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REVIEW

Ziziphus mucronata: an underutilized traditional medicinal plant in Africa

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Abstract In Africa, rural people depend heavily, if not exclusively, on medicinal plants and indigenous healthcare knowledge to meet their medical needs. Over 80000 flowering plant species are used medicinally worldwide. Amongst them are the underutilized *Ziziphus* species in the Rhamnaceae family. In terms of abundance and economic value, *Z. jujuba* and *Z. mauritiana* are currently the most important, especially in China and India where they are cultivated and exploited for medicinal use and their edible fruits. We examined a related common species widely distributed in Africa, *Z. mucronata*, whose economic value has not, as yet, been explored. Local people in various African countries use its different parts to cure a large number of diseases, many of which are similar to those treated with *Z. jujuba* and *Z. mauritiana*. Several studies have shown that *Z. mucronata* has cyclopeptide alkaloids, i.e., mucronines F, G and H, with antibacterial properties. Conservation strategies to sustain and maximize the benefits of *Z. mucronata* to people are proposed.

Key words Africa, medicinal plant, traditional remedy, underutilization, *Ziziphus mucronata*

1 Introduction

Medicinal plants contain inherent active ingredients used to cure diseases or relieve pain (Okigbo et al., 2008). Traditional remedies made from these plants play an important role in maintaining the health of 70%–80% of people in rural and indigenous communities throughout Africa (Cunningham, 1993). In fact, in some African countries, the number of traditional healers far outnumbers that of modern, western-educated doctors (Table 1). Even where modern medical services are available, use of medicinal plants has remained a more feasible option. This is due to their affordable prices, relative accessibility, local availability, trust in their efficacy, given the emergence of new and incurable diseases, such as HIV/AIDS, cancer, malaria and diabetes (Aumeeruddy-Thomas, 2002).

For example, both China and Mongolia are pursuing health care systems based on the practice of traditional medicine. In China, health care professionals use medicinal plants to treat and prevent diseases as well as to foster primary health of 40% of their patients (Brown, 1995; Zhang, 1998). After the discovery of the first influenza A virus (the subtype H1N1) in May 2009, for example, the Chinese government recommended a combination of western medicine and traditional Chinese medicine (TCM) as the primary course of treatment. In 2003, the SARS outbreak was also combated in the same way in China, resulting in 60% proven efficacy among more than 5000 patients treated (Shan, 2010). China has at least 800 manufacturers of herbal products, with an output worth about $1.8 billion per annum. Moreover, on a total planted area of 140836 ha for medicinal herbs, 13000 central farms specialize in the production for traditional medicine and 340000 farmers cultivate medicinal plants (WHO, 2001).

One of the medicinal plants used in China to cure diseases is *Ziziphus jujuba* Mill. (Chinese date or Chinese jujube) of the family Rhamnaceae. Over time, interest in expanding the use of underutilized crops, i.e., *Ziziphu*s species, has been sporadic, especially in relation to rural development initiatives. In India, *Z. mauritiana* Lam. has already been included in the national program on underutilized crops (Pareek, 2001). Similarly, Azerbaijan also recognized the underutilization of *Ziziphus* species and thus gave Chinese jujube a priority in its national programs (Pareek, 2001).

Different *Ziziphus* species, especially *Z. mucronata* in Africa, *Z. mauritiana* in India and *Z. joazeiro* in

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South America, are also valuable sources of traditional African, Indian and South American medicines, respectively. Our primary focus is on *Z. mucronata*. The objectives are: 1) to present an overview of traditional medicinal use of *Z. mucronata* in the African continent using available literature, 2) to outline briefly similar medicinal use of *Z. mucronata* with other *Ziziphus* species and their economic value, 3) to highlight the potential economic importance of *Z. mucronata* in relation to other vital *Ziziphus* species and subsequently 4) to suggest some possible conservation measures necessary to ensure its lasting supply to the communities it serves.

