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REVIEW

Therapeutic potential of *Cymbopogon schoenanthus* (L.) developed into nanoparticle technology

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Abstract

Introduction: One of plants that may have therapeutic potential is the Cymbopogon schoenanthus (L.) Spreng, also known as camel grass. **Aim:** This review aims to investigate and gather comprehensive information about camel grass plants and their potential to be developed into a nanotechnology drug delivery system. **Methods:** This review examined a variety of online literature. **Results:** It was found that camel grass contains essential oil such as piperitone. Piperitone is efficacious as an antioxidant, antimicrobial and anti-inflammatory, in addition to other properties . The development of camel grass essential oil into lipid-based nanotechnology preparations can improve its bioavailability, solubility, and stability, thereby improving its potential effectiveness.

Introduction

Cymbopogon schoenanthus (L.) Spreng is a natural herb that grows in tropical regions such as northern and western Africa, the Arabian desert, and Egypt. This plant is also known as *"Izkhir"* in Arabic, *"El bekhirai"* in Tunisian, and *"Tsabre"* in North African. *Cymbopogon schoenanthus (L.) Spreng* tends to grow in dry places such as the desert and is often used for camel feed, so it is also known as *"camel grass"* (Burkill & Dalziel, 1985; IUCN, 2005). In addition, this plant is also found at an altitude of 2000 meters or more in the province of Kiman, Iran (Amina et *al*., 2013).

Camel grass is shaped like a typical grass with a height of 60-90 cm (Figure 1). It grows in dry areas away from water sources. Camel grass has a distinctive taste and aroma due to its essential oils (Ben Othman et *al*., 2013). So, it is often used as a flavouring agent, fragrance, cosmetics, or perfume (Amina et *al*., 2013; Avoseh et *al*., 2015). The classification of camel grass plants is explained as follows (ITIS, 2020) :

Kingdom	: Plantae
Division	: Tracheophyta
Class	: Magnoliopsida
Order	: Poales
Family	: Poaceae
Genus	: Cymbopogon
Species	: *Cymbopogon schoenanthus (L.) Spreng.*

Figure 1: *Cymbopogon schoenanthus (L.) Spreng* (African Plants, 2020)

Cymbopogon schoenanthus (L.) Spreng contains essential oil, which is a typical source of monoterpenes such as piperitone and several other components known as intermedeol, δ-2-carene, and elemol (Pavlovic et *al*., 2017). Based on previous research, the chemical compounds of camel grass essential oil is efficacious as an antioxidant, antiacetylcholinesterase, antimicrobial, anti-inflammatory, spasmolytic, and contains other properties; Khadri et *al*., 2010; Pavlovic et *al*., 2017). However, currently, there are no articles that summarize specifically the content of chemical compounds, potential efficacy and benefits of camel grass. Therefore, this review article aims to collect comprehensive information about the efficacy of *Cymbopogon schoenanthus (L.) Spreng* and its potential development into pharmaceutical nanotechnology.

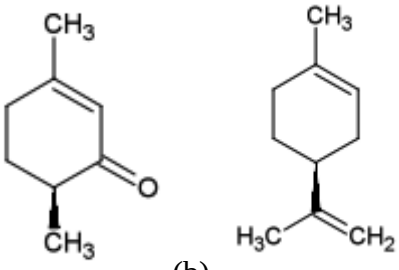
Methods

The authors utilised various online databases to carry out a literature review, such as PubMed, ScienceDirect, Research Gate, and Google Scholar. The search keywords used were *Cymbopogon schoenanthus (L.) Spreng*, camel grass, chemical compounds, therapeutic activity, and nanotechnology. The inclusion criteria were 1) published national and international articles; 2) English language; and 3) Indonesian language. The exclusion criteria were 1) unpublished articles; and 2) articles with invalid sources. The authors found and screened 35 references using the inclusion and exclusion criteria. The authors then used 27 references selected by the inclusion criteria to be reviewed in this article.

Results and discussion

Chemical compounds of camel grass

Camel grass has many chemical compounds. A study conducted by Pavlovic and the authors (2017) using camel grass from Sudan, showed in GC-MS testing that there were up to 45 different components in essential oils from camel grass. The flower and stem of the plant are used with camel grass flowers containing essential oils of 1.9-2.0% (v/w) compared to the stems of 0.2-0.6% (v/w). Piperitone makes up 47.7 to 71.5% of camel grass essential oil (Figure 2). Other compounds in camel grass include intermedeol (6.1-17.4%), δ-2-carene (4.5-10.0%) and elemol (5.2-9.0%) (Pavlovic et *al*., 2017). Studies on camel grass from Algeria also obtained similar results showing a compound composition of piperitone (63.3%), eudesmol (9.3%), δ-2-carene (4.9%), and elemol (6.9%) (Naima et *al*., 2016).



