ISSN 0976 – 3333

Available Online at www.ijpba.info

International Journal of Pharmaceutical & Biological Archives 2012; 3(5):1035-1043

REVIEW ARTICLE

Potential Functions of Lemon Grass *(Cymbopogon citratus)* in Health and Disease

Vanisha S. Nambiar* and Hema Matela

Department of Foods and Nutrition, Faculty of Family and Community Sciences, The M.S. University of Baroda, Vadodara-390002,Gujarat, India

Received 06 May 2012; Revised 05 Oct 2012; Accepted 15 Oct 2012

ABSTRACT

Plants are utilized as therapeutic agents since time immemorial in both organized (Ayurveda, Unani) and unorganized (folk, tribal, native) form. Plants have been identified as the potent therapeutic agent, due to the presence of nutritional (minerals and vitamins) and non-nutritional (fibres, active phytochemicals, including the flavonoids, terpenoids, lignans, sulfides, polyphenolics, carotenoids, coumarins, saponins, plant sterols, curcumins, and phthalides) component, hence promoted as "functional food". The present paper highlights the functional properties of Lemon grass (*Cymbopogon citratus*), which has been consumed in various forms such in Thai, Vietnamese and South East Asian cuisines. It is a highly rated folk medicine in Brazil and have been associated with health claims such as treatment in coughs, constipation, elephantiasis flu, gingivitis, headache leprosy, malaria, ophthalmia, pneumonia, vascular disorders, diarrhoea and stomach ache. It has been claimed to be anti-inflammatory, vasorelaxing, diuretic, remedy in treating ringworm infestation, for nervous, gastrointestinal disturbances, fevers and hypertension. Lemon grass has high antioxidant levels. However, though it has obtained a GRAS status, clinical trials on humans are warranted.

Key words: functional food, lemon grass, Cymbopogon citratus, antioxidant.

INTRODUCTION

Lemon grass *Cymbopogon citratus* is an aromatic perennial tall grass with rhizomes and densely tufted fibrous root. It has short underground stems with ringed segments, coarse, green slightly leathery leaves in dense clusters (Carlin, *et al*., 1986). The plant is a native herb from India and is cultivated in other tropical and subtropical countries. (Figueirinha *et al* 2008). The Botanical classification of lemon grass is presented in (**Table 1**). Several species of lemon grass such as *Cymbopogon bombycinus* , *Cymbopogon ambiguus* , *Cymbopogon obtectus* , *Cymbopogon refractus*, *Cymbopogon citrate*, *Cymbopogon nardus*, *Cymbopogon schoenanthus* etc found in countries such as Australia, China, India, Africa and others (**Table 2**). There are several varieties of lemon grass available in the market ranging from Sugnadhi OD 19 to CKP 25 as seen in (**Table 3**).

Agro-climatic Requirements

The crop grows well in both tropical and subtropical climates at an elevation up to 900 m. However, ideal conditions for growing lemon grass are warm and humid climate with sufficient sunshine and 250-330 cm rainfall per annum, evenly distributed over most part of the year. A temperature ranging from 20-30^0 C and good sunshine throughout the year is conducive to high crop yield. Lemon grass can also be grown in semi-arid regions receiving low to moderate rainfall.

Lemon grass can grow well over medium fertile soils and moderate irrigation. Well drained sandy loam is most suitable for the growth of the plant. It can be grown on a variety of soils ranging from loam to poor laterite. Calcareous and water logged soils should be avoided as they are unsuitable for cultivation.

Traditional use of lemon grass

Lemon grass has been used as a food ingredient, in cosmetics and as folk medicines in several regions of the world (**Table 4**).

As a Food ingredient:

Lemon Grass is used as a basis of a popular drink in the tropics. It is known as "Takrai" in Thailand

***Corresponding Author:** Dr. Vanisha S. Nambiar, **Email:** vanishanambiar@gmail.com

as it is used in many Thai cuisines. In the western world, it is often used in curries, marinades and sea foods soups (www.floridata.com); added to salads in Vietnam (www.viable_herbal.com); used for the preparation of soft drinks and as an aromatic, pleasant- tasting herbal tea all around its distribution area in Peru. In Java, it is used in preparation of highly spied "sherbet" (Burkill, 1935).

In Cosmetics:

Due to its lovely fragrance, lemon grass is used as a flavouring ingredient in several products such as soaps, perfume, candle, mosquito and other insect repellents (Praditvarn, 1990).

In Folk medicine:

Though there are limited scientific data on the medical claims of lemon grass, it has been used in traditional medicine for treatment of several ailments (Simon *et al* 1984), stated that *C. citratus* is used in different parts of the world in the treatment of digestive disorders, fevers, menstrual disorder, rheumatism and other joint pains .The infusion or decoction of aerial parts of Lemon Grass has wide spread used in folk medicine. (Carlin *et al* 1986) has reported that this plant is recommended to treat digestive disorder, inflammation, nervous disorder and fever as well as other health problems.

In Ref Heinerman's Encyclopedia of Healing Herbs & Spices, John Heinerman recommends using one cup of lemongrass tea every four hours to reduce fever. In the Green Pharmacy, prominent herbalist James Duke recommends drinking one to four cups of lemongrass tea a day to benefit from its anti-fungal properties.

