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PHARMACOLOGICAL PROFILE OF CYMBOPOGANCITRATUS

Apoorav Mishra*, Meenakshi Malhotra, AkwinderKaur, Ajeet Pal Singh & Amar Pal Singh

Department of Pharmacology, St. Soldier Institute of Pharmacy, Lidhran Campus, Behind NIT (R.E.C.), Jalandhar –Amritsar by pass, NH-1, Jalandhar -144011, Punjab, India.

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Abstract

Cymbopogoncitratus is an aromatic plant of Gramineae family well-known as lemon grass. Cymbopogon is derived from Greek word "kymbe – pogon" which means boat-beard. The lemon-like scent could be ascribed to the existence of a cyclic monoterpene (citral). The herb is a perennial grass, native and distributed in Asia, Africa, South and North America. It contains considerable group of flavonoids, essential oils, phenolic compounds and other phytochemical constituents which possesses pharmacological activities such as anti-obesity, anti-carcinogenic, anti-bacterial, anti-fungal, anti-nociceptive, anti-oxidants anti-diarrheal, and anti-inflammatory properties which could enhance health.It has also been known to restrain platelet composition, cure diabetes, gastrointestinal infections, anxiety or depression, malaria and pneumonia. Industrially, they serve as additive, flavour, insecticides and preservative in beverages, baked foods and cuisines. The essential oil of the plant is used in aromatherapy. The compounds identified in Cymbopogoncitratus are mainly terpenes, alcohols, ketones, aldehyde and esters. Some of the reported phytoconstituents are essential oils that contain Citral α, Citral β, NerolGeraniol, Citronellal, Terpinolene, Geranyl acetate, Myrecene and TerpinolMethylheptenone. The plant also contains reported phytoconstituents such as flavonoids and phenolic compounds, which consist of luteolin, isoorientin 2'-O-rhamnoside, quercetin, kaempferol and apiginin. Studies indicate that Cymbopogoncitratus possesses various pharmacological activities such as anti-amoebic, antibacterial, antidiarrheal, antifilarial, antifungal and anti-inflammatory properties. Various other effects like antimalarial, antimutagenicity, antimycobacterial, antioxidants, hypoglycemic and neurobehaviorial have also been studied. These results are very encouraging and indicate that this herb should be studied more extensively to confirm these results and reveal other potential therapeutic effects.

Keywords: Cymbopogoncitratus, anti-carcinogenic, anti-bacterial, anti-fungal, anti-nociceptive and neurobehavioral.

***Corresponding Author**

Apoorav Mishra

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Introduction

Cymbopogon comprises approximately 55 species, primarily found in tropical and semi-tropical regions of Asia, although they're also grown in South and Central America, Africa, and other tropical locales. These plants are characterized by tufted perennial C4 grasses, boasting multiple rigid stems emerging from a compact, rhizomatous rootstock [1 ,2], as with citrus flavor, and can be dried and powdered or used fresh. The name Cymbopogon is derived from the Greek words "kymbe" (boat) and "pogon" (beard), referring to the flower spike arrangement [3, 4]. In the past, an increasing number of consumers are looking for new herbal products with unique features that provide acceptable moments while having enough health benefits4. Herbal drugs were produced from scientific or systematic study of the bioactive constituents, ethnopharmacology or indigenous knowledge of medicinal herbs [5, 6]. This forms the bedrock of the advancement in phytochemistry. In recent times, almost 10,000 medicinal herbs have been documented and about 4500 have been examined for the bioactive components and pharmacological assays. One of the medicinal herbs with immeasurable pharmacological activities is C. citratus. Lemongrass (Poaceae) is a perennial grass which is evenly dispersed and found in the tropic regions, South and Central America widely used for their pleasant taste and therapeutic properties [5,7]. It is widely known as lemongrass or citronella but due to its distribution, it has several names

Figure 1: Different Species of Cymbopogoncitratus

Taxonomy

Kingdom: Plantae, Division: Magnoliophyta, Class: Liliopsida, Order: Poales, Family: Poaceae, Genus: CymbopogonSpreng, Species: citratus

Local Names

Brazil (Capim-cidrao, Capim-santo), Chinese (Xiangmao), Egypt (Lemon grass), Ethiopia (Tej-sar), Indonesian (Sereh), India (Gandhabene), Italian (Cimbopogone), Malaysia (Sakumau), Mexico (Zacatelimon), Swedish (Citrongrass), Thailand (Ta-khrai), Turkish (Limon out), USA (Citronella)[4].