2 Description of *Z. mucronata*

2.1 Taxonomy

Ziziphus mucronata Willd. subsp. *mucronata* belongs to the buckthorn family (Rhamnaceae) in the order Rhamnales. It is a plant species in the genus *Ziziphus* Tourn. ex L. (Azam-Ali et al., 2006). The Latin name '*Ziziphus*' means thorny and '*mucronata*' refers to the pointed leaves of this species (World Agroforestry, 2010). *Ziziphus* is a generic name derived from the Arabic word zizoufo (World Agroforestry, 2010) used for *Z. lotus* (L.) Desf., but also related to the ancient Persian words zizfum or zizafun; ancient Greeks used the word ziziphon for the jujube (Azam-Ali et al., 2006). The genus *Ziziphus* is of some historical importance. It is believed that Christ's crown was made from *Z. spina-christi* Willd., a species which closely resembles *Z. mucronata* but grows from central Africa northwards (Palmer and Pitman, 1972). Nevertheless, this is not certain, since *Paliurus spina-christi* Mill., synonym *P. aculeatus*, has also been proposed (Azam-Ali et al., 2006).

Generally, there is a consensus that the genus *Ziziphus* consists of approximately 86 species (Johnston, 1972; Hyde and Wursten, 2010). Bhansali (1975) suggested that there could be up to 135 species and studies by some authors (Liu and Cheng, 1995; Islam and Simmons, 2006; Liu and Zhao, 2009) showed that there could be up to 170 species. A major factor contributing to this complexity may be that, in some cases, the same specific epithet has been used by different authors for different species. For example, *Z. mauritiana* Lam. has had the specific epithet of *jujuba* applied as *Z. jujuba* (L.) Lam. and *Z. jujuba* (L.) Gaertn. (Azam-Ali et al., 2006). Moreover, inter-regional comparisons are sometimes not taken into consideration when naming the species. For instance, Johnston (1972) proposed possible affinities between *Z. lotus* of Mauritania and the Sahara and also between *Z. hamer* of East Africa and *Z. leucodermis* (Baki) O. Schwartz of Arabia and as such suggested a more detailed study of the genus; but up to date no literature has been found to show that this has been done.

Synonyms of *Z. mucronata* include *Z. adelensis* Del., *Z. mitis* A. Rich, *Z. mucronata* Willd. var. *glabrata* Sonder, *Z. mucronata* Willd. var. *glauca* Schinz, *Z. mucronata* Willd. var. *inermis* Engl. and *Z. mucronata* Willd. var. *pubescens* Sonder (World Agroforestry, 2010). The common English name of *Z. mucronata* is buffalo thorn. Alternative names include cape thorn, shiny leaf and wait-a-bit. Apart from *Z. mucronata*, other *Ziziphus* species widely found in Africa include *Z. abyssinica* Hochst. ex A. Rich. and *Z. spina-christi* Willd. (Azam-Ali et al., 2006).

Table 1 Ratios of doctors practicing western and traditional medicines to patients in some African countries

Country	Doctor:Patient	TMP*:Patient	Reference
Ethiopia	1:33000	NA	World Bank, 1993; Hamilton, 2003
Ghana (Kwahu**)	1:20625	1:224	Anyinam, 1987
Kenya	1:7142	1:987	World Bank, 1993
Madagascar	1:8333	NA	World Bank, 1993
Malawi	1:50000	1:138	Hamilton, 2003
Mozambique	1:50000	1:200	Green, 1994
Nigeria (Benin***)	1:16400	1:110	Oyeneye and Orubuloye, 1984
South Africa	1:1639	1:700/1:1200 (Venda**)	World Bank, 1993
Sudan	1:11000	NA	World Bank, 1993
Swaziland	1:10000	1:100	Green, 1985; Hamilton, 2003
Tanzania	1:33000	1:350–1:450	World Bank, 1993
Uganda	1:25000	1:708	World Bank, 1993
Zambia	1:11000	NA	World Bank, 1993
Zimbabwe	1:6250	1:234 (urban)/1:956 (rural)	Gelfand et al., 1985; World Bank, 1993; Cunningham, 1997

Note: TMP*, traditional medical practitioners; **, region; ***, city; NA, data not available.