The study was performed by (Carbajal *et al* 1989) with doses similar to those employed in traditional medicine and reported a weak diuretic and anti-inflammatory effect for the oral intake of a 10 or 20% decoction at a dose of 25 mL/kg in rats.

(Puatanachokchai *et al* 2002) stated that lemongrass contains some components that may be cancer chemo preventive. In fact, the extract has been shown to inhibit rat colon carcinogenesis in animal models.

(Stehmann *et al* 1995*)* reported that The LG tea also has diuretic properties and can help in urinating difficulties and water retention.

According to (Nogueira *et al* 1983) Lemon Grass was indicated as medicine for "psychoneurological diseases" by 201 out of 479 women that attend health centre in Sao Paulo, being the most used plant for this purpose**.** In support to this study (Ramirez *et al* 1988) reported that extracts of both the leaves and stalks of *Cymbopogon citratus* are used as an herbal medicine to treat nervous condition and inflammation.

Chemical analysis of *Cymbopogon citratus* extracts

Proximate analysis of lemon grass:

Asaolu *et al* 2009, from Department of Biochemistry, University of Ado-Ekiti, Ado-Ekiti, Nigeria conducted proximate analysis of lemon grass, 300 g of powdered leaves of Cymbopogon citratus were soaked in 500 ml of 95% ethanolThe extracts was filtered and the filtrates was concentrated by rotary evaporation to form ethanolic extract and the results are shown in (**Table 5**) .

The low moisture content (5.7%) of C*ymbopogon citratus* is desirable, as it will prevent microbial attacks and allows for high storage capacity ,The carbohydrate content is high (55.00%). This shows that *Cymbopogon citratus* is a very good source of energy. The crude fibre content (9.28%) of *Cymbopogon citratus* on the other hand is higher than that reported for other leaves; this makes *Cymbopogon citratus* to be a good source of crude fibre than other conventional leaves (Tindall *et al* 1986).

Mineral composition (dry weight, mg/100g)

Fagbohun et al 2010, studied the mineral composition of Lemon Grass, the plants was air-dried and pulverized into powder. About 5g of the powdered sample was weighed into100ml of distilled water and 75g of the powdered sample of was weighed into 175ml of methanol in a separate conical flask and was allowed to soak for five days. The extract was decanted and filtered with Whatman No.1 filter paper. The filtrate (extract) was evaporated to dryness at 40 ^{0}C in a rotary evaporator. The concentrated extract plant was stored at 4 ^{0}C until when required for use

(**Table 6**). The absence of some heavy metals (Lead, Mercury etc.) in *Cymbopogon citratus* makes it desirable for consumption.

They also evaluated that the Phytates content of lemon grass is 11860mg /100g, Phytate and Zn ratio is 9.6, Ca / Phytate 0.05. Harland & Oberleas (1986), showed that foods with a molar ratio of Phytate : Zn less than 10 showed adequate availability of Zn and problems were encountered when the value was greater than 15. (Frans *et al*

1980) demonstrated a lower availability of Zn in rats when fed with foods of high molar ratios of Phytate: Zn. According to (Wise 1983) Ca: Phytate at molar ratios lower than 6:1, Phytate precipitation is incomplete, so that some of the dietary Zn remains in solution. The proportion remaining in solution increases with decreasing Ca: Phytate molar ratios. So we conclude that lemon grass can be used as a rich source of Zn.

Phytochemical composition

Shah *et al* 2011, identified terpenes, alcohols, ketones, aldehyde and esters as main compounds in in *Cymbopogon citratus*. The major phytoconstituents are essential oils (that contain Citral α, Citral β, Nerol Geraniol, Citronellal, Terpinolene, Geranyl acetate, Myrecene and Terpinol Methylheptenone.) flavonoids and phenolic compounds, which consist of luteolin, isoorientin 2'-O-rhamnoside, quercetin, kaempferol and apiginin.

Asaolu *et al* 2009, analysed the phytochemical constituents of the leaves of *Cymbopogon citratus* using the methods of (Sofowora et al. 1982). It shows that Lemon Grass contains alkaloids, saponins, tannins, anthraquinones, steroids, phenols and flavonoids. Each or these phytochemicals is known for various protective and therapeutic effects. For instance, phenol was known to be an erythrocyte membrane modifier, (Adesanya and Sofowora, 1983, **Table 7**).

Lemon grass as a source of antioxidant

A study conducted in Manipal University, Karnataka India by (Rao *et al* 2009) under the broad objective "to check the free radical scavenging and antigenotoxic effect of hydro-alcoholic extract of *Cymbopogon citratus* (CCE)." Revels that The CCE at a concentration of 60 µg/mL resulted in a significant scavenging ability of 2,2-diphenyl-2-picryl hydrazyl (DPPH; (85%), 2,2-azinobis (3-ethyl benzothiazoline-6-sulphonic acid) (ABTS; 77%), hydroxyl (70%), superoxide (76%), nitric oxide (78%) free radicals generated using *in vitro* and also a moderate anti-lipid per oxidative effect (57%) and concluded that Lemon grass has high antioxidant capacity.

