

Review

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Therapeutic value of the genus *Alpinia*, Zingiberaceae

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Abstract: Plants containing bioactive substances have increasingly become the object of research studies, particularly those plants with therapeutic value. Many species of the genus *Alpinia* provide a variety of medicinal properties, such as, *Alpinia zerumbet* (Pers.) Burt et Smith and *A. purpurata* (Vieill) K. Schum, which have a significant presence in Brazil. These species have been commercialized in the food and cosmetic industries. However, their greatest importance arises from the medicinal properties of their essential oils containing flavonoids, terpenoids and kavalactones which have been used in folk medicine to treat, for example, arterial hypertension and inflammatory processes. In addition, such species are also used in multidisciplinary studies, including phytochemistry, ethnobotany and biology, indicating the key pharmacological role of this genus in everyday life. Therefore, this work aims to present a bibliographic review of the genus *Alpinia* and its significance in therapeutic applications.

Introduction

Plants containing bioactive substances have increasingly become the object of research studies, opening alternative paths for therapeutic treatments or revealing substances that could later be explored and synthesized to produce pharmaceutical, cosmetic and agrochemical formulations (Fabricant & Farnsworth, 2001; Victório & Lage, 2008). Approaches based on ethnopharmacological knowledge, followed by scientific studies of medicinal plants, improve the outlook of therapeutic alternatives and new medications (Gurib-Fakim, 2006). The study of medicinal plants is wide-ranging and has attracted the attention of botanists, pharmacologists, and even plant biotechnologists. Such multidisciplinary studies are a virtual necessity given the range of secondary metabolites produced from an equally broad spectrum of flora. Therefore, this work aims to present a comprehensive bibliographic review of the genus *Alpinia* and its significance in therapeutic applications.

Zingiberaceae

This family comprises 53 genera and over 1,200 species native to tropical regions, especially South and Southeast Asia (Kress et al., 2005), expanding to Africa and throughout South and Central America (Tomlinson, 1969). Individuals from this family, including *Zingiber officinale* Roscoe (ginger), *Curcuma longa* L. (turmeric) and

Elettaria cardamomum White et Maton (cardamom), are well known for their medicinal, condimental, ornamental and agrochemical uses (Pancharoen et al., 2000). The genus *Alpinia* originated in East Asia (Dahlgren et al., 1985), but it is currently cultivated in various regions, as a particular consequence of its ornamental and therapeutic value (Leal-Cardoso et al., 2004). By 1999, 250 species of *Alpinia* had been recorded (Sirirugsa, 1999), making it the largest genus of the Zingiberaceae (Cronquist, 1981). According to reports, the rhizomes of members of this family arrived in Brazil by accident, having been mixed in the sand that served as ballasts for the Portuguese caravels returning from the Indies (Winters, 1995).

Considerations on the genus Alpinia

The genus *Alpinia* was first classified by Plumier, but it was named after the 16th century Italian botanist Prospero Alpino. This genus belongs to the division Magnoliophyta (Angiospermae), the subclass Zingiberidae and the order Zingiberales (Kress et al., 2005). It is characterized morphologically by the presence of rhizome, simple wide-brim leaves protected by showy bracts, and terminal inflorescence. All parts of this plant are aromatic, a property which derives from the variety of components in its essential oils. The most remarkable trait of this genus is the beauty of its inflorescence, which explains its wide ornamental use through the commercialization of its seedlings and flowers (Figure 1). Furthermore, it enjoys extensive medicinal uses in various parts of

Asia and the Americas. According to Almeida (1993), the medicinal properties of this genus are related to different parts of the plant: leaves, flowers and rhizomes.

Folk use

The genus *Alpinia* is part of the human diet in several parts of Asia. Specifically in Okinawa, Japan, one of the staples of the local diet is made from rice and *A. zerumbet* leaves. Rhizomes are also used to make seasonings and beverages. In a work on the diversity and use of species from the family Zingiberaceae in Thailand, Siriruga (1999) describes the species *A. conchigera* used for the treatment of bronchitis, rheumatism and arthritis, while Ibrahim et al. (2009) recently detected a broad spectrum of antibacterial and antifungal actions in that species. According to Khattak et al. (2005), *A. galanga* is used in several Asian locations against colic, dysentery, stomach cancer, and to treat diabetes mellitus, fever, dyspepsia, and urinary incontinence, while also presenting a pronounced anti-inflammatory effect (Namsa et al. 2009). In some African tribes, the species *A. smithiae* is used in the therapeutic treatment of both humans and cattle (Joseph et al., 2001).

