Mini Review

Biological properties of lemongrass: An overview

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Abstract

The use of herbal preparations remained the main approach of folk medicine to the treatment of ailments and debilitating diseases. Initial intensive researches conducted on Lemongrass extracts (tea) may have showed conflicting evidences, however the resurgence in claims of folk medicine practitioners necessitated further inquiry into the efficacy of the tea. Lemongrass tea contains several biocompounds in its decoction, infusion and essential oil extracts. Anti-oxidant, anti-inflammatory, anti-bacterial, anti-obesity, antinociceptive, anxiolytic and antihypertensive evidences of lemongrass tea were clearly elucidated to support initial pharmacological claims. Lemongrass tea was non-toxic, non-mutagenic and receives wide acceptance among alternative medicine practitioners in several developing countries. This review therefore presents previous research activities, technologies and information surrounding bioactivities of lemongrass tea. Areas of future researches which may elucidate mechanisms of the biological properties of lemongrass extracts were highlighted.

Introduction

The use of whole herbs and extractives has remained the main approach of folk medicine practitioners in the treatment of ailments and debilitating diseases. They usually claimed that such whole herbs and extractives are efficacious against several ailments and diseases without recourse to scientific proofs. Increased cases of opportunistic diseases emanating from side effects associated with synthetic drugs continue to necessitate incremental efforts in searching for effective biological substitutes with little or no side effects. Therefore, efforts are being directed towards elucidating potential sources such as ethno-medicinal plants (Patil, 2010). New, robust and less cumbersome extraction techniques assisted by recent developments in biotechnology have enhanced investigation of natural compounds faster with more precision than before leading to isolation of bioactive compounds with intense health benefits (Wang and Weller, 2006). According to folk medicine, several plants possess ethno medicinal benefits and Cymbopogon citratus Stapf, also known as lemongrass remained one of them.

Lemongrass is a perennial grass plant widely distributed worldwide and most especially in tropical and subtropical countries (Francisco et al., 2011). Several reports have linked its origin to Asia (Indochina, Indonesia and Malaysia), Africa and the Americas. The plant could grow up to 6 inch high and its bulblike stems consist of terete and glabrous linearly venated sheathed leaves with narrow base and acute apex. The leaf height is about 100 cm in length and 2 cm in width. When squeezed, the leaves usually produce yellow or amber colored, aromatic, essential oil (Adejuwon and Esther, 2007). Its aqueous extract is commonly used as an aromatic drink while the whole plant is well incorporated into traditional food for its lemon flavour. It also enjoyed wide application in folk medicine (Figuerinha et al., 2008). Traditionally, tea made from lemongrass leaves is popular among countries of South America, Asia and West Africa having been widely utilized as antiseptic, antifever, antidiyspeptic, carminative and anti-inflammatory effects. Others are febrifuge, analgesic, spasmylocytic, antipyretic, diuretic, tranquilizer and stomachic agent (Sawyerr, 1982, Viana et al., 2000, Negrelle and Gomes, 2007; Adejuwon and Esther, 2007; Tatiana et al., 2011). In this review however, details about main medicinal properties of lemongrass tea will be clearly elucidated, while area of future researches will be well highlighted.

Lemongrass phytochemistry and technology

Lemongrass contains several important bioactive compounds which are useful in several health issues. These active compounds are normally found in the leaves and this is summarized in Table 1. The various methodologies used in extracting such bioactive compounds are also summarized in Figure 1. The root of lemongrass is also being used as chewing stick for mouth cleaning in several parts of the world.
Figure 1. Methods of extracting bioactive compounds from lemongrass

(Sawyer, 1982).

Essential oil is one of the important components of lemon grass extracts and its applications include co-ingredients for perfumes and cosmetics. Its high citral composition has made it important for several chemical syntheses (Negrelle and Gomes, 2007). Similarly, investigations carried out on different lemongrass extracts showed other important therapeutic potentials such as anti-cancer, anti-hypertensive and anti-mutagenicity. Others include non-toxic properties, anti-diabetic, anti-oxidant, anxiolytic, anti-nociceptive and anti-fungi (Shah et al., 2011).

Initially, the use of lemongrass extract in folk medicine for the treatment of certain ailment was disputed, but recent findings have confirmed its efficacy (Adejuwon and Esther, 2007; Celso et al., 2011a). Despite this, lemongrass tea and its essential oils is becoming unpopular especially among developing nations. This might be due to lack of awareness of published results on the efficacy of the extracts on several health related issues. Hence, the focus of this review is to concisely document all the extracts on several health related issues. Hence, awareness of published results on the efficacy of developing nations. This might be due to lack of technological advancement. Therefore, inflammation accounts for more cases of mortality among people. Importantly, it has been linked with other health problems like cancer, cardiovascular rheumatoid, neurodegenerative and diabetes (Jaswir and Monsur, 2011). Inflammation in animal tissue is usually triggered by physical stress or when chemical inducers (e.g. lipopolysaccharide) are present within the tissue composition. Mechanistically, inflammation will occur when lipopolysaccharide (LPS) is incubated with macrophages thereby leading to secretion of pro-inflammatory mediators such as nitric oxide (NO), prostaglandin E2 (PGE2). Other inductive factors include reactive oxygen species (ROS), cytokines which includes tumor necrosis factor-TNF-α, interleukins and up-regulation of nuclear factor keppa-B cells proteins (NF-κB).

Inducible Nitric Oxide Synthase (iNOS) and Cyclo-oxygenase (COX-2) are responsible for the release of NO and PGE2 while TNF-α trigger NF-κB and mitogen-activated protein kinases (MAPK) pathways. To complete the list, the latter is responsible for p38-MAPK, c-Jun N-terminal kinases (JNK) and extracellular-signal-regulated kinases (ERK) (Kulinsky, 2007).

Table 1. Bioactive compounds from lemon grass extract and essential oil

<table>
<thead>
<tr>
<th>Component</th>
<th>Biological activities</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myrcene</td>
<td>Antibacterial activity</td>
<td>Grace et al., 1984</td>
</tr>
<tr>
<td>Citral</td>
<td>Antimicrobial activity</td>
<td>Grace et al., 1984; Viana et al., 1984</td>
</tr>
<tr>
<td>α-citral (geranial)</td>
<td>Antinociceptive activities</td>
<td>Viana et al., 2000; Dharmendra et al., 2001</td>
</tr>
<tr>
<td>β-citral (neral)</td>
<td>Antioxidant activity</td>
<td>Dharmendra et al., 2001</td>
</tr>
<tr>
<td>Heptenone</td>
<td>Not available</td>
<td>Grace et al., 1984</td>
</tr>
<tr>
<td>Dipentene</td>
<td>Not available</td>
<td>Grace et al., 1984</td>
</tr>
<tr>
<td>Limonene</td>
<td>Not available</td>
<td>Berenice et al., 1991; Grace et al., 1984</td>
</tr>
<tr>
<td>Linalool</td>
<td>Not available</td>
<td>Berenice et al., 1991; Grace et al., 1984</td>
</tr>
<tr>
<td>Borneol</td>
<td>Not available</td>
<td>Grace et al., 1984</td>
</tr>
<tr>
<td>Geranial</td>
<td>Antimicrobial activity</td>
<td>Mirghani et al., 2012</td>
</tr>
<tr>
<td>Geraniol</td>
<td>Antiviral activity</td>
<td>Celso et al., 2011;</td>
</tr>
<tr>
<td>Limonene</td>
<td>Anti-oxidant activity</td>
<td>Bidinotto et al., 2010;</td>
</tr>
<tr>
<td>β-myrcene</td>
<td>Anti-gout activity</td>
<td>Blanco et al., 2009;</td>
</tr>
<tr>
<td>6-methyl-5-hepten-2-one</td>
<td>Antidiabetic activity</td>
<td>Costa et al., 2006;</td>
</tr>
<tr>
<td>Undecan-2-one</td>
<td>Anti-inflammatory activity</td>
<td>Viana et al., 2000; Dharmendra et al., 2001; Shigebaru et al., 2001;</td>
</tr>
<tr>
<td>Linalool</td>
<td>Anti-fungal activity</td>
<td>Berenice et al., 1991</td>
</tr>
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Anti-inflammatory properties