Naiyana *et al* 2010, determined antioxidant capacity of Lemon Grass through different methods **[** DPPH (1,1,3,3-tetramethoxypropane and 1,1- diphenyl –2 – picryl – hydrazyl), FRAP (Ferric Reducing Antioxidant Potential) , ABTS (2,2′-azino-bis-(3-ethyl benzothiazoline-6-sulfonic acid) **]** using different standards [g Gallic acid equivalent (GE), g ascorbic acid equivalent (AE), g ρ-hydroxycinnamic acid equivalent (HCE) & g Trolox equivalent (TE)] and the results are given in (**Table 8**).

The most active principle having antioxidant property found in botanical products are not only vitamins but also chemicals like phenols, polyphenols and flavonoids. Flavonoids are products of plants metabolism and have different phenolic structure (Oberley 1988).

Patel and Mehta 2006,evaluated the compounds having antioxidant property in lemon Grass and found that dry lemon grass contain more phenol and flavonoids than fresh one. Hence we can infer that the dried lemon has greater antioxidant potential than the fresh lemon grass (**Table 9**).

A study conducted by (Oboh *et al* 2010) in Nigeria with a broad objective "to study the phenolic phytochemicals and antioxidant properties of cold water extract (CWE) and hot water extract (HWE) of *Cymbopogon citratus"* showed that in a dose dependent manner, Hot Water Extract had significantly higher DPPH radical scavenging ability, Fe2+ chelating ability and OH* scavenging ability than Cold Water Extract. Conclusively, heat treatment may affect antioxidant properties due to release of phenolic phytochemicals, hence contributing to the health promoting and disease preventing abilities of *Cymbopogon citratus*.

Orrego *et al* 2009, compared antioxidant property of two types of Hot extract (infusion and decoction) they prepared Infusion by soaking 10 g of air-dried, powdered plant material in 250 mL of boiling water for 15 min. Decoction 10 g of air-dried, powdered material boiled in 250 Ml of water for 2.5 h. results of HPLC analysis of infusion and decoction prepared from Lemon Grass shows that infusion is better than decoction (**Table 10**).

The main compounds obtained from the plant *C*-glycosylflavones orientin and isoorientin as well as chlorogenic acid. Recently, isoorientin and chlorogenic acid have been shown to display hypoglycaemic effects in streptozotocin diabetic rats, (**Table 11**) (Andrade-Cetto and Wiedenfeld , 2001).

Myeloperoxidase is an oxidant enzyme which has pronounced effects on the inflammation and atherogenesis, Flavonoids through a series of steps reacts with MPO in the presence of hydrogen

peroxide and prevents reaction of NO_2 with LDL. Thus preventive to per oxidation of lipid moiety and tyrosine nitration of apo-protein (Sies *et al* 2005)

Antioxidant potential of lemon grass in comparison to other herbs

Tangkanakul 2009, conducted a comparative study on Antioxidant capacity and total phenolic content of herbs, spices and vegetables and found that Lemon Grass has better antioxidant capacity than Coriander (leave and stem) Ginger, Tomato and Garlic. And less TAC than Turmeric, Cumin, dried Curry powder. Order of total antioxidant capacity of herbs analysed in the study was Turmeric > Cumin, dried > Curry powder > Lemon Gras > Coriander (leave and stem) > Ginger > Tomato > Garlic (1126.12 ± 94.2 > 302.26 ± 0.9 > 236.55 ± 7.9 > 120.57 ± 5.46 >92.18 ± 62.9 > 62.24 ± 0.19 > 22.97 ± 4.8 > 8.77 ± 1.93 mg VCE/100 g respectively.)

Out of these Turmeric, Cumin (dried), Curry powder, Coriander (leave and stem), Ginger, Tomato, Tamarind juice, Garlic are very regularly used spices and herbs in Asian diet but lemon grass is not used as much, as lemon grass has good Antioxidant capacity than many other spices so it can a suitable vehicle to improve the body antioxidant capacity by incorporating in our diet (**Table 12**).

Apart from health promoting bioactive compounds (Masuda *et al* 2008) 1st time reported the tyrosinase inhibitory activity of trans and cis geranic acid present in lemon grass in dose dependent manner between 0.03-1 Mm. The tyrosinase inhibitory activity of the trans- and cis-geranic acids (1 and 2) was measured. trans-Geranic acid showed a clear dose–response curve between 0.03 and 1 mM, Although the cis-geranic acid also showed a dose–response curve, the activity of 2 was much weaker than that of 1 (IC50) 2.3 mM). The activities of these geranic acids were weaker than that of kojic acid (IC50) 0.017mM), a potent tyrosinase inhibitor.

Clinical trials studies of lemon grass

Animal studies:

In a study of twenty rats, carageenan-induced edema was inhibited by 18.6% in rats receiving oral doses of a 20% lemongrass leaf decoction as compared to 58.6% in the control group of rats receiving indomethacin (Carbajal *et al*, 1989).