In Brazil, the species *A. zerumbet* and *A. purpurata* are widely cultivated. *A. zerumbet* has been given several common names: "colônia", "pacoseroca", "cuité-açu" and "pacová" (Almeida, 1993). Table 1 summarizes the therapeutic properties of *Alpinia zerumbet* and *A. purpurata*.

According to Carlini (1972), *A. zerumbet* is used by agricultural workers in the Ribeirão Preto (SP, Brazil) area to treat rheumatism and heart disease. In the northeast and southwest regions of Brazil, the tea made from its leaves is frequently used as an antihypertensive and diuretic medication (Medeiros et al., 2004). This species is among the most frequently cited for medicinal use in different regions of Brazil, and it has been suggested for use by Brazil's Public Health System (SUS) (Bieski, 2005). On the island of

Martinique, a French possession located in the eastern Caribbean Sea, it is used as a treatment against influenza (Longuefosse & Nossin, 1996).

In the field of ethnopharmacology, *A. zerumbet* is the object of several studies based on its frequent use in Afro-Brazilian rituals (Camargo, 1998). Albuquerque & Chiappeta (1997) investigated rituals in macumba yards and reported the use of this species by the faithful for 'cleansing' or 'discharge' baths, and it is also indicated for the common cold.

A. purpurata, which is known worldwide in the ornamental plant market, occurs widely in Brazil, but is rarely used for its therapeutic value (Sangwanangkul et al., 2008; Victório et al., 2008). However, it should be noted that Victório et al. (2009a) recently verified the vasodilator effect of *A. purpurata* in studies on the mesenteric bed of rats. In ethnobotanical studies developed in the State of Trujillo, Venezuela, the oral use of the boiled inflorescence of *A. purpurata* was observed to treat cough symptoms (Bermúdez & Velásquez, 2002).

Phytochemical studies

The family Zingiberaceae is rich in substances having therapeutic value (Figure 2), such as flavonoids, which have been detected in several species (Iwashina, 2000). In fact, flavonoids are considered chemosystematic markers of the order Zingiberales (Pugialli et al., 1993). The variety of these phenolic constituents in the genus, as represented by flavonoids, tannins and some terpenoids, is evidence of its therapeutic efficacy. These substances show significant antioxidant activity by capturing reactive oxygen species associated with aging, heart disease, brain dysfunction and neurodegenerative disorders, rheumatism, and the onset of cancers, among others (Oliveira et al., 2009). Some flavonoids, such as cardarmomin and alpinetin (**1**), have already been identified in rhizomes and seeds of the species *A. zerumbet* and *A. katsumadai* (Krishna, 1973; Itokawa, 1981; He et al., 2005). Rutin, isoquercitrin, catechin, epicatechin, kaempferol (**2**), kaempferol-3-

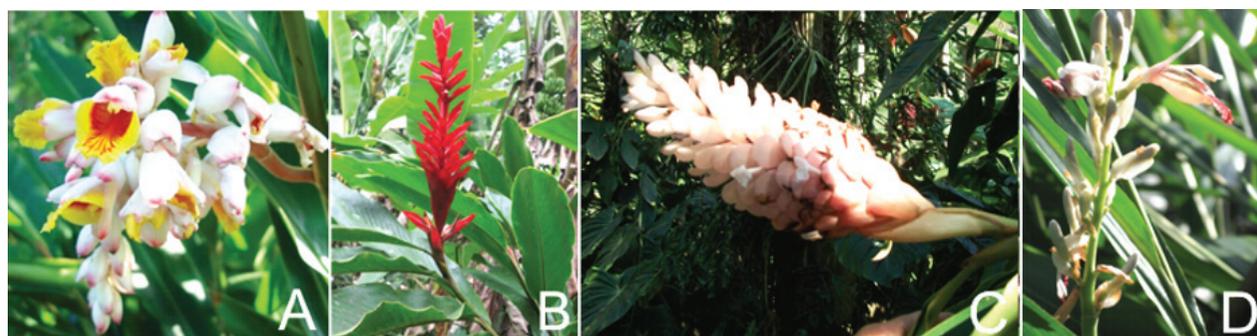


Figure 1. *Alpinia* species. A. *A. zerumbet*; B and C. *A. purpurata*; D. *A. calcarata*.

Table 1. Summary of the biological activities of *Alpinia* species common in Brazil: folk use and scientific confirmation.

Species	Folk use	Scientific confirmation	Locations	Reference
<i>A. zerumbet</i>	Rheumatism	n.f.	Ribeirão Preto (SP)	Carlini, 1972
	<i>Influenza</i>	n.f.	Island of Martinica	Longuefosse & Nossin, 1996
	Cardiovascular disease	f.	Brazil	Lahlou et al., 2002; Soares de Moura et al., 2005
	High blood pressure	f.	Brazil	Leal-Cardoso et al., 2004 Mendonça et al., 1991
	Gastric lesions	n.f.	Tropical and Subtropical	
	Diuretic	f.	Tropical and Subtropical	Laranja et al., 1991
	Antifungal			
	Antibacterial	f.	Tropical and Subtropical	Janssen & Scheffer, 1985 Lima et al., 1993
	Antioxidant	n.f.	Japan China	Elzaawely et al., 2007b Liao et al., 2000 Vankar et al., 2006
	Antinociceptive	f.	Tropical and Subtropical	Araújo Pinho <i>et al.</i> , 2005
	Anti-inflammatory	n.f.	Tropical and Subtropical	Zoghbi et al., 1999
<i>A. purpurata</i>	Cough	n.f.	Trujillo (Venezuela)	Bermudez & Velasquez, 2002
	n.f.	Vasodilator	Rio de Janeiro	Victório, 2009a

f.: found; n.f.: not found

O-glucuronide and kaempferol-3-*O*-rutinoside were isolated by Mplantinos *et al.* (1998) from extracts of *A. zerumbet*. Recent studies have shown the presence of rutin and kaempferol-3-*O*-glucuronide in the extracts of *A. purpurata* and *A. zerumbet* leaves obtained in the field and from *in vitro* culture systems of plant tissue (Victório *et al.*, 2007; Victório *et al.*, 2009b; Victório *et al.* 2009c; 2009d; 2010a). The flavonoid galangin was identified for the species *A. officinarum* (Tao *et al.*, 2006). The presence of flavonoids in rhizomes of *A. calcarata*, especially the labdane diterpene type, is widely distributed among Zingiberaceae (Hema & Nair, 2009). Another substance identified in some species is resveratrol, which is regarded as one of the dietary components of the Japanese living on Okinawa, thus potentially contributing to their longevity (Murakami *et al.*, 2005).

Species from the genus *Alpinia* are frequently used for their aromatic properties, which are related to volatile compounds that have been detected by different extraction techniques (De Pooter, 1995; Zoghbi *et al.*, 1999; Joseph *et al.*, 2001; Ali, *et al.*, 2002; Mallavarapu *et al.*, 2002; Fang *et al.*, 2003; Elzaawely *et al.*, 2007a; Victório *et al.* 2010b; 2010c; 2010d). Certain companies in Japan invest in the extraction of essential oils from *A. zerumbet* leaves and use them to produce cosmetics, perfumes and soaps (Elzaawely *et*

al., 2007; Tawata *et al.*, 2008). Starting in 1973, studies have identified the components of the essential oil from different parts (*i.e.*, leaves, flowers and rhizomes) of *A. zerumbet*, *A. smithiae* and *A. galanga*. These include monoterpenes, terpinene, limonene, 1,8 cineol (**3**), camphene and sabinene. The presence of monoterpenes is predominant among *Alpinia* species. In the essential oil of *A. purpurata*, α -pinene, β -pinene and 1,8 cineol predominate in leaves and flowers. Sesquiterpenes β -caryophyllene and caryophyllene oxide are also common among this species (Zoghbi *et al.*, 1999; Joseph *et al.*, 2001; Mallavarapu *et al.*, 2002; Victório *et al.*, 2009e; 2009f; 2010b).

More data are available on flavonoids and terpenoids, but the presence of diarylheptanoids, quinoids and alkaloids was reported as well. Diarylheptanoids are present in several *Alpinia* species and are related to anti-inflammatory activities by interfering with the biosynthesis of prostaglandins and leukotrienes, as well as interfering with the production of nitric oxide in macrophages (Prasain *et al.*, 1997; Yadav *et al.*, 2003). Tannins are cited as very commonly occurring substances in all Zingiberaceae species (Tomlinson, 1969); however, they have been understudied in the genus *Alpinia*. The leaves and roots of *A. zerumbet* contain kavain (**4**) and dehydro-kavain (Kuster *et al.*, 1999); kavalactones act on the central

nervous system and give this plant the same anxiolytic and sedative properties of the plant popularly known as “kava-kava” (*Piper methysticum*) (Cass, 2004).