Tissue inflammation is one of the main health issues worldwide. The hike in its prevalence has been attributed to sophisticated lifestyles occasioned by technological advancement. Therefore, inflammation will occur when lipopolysaccharide (LPS) is incubated with macrophages thereby leading to secretion of pro-inflammatory mediators such as nitric oxide (NO) and prostaglandin E2 (PGE2). Other inductive factors include reactive oxygen species (ROS), cytokines which includes tumor necrosis factor-TNF-α, interleukins and up-regulation of nuclear factor keppa-B cells proteins (NF-κB).
devoid of lipid and essential oil and polyphenol fractions (phenolic acids, flavonoids and tannins) of lemongrass leaves were investigated for their anti-inflammatory properties. Aqueous lemongrass extract inhibited secretion of NO, PGE2 and expression of iNOS, but not COX-2 in LPS induced RAW 264.7 macrophage cell lines and skin-derived dendritic cell line (FSDC) (Figueirinha et al., 2010; Francisco et al., 2011). Furthermore, same extract was also reported to inhibit LPS induced phosphorylation of p38MAPK and JNK 1/2 but no effect on ERK 1/2 activation. Degradation of IκBα by LPS induction was prevented by aqueous extract by inhibiting NF-κB activation (Francisco et al., 2011).

The polyphenolic fractions of the extracts have been demonstrated to reduce secretion of NO and expression of iNOS in LPS stimulated skin-derived dendritic and RAW 264.7 cell lines. However, flavonoids and tannins fractions exhibited better anti-inflammatory potency due to presence of luteolin glycosides. Phenolic acids on the other hand exhibit satisfactory inhibition of PGE2 production in LPS induced RAW 264.7 macrophage. None of the lemongrass polyphenolic fractions inhibited COX-2 expression (Lee et al., 2008; Figueirinha et al., 2010; Francisco et al., 2011). The removal of the essential oil, which contains citral has been opined for such inactivity. Similarly, ethanolic lemongrass extract (50%) is efficacious against inflammation caused by LPS induced by murine alveolar macrophages. The mechanism of action is by inhibiting the secretion of NO and pro-inflammatory cytokine tumor necrosis factor TNF-α (Tiwari et al., 2010).

Citral, and other monoterpenes from lemongrass, exhibits in-vivo anti-inflammatory using carrageenan induced paw edema and peritonitis in model rat. Paw edema was reportedly reduced by application of citral (100 and 200 mg/kg body weight) and peritonitis was also reduced as leukocyte conversion to peritoneal cavity was mitigated (Quintans-Júnior et al., 2010). In addition, citral is dose dependent in reducing COX-2 mRNA, protein expression and activated peroxisome proliferator-activated receptor (PPARα and γ) in LPS induced U937 human macrophage-like cells (Katsukawa et al., 2010). PPARα and γ are group of nuclear receptor proteins that play essential role in regulation of cell development, differentiation and metabolism by functioning as transcription factor (Kulinsky, 2007).

Equally, Citral was reported to inhibit cytokine production by reducing IL-1β, IL-6 and IL-10 production before and after LPS introduction in animal and peritoneal macrophages, while aqueous methanolic (70%) extract of lemongrass only inhibited IL-6 production (Sforcin et al., 2009; Bachiega and Sforcin, 2011). Water extract of lemongrass, containing linalool and epoxy-linalool oxides, was reported to inhibit IL-1β but induce IL-6 (Sforcin et al., 2009).

Lemongrass tea has been proven to possess analgesic activity due to presence of terpenes (especially myrcene). Hyperalgesia induced by both carrageenan and PGE2, but not dibutyryl cyclic AMP in rat was reported to ameliorated by oral administration of lemongrass infusion in a dose dependent manner (Lorenzetti et al., 1991; Sforcin et al., 2009). Oral application of decoction obtained from lemongrass also possess anti-inflammatory properties by reducing rat hind paw edema previously induced by a subplantar injection of carrageenan (Carbajal et al., 1989).