Lorenzetti *et al* 1991, studied on myrcene mimic the peripheral analgesic activity of Lemon Grass Tea. Oral administration of infusion of LG fresh leaves to rats produced a dose depressant analgesia for the hyperalgesia induced by subplantar injections of either carrageen or prostaglandin E2, but did not affects that induced by dibutyryl cyclic AMP. These results indicate peripheral site of action which was confirmed with these essential oil obtained by steam distillation of leaves. Silica gel column fractionation of the essential oil allowed identification of myrcene as a major analgesic component in the oil. Identification of the component was made by thin layer chromatography and checked by mass spectrometry. The peripheral analgesic effect of myrcene was confirmed by testing a standard commercial preparation on the hyperalgesia induced by prostaglandin in the rat paw test and upon the contortions induced by intraperitoneal injections of iloprost in mice. In contrast to the central analgesic effect of morphine, myrcene did not cause tolerance on repeated injection in rats. This analgesic activity supports the use of lemongrass tea as a "sedative" in folk medicine.

Terpenes such as myrcene may constitute a lead for the development of new peripheral analgesics with a profile of action different from that of the aspirin-like drugs.

Lalitha *et al* 1985, studied on mevalonate decarboxylation in Lemon Grass Leaves. The activity of mevalonate-5-pyrophosphate (MVAPP) decarboxylase was assayed in the extracts of green leaves of Lemon Grass. The enzyme was found to be exclusively cytosolic, had a pH optimum of 6.0 and had a specific requirement for ATP, Mg^{2+} was required and Mn^{2+} could replace it partially. The phenolics compounds, P- Coumaric acid, protocatecheic acid, ferulic acid and phloroglucinol carboxylic acid inhibited the activity.

Gayathri *et al* 2010, evaluated the cardioprotective effect of Cymbopogon citratus (LG) in isoproterenol-induced cardiotoxicity. Male Wistar albino rats were segregated into five different groups, Group I and II rats were treated with vehicle. Groups III and IV rats were treated with 100 and 200 mg/kg body weight of LG. Group V with 100 mg/kg body weight of vitamin E. on 58^{th} and 59^{th} day isoproterenol is aiduced at a dose of 85 mg/kg twice at 24-hour interval. Animals were sacrificed on the 60^{th} day. And found that LG administration decreased the toxic events of lipid peroxidation (TBARS) in both serum and heart

tissue, by increasing the level of enzymatic antioxidants and non-enzymatic antioxidants significantly in both heart homogenate and serum sample ($p < 0.05$). LG pre-treatment exhibited cardioprotective activity as evidenced by decreased activity of cardiac markers in serum and increased the same in heart homogenate ($p < 0.05$).

The results of the above study reveal that LG is cardio protective and anti-lipid per oxidative by increasing various antioxidants at a dose of 200 mg/kg body weight, which is comparable with that of vitamin E.

Human trials

Although lemon grass is being used as folk medicine since ages but very scanty studies/ literature are available on human population.

According to the study conducted by Centre for Advanced Research in Indian System of Medicine, SASTRA University, Tamil Nadu, India, REF on rat results reveal that Lemon Grass is cardioprotective and antilipid peroxidative by increasing various antioxidants at a dose of 200 mg/kg body weight, which is comparable with that of vitamin E.

Ray, 2010, supplemented 250 millilitres of lemon grass decoction (decoction was prepared by boiling 20 leaves about 1 foot in length including its roots in 1 litre for 20 minutes.) to the 31 hypertensive individuals for the period of 16 weeks to evaluate the effect of twice-a-day intake of lemon grass decoction among hypertensive individuals in Barangay Situbo, Municipality of Tampilisan, Zamboanga Del Norte. And found that twice-a-day intake of lemon grass decoction had a significant effect on the mean arterial pressure.

However, the twice-a-day intake of lemon grass decoction had no significant effect on the mean heart rate and on the clinical symptoms in relation to hypertension.

Toxicological studies:

Lemongrass is "Generally Recognized As Safe" (GRAS) in the US. (http://www.online-family-doctor.com/alternative-medicines/ lemongrass.html).According to 21 Code of Federal Regulations Section 182.20 (1982) lemon grass plant extract/essential oil is safe for human consumption (http://cfr.regstoday.com/21cfr182.aspx).

Formingoni *et al* 1986, studied on pharmacology of lemon grass of daily 2 months administration in male and female rat and in offspring exposed “in utero”. An infusion prepared from leaves of lemon grass administered orally to adult rats for 2 months, in dose up to 20 times larger than the estimated corresponding human dosage did not induce any effect which could be taken as evidence of toxicity. An absence of effects was also noted in male and female rats and in their offspring when the infusion was administered prior to mating or during pregnancy. These data strongly suggest that Lemon Grass as used in Brazilian folk medicine has no toxic properties.