Biological activities

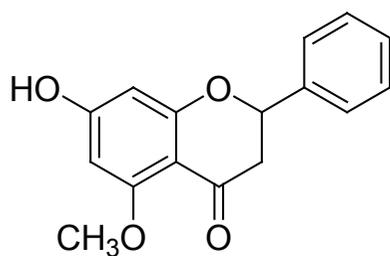
The genus *Alpinia* has been extensively studied for its cancer-fighting properties. Different substances from these species have been reported as having a beneficial effect in preventing and treating cancer (Surh, 1999). For instance, the essential oil from the species *A. oxyphylla* has proven effective against cancerous lineages (Lee et al., 1998; Lee & Houghton, 2005). Also, Hahm et al. (2003) studied the action of substances extracted from the seeds of *A. katsumadai*, which were cytotoxic for cell lineages of human lung cancer and leukemic lineages. Finally, rhizome extracts from *A. officinarum* were found to be efficient in inhibiting melanogenesis in studies with B16 melanoma cells (Matsuda et al., 2009).

The essential oil of *A. zerumbet* is active against Gram (+) and (-) bacteria, as well as fungi (Lobato et al., 1989; Victório et al., 2009f). The antimicrobial activity of the essential oil from the flowers of *A. zerumbet* was patented by Morita in 1992. Studies using ethanol extract from *A. zerumbet* roots inhibited the growth of *Helicobacter pylori* strains isolated from the stomach of patients at Taiwan Hospital (Wang & Huang, 2005). In addition to antibacterial activity, the crude extract of *A. nigra* resulted in paralysis, deformation and death of the *Fasciolopsis buski* trematode (Roy & Tanon, 1999). The essential oil from this same species showed larvicide activity on *Aedes*

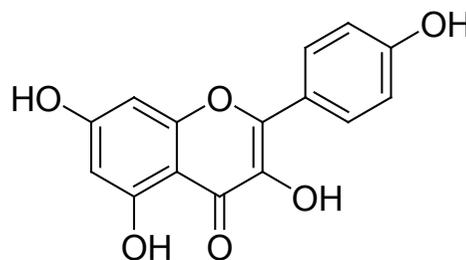
aegypti (Cavalcanti et al., 2004). Also, Morita (1992) reported on the production of a natural insecticide based on the essential oils of the *A. zerumbet* flower.

Extracts of *Alpinia* species have been applied in the treatment of inflammatory processes. For example, the species *A. officinarum* proved to be effective in the therapeutic or preventive treatment of acute or chronic arthritis (Lee et al., 2009).

The main studies on *Alpinia* species concern their vasodilation and hypotensive activities. Flavonoids are described as the metabolites involved in the hypotensive activity afforded by this species (Da Costa et al., 1998). Similarly, in studies on mice, components of the essential oil of *A. zerumbet* showed a hypotensive effect attributed to terpineol-4 (Lahlou et al., 2003). In other studies by the same group, it was verified that the antihypertensive action of the essential oil occurs independently from the sympathetic nervous system, suggesting an action related directly to the relaxation of blood vessels (Lahlou et al., 2002). Studies on the vasodilator effect of hydro-alcohol extracts from *A. zerumbet* showed that the variation in the effect results from the action of vasoactive substances released by endothelial cells, such as bradykinin (B_2) and NO-cGMP (Soares de Moura et al., 1998; Soares de Moura et al., 2005). As noted above, Victório et al. (2009a) studied the vasodilator effect of *A. purpurata* and found that plant extracts were able to induce a long-lasting endothelium-dependent vasodilation, reaching 87% of efficiency activity at concentration of 60 μg . Laranja et al. (1992) and Mendonça et al. (1991) conducted studies using the tea from the leaves of *A. zerumbet* and confirmed the antihypertensive effect of



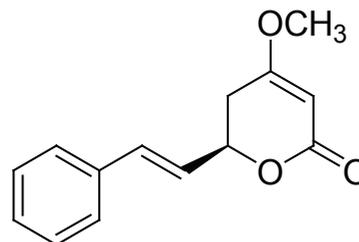
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A. zerumbet. Mpalantinos et al. (1998) suggest that the substances that promote this therapeutic action are the flavonoids and kavalactones obtained from the aqueous extract of *A. zerumbet*. Concomitant with these studies, the diuretic effect of *A. zerumbet* was also observed (Almeida, 1993).

Final consideration

Folk use of medicinal plants and the empirical perception of their therapeutic actions both act as a guide for scientific studies and make possible new therapeutic alternatives for treatment. The data and references presented in this review illustrate the medicinal importance of the genus *Alpinia*. When studying this genus, it can be observed that the therapeutic value of various species is closely related to the folk use of these plants. Based on the high number of antioxidant substances, such as flavonoids and the components of essential oils, the main therapeutic emphasis is related to cardiovascular disease and blood pressure. With regard to phytochemistry, several studies discuss the composition of essential oils, kavalactones and flavonoids, the latter being regarded as chemosystematic markers of the order Zingiberales. Although this work has described some of the therapeutic properties of the genus, the value of the *Alpinia* species extends to their cosmetic and agrochemical uses, as well.

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