2.2 Ecological features

Z. mucronata is a common, drought resistant species distributed throughout the summer rainfall areas of sub-Saharan Africa, extending from South Africa northwards to countries such as Eritrea, Ethiopia, Ghana and Senegal (Schmidt et al., 2002). It also occurs in Yemen in the Arabian Peninsula (United States Department of Agriculture, 2010). Figure 1 shows its overall distribution. *Z. mucronata* regenerates naturally from seeds in various habitats with a mean annual temperature of 12–30°C and a mean annual rainfall of 446–1200 mm (Orwa et al., 2009; World Agroforestry, 2010). However, it is more common on flat and open woodlands, in alluvial soils along rivers, around pans as well as on termite mounds (Palgrave et al., 2002; Azam-Ali et al., 2006). *Z. mucronata* occurs both in coastal regions and inland, up to 2000 m above the sea level (Orwa et al., 2009; World Agroforestry, 2010). In addition, *Z. mucronata* can be propagated in nurseries, where it grows reasonably quickly from seeds or cuttings in any soil type and reaches 4 to 6 m in 4–5 years (Orwa et al., 2009; World Agroforestry, 2010).

2.3 Biological features

Z. mucronata is a shrub to medium-sized deciduous tree, up to 10 m in height, with an irregular spiky canopy (Shackleton et al., 2005). It has a single trunk that is often crooked; its branches spread and droop, branching above ground or sometimes near the base (World Agroforestry, 2010). *Z. mucronata* has distinctive angular zigzag branchlets and twigs, together with the hooked and straight thorns. The thorns of this species, usually present at the base of the leaf, are often in pairs, reddish brown, one straight (up to 2 cm; World Agroforestry, 2010) and the other shorter, stronger and hooked.

Leaves of *Z. mucronata* are shiny and light green, simple (30–80 mm × 20–50 mm), alternate or in tufts, with blade prominently 3–5 veined from their base (Schmidt et al., 2002). The small (± 4 mm in diameter), yellowish-green star-shaped flowers are borne in dense clusters above each leaf during October and November (Shackleton et al., 2005). The normally round fruits always appear thereafter from January to July (Shackleton et al., 2005), which often stay attached to the plant long after the leaves have fallen. The fruits of *Z. mucronata* are green when young, usually up to 2.5 cm in diameter and turn to reddish-brown when ripe (Maundu et al., 1999). They contain a large stone inside and as such have relatively little pulp which is usually dry and mealy. The seeds are usually solitary, elliptic and compressed. Mature trees produce about 500–2000 kg of seeds (Orwa et al.,