### Anti-oxidant properties of lemongrass tea

Oxidation is a fundamental process in human cells, tissue and systems leading to formation of reactive oxygen species (ROSs) which include hydrogen peroxide (H2O2), superoxide anion (O2-) and free radicals (Heo et al., 2003). Due to its reactivity, ROSs damage biochemical components like cell membrane, cellular lipids, proteins and DNA (Devasagayam et al., 2004). Additionally, ROS(s) function as major inducer of several health issues like atherosclerosis, rheumatoid arthritis and muscle destruction. Others are cataracts, certain neurological disorders, cancer and ageing. Antioxidants have to be present in the body to offer protective mechanism against damaging effects of oxidation process caused by these radicals (Finkel, 1998; Thannickal and Fanburg, 2000).

Researchers have identified antioxidant potentials of lemongrass extracts and documented their abilities to reduce ROSs. Such mechanism include inhibition of lipoperoxidation and decolorization of 2,2-diphenyl-1-picrylhydrazyl (DPPH) (Sharma and Bhat, 2009; Mirghani et al., 2012). Infusions and decoctions prepared from lemongrass showed antioxidant properties by scavenging superoxide anion, inhibiting lipoperoxidation and decolorizing DPPH. These effects are higher in infusion than decoction (Cheel et al., 2005). Similarly, lemongrass infusion exhibited stronger antioxidant activities in relation to other extracts (methanolic, 80% aqueous ethanol and decoction). Further studies revealed that tannin and flavonoid fractions of oil-free infusion extract were most active anti-oxidative agents compared to phenolic acids fraction (Figueirinha et al., 2008). Aqueous ethanol extract was reported to exhibit antioxidant properties by decreasing reactive oxygen species production and lipid peroxidation, as well
as, increasing superoxide dismutase activity and glutathione formation (Tiwari et al., 2010). Recently, essential oil of lemongrass was also reported to show antioxidant property by DPPH scavenging test. The results showed that both leaves and stalk extracts possess radical scavenging ability in a dose dependent manner (Mirghani et al., 2012).

**Anti-bacteria potential of lemongrass tea**

Anti-bacterial activity in extracts of plant materials has been elucidated from various sources in recent times with promising results. This characteristic has also been investigated in the volatile oil portion of the aqueous extract of lemon grass (Grace et al., 1984). Among the major bioactive compounds identified in the oil were α-citral (geranial) and β-citral (neral) components. These components demonstrate their antibacterial activity by inhibiting the growth of both Gram positive and Gram negative bacteria. However the third component- myrcene possess no antibacterial activity individually but do enhance activity when combined with others (Grace et al., 1984).

**Anti-obesity and antihypertensive activity of lemon tea**

Several investigations have been carried out on the potentials of lemon grass extract as a source of hypolipidemic and hypoglycemic substances which may lower the risks of hypertension and obesity. Available reports showed that citratus aqueous extracts when fed to rats at 500 mg/kg/day led to significant reduction in hypoglycemic index in spite of counter-regulatory factors such as catecholamine, cortisol and glucagon. Hypolipidemic effect was recorded with noticeable reduction in low density lipids levels in the blood stream. The mechanism by which the tea effectively performs these effects remained elusive but several researchers have associated it with increased insulin synthesis and secretion (hyperinsulinemia) or increased peripheral glucose utilization (Adejuwon and Esther, 2007; Celso et al., 2011a).

The presence of anti-hypertensive compounds such as flavonoids and alkaloids has been reported to assist in the hypoglycemic properties exhibited by lemon grass aqueous extract since it contains essential oil and other extractants (Onabanjo et al., 1993; Oladele et al., 1995). Similarly, lemon grass extracts were efficacious in reducing cholesterol levels in the blood stream. Investigators opined that this could be due to the presence of an endogenous ligand of central-type benzodiazepine receptors known as endozepine octadecaneuropeptide (ODN), which are inhibitors of food intake in small animals (Do Rego et al., 2007).