Leite *et al* 1986, studied on the assessment of eventual toxic, hypnotic and anxiolytic effects of Lemon Grass Herbal Tea (infusion) on human. A herbal tea [called an Abafads (infusion) in Brazil] prepared from dried leaves of Lemon Grass was administer to healthy volunteers following a single dose or 2 weeks of daily oral administration , the infusion produced no changes in Serum Glucose, Urea, Creatinine, Cholesterol, TG, LipidTotal Billirubin, Indirect Billirubin, Alkaline Phosphates, Total Protein and Albumin. Urine analysis (protein, glucose, ketones, Billirubin and Urobillinogen) showed no abnormalities. There was slight elevation of direct Billirubin and amylase in some of the volunteers but without any clinical manifestation.These results taken together indicate that Lemon Grass as used in Brazilian folk medicine is not toxic for human. The hypnotic effect of Lemon Grass was investigated in 50 volunteers who ingested samples of Lemon Grass the parameters (ie. Sleep induction, sleep quality, dream recall, and reawakening) did not show any effect of Lemon Grass. Eighteen subjects with high scores of trait – anxiety were submitted to an anxiety – induced test following taking Lemon Grass. Their anxiety levels were similar, indicating that the infusion of the plant does not have anxiolytic properties.

It is concluded that the Lemon Grass one of the most popular Brazilian herbal medicine used for its alleged CNS-Depressant effects, is non -toxic and lacks hypnotic or anxiolytic properties.

According to (Silva *et al*. 1991 and Zamith *et al*. 1993), the lemon grass does not present genotoxical action. According to (Kauderer *et al*. 1991), it is not mutagenical either.

Table 1: Botanical classification of lemon grass

Kingdom:	Plantae
(unranked):	Angiosperms
(unranked):	Monocots
(unranked):	Commelinids
Order:	Poales
Family:	Poaceae
Subfamily:	Panicoideae
Tribe:	Andropogoneae
Subtribe:	Andropogoninae
Genus:	*Cymbopogon*

Table 2: Species of lemon grass

Species	Country
Cymbopogon bombycinus , *Cymbopogon ambiguus* , *Cymbopogon obtectus* , *Cymbopogon refractus*	Australia
Cymbopogon citratus	China
Cymbopogon nardus	Thai
Cymbopogon proximus	Egypt
Cymbopogon schoenanthus	southern Asia and northern Africa
Cymbopogon flexuosus , *Cymbopogon citriodora*.	India

Table 3 : Currently grown varieties and their description

Variety	Description
Sugandhi (OD 19)	· It is adapted to a wide range of soil and climatic condition. · A red stemmed variety with plant height 1 to 1.75 m and profuse tillering. · The oil yield ranges from 80 to 100 kg per hectare with 85-88 per cent of total citral produced under rain-fed conditions (with life saving irrigation).
Pragati	· It is a tall growing variety with dark purple leaf sheath suitable for north Indian Plains and tarai belt of subtropical and tropical climate. · Average oil content is 0.63 per cent with 75-82 per cent citral.
Praman	· Evolved through clonal selection and belong to species *C. pendulus*. · It is a medium sized variety with erect leaves and profuse tillering. · The oil yield is high with 82 per cent citral.
Jama Rosa	· Very hardy with vigorous growth. · The variety yields about 35 tonnes of herbage per ha. containing 0.4 % oil(FWB). · The variety yields up to 300kg oil in 4-5 cuts in 16-18 months growing period.
RRL 16	· Average herbage yield of this variety is 15 to 20 tonnes/hectare/annum giving 100 to 110 kg oil. · The oil content varies from 0.6 to 0.8 per cent (fresh weight basis) with 80 per cent citral.
CKP 25	· A hybrid between *C.khasianum* X *C.pendulus*. · Gives 60 t/ha herbage in North Indian plains under irrigation. · The oil contains 82.85% citral.
Other Varieties	· OD-408, Kaveri (OD-408 is white stemmed selection from OD-19 and is an improvement in yield in terms of oil and citral content. Kaveri needs high soil moisture to produce luxuriant growth and is evolved for river valley tracts.)

Table 4: Country wise use and application of Lemon Grass

Country	Purpose	Reference
India	Used for gastrointestinal problems.	Alves *et al* (1960)
	A decoction made from the leaves in recommended as diaphoretic in fever	Chopra *et al* (1958)
China	as ansiolitic.	Peigen *et al*(1983)
Mauricio islands, Malay Peninsula	Common to use the lemon grass tea against flu, fever, pneumonia, and to solve gastric and sudorific problems	São Paulo (1959)
Nigeria	As antipyretic, and for its stimulating and antispasmodic effects	Olaniyi *et al* (1975)
Indonesia	Indicated to help the digestion, to promote diuresis, sweating and as emmenagogue.	Hirschorn (1983)
Cuba and other Caribbean region	For analgesic and anti-inflammatory actions.	Ortiz *et al* (2002)
Africa and Asia	Considered as antitussive, antiseptic, sudorific, stomachis, anti-rheumatic and to treat backache, sprain and haemoptysis.	Alves & Souza (1960)
London	The grass has been reported to revitalize the body and promote good health. It aids digestion and inhibit chemical–induced carcinogenesis by modulating xenobiotic-metabolizing enzymes in the liver and intestine	Vickery *et al* 1979

Table 5: Proximate analysis of the Lemon grass

S No	Content	Method	Values
1	Moisture content	AOAC (1990)	5.76%
2	Ash content		20.00%
3	Crude fat		5.10%
4	Crude fibre		9.28%
5	Energy		360.55 Cal/100 g
6	Crude protein	Nitrogen to protein conversion factor of 6.25	4.56%
7	Carbohydrate	Carbohydrate was determined by difference	55.00%

Asaolu *et al* (2009)

Table 6: Mineral content of the Lemon grass

Mineral	Amount (mg/100g)	Method
Na	54.8	AOAC
K	59.5	
Ca	39.5	
Mg	70	
Fe	0.024	
Mn	0.952	
Zn	121	
P	89.3	Phosphovanado- molybdate Method
Phytate	11860	
Phytates : Zn *	9.68	
Ca : Phytate **	0.05	

mg of Phy/ mol.wt of Phy;mg of Zn/mol.wt of Zn, mg of Ca/mol.wt of Ca;mg of Phy/mol.wt of Phy*

Fagbohun *et al* 2010

Table 7: Phytonutrient constituent of leaves

Content	Values
Alkaloids	0.520
Saponins	0.645
Tannins	0.600
Anthraquinones	0.005
Cadenolides	ND
Phlobatannins	ND
Steroids	0.058
Cyanate	ND
Phenols	0.400
Flavonoids	0.532

Adesanya and Sofowora, 1983

Table 8: Comparison of Total Antioxidant Capacity of Lemon Grass

Method	µ mole GE/g dw	µ mole AE/g dw	µ mole HCE/gdw	µ mole TE/g dw
DPPH	4.75±0.19	21.92±0.74	3,769.66±227.89	15.96±0.53
FRAP	5.08±0.27	2.92±0.08	167.28±6.73	23.40±1.19
ABTS	7.53±0.03	3.47±0.01	12,846.16±17.07	31.50±0.13

Naiyana *et al* (2010)

Table 9: Antioxidant compounds of Lemon Grass

S No	Antioxidant compound (mg %)	Amount	
		Fresh	Dry
1	Phenol	519.3 ± 36.92	1324.9 ± 31.06
2	Flavonoid	415.2 ± 54.13	725.4 ± 66.65

Patel and Mehta (2006)

Table 10: Phytochemicals present in decoction and infusion

S No	Compounds	Decoction	Infusion
1	Isoorientin	Traces	0.08 □0.04
2	Isoscoparin	Traces	Traces
3	Swertiajaponin	0.37 ±0.05	0.29 ±0.02
4	Isoorientin-2-O-rhamnoside	0.37 ±0.02	0.37 ±0.03
5	Orientin	0.14 ±0.03	0.08 ±0.02
6	Chlorogenic acid	Traces	0.35 ±0.04
7	Caffeic acid	0.07 ±0.01	0.10 ±0.02

Orrego *et al* (2009)

Table 11: Antioxidant potential of above flavonoid

Compounds	Decolouration of DPPH (%)	Scavenging of the uperoxide anion (%)	Inhibition of lipoperoxidation (%)
Isoorientin	9.1	52.9	71.3 □8.3
Isoscoparin	39.6	52.3	41.7 □4.0
Swertiajaponin	13.4	110.3	60.6 □8.3
Isoorientin 2-O-rhamnoside	17.5	84.4	60.6 □9.9
Orientin	10.0	79.0	68.7 □6.9
Chlorogenic acid	13.8	13.8	33.8 □4.2
Caffeic acid	9.4	68.8	84.9 □0.4
Quercetin	9.1	72.0	80.7 □1.0

Andrade-Cetto and Wiedenfeld , 2001.

Table 12: Antioxidant capacity and total phenolic content of some Herbs and Spices

Vegetables	Antioxidant capacity (mg VCE 1/100 g)	Total phenolic content (mg GAE 2/100 g)
Turmeric *(Curcuma longa)*	1126.12 ± 94.26	1340.70 ± 54.27
Cumin, dried *(Cuminum cyminum)*	302.26 ± 0.91	526.74 ± 7.69
Curry powder	236.55 ± 7.96	103.15 ± 6.92
Lemongrass *(Cymbopogon citratus)*	120.57 ± 5.46	152.93 ± 4.61
Coriander (leave and stem) *(Coriandrum sativum)*	92.18 ± 62.99	90.02 ± 17.04
Ginger *(zingiber offcinale)*	62.24 ± 0.19	99.70 ± 0.58
Tomato *(Lycopersicom esculentum)*	22.97 ± 4.85	62.48 ± 7.91
Tamarind juice *(Tamarindus indica)*	13.44 ± 0.07	23.84 ± 0.82
Garlic *(Allium sativum)*	8.77 ± 1.93	63.51 ± 3.67

Tangkanakul, 2009

CONCLUSIONS

A range of bioactive compounds in herbs and spices have been studied for health promoting properties in animals, but the challenge lies in integrating this knowledge to ascertain whether any effects can be observed in humans, within permissible doses. Antioxidant effectiveness in vivo depends on the bioavailability of responsible compounds; which was assumed to be low. However, recent studies with improved methodology indicate that some plant phenolics appear in plasma and body tissues and, thus, may be important nutritional antioxidants. However, this cannot be established with certainty until their effects on biomarkers of oxidative stress are established (Duthie *et al* 2000).

Studies of lemon grass are present on human population to determine the toxicological properties but there is a dearth of data available of clinical trial for therapeutic use to promote health. It is necessary to conduct clinical trial study, to support the laboratory analysis of having high antioxidant capacity, lemon grass will be helpful to improve the body's antioxidant defence system by increasing serum antioxidant levels & reduce the free radical mediated diseases.

There are no clinical trials with lemon grass on the Indian population, either on healthy or on diseased populations to support its antioxidant claims or its use in any therapeutic condition. Thus efforts need to be directed to assess the pharmacological potential of lemon grass.

REFERENCES

1. Adesanya, S. A. and Sofowora, A.(1983). Biological standardization of Zanthoxylum roots for antisickling activity. *Planta Med*, 48: 27-33.
2. Alves, A. C., Souza, A.F. (1960). Nota prévia sobre o estudo fitoquímico de Cymbopogon citratus (D.C.) Stapf. *Garcia de Orta*, 8: 629-38.
3. Andrade-Cetto, A. and Wiedenfeld, H. (2001). Hypoglycaemic effect of Cecropia obtusifolia on streptozotocin diabetic rats. *J. Ethnopharmacol*, 78, 145-149.
4. Asaolu, M.F., Oyeyemi, O.A. and Olanlokun, J.O.(2009).Chemical Compositions, Phytochemical Constituents and in vitro Biological Activity of Various Extracts of Cymbopogon citratus, *Pakistan Journal of Nutrition*, 8 (12),1920-1922.
5. Burkill, I.H. (1935). A Dictionary ofEconomic Products of Malay Peninsula Crown Agents for Colonies, London, 2 ,726.
6. Carbajal, D., Casaco, A., Arruzazabala, L., Gonzales, R., & Tolon, Z .(1989) Pharmacological study of Cymbopogon citratus leaves. J.Ethnopharmacol; 25: 103-107

7. Carlin, E., Contar, J. de., & Silva-Filho, D.P. (1986). Pharmacology of lemon grass (Cymbopogon citratus Stapf) 1 Effects of teas prepared from leaves on laboratory animals. *J. Ethnophamacology*, 17 (1),37-64.
8. Chopra, R.N., Chopra, I.H. and Kapur, L.D. (1958).Indigenous drugs of India U.N. Dhur and Sons. *Private Ltd. Calcutta*, 67,502.
9. Figueirinha, A., Paranhos, A., Perez-Alonso, J. J., Santos-Buelga, C., & Batista, M.T. (2008). Cymbopogon citratus leaves. Characterisation of flavonoids by HPLC-PDA-ESI/MS and an approach to their potential as a source of bioactive polyphenols. *Fd. Chem*, 110, 718-728.
10. Formingoni, Helena, M.L., Oswaldo, G., Filho,T., Ferreira, M.S., & Carlini, E.A.(1986). Pharmacology of lemongrass. Effects of daily two month administration in male and female ratsand offspring exposed "in utero" *journal of Ethnophamacology*,17 (1),65-74.
11. Gayathri, K., Jayachandran, K.S., Vasanthi ,H. R., & Rajamanickam, G.V. (2011). Cardioprotective effect of lemon grass as evidenced by biochemical and histopathological changes in experimentally induced cardiotoxicity, *Hum Exp Toxicol* ,30(8),1073-82.
12. Harland, B.F.,& Oberleas, D. (1986). Anion-exchange method for determination of phytate in foods (hexaphosphate equivalents): collaborative study. *J Assoc off Anal Chem* , 64(4), 667-70.
13. Hirschorn, H.H. (1983.) Botanical remedies of the former Dutch East Indies (Indonésia). Part 1: Eumycetes, Pteridophyta, Gmnospermae, Angilospermae (Monocotyledones only). *Journal of Ethnopharmacology*; 7,123-56.
14. Orrego R, Leiva E & Cheel J (2009). Inhibitory Effect of Three *C*-glycosylflavonoids from *Cymbopogon citratus* (Lemongrass) on Human Low Density Lipoprotein Oxidation,*Molecules*, *14*, 3906-3913; doi:10.3390/molecules14103906
15. Kauderer, B., Zamith, H., Paumgartten, F.J., Speit, G. (1991). Evaluation of the mutagenicity of beta-myrcene in mammalian cells in vitro. *Environ Mol Mutagen*, 18(1),28-34.
16. Leite , J.R. , Maria De Lourdes, V., Maluf, E., Assolant, K. ,Sucheki D., Tufik, S., klepacz, S., Calil, H.M.,& Carlini , E. A.(1886). Assessment of eventual toxic, hypnotic and anxiolytc effects on humans. *journal of ethnopharmacology* ,17(1),75:83.
17. Leite, J.R, Seabra ,M.V., Maluf, E., Assolant, K., Suchecki, D., Tufik, S., Klepacz, S., Callil, H.M., & Carlini EA (1986). "Pharmacology of lemon grass (Cymbopogon citratus Stapf)III. Assessment of eventual toxic, hypnotic and anxiolytic effects on humans". *Journal of Ethnopharmacology*,17, 75 – 81
18. Lalitha, George, R., Ramasarma, T. (1985). Mevalonate decarboxylation in Lemon Grass Leaves, *Journal of photochemistry*, 24 (11),2569-2571
19. Lorenzetti, B.B., Souza, G.E., Sarti ,S.J., Santos, F. D., & Ferreira, S.H.(1991). Myrcene mimics the peripheral analgesic activity of lemongrass tea. *J Ethnopharmacol*,34(1),43-48.
20. Masuda, T., Odaka, Y.,Ogawa, N. ,Nakamoto, K., & Kuninaga, H., (2008). Identification of Geranic Acid, a Tyrosinase Inhibitor in Lemongrass (Cymbopogon citratus).*J. Agric. Food Chem*, 56,597–601.
21. Nogueira MJC. (1983). Fitoterapia popular enfermagem comunitaria. Tese (livre docencia em enfermagem): 257.
22. Oboh, G., Adefegha, S.A., Ademosun, A.O., & Unu, D.(2010). Effects of hot water treatment on the phenolic phytochemicals and antioxidant activities of lemon grass (cymbopogon citratus) ejeafche, 9 (3), 503-513.
23. Olaniyi, A.A, Sofowora, E.A., Oguntimenin, B.O. (1975). phytochemical investigation of some nigerian plants used against fevers. II Cymbopogon citratus. *Planta Medica*, 28,186-190.
24. Ortiz, R.S., Marrero, G.V.,& Navarro, A.L.T. (2002). Instructivo técnico del cultivo de Cymbopogon citratus (D.C) Stapf (caña santa). *Revista de Plantas Medicinales*, 7, 2.
25. Patel, V., & Metha, B. J. (2006). Evaluation of Antioxidantsin Lemon Grass and optimization of herbal tea formulae using Lemon Grass. M.Sc. Dissertation,PG. Department of Home