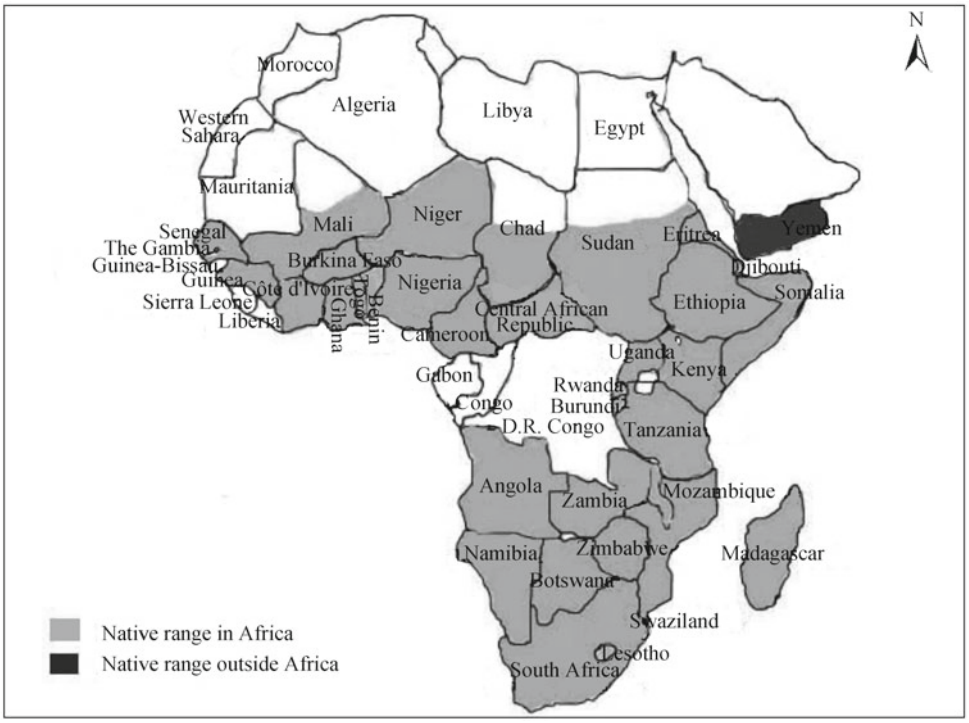

Fig. 1 Distribution map of *Z. mucronata*. The natural habitat of *Z. mucronata* includes both tropical and temperate climates. Outside Africa, *Z. mucronata* occurs in Yemen. The map represents the documented native regions. It does not suggest that the species is found in every ecological region in the specified countries. For example, it does not occur in the central and south Western Cape in South Africa, neither at high elevation in the mountains. It is also notably absent in most north African countries, i.e., Mauritania, Morocco, Algeria, Tunisia, Libya and Egypt. Sources: Maier et al., 2006; Orwa et al., 2009; African Flowering Plants Database, 2010; United States Department of Agriculture, 2010.

2009; World Agroforestry, 2010). The bark of *Z. mucronata* is normally red-brown and smooth but only on young stems. In older trees, it is roughly mottled grey and often cracked in small rectangular blocks, revealing a stringy red under-bark. The main stem of *Z. mucronata* is green and hairy when young (Schmidt et al., 2002).

3 Medicinal properties and other uses of *Z. mucronata*

3.1 Plant parts used in treating various diseases

Modern scientific medicine is a highly regulated social and economic activity. However, most people, particularly in the developing countries, still rely on various forms of traditional medicine (Akerele, 1988). In Africa, traditional healing systems exist in almost all countries. Table 2 shows medicinal roles of *Z. mucronata* in healing various health conditions in several African countries. Medicines, obtained from its roots, bark, leaves and/or fruits, are applied in various ways, usually as drinks, food and even as poultice. Common ailments treated using *Z. mucronata* include chronic cough, boils, toothache, rheumatism and swellings (Roodt, 1998; Iwalewa et al., 2007; Orwa et al., 2009).

3.2 Active medicinal components

As noted by Pareek (2001), most parts of the *Ziziphus* plants have medicinal value due to their inherent constituents. In particular, the traditional medicinal use of *Z. mucronata* can be attributed to the various cyclopeptide alkaloids it contains (Table 3) (Auvin et al., 1996; Pareek, 2001). These include mucronines A –H (Moloto, 2004), the recently discovered mucronine J (Auvin et al., 1996), abyssenine A and frangufoline (sanjoinine A) which are isolated from the bark of its stem, root bark, roots and leaves (Auvin et al., 1996; Tan and Zhou, 2006). The frangufoline (sanjoinine A), possessing a strong sedative property, has attracted increasing attention in chemical investigations of natural products since the mid 1960's (Tan and Zhou, 2006). Together with mucronines F–H found in the bark of *Z. mucronata* stem, they give this traditional medicinal plant its antibacterial properties (Tan and Zhou, 2006).

McGaw et al. (2007) also support the antibacterial activity of *Z. mucronata* in a study using *Escherichia coli*, *Enterococcus faecalis*, *Pseudomonas aeruginosa* and *Staphylococcus aureus* bacterial strains in leaf extracts. The average antibacterial activities for these bacterial strains, expressed in minimum inhibitory concentration in $mg \cdot mL^{-1}$, were > 7.1 in methane, > 7.8 in hexane and > 12.5 in water. For *P. aeruginosa* and *E. coli*, the antibacterial activity was more than 12.5 $mg \cdot mL^{-1}$ in all three extracts, while *E. faecalis* and *S. aureus* recorded 12.5 $mg \cdot mL^{-1}$ in water and 3.1 $mg \cdot mL^{-1}$ in hexane (McGaw et al., 2007). A study by Moloto (2004) provides similar support for the use by traditional medical practitioners to treat bacterial infections such as gonorrhea, syphilis, cholera, dysentery and boils using *Z. mucronata* extracts, as shown in Table 2.

In addition, *Z. mucronata* has antifungal and antiplasmodial properties, probably due to the tetracyclic triterpenoid saponins and flavonoids in its fruits (Prozesky et al., 2001; Pillay et al., 2008). The species is reported to have a high antisickling activity as well. Based on Mpiana et al. (2008), the antisickling property arises from anthocyanins, extracted from its roots and bark. The bark of Z. *mucronata* has 12%–15% tannin (Orwa et al., 2009), an astringent often used to treat diarrhea. Moreover, *Ziziphus* species, *Z. mucronata* included, commonly have a lot of vitamin C. Its concentration ranges from 70 to 165 mg per 100 g (Bal and Mann, 1978), which is beyond the 30 mg daily intake recommended by Passmore et al. (1974) for adults.

While some cyclopeptide alkaloids in the Rhamnaceae family, including the ones specified for *Z. mucronata*, have shown antibacterial, antifungal, antiplasmodial and sedative activities, there have not been any potential applications of cyclopeptide alkaloids in new drug research and development (Tan and Zhou, 2006). Therefore, this remains to be explored in the future.

3.3 Other uses of *Z. mucronata*

Due to its abundance, *Z. mucronata* is also a valuable source of food for all browsers such as giraffe, springboks, antelopes, black rhinos and elephants (Setshogo and Venter, 2003; Shackleton et al., 2005; Orwa et al., 2009). Its highly nutritious fruits are usually eaten by monkeys, baboons, warthog and birds. The fruits can be made into porridge and flour once they are dried and grounded (Roodt, 1998). Sometimes the fruits are sucked by children and are reportedly sold in rural markets in Zimbabwe (van Wyk and Gericke, 2000). If fermented properly, the fruits can also be made into a traditional beer (Setshogo and Venter, 2003).

Though rarely practiced, the seeds can be used as a coffee substitute (Maundu et al., 1999; Shackleton et al., 2005). The leaves are edible and young ones can be cooked and eaten as spinach. They play a central role in the nutrition of larval caterpillars, such as *Tuxentius melaena*, *T. calice calice* and *Zintha hintza* (Orwa et al., 2009). *Z. mucronata* are also used in

Table 2 Diseases treated using *Z. mucronata* in some African countries

Country	Diseases	Parts used	Methods of administration	References
Angola	Diarrhea, urogenital infection	Roots	Extracts taken orally	Bossard, 1996
	Sore throat, mouth abscess	Roots	Decoction taken orally or used as mouth wash or to gargle	Bossard, 1996
Benin	Oedema	Roots	NS*	Adjanohoun et al., 1989
	Snake bite	Bark of underground parts	NS*	Adjanohoun et al., 1989
	Convulsions	Leaves, stem	NS*	Adjanohoun et al., 1989
	Amnesia	Leaves, roots	Decoction taken orally and for bathing	Adjanohoun et al., 1989
Botswana	Swollen glands, boils, wounds, sores	Leaves, roots	Pastes applied as poultice	Setshogo and Venter, 2003
	Measles	Leaves, shoots	Decoction vapour used as inhalant	Roodt, 1998
	Chest complaints, stomach ailments	Bark, leaves	Extracts taken orally	Roodt, 1998
Cameroon	Stomach worms	Fruits, roots	Fruits eaten, root infusion drunk	Neuwinger, 1996
Kenya	Boils, skin infections, chest infections	Leaves, roots	Poultices applied directly	Maundu et al., 1999
	Enlarged spleen	Bark	Cold infusion taken orally	Maundu et al., 1999
	Rheumatism	Bark, stem	Decoction drunk	Lindsay and Hepper, 1978
	Stomach pains, stomach ulcers, gastric ulcer, colic, heartburn, abdominal pains	Bark	Infusion drunk	Glover et al., 1966
Mali	Psychiatric	Roots	NS*	Neuwinger, 1996
Namibia	Diarrhea with blood in the stool, stomach ulcers, vomiting with blood, coughing blood, tuberculosis	Roots	Decoction taken orally	Palgrave et al., 2002
Niger	Diarrhea	Roots	Macerate drunk	Adam et al., 1972
	Fever, gastric infections, diuretic, venereal diseases	Leaves, roots	NS*	Adam et al., 1972
Nigeria	Wounds, abscesses, boils	Leaves	Pounded and directly applied	Adam et al., 1972
	Diarrhea	Bark	Decoction drunk	Adam et al., 1972
	Colic	Bark	Decoction drunk	Neuwinger, 1996
Senegal	Dysentery, diabetes, hypertension	Leaves	Macerate drunk	Adam et al., 1972
	Toothache, rickets	Bark	NS*	Adam et al., 1972
	Syphilis, gonorrhea, leprosy, madness, diuretic, purgative	Bark, roots, stem	Decoction drunk	Kerharo and Adam, 1974
	Syphilis, gonorrhea	Bark of underground parts, sap	Bark powdered and locally applied, sap applied locally	Kerharo and Adam, 1974
	Urogenital infection, bilharzia, schistosomiasis	Fruits	Infusion taken orally	Kerharo and Adam, 1974

(To be continued)

Table 2 (continued)

Country	Diseases	Parts used	Methods of administration	References
South Africa	Diarrhea, toothache, dysentery	Roots	Decoction taken orally	Appidi et al., 2008
	Bronchitis, chest pains, fever, dysentery, rheumatism, stomach problems	Bark	Infusion taken orally	Palmer and Pitman, 1972; van Wyk and Gericke, 2000; Orwa et al., 2009
	Menorrhagia, general body pains	Roots	Maceration or decoction drunk	Arnold and Gulumian, 1984
	Syphilis, infertility, swollen glands	Leaves, roots	Decoction taken orally	van Wyk et al., 1997
	Wounds, boils, sores	Leaves, roots	Fresh leaves chewed or pulped and applied directly, roots decoction applied	van Wyk and Gericke, 2000; Luseba et al., 2007
Tanzania	Snake bite, stomachache, headache	Roots	NS*	Hutchings et al., 1996; Chettleborough et al., 2000
Zambia	Ulcers, gonorrhea	Leaves	NS*	Adam et al., 1972
	Dysentery	Root	Infusion taken orally	Adam et al., 1972
	Chest pain	Bark	Decoction drunk	Adam et al., 1972
Zimbabwe	Skincare	Leaves, roots	Steam bath to purify and improve complexion	WHO/DANIDA, 1991
	Myopia	Leaves, roots	Decoction taken orally, steam bath	Gelfand et al., 1985
	Wounds, cuts, boils, pimples, herpes, skin rash, snake bite	Leaves, roots	Powder applied locally	Gelfand et al., 1985
	Pneumonia	Leaves, roots	Decoction drunk	Gelfand et al., 1985
	Gastric ulcer, stomach ulcer, colic, bilharzia, diarrhea, cholera, dysentery, nausea, bile lithiasis, bladder illness	Roots	Infusion taken orally	Gelfand et al., 1985
	Arthritis, cramp, kidney pain, lameness, rheumatism, muscular inflammation	Bark, branches, roots	Infusion applied on scarifications, infusion taken orally	Gelfand et al., 1985
	Diarrhea, tape worms, malaria, hypertension, syphilis, gonorrhea, urinary, gynecological complaints	Bark, leaves, roots	NS*	Palmer and Pitman, 1972; WHO/DANIDA, 1991

Note: NS*, not specified.

connection with burial rites by the Zulu tribe in South Africa and the Swazi tribe in Swaziland (Shackleton et al., 2005). In Botswana as well as in most parts of South Africa, it is believed that *Z. mucronata* is immune against lightning, so anyone sheltering under it in a storm is considered to be safe.

In rural areas, the termite resistant timber from *Z. mucronata* trees is used for a variety of household items such as tables, chairs, spoons and dishes (Palmer and Pitman, 1972). The wood of *Z. mucronata* is fairly dense and can be used to make long burning firewood and charcoal. *Z. mucronata* is also commonly used as a live fence, for instance in schools and gardens, as well as a form of protection against animals in fields, homesteads and kraals, at least for 10 years before the crown is too high off the ground to act as a barrier (World Agroforestry, 2010). Moreover, *Z. mucronata* is considered to be a good indicator of underground water in areas where it naturally occurs (Setshogo and Venter, 2003) as well as a valuable source of nectar by beekeepers (Orwa et al., 2009).

4 Other related *Ziziphus* species

4.1 Medicinal value

Species in the genus *Ziziphus* are increasingly becoming popular due to their outstanding advantages, such as early bearing, high fruit yield, rich nutrition, multiple uses, long flowering season and high tolerance to drought and barren soils (International Centre for Underutilized Crops, 2001; Liu and Zhao, 2009). In addition to *Z. mucronata*, several other *Ziziphus* species are exploited for medicinal use in other parts of the world as well. Examples include *Z. jujuba*, *Z. mauritiana* and *Z. spina-christi*. Medicinal uses of these three species are generally similar to those of *Z. mucronata* in Africa.