(a) (b)

Figure 2: Chemical structure of piperitone (a) and limonene (b) (Ganjewala, 2009)

Studies of camel grass harvested from Tunisia in June-July 2006 found that it contained 30 different components dominated by limonene (10.5-27.3%), β-phellandrene (8.2-16.3%), δ-terpinene (4.3-21.2%) and α-terpineol (6.8-11.7%) (Khadri et *al*., 2008). Hence, this shows that chemical compounds obtained from camel grass can be influenced by geographical conditions, seasons, and time of harvest (Khadri *et al*., 2008; Ganjewala, 2009; Naima et *al*., 2016; Pavlovic *et al*., 2017).

Pharmacological activity

Antioxidant

Antioxidant activity was tested by using the DPPH test method. This test illustrates the ability of the camel grass essential oil to capture free radicals from 2,2-diphenyl-1-picryl hydrazyl (DPPH) by releasing hydrogen atoms or electrons. The study conducted by Khadri and authors (2010) obtained IC_{50} values, ranging from 12.6±3.4 µg/mL to 26.4±6.8 µg/mL. Camel grass was harvested from 3 different types of places i.e. desert, mountain, and plant culture (Khadri et *al*., 2010). Due to its antioxidant ability, camel grass can be utilized in the food industry as a substitute for synthetic antioxidants (Khadri et *al*., 2008).

Anti-acetylcholinesterase

Acetylcholinesterase (AChE) is an enzyme that plays a role in inhibiting the transmission of nerve impulses in cholinergic synapses by hydrolyzing acetylcholine. When acetylcholine levels in the body are too low, it can result in neurological diseases such as Alzheimer, dementia, ataxia, and myasthenia gravis. The inhibitory activity of acetylcholinesterase can be found in many plants (Mukherjee *et al.,* 2007). *Cymbopogon schoenanthus (L.) Spreng* has been shown to have moderate anti-acetylcholinesterase activity with IC_{50} values between 0.23 mg/mL to 0.75 mg/mL (Khadri et *al*., 2010).

Antimicrobial

A study tested the antimicrobial activity of essential oils from camel grass against bacteria of the streptococci species, namely *S. mutans* and *S. sobrinus,* which commonly cause dental caries. The results obtained showed that its antimicrobial activity effectively inhibits the growth of *S. sobrinus* bacteria at concentrations of 4 mg/mL and 8 mg/mLwhilebacterial growth inhibition activity for *S. mutants* was seen at a concentration of 32 mg/mL (Khadri et *al*., 2010).

Cymbopogon schoenanthus (L.) Spreng also registered strong antimicrobial activity in studies on inhibitory zonesagainst *Enterococcus faecium* (21±1.4 mm), *Staphylococcus aureus* (19.5±0.7 mm), *Escherichia coli* (15±1.4 mm), *Salmonella typhimurium* (10.5±0.7 mm), *Streptococcus agalactiae* (12.75±0.3 mm), and *Candida albicans* (12±1.4 mm) (Naima *et al.*, 2016).

Anti-inflammatory

Anti-inflammatory activity can be found in camel grass essential oil, according to a study that conducted anti-inflammatory tests through carrageenan-tests on mice. Camel grass essential oils were administered intraperitoneally and found to significantly reduce paw oedema in doses of 50, 100, and 200 mg/kg, proving that camel grass essential oil has an effective anti-inflammatory effect in the acute inflammation phase (Talaei *et al.*, 2019). Other studies have shown that camel grass essential oil can inhibit the release of Nitric oxide (NO), which is an inflammatory mediator in RAW 264.7 cells, while IC_{50} test results show concentration values between 1.32±0.17 mg/mL to 1.38±0.04 mg/mL (Gomes *et al.*, 2017; Sukaboon *et al.*, 2019).

Spasmolytic activity

A study revealed that *Cymbopogon schoenanthus (L.) Spreng* essential oil has spasmolytic activity in the concentration range of 10-130 µg/mL. Testing was done by inducing acetylcholine in mice to observe effectiveness in inhibiting spontaneous contractions in rat ileum. The strongest spasmolytic activity was seen at a concentration of 130 µg/mL, which is equivalent to the maximum relaxant effect of atropine at a concentration of 6.4 µM (Pavlovic *et al.*, 2017). Another experiment method was also carried out to induce Potassium Chloride (KCl) (80 mM), which causes tonic contractions. Camel grass essential oil was found to inhibit the contraction effect of KCl by up to 19.67±20.26% at a concentration of 30 µg/mL (Pavlovic *et al.*, 2017).