Botanical classification

Cymbopogoncitratus is a perennial herb with tiny long and needle-like leaves. The strap-like leaves are about 1.3–2.5 cm in width, 0.9 cm long with loose tips and glossy bluish-green colouration with a citrus aroma when grounded due to the presence of citral and high content of neral and aldehyde geranial [8, 9]. The leaf blade is about 18–36 cm with parallel venation and showy fall characteristics. They do not produce flowers or panicles (cultivars). The inflorescence is approximately 30–60 cm with paired racemes of spike-lets for partial inflorescence. The plant grows in fertile clumps and can reach about 1.8 m and 1.2 m in height and width, respectively [10.] The dry leaf contains about 1–2% of essential oil11 with bioactive chemical constituents varying depending on their habitat, genetic differences and agrarian treatment.

Propagation

The plant is propagated via division of clumps or genetically clones through vegetative means. Genetic propagation could result to discrepancy, deterioration and reduction of oil yield and quantity. The plant grows well on fertile, sandy-loam soil (pH of 2–12) with constant moisture [12].

Traditional Importance

In Asia, South America and Africa continents, the leaves have been traditionally used as tea or decoction. The leaf contain vital bioactive compounds which dictate the anti-inflammatory, antiseptic, anti-dyspeptic, and anti-fever effects, antispasmodic, analgesic, antipyretic, tranquilizer, anti-hermetic and diuretic properties of the plant6. They serve as deodorants in several products such as perfume, local soaps, candle and other insect repellents. It has been used as snake and reptile repellents in some part of Asia and African countries.

Economic importance

Essential oils such as citral, genariol, α-oxobisabolene and myrcene isolated from C. citratus are important raw materials in soap and detergent, food, beverage, perfume, cosmetic and confectionaries industries.

Phytochemistry

The chemical composition of the essential oil of Cymbopogoncitratus varies according to the geographical origin, the compounds as hydrocarbon terpenes, alcohols, ketones, esters and mainly aldehydes have constantly been registered. The essential oil (0.2–0.5%, West Indian lemon grass oil) consists of, mainly, citral.Citral is a mixture of two stereoisomericmonterpenealdehydes7,12; the trans-isomer geranial (40–62%) dominates over the cis isomer neral (25–38%) [13].

The therapeutic potential of medicinal herbs could be associated to the presence of phytochemicals or secondary metabolites. These compounds are evenly spread in medicinal plants. The Important compounds such as phytosterols, anthocyanin, amino acids, organic acid, phenolic compounds, volatile components, fatty acids, fumesol, flavonoids, isovaleranic aldehyde, methylheptenone, valericesters, L-linanool, furfurol, isopulegol, p-coumaric acid have been isolated and characterized from C. citratus.

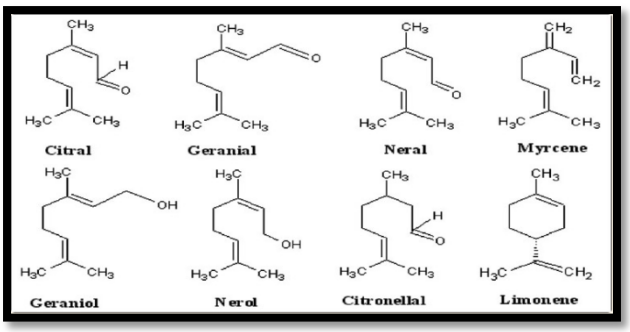


Figure 2 Chemical Structure of major constituents of *CymbopoganCitratus*

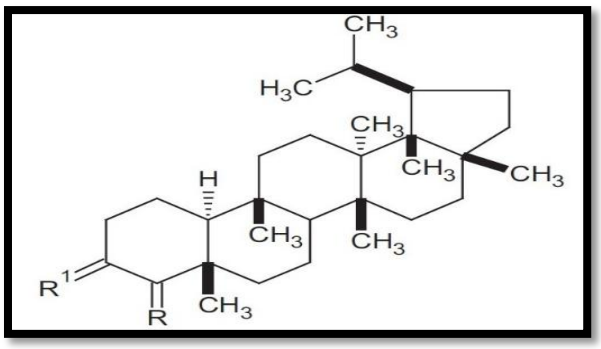


Figure 3. Chemical structure of cymbopogone and cymbopogonol

Essential Oil

Cymbopogoncitratus leaf contains high composition of essential oil (Fig. 1) [14]. It contains citral (mixture of terpernoids and geranial), mycrene, genariol, citronellol (cymbopogonol and cymbopogone) and α-oxobisabolene. Their contents varies depending on plant species and geographical location (West Indian lemon grass has 12–15%, East Indian has 10–13%) [15]. Citral is important in flavor formation of the plant [47]. Major constituents such as neointermediol (7.2%), selina-6-en-4-ol (27.8%), α-cadinol (8.2%), methyheptenone (1.2%), eudesma-7(11)-en-4-ol (5.3%), 3,7-dimethyl-1,3,6-octatriene (0.58%), decanal (0.25%) and naphtalene(0.79%), have been reported. Recent analyses revealed the presence of elemol (41%), β-eudesmol (45%), cubebol (4.7%), humulene (4%), citral acetate, citraldiethylacetal, verbenone, sabinene, geranyl acetate, citronella, mentha-1(7), limonene (19.33%), 8-dien-2-ol cis (17.34%), mentha-2,8-diene-1-oltrans-para (13.91%), mentha-1(7),8-dien-2-ol trans (13.95%) and mentha-2,8-diene-1-ol cis-para (8.10%) [16].

Proximate Analysis

Cymbopogoncitratus contains low moisture content (5.7%) (Responsible for the marked antimicrobial activities and storage capacity), crude fiber (9.28%) (Aids digestion of food and makes food well absorbed by the body), crude fat, crude ash, crude protein and 5% carbohydrate (energy supplier or booster). However, crude fiber is considerably high in lemon grass when compared to other conventional plants [17].

Mineral content

Cymbopogoncitratus contains important mineral constituents such as potassium (K), sodium (Na), magnesium (Mg), manganese (Mg), iron (Fe), zinc (Zn), phytate and phosphorus (P) (Table 4). The phytate concentration has been estimated as11860 mg/100 g and reported to have sufficient amount of zinc due to the molar concentration of Phytate: zinc of 10 (recommended limit) to 15 (unsafe due to excess amount), Calcium to Phytate (0.05), Phytate to Zinc (9.6) and Calcium to Phytate (6:1) [18].

Triterpenoids

Isolated and identified new triterpenoids from leaf wax are cymbopogone and cymbopogonol.

Flavonoids and Phenolic Compounds

Lemongrass consists of luteolin and its 6-C and 7-O–glycosides, 9 isoorientin 2'-O-rhamnoside10 and isolation of the flavonoids quercetin, kaempferol and apiginin11 from the aerial parts. The phenolic compounds elimicin, catecol, chlorogenic acid, caffeic acid and hydroquinone are also isolated from the plant [19].

Pharmacological Activity

Toxicology

The toxicological studies of lemon grass have been mired, owing to reports of some intriguing factors such as application time and duration, mode of extraction, presence of interfering elements such as heavy metal contamination from the soil, adulteration, and the health status of tested organisms and chemical response of organisms to stimuli. The presence of coumarins, tannins, anthraquinone and saponins had been reported to contribute to the toxicity of the plant. Despite these hypotheses, herbal drugs from the plant are safe with no health issues from its usage due to the acceptable concentrations limit of these compounds [20]. The plant contains low anti-nutrients and this could be due to the absence of phlobatannins, heavy metals, and glycosides [21]. The leaves have been processed as herbal drinks in sup- pressing stress and anxiety [22]. Despite scientific reports of low toxicity level of C. citratus, frequent consumption should be carefully addressed and individual with health challenges such as liver and kidney diseases, pregnant and lactating women and children under age of 4 years should cautiously handle herbal drugs, tea or decoction prepared from the plant.