The fruits, leaves and seeds of *Z. jujuba* are commonly used in China to treat illnesses, such as irritability, insomnia, heart palpitations, constipation, lack of appetite, inflammation, sore throat and shortness of breath (Zhu, 1998; Azam-Ali et al., 2006; Jiang et al., 2007; Naftali et al., 2008). Similar diseases treated with *Z. mucronata* in Africa cover psychiatric cases in Mali, rheumatism in Kenya and South Africa as well as measles in Botswana. Just like *Z. mucronata*, *Z. jujuba* possesses saponins which have some sedative effects. The saponins in *Z. jujuba* are ziziphin and jujubosides A and B, acetyljujuboside B and protojujubosides A, B and B1 (Azam-Ali et al., 2006). In addition, this species also contains triterpenoic acids (e.g. oleanolic acid, betulonic acid, oleanonic acid and colubrinic acid) and some phospholipids (Lee et al., 2003; Jiang et al., 2007).

Some medicinal uses of *Z. mauritiana* in India are similar to those of *Z. mucronata* in Africa. These include the treatment of diarrhea, dysentery, nausea, vomiting, mental retardation, rheumatism, ulcers, wounds and fever (Ara et al., 2008). The plant parts used in treatments are leaves, roots, seeds, bark and in some instances, flowers. Alkaloids, such as mauritines A–H and J, amphibines B and D–F, frangufoline, hysodricanin A, scutianin F and aralionin C, are examples of cyclopeptide alkaloids found in *Z. mauritiana* (Jossang et al., 1996).

Moreover, traditional medicinal uses of *Z. mucronata* are comparable to those of *Z. spina-christi*. For instance, based on Dafni et al. (2005), *Z. spina-christi* in Morocco is similarly used in snake bite treatments as *Z. mucronata* in Benin, Tanzania and Zimbabwe (Table 2). Other ailments, such as arthritis, muscle pains, chest pains, headache, colds, measles, swollen organs and liver problems, treated with *Z. spina-christi* (Dafni et al., 2005), are in certain African countries cured using *Z. mucronata* (Table 2). The active components of *Z. spina-christi* include zizyphine F,

Table 3 Cyclopeptides alkaloids in *Z. mucronata*

Cyclopeptide (synonym)	Molecular formula	Plant part
Abyssenine A (*N*-desmethyl-mucronine C)	$C_{25}H_{38}N_4O_4$	Root bark
Mucronine A	$C_{29}H_{38}N_4O_4$	Stem bark
Mucronine B (*N*-desmethyl-mucronine A)	$C_{28}H_{36}N_4O_4$	Stem bark
Mucronine C	$C_{26}H_{40}N_4O_4$	Stem bark
Mucronine D	$C_{37}H_{51}N_5O_6$	Stem bark, root bark, root
Mucronine E (4-methoxy-abyssinine A)	$C_{26}H_{40}N_4O_5$	Stem bark
Mucronine F (*N*-desmethyl-mucronine E)	$C_{25}H_{38}N_4O_5$	Stem bark
Mucronine G (4-methoxy-abyssinine C)	$C_{25}H_{38}N_4O_5$	Stem bark
Mucronine H (*N*-desmethyl-mucronine B)	$C_{27}H_{34}N_4O_4$	Stem bark
Mucronine J	$C_{27}H_{40}N_4O_4$	Root bark
Frangufoline (sanjoinine A)	$C_{31}H_{42}N_4O_4$	Root bark, seeds

Sources: Auvin et al., 1996; Tan and Zhou, 2006.

jubanine A, amphibine H and spinanine A (Shappira et al., 1990). Therefore, in view of these similarities, *Z. mucronata* is an equally potential source of medicine.

4.2 Commercial importance

The two major domesticated *Ziziphus* species, *Z. mauritiana* and *Z. jujuba*, occur on nearly every continent. However, other species, such as *Z. nummularia*, *Z. spina-christi* and *Z. mucronata*, are restricted in their distribution to distinct areas. So far, no establishment of *Z. mucronata* outside its native African continent has been recorded, except in Yemen. Furthermore, *Z. mucronata* is currently not exploited commercially. A brief overview of the economic importance of *Z. jujuba* and *Z. mauritiana* may as well underscore the untapped potential of *Z. mucronata*.