**Anxiolytic properties of lemongrass tea**

In order to elucidate its efficacy in curing anxiety related conditions, researchers have investigated anxiolytic properties of lemongrass tea (Liberalli et al., 1946; Alves et al., 1960; Olaniyi et al., 1975; Nogueira, 1983). Earlier investigations reported negative effects related to anxiolytic properties of the decoctions made from lemon tea (Carlini et al., 1986; Leite et al., 1986). However, recent experimental results revealed that decoctions and infusion (lemon grass tea) made from lemon grass actually exhibit the potential to cause anxiolytic effects when they are fed to animals (Celso et al., 2011a). This was evident from positive results recorded in Light/dark box test. In this particular test, a biphasic dose response (U-shaped) curve which was similar to the curves extensively studied by Calabrese and Baldwin (2003) was reported. Similarly, the anxiolytic effects of the extract appeared to follow a GABAergic system signaling behaviour with established anxiolytic drugs (Celso et al., 2011b). These reports therefore buttressed the use of lemongrass extracts for treatment of ailments of central nervous system (CNS) in folk medicine. However, there are unanimous reports among researchers on the safety of lemon grass tea for domestic and other uses as opined by folk medicine practitioners (Souza Formigoni et al., 1986; Leite et al., 1986; Carlini et al., 1986; United States Environmental Protection Agency, 1997).

**Antinociceptive properties of lemon tea**

The possibility of lemon tea possessing antinociceptive effects has been well researched over the years. Earlier reports showed that lemon grass extracts has little or no positive actions thereby negating the claims in folk medicine (Carlini et al., 1986; Leite et al., 1986; Souza-Formigoni et al., 1986). However, recent investigations presented contra reports. According to Viana et al. (2000), lemon grass tea possessed antinociceptive property which was evident in positive results from different nociceptive testes performed on the extract. Essential oil of lemon grass, which contained citral but no myrcene was investigated for their antinociceptive activities using three experimental models of nociception in mice. The hot plate test showed that response to stimulus by the mice was increased by essential oil administered intra-peritoneally (I.P) while writhing by acetic acid induction showed that intra-peritoneal and oral administration of essential oil caused inhibition of abdominal contraction in a dose dependent manner. In the formalin test, licking time was drastically inhibited by essential oil administered I.P. at both first and second phase of the
experiment (Viana et al., 2000). They reported that opioid receptors are involved in the antinociceptive action since antagonist naloxone blocked the effects of the tested essential oils present in the extract. Same group of investigators opined that the discrepancy noticed with regards to earlier reports could be due to differences in plant chemotypes used for analysis. Citral, obtained from lemongrass, has been reported to possess anti-nociception properties according to the findings of Quintans-Junior et al. (2011) using acetic acid induced writhing and nociception induced by formalin. It was concluded that citral is capable of exhibiting peripheral antinociceptive property by inhibiting writhing and nociception.

**Anti-fungi properties of lemon tea**

The action of essential oils extracted from lemon grass decoction against both pathogenic and edible fungi is of immense contribution as investigated by researchers. Lemon grass oil showed a promising prospect among several essential oils by inhibiting the growth of fungi cells which are implicated in secreting mycotoxins during storage of grains and other food products (Fandohan et al., 2008; Nguefacka et al., 2012). Here, the synergistic effects of oil fractions showed both synergistic and antagonistic effects among different portion of characterized oils (Viana et al., 2000; Nguefacka et al., 2012). Essential oil fraction of lemon tea has been reported to exhibit anti-fungal effects against filamentous fungi of different classes thereby showing its broad spectrum of activity against both disease causing and non pathogenic fungi. Similarly, the oil is capable of inactivating disease causing yeast cells (*Candida spp.*) by inhibiting their growth (Dharmendra et al., 2001).