Effect on Obesity

The study found that the combination of Cymbopogoncitratus herbal tea consumption and physical exercise led to significant declines in anthropometric parameters and hemodynamic

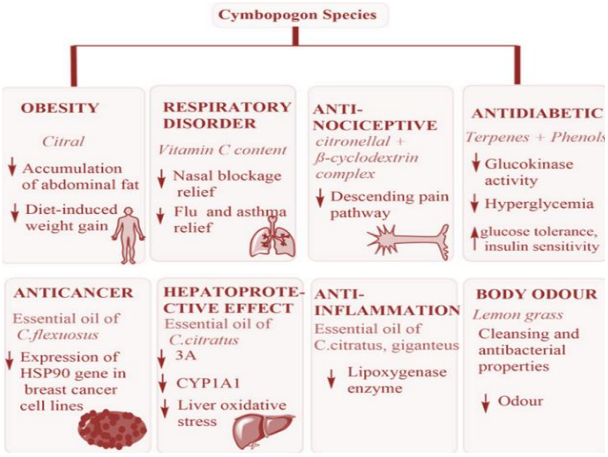
factors in obese women, compared to isolated treatments. This aligns with previous research indicating that aerobic exercise and dietary fiber-rich foods can reduce weight and improve cardiovascular health. Specifically, the combined treatment resulted in a more pronounced decrease in anthropometric measures and better control of blood pressure and heart rate compared to individual treatments. These findings support the synergistic effects of combining herbal tea consumption and exercise for managing obesity-related risks [23].

Anti-amebic Effect

The essential oil in broth culture was active on Entamoebahistolytica [24].

Antibacterial Activity

The chromatographic fraction of the essential oil in agar plate was active on Bacillus subtilis, Escherichia coli, Staphylococusaureusand Salmonella paratyphi and Shigellaflexneri. These activities are shown in two of the three main components of the oil identified through chromatographic and mass spectrometric methods. While the α-citral (geranial) and β-citral (neral) components individually elicit an antibacterial action on gram-negative and gram-positive organisms, the third component, myrcene, did not show any observable antibacterial activity on its own.The extract was also active when the volatile oil extract was oxidized via the active oxygen method [20]. In folk medicine, the plant has been used to combat bacterial infections such as meningitis, pneumonia, impetigo, cellulitis, folliculitis and food poisoning. They have been reported to be effective against Clostridium botulinum, Campylobacter jejuni, Escherichia coli, Salmonella and Listeria monocytogenes. Myrcene, an essential oil in C. citratus has been reported to show low inhibition against bacteria but incorporation with other essential oils could give significant activities [24].



Antidiarrheal Activity

Cymbopogoncitratus stalk decoction reduced the fecal output in a dose-dependent manner [24].

Antifilarial Activity

Fresh leaves were active on Setariadigitata [21].

Antinociceptive activity

In folk medicine, lemon grass has been significantly important in reducing pains and anxiety in living organisms. In ancient time, the plant was used as analgesic or pain reliever for surgical operations and could help reduce behavioural and physiological responses of the body to excessive pains [25,26]. Antifungal Activity Lemon grass oil is active against such dermatophytes such as Trichophyton mentagrophytes, T. rubrum, Epidermophyton floccosum and Microsporum gypseum and is among the most active agents against human dermatophytes. Other studies reported that lemon grass oil is active against keratinophilic fungi, 32 ringworm fungi and food storage fungi. Lemongrass oil is also effective as an herbicide and as an insecticide because of these naturally occurring antimicrobial effects22.Essential oils from lemon grass have been reported to show significant resistance to pathogenic fungi cells causing disorder in proper secretion of mycotoxins during storage of grain and other food substances [8,9]. It also shows pronounced inhibition against fungal infections such as athlete's foot, ringworm, jock itch and yeast infections, antagonistic and synergistic effects by inhibiting the growth of filamentous fungi via inactivating of yeast cells.

Antioxidant activity

Cymbopogoncitratus contain natural antioxidants, such as caffeoylquinic acid, flavonoids, chlorogenic acids, phenolic aciids, swertiajaponin and isoorientin. These compounds could be responsible for the diminishing low-density lipoprotein (LDL) oxidation induced by Cu2+27, reducing capability of

plasma (FRAP), β-carotene and 1, 1-diphenyl-2-picryl-hydrazyl (DPPH) assays [19]. It also help suppress oxidative stress in Winstar rats investigated for diabetic conditions.

Anti-inflammatory Activity

The hot water extract of the dried leaves administered intragastrically to rats was active when compared with carrageenin-induced pedal edema24. Chronic inflammation is one of the prominent global health challenges and had been linked with life-threatening diseases, such as cancer28. Natural products have been used in folk medicine to combat the insurgence of tissue inflammation in man. The ethnopharmacological studies of lemon grass explained its usage as anti-inflammatory herbal drugs in African and Asia countries. Citral extracted from C. citratus has enormously inhibited inflammatory mediators and serve as additives in creams and ointments to treat topical inflammation. It has also been reported to suppress tumor necrosis factor (TNF)-α-induced neutrophil adherence at concentration of 0.1% 29, inhibit inducible nitric oxide synthase (iNOS), nitric oxide production (NO) and other lipopolysaccharide (LPS)-induced pathways , covalently bind to the receptors thereby inhibiting the nuclear factor-kappaB (NF-ƙB) pathway 30, 60–70% suppression of COX-2 and peroxisome proliferator-activated receptor alpha (PPAR-α) and orally and topically inhibit tissue inflammation (80–90%). Certain isolated compounds and derivative isolates from C. citratus such as citral, epoxyestragole, 6,7-epoxycitral, Luteolin, peritoneal and 6,7-epoxycitronellal, glycoside (O-,C-), 8,9-epoxycarvone, and carvone, have effectively inhibited the secretion of the prostagladins (PGE2) and NO associated with inflammations, anti-inflammatory mediators connecting the sugar moiety and the aglycone and suppressing postoperative cramps and pains identified with surgery by lowering the expression of specified pain mediators.

Antimalarial Activity

The essential oils of Cymbopogoncitratus were found to produce 86.6% suppression in the growth of Plsmodiumberghei when compared with chloroquine (taking inhibition by chloroquine as 100%) [24, 31]. Secondary metabolites such as citral (3, 7-dimethyl-2, 6-octadienal), myrcene and citronellal have been isolated from lemon grass and were characterized as antimalarial compounds. These isolated compounds show pronounced activity against Plasmodium species. Dichloromethane extract of C. citratus was tested against P. berghei and P. falciparum with pronounced activities of 2–10 µg/mL27,32. Ethanolic extracts show pronounced antiplasmodial activities of EC50 against two strains of P. falciparum (multidrug resistant (Dd2) (54.84) and CQ-sensitive (3D7) (28.75). It could also improve the antioxidant status of oxidative stress-associated complications during malaria.

Antimutagenicity

The ethanolic extract of lemon grass extract exhibits an antimutagenic activity in various modelsand retards the growth of fibrosarcoma cells transplanted in mice in association with the prevention of lung metastasis. Theplant extract is known to show inhibition on the formation of azoxymethane-induced DNA adducts and aberrant crypt foci in the rat colon. Inhibitory effects of the plant extract on the early phase of hepatocarcinogenesis after initiation with diethylnitrosamine were seen in 34 male Fischer rats [33, 34].

Antimycobacterial Activity

The essential oil in agar plate was active on Mycobacterium smegaris35.

Ascaricidal Activity

The fresh leaf essential oil has an ascaricidal activity [36, 37].

Anti-HIV activity

Citronella oil isolated from C. citratus leaf was reported to effectively cure mouth thrush caused by Candida albicans in HIV/AIDS patients within 1–5 days [38].

Antiprotozoan Activity

A dose-dependent antiprotozoan effect of the essential oil of Cymbopogoncitratus could be observed on two strains of Crithidadeanei [19].

Free Radical Scavengers and Antioxidant Effects

Methanol, MeOH/water extracts, infusion and decoction of Cymbopogoncitratus were shown to have free radical scavenging effects by measuring the bleaching of the 1, 1-diphenyl-2-picryl-hydrazyl (DPPH) radical, scavenging of the superoxide anion and inhibition of the enzyme xanthine oxidase and lipid peroxidation in human erythrocytes [39].

Insecticidal activity

Essential oils from C. citratus have been applied in the control of pathogens and insects [40]. It has been reported to be effective against Aedesaegypti,

Phemacoccussolenopsis, Muscadomestica and Dermatophagoidessp [41].