There are 14 *Ziziphus* species in China (Azam-Ali et al., 2006; Liu and Zhao, 2009), of which *Z. jujuba* is the most important in terms of resource abundance and economic value. It has been cultivated for over 4000 years and introduced to over 30 countries. For example, *Z. jujuba* has been introduced and grown under plantation conditions in California and Florida, USA (Azam-Ali et al., 2006). In South Korea, it has become a commercially cultivated fruit tree. In 2006, it was grown on roughly 150 million ha of land in China, with production of 3.05 million tons on a fresh weight basis, accounting for 99% of world production (Liu and Zhao, 2009). Chinese date (jujube) is eaten as fresh fruit, or dried and soaked in water before use in savory and sweet dishes. A wine made from *Z. jujuba* fruits called "hong zao jiu" is also produced in China. In Korea, jujubes are called "daechu" and used in teas to help cure the common cold.

Similar to *Z. jujuba*, *Z. mauritiana* (Indian jujube) is mainly cultivated for its fruits in India (Pareek, 2001). It is one of the 17 *Ziziphus* species found in India (Ara et al., 2008). *Z. mauritiana* is native from Yunnan Province, China, to Afghanistan, Malaysia and Australia (Kaaria, 1998). It is also found in the Bahamas, Fiji, Colombia, Philippines and Venezuela. In 1939, six trees from Malaysia were introduced into Israel and flourished there. The USA has also imported germplasm of *Z. mauritiana* and a small number of trees are cultivated in southern Florida (Azam-Ali et al., 2006). Between 1994 and 1995, 0.9 million tons of *Z. mauritiana* fruits were produced in India from an area of 88000 ha. *Z. mauritiana* can produce an annual fruit yield of 50–250 kg·tree^{-1} and is relatively easy and inexpensive to cultivate (International Centre for Underutilized Crops, 2001). Among India, Thailand and Pakistan, only Thailand exports *Z. mauritiana* fruits to the Middle East, Malaysia and the Far East throughout the year. About 175000 tons of *Z. mauritiana* fruits have been produced in Thailand between 1989 and 1995 (International Centre for Underutilized Crops, 2001). The ripe fruits of *Z. mauritiana* contain large amounts of vitamins A and C and are mostly eaten raw in India and sometimes stewed. In Indonesia, young leaves are cooked and eaten while in Venezuela, a jujube liqueur is made and sold. *Z. mauritiana* is also a source of fodder for cattle, sheep and goats.

5 Discussion

Plants have long provided mankind with herbal remedies for many infectious diseases and even today, they continue to contribute immensely as primary health remedies in developing countries. From a research and development point of view, many *Ziziphus* species have not received any major emphasis from governments and as such, they remain underutilized (Azam-Ali et al., 2006). Nonetheless, we have shown that they serve valuable medicinal and cultural roles to millions of people. *Z. mucronata* helps in the treatment of diseases such as diarrhea, syphilis and gastric ulcers. It also helps heal boils, wounds and hypertension in many African countries. Moreover, it provides food to animals as well as material for handicrafts to local people in various African countries. As such, there is a need to preserve this species in order to ensure its lasting supply to local communities. Some possible conservation strategies are mentioned below.

If *Z. mucronata* is to be maintained as a renewable resource, more domestication initiatives such as those taken for *Z. jujuba* and *Z. mauritiana* can be employed. This will likely take pressure off the existing wild stocks. Additionally, *Z. jujuba*, *Z. spina-christi* and *Z. mauritiana* have been successfully introduced in areas outside their natural habitats. They widely occur in almost all continents. Attempts can be made to introduce *Z. mucronata* to other continents as well, since it can tolerate various environmental conditions, just like the *Ziziphus* species mentioned earlier. Presently, the distribution of *Z. mucronata* is mainly restricted to Africa.

Furthermore, to maximize the use of *Z. mucronata*, collaboration among nations is crucial in enhancing scientific research on the pharmacological potential of this species in the global market. A number of the traditional medicinal uses of *Z. mucronata* in various African countries are similar to those of the widely recognized *Z. jujuba* and *Z. mauritiana*. This indicates that with more research, *Z. mucronata* can be economically valuable as well.

Compared to India and China, many African countries still have much to do in terms of effectively inte-

grating medicinal plants and the associated indigenous healthcare knowledge in modern healthcare systems. To achieve this, the preservation and documentation of indigenous medicinal knowledge related to medicinal plants, i.e., *Z. mucronata*, with the involvement of traditional medical practitioners is vital.

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