**Cytotoxicity and anti-mutagenicity**

Several studies (both *in-vivo* and *in-vitro*) have been conducted to investigate cytotoxicity and mutagenicity effects of lemongrass extract in order to confirm the safety of lemongrass tea. All phenolic compounds isolated from methanolic extract of lemongrass were nontoxic to human lung fibroblasts even at high concentration (1 mM) (Cheel et al., 2005). In another study, adult rats subjected to oral consumption of lemongrass tea for 2 months did not cause any toxicity effect on both the rat and their resulting offspring (Lucia et al., 1986). Rat repeatedly feed with lemongrass myrene did not develop tolerance unlike analgesic drug morphine (Sforcin et al., 2009). Protection of mitochondria membrane integrity in stressed murine alveolar macrophages was reportedly restored by 5% ethanol extract of lemongrass therefore exhibiting cytoprotective property (Tiwari et al., 2010). Lemongrass extract obtained using 80% ethanol did not show any mutagenic properties in *Salmonella* mutation test. Even, the extract was able to counter chemical mutation in *Salmonella typhimurium* strains TA98 and TA100 (Vinikettakumuen et al., 1994). Also, damage to chromosome induced by mitomycin C in human lymphocytes was inhibited by lemongrass (Meevatee et al., 1993). Bidinotto et al. (2011) investigated protective effect of essential oil from lemongrass in N-methyl-N-nitrosurea (MNU) induced leukocyte DNA female Balb/C mice. It was reported that lemongrass essential oil exhibited protective action against MNU-induced DNA damage. Consumption of lemongrass infusion preparation was tested for toxicity effect on human. The toxicology effect was reported to be negative as there were no differences in serum biochemical assays, urine analysis and physical examination after 6 and 14 days of drinking lemongrass tea. Although, slight increase in bilirubin and amylase in some of the volunteers observed, such increase did not exhibit any medical implication. Furthermore, lemongrass tea did not show any hypnotic and anxiolytic properties (Leite et al., 1986).

Toxicity and gastric tolerance of three essential oils, including that of lemongrass, were tested in adult rat. Lemongrass essential oil did not show any acute (1 day) and sub-acute (14 days) toxicity when dosed at 5-1500 mg/Kg body weight, but at higher dose, 2000 and 3000 mg/Kg body weight, abnormalities were recorded. LD50 is >3500 mg/Kg body weight. Also, low dosage of oil did not show change in morphological structural of rat stomach and liver, however, higher dosage of oil result into hepatocytes necrosis and leukocytes infestation of liver parenchyma alongside with alteration of stomach structure. Therefore, essential oil from lemongrass is safe for human consumption and can be used for maize storage at prescribe concentration (Fandohan et al., 2008).

**Future trends**

Most studies on lemongrass tea and extracts are prepared through infusion, decoction or organic solvent extraction without considering effects of other factors, such as method of cultivation, harvesting time, controlled oxidation/fermentation, roasting/frying and withering conditions. Previous works have reported that these factors affect composition, physicochemical and biological properties of tea from other sources (Dix et al., 1981). There are possibilities that properties of lemongrass tea
might also be affected if studies consider the above mentioned factors.

Also, conventional solvent extraction techniques form majority of the works on lemongrass. Other extraction aiding method like microwave aided extraction, ultrasonic aided extraction, enzymatic aided extraction, high pressure processing, sub-critical water extraction and supercritical fluid extraction have not been well explored, if studied at all. These novel techniques have been reported to give improve yield and biological properties of products (Wang and Weller, 2006). Supercritical fluid extraction of essential oil from lemongrass was reported to give higher yield compared to hydro-distillation method (Marongiu et al., 2006). Efforts have also been made to investigate the effects of ultrasound processing during the production of lemongrass essential oil-alginate nanoemulsions. This will eventually enhance incorporation of lemongrass essential oil in food matrix and increase its bioavailability (Salvia-Truijillo et al., 2012).

Furthermore, it has been reported that clarification of beverage improve appearance and beverage qualities, no study of such on lemongrass tea has been reported. All these areas that have been identified should form the focus of future researchers working on lemongrass.

References


Wang, L. and Weller, C. L. 2006. Recent advances in extraction of nutraceuticals from plants. Trends in Food Science and Technology 17: 300–312.