Anti-stress activity

The anti-stress activity of camel grass essential oil was tested on SH-SY5Y human cells and heat-stressed HSP47-transformed cells. It was also tested in mice using the tail suspension test (TST) and forced swimming test (FST) methods. TST and FST tests are used as these are methods that most closely resemble the condition of depression in humans (Ben Othman *et al.*, 2013). Camel grass essential oil was found to protect these cells from stress-related disruption. In experiments using mice, camel grass essential oils at doses of 100 and 200 mg/kg administered orally were able to reduce the immobility time in the TST and FST tests indicating anti-stress activity.

Anthelmintic activity

Cymbopogon schoenanthus (L.) Spreng has a terpenoid compound that can inhibit the parasite growth phase. It has shown good anthelmintic activity as evidenced by four different tests: 1) Egg hatching assay (EHA) test; 2) larval development assay (LDA); 3) larval feeding inhibition assay (LFIA); and 4) larval escheatment assay (LEA) and in which the LC_{50} values obtained were 0.045 mg/mL, 0.063 mg/mL, 0.009 mg/mL, and 24.66 mg/mL, respectively. *Cymbopogon schoenanthus (L.) Spreng* is the best candidate for nematode control when compared to *Cymbopogon martinii* and *Mentha piperita* in the same study (Katiki *et al.*, 2011).

Insecticidal activity

The piperitone component in camel grass is known to inhibit the growth of neonatal eggs and larvae of *Callosobruchus maculatus,* whereas camel grass essential oil is also found to reduce the fertility of *C. maculatus* females by affecting the number of eggs produced (Ketoh *et al.*, 2006; Aous *et al.*, 2019).

Nanotechnology application

The use of nanotechnology in pharmaceutical preparations is able to cover the deficiencies of active substances, especially those derived from herbs or natural ingredients. Essential oils have an oil base, so they are more difficult to absorb in the body and have low bioavailability. Traditional processing of natural ingredients also usually requires a greater number of doses (Mukherjee *et al.*, 2015). Nanotechnology is divided into several dosage forms depending on the material used in the formulation and the method used for manufacturing. Generally, the nanotechnology form has a particle size between 20-200 nm, therefore it is often also referred to as nanoparticles. This preparation can improve bioavailability, solubility, and poor stability. This preparation also helps deliver active substances through cell membranes to reach action sites (Chabib *et al.*, 2020).

A study conducted by Ujilestari *et al.* was able to formulate essential oils from Cymbopogon citratus (lemongrass) in the form of spherical-shaped particles in self nano-emulsion drug delivery systems (SNEDDS). The characterization results showed the lemongrass SNEDDS preparation had a particle size of 20.7 nm and a polydispersity index (PI) of 0.378 (Tri Ujilestari *et al.*, 2018). Further studies also carried out an antibacterial test of *Cymbopogon citratus* in SNEDDS preparations and proved its effectiveness in inhibiting the growth of *Escherichia coli*, *Salmonella thyphimurium*, and *Lactobacillus acidophilus* bacteria (T Ujilestari *et al.*, 2019).

Another study conducted by Manju and the authors (2016), successfully formed a gold nanoparticle preparation from the essential oil of *Nigella sativa*. Its particle size range was 15.6-28.4 nm in a spherical, triangle, and hexagonal shapes. *Nigella sativa* SNEDDS was able to inhibit the growth of *Staphylococcus aureus* (16 mm) and *Vibrio harveyii* (5mm) at a concentration of 10 µg/mL. In the dosage range of 20-80 µg/mL, it was also shown to inhibit the biofilms of *S. aureus* and *V. harveyii* formed. In anti-cancer testing on A549 lung cancer cells, gold nanoparticles were able to inhibit the growth of cancer cells with IC_{50} values of 5-50 µg/mL (Manju *et al.*, 2016).

The results of the two studies above suggest that it is possible to develop camel grass essential oils into nanotechnology drug delivery systems. It is assumed that camel grass has the same essential oil profile as other plants, which can be developed into the nanoparticle dosage form.

Conclusion

Cymbopogon schoenanthus (L.) Spreng or camel grass is one of the medicinal plants mentioned in the Al-Quran and Hadith, which contains essential oils and substances like piperitone, intermedeol, δ-2-carene, and elemol. It is useful pharmacologically, containing antioxidant, anti-acetylcholinesterase, antimicrobial, anti-inflammatory, spasmolytic, anti-stress, anthelmintic, and insecticidal properties. Essential oils from *Cymbopogon schoenanthus (L.) Spreng* also has the potential to be developed into a nanotechnology drug delivery system.

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