybenzoic acid ethyl ester (**10**), gallic acid (**11**), gallic acid ethyl ester (**13**), 3,4-dihydroxy-*trans*-cinnamic acid (**14**), 3,4-dihydroxy-*trans*-cinnamic acid ethyl ester (**15**), 3,4-dihydroxy-*trans*-cinnamic acid pentyl ester (**16**) and one lignan, (-)-lyoniresinol (**17**), were isolated.[12,13]

The bark of *A. confusa* is a good source of condensed tannins (proanthocyanidins). The stem bark extract and the root bark extract comprised 247.76 ± 10.93 and 280.70 ± 11.75 mg/g of extractable condensed tannins. According to the results of MALDI-TOF MS, the degree of polymerization (DP) for both extracts can

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