Science, Sardar Patel University, Vallabh Vidyanagar.
26. Peigen, X. (1983). Recent developments on medicinal plantsin China. *Journal of Ethnopharmacoloy*,7, 95-109.
27. Puatanachokchai, R., Kishida, H., Denda, A., Murata, N., Konishi, Y., Vinitketkumnuen, U., & Nakae, D. (2002). Inhibitory effects of lemon grass (Cymbopogon citratus, Stapf) extract on the early phase of hepatocarcinogenesis after initiation with diethylnitrosamine in male Fischer 344 rats. *Cancer Lett*, 183, 9-15.
28. Ramirez, V.R., Mostacero, L. J. & Garcia, A.E. (1988). Vegetable Employed in Traditional Medicine. *J. Univ. Trujillo*, 1, 54-58.
29. Rao, B.S.S., Shanbhoge, R., Rao, B.N., Adiga, S.K., Upadhya, D., Aithal, B.K., & Kumar, M.R.S. (2009). Alcoholic extract of Cymbopogon citratus against radiation-induced DNA damage on V79 cells and free radical scavenging ability against radicals generated in vitro, doi. *Hum Exp Toxicol*, 28 (4), 195-202.
30. Ray, C.I.(2010). The effect of twice-a-day intake of lemon grass decoction among hypertensive individuals of barangay situbo, tampilisan, zamboanga del norte.
31. São-Paulo (1985). Farmacologia pré-clínica e toxicologia do capimcidrão, Cymbopogon citratus. Brasília, *CEME*,52.
32. Shah, G., Shri, R., Panchal, V., Sharma, N., & Singh, B. (2011). Scientific basis for the therapeutic use of Cymbopogon citratus. *J Adv Pharm Technol Res*, 2(1), 3–8.
33. Sies, H. (1986) . Biochemistry of Oxidative Stress. *Angew Chem Internat Ed Eng* , 25,1058-71.
34. Simon, J.E., Chadwick, A.F., & Cracker, L.E. (1984). The scientific literature on selected herbs and medicinal plants of the remperate zone. *Arch. Int. Med*, 148, 36-39.
35. Sofowora, E.A., Olaniyi, A.A. & Oguntimehin, B.O. (1982). Pyhtochemical Investigation of some Nigerian Plants used against fevers. *Planta Med*, 28, 186-189.
36. Stehmann, J.R. & Brandaw, M.G.L. (1995). Medicinal plants of Lauras Novas. *Fitoterapia*, 56, 515-520.
37. Tangkanakul, P., Auttaviboonkul, P., Niyomwit, B., Lowvitoon, N., Charoenthamawat, P., & Trakoontivakorn, G., (2009). *International Food Research Journal*,16, 571-580 .
38. Tindall, H.D. (1986). Vegetables in the tropics. Macmillan Edu. Ltd. Hampshine, 267-268.
39. Wise, A. (1983). Dietary factors determining the biological activities of phytate. *Nutr Absr Rev Clin Nutr*, 53(9), 791-806.
40. Zamith, H.P., Vidal, M. N., Speit, G., & Paumgartten, F.J. (1993). Absence of genotoxic activity of beta-myrcene in the in vivo cytogenetic bone marow assay. *Braz J Med Biol Res* , 26(1),93-98.