Hypocholesterolemic Effect

The elevated cholesterol concentration was significantly lowered in the animals given the plant extract. This reduction was found to be dose dependent. This result shows that the extract possesses a hypocholestecolemic potential [42].

Hypoglycemic and Hypolipidemic Effects

A fresh leaf aqueous extract of Cymbopogoncitratus administered in normal rats lowered the fasting plasma glucose and total cholesterol, triglycerides, low-density lipoproteins and very low-density lipoprotein dose dependently while raising the plasma high-density lipoprotein level in the same dose-related fashion, but with no effect on the plasma triglyceride levels [43]. Lemon grass has been incorporated in hypolipidemic and hypoglycemic drugs. In folk and Ayurvedic medicine, it has been used to regulate glucose, lipid and fat level in the blood serum which could prevent obesity and hypertension, usually taken as tea [10]. The plant has been used to maintain blood glucose through secretion of insulin (hyperinsulinemia). It reduces blood pressure which could lead to hypertension [11]. Citral isolated from C. citratus has function as endothelium-independent vaso-relaxation through the blockage of Ca2+ influx and prostacyclins (PGI2) channel.

Dermatotoxicity activity

Cymbopogoncitratus has been incorporated in herbal soap to treat rashes, itchy and swollen skin44. Herbal soap produced from C. citratus leaf, tea tree oil and orange peel was investigated for their dermatoxicity potency using clinical samples. Significant activity of 60% ($p < 0.05$) was observed after 40 days of treatment with the soap [99]. Similar investigation reported significant inhibition of 85.35% against Microsporumcanis when treated with C. citratus oil (1 µL/mL). Shampoo incorporated with citral was effective against fungus (Malassezia furfur) inherent in dandruff [45].

Larvicidal Activity

The fresh leaf essential oil has a larvicidal activity [46].

Neurobehavioral Effect

The essential oil was evaluated for sedative/hypnotic activity through pentobarbital sleeping time, anxiolytic activity by elevated plus maze and light/dark box procedures and anticonvulsant activity through seizures induced by pentylenetetrazole and maximal electroshock. The essential oil was effective in increasing the sleeping time, the percentage of entries and time spent in the open arms of the elevated plus maze as well as the time spent in the light compartment of the light/dark box. In addition, the essential oil delayed clonic seizures induced by pentylenetetrazole and blocked the tonic extensions induced by maximal electroshock, indicating the elevation of the seizure threshold and/or blockage of the seizure spread[47].

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S.No.	Study Type	Dose	Outcomes	Reference
1.	In vitro	Hydrogel was developed using nanoparticles	anti-herpetic activity	48
2.	In vitro	60 mg L−1 of C. citratus EO	controlling infection by monogeneans in C. macropomum	49
3.	In silico and In vitro		in vitro CEO exhibit good DPPH radical scavenging activity; *In silico* prediction and molecular docking studies showed that Caryophyllene oxide and β-Caryophyllene contributed to antioxidant and anti-inflammatory activity of CEO	50
4.	in vitro	0, 50, 100, 150 and 200 µg/mL	anticarcinogenic effect	51

Conclusion

In conclusion, *Cymbopogon citratus* (lemongrass) is a highly valuable medicinal plant with a broad spectrum of pharmacological activities, attributed to its rich phytochemical profile, including essential oils, flavonoids, and phenolic compounds. The presence of bioactive compounds such as citral, geraniol, and flavonoids like luteolin and quercetin contributes to its diverse therapeutic properties. Scientific studies have demonstrated its anti-inflammatory, antioxidant, antibacterial, antifungal, anti-diarrheal, and antimalarial properties, among others. Furthermore, its potential in treating conditions such as diabetes, gastrointestinal infections, anxiety, and depression highlights its significance in traditional and modern medicine. The plant's industrial applications as a flavoring agent, preservative, and insecticide further enhance its utility. While current research is promising, further in-depth studies are required to fully explore and confirm the therapeutic potentials of *Cymbopogon citratus*, opening new avenues for its use in clinical and pharmaceutical settings.

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If any

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Conflict of Interest

No conflict of Interest

Informed Consent

Not applicable

Ethical Statement

Not declared

Author Contribution

All Authors Contribute equally

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