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Antioxidant potential, phytochemicals, minerals and amino acids content of lemongrass (*Cymbopogan citratus*)

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Abstract
The benefits of phytomedicine cannot be overemphasized. Lemongrass (*Cymbopogon citratus*) is a medicinal plant commonly explored in folk medicine for the treatment of diverse ailments. In this research, its antioxidant potential, phytochemicals, minerals and amino acids content were analyzed using standard methods. The results of the phytochemical analysis revealed the presence of flavonoids, tannins, saponins, alkaloids, cardiac glycosides and phenols. Minerals analysis shows that Lemongrass contains Copper, Zinc, Iron, Manganese, Magnesium, Aluminium, Chromium, Calcium, Selenium, Lithium, Sodium and Potassium. It also contains Lead, Mercury and Cadmium within the permissible limits. The result also shows direct relationship between antioxidant activity and concentration of the plant extract. Amino acids analysis revealed that it contains non-essential amino acids and all the essential amino acids. These results suggest that Lemongrass may be utilized as an antioxidant, as well as, source of the aforementioned phytochemicals, minerals and amino acids whose essentiality to life is undoubted.

Keywords: Lemongrass, phytochemicals, minerals, antioxidants, amino acids

Introduction
Plants are the earliest and main source of food and medicine to man [1]. Through trial and error, early man was able to identify and differentiate plants that are edible, poisonous and therapeutic. Many at times, the therapeutic effects of plants are due to secondary metabolites - phytochemicals - which they contain. Among these phytochemicals are Flavonoids, Tannins, Saponins, Alkaloids, Cardiac glycosides and Anthraquinones. Most of the inhabitants of the world rely chiefly on traditional medicine - which is largely of plant origin - for their primary healthcare needs [2]. As search for drugs of plant origin - so as to replace the synthetic ones which are proven to have adverse effect - is on the rise, many plants have been screened for the presence of phytochemicals as well as other nutritive components which qualify them to have different therapeutic activities [3].
In Nigeria, there are many plants that are used as medicine and (or) food. Lemongrass (*Cymbopogan citratus*) is one of the plants that are identified to have both therapeutic and nutritive value. The origin of the name *Cymbopogan* is from the Greek word "Kymbe-pogan", meaning boat-beard (due to its flower spike configuration), and *citratus* (Latin) means lemon-scented leaves [1]. It belongs to the family Gramineae [4]. It is a tufted perennial C_4 grass with numerous stift of stems arising from a short rhizomatous root stick. It flourishes in sunny, warm and humid conditions of the tropics and grown in a wide variety of soils [5]. It is a grass that can be grown in the compound of houses. It can be used a fresh or dried into powder. It can be used in tea, soup and cooked foods [6, 7]. The leaves were found to have anti-inflammatory activity [8]. Its oil has been reported to have antimicrobial effect [9]. The oils also are widely used in flavours, fragnances, cosmetics, soaps, detergent and perfumery owing to their lemon-like aroma [4]. It stalk has antidirrheal activity [10]. Many reports on its medicinal value were recorded as indicated above, and still, there are a lot of its potentialities that are yet to be explored. Thus, in this research, the antioxidant potential, phytochemicals, minerals and amino acids content of Lemongrass will be further explored.

Materials and Methods
Plant Material: Lemongrass leaves were obtained from a residence in Fadaman-Mada area, Bauchi town, Bauchi State, Nigeria. It was identified and authenticated by Mr. Musa

Muhammad of the Biological Science Department, Abubakar Tafawa Balewa University, Bauchi, Nigeria.

Plant Extract Preparation

Methanol extract of the plant was prepared. In brief: The leaves were washed under running tap water, cut into pieces and air-dried under shade. It was then pulverized into powder. 100g of the powdered sample was dissolved in 500ml of 80% methanol solution in a stoppered container for 3 days with frequent agitation. After 3 days, the mixture was filtered. The filtrate was evaporated to obtain the extract [11].

Phytochemical Analysis

Flavonoids, Tannins, Saponins, Alkaloids, Cardiac glycosides and Anthraquinones in the sample were analysed using standard procedures [12, 13].

Determination of Antioxidant Potential

The antioxidant potential was determined using 2, 2 - diphenyl-1-picryl hydrazyl (DPPH) method [14]. In brief: A stock solution (1mg/ml) of each fruit extract was diluted to a dilution series (50, 100, 150, 200 and 1000 µg/ml). 2.7ml of 0.2mM DPPH solution was added each to 0.3 ml of each of the different extracts concentrations. The mixture was shaken vigorously and incubated at room temperature in the dark for 1 hour. The absorbance was taken at 517 nm. The radical scavenging activity was then calculated [14].

Minerals Determination

Minerals in the plant were identified using atomic absorption spectrophotometer according to the method of AOAC [15].

Amino acid Analysis

The amino acid profile of the plant was determined using method described by Benitez [16]; the powdered sample was dried to a constant weight, defatted, hydrolysed, evaporated in rotary evaporator and loaded into the Applied Biosystems PTH Amino Acid Analyser.

Statistical Analysis: Descriptive statistics was used to analyse the data. The values were expressed as Means ± Standard deviation. Tables and graphs were used to present the data.

Results

Table 1 shows the results of phytochemical analysis of the lemongrass leaves. The results show that it contains Flavonoids, Tannins, Saponins, Alkaloids, Cardiac glycosides and Phenols, while anthraquinones are absent.

Table 1: Phytochemicals in Lemongrass leaves

Phytochemical	Inference
Flavonoids	+
Tannins	+
Saponins	+
Alkaloids	+
Cardiac glycosides	+
Anthraquinones	_
Phenols	+

Table 2 displayed the minerals content and their concentration in Lemongrass leaves. The results show that it contains Cu, Zn, Fe, Pb, Mn, Mg, Al, Cr, Ca, Li, Se, Hg, Na, Cd and K.

Table 2: Minerals content and their concentrations in Lemongrass leaves

Mineral	Concentration (ppm)
K	45.68±5.69
Na	23.81±0.60
Ca	3.93±0.00
Fe	2.93±0.00
Zn	0.49±0.00
Mg	0.45±0.01
Cu	0.28±0.00
Al	0.16±0.00
Mn	0.14±0.00
Pb	0.09±0.00
Cr	0.05±0.00
Se	0.05±0.02
Hg	0.03±0.02
Li	0.01±0.00
Cd	0.01±0.00

Values are expressed as Mean ± Standard deviation

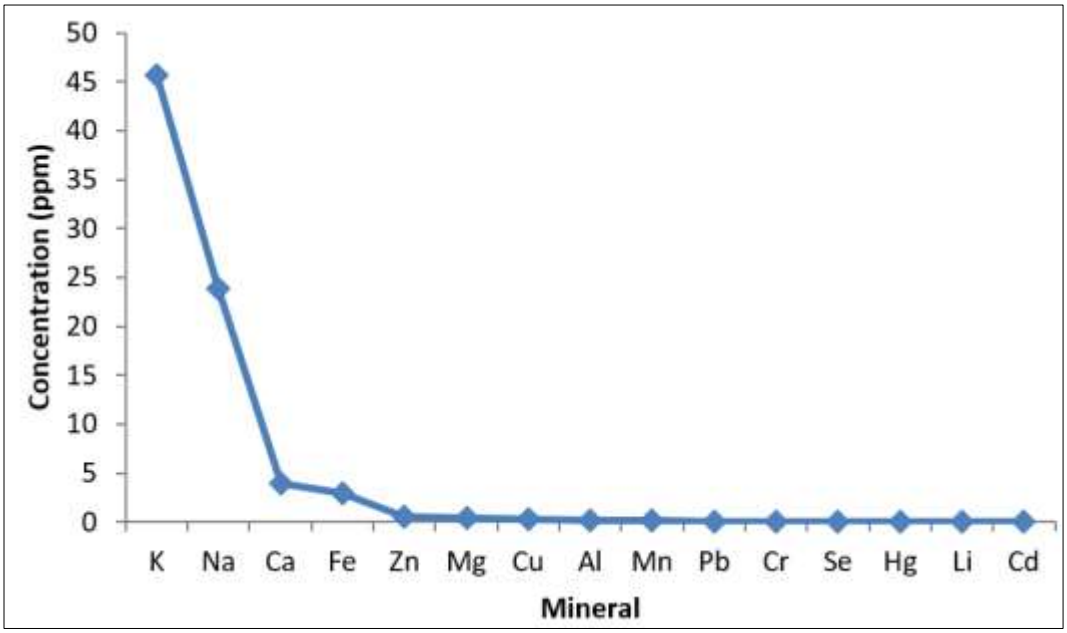

Fig 1: A graph showing the Minerals content and their concentration in Lemongrass leaves

The Antioxidant potential of the different concentrations of the extract is presented in table 3. The result shows that the *in vitro* Antioxidant activity is directly proportional to the concentration of the extract.

Table 3: Antioxidant potential of Lemongrass leaves

Extract concentration (µg/ml)	Antioxidant potential (%)
50	55.60±1.72
100	59.22±0.42
150	66.88±0.31
200	83.38±0.54
1000	92.19±0.36

Values are expressed as Mean ± Standard deviation

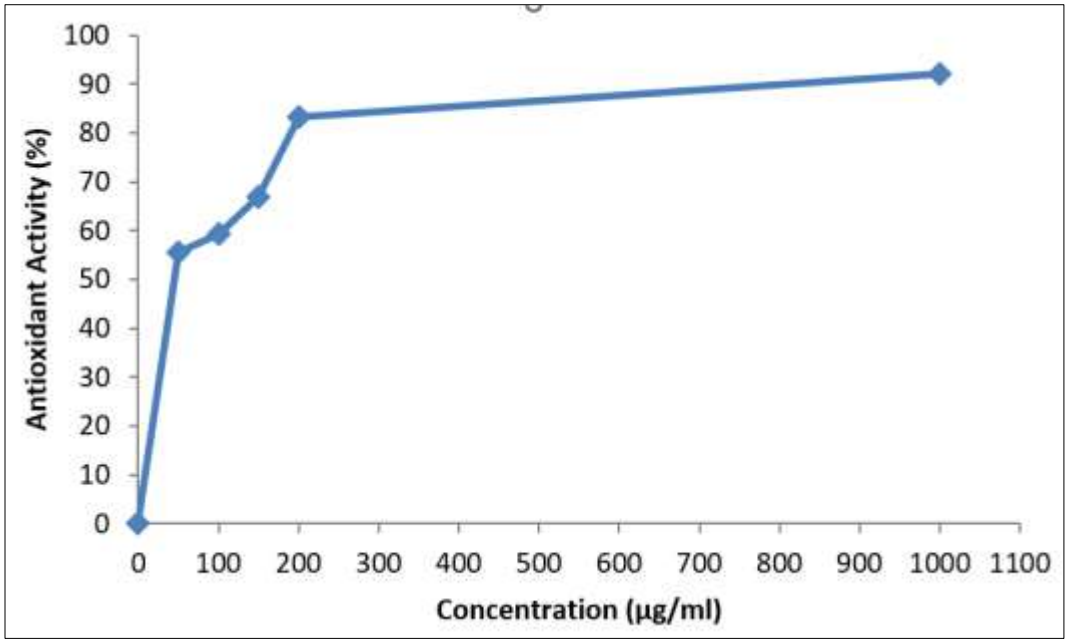

Fig 2: A graph showing the Antioxidant potential of the different concentrations of Lemongrass leaves extract

The EC_{50} of the extract as calculated from the graph above is 45.0 µg/ml.

Table 4 shows the Amino acids content and concentration in Lemongrass leaves

Table 4: Amino acids content and concentration in Lemongrass leaves

Amino Acid	Concentration: g/100 g protein
Leucine	6.79
Lysine	4.53
Isoleucine	4.84
Phenylalanine	4.61
Trytophan	1.15
Valine	5.02
Methionine	2.03
Proline	3.45
Arginine	5.41
Tyrosine	3.95
Histidine	2.27
Cystine	0.97
Alanine	4.77
Glutamic acid	9.75
Glycine	5.10
Threonine	3.69
Serine	4.21
Aspartic acid	7.22

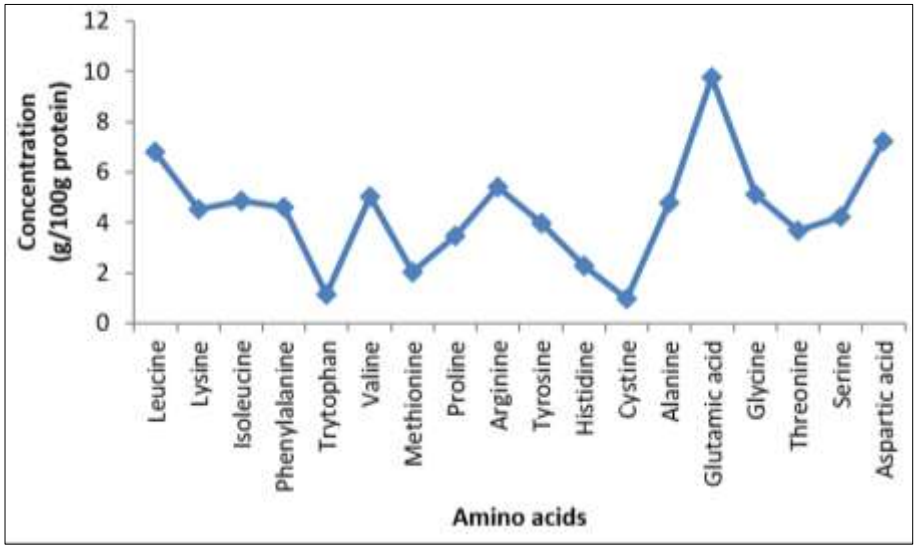

Fig 3: Graph of Amino acids content and concentration in Lemongrass leaves

Discussion

The benefits of phytomedicine cannot be over emphasized. At present, medicinal plants occupy a key position in plant research and medicine [17]. Although, researches were conducted on various potentialities of numerous plants, further researches need to be conducted to ascertain earlier findings and to explore plants (or their aspects) which are yet to be explored. Among the medicinal plants used, Lemongrass is prominent and commonly explored in folk alternative medicine for the treatment of diverse ailments. It is widely used for tea and the treatment of malaria [18]. It was reported to have folk remedy for coughs, elephantiasis, opthalmia, pneumonia and vascular disorders. Its antidepressant, antiseptic, astringent, bactericidal, fungicidal were also reported [19]. Tea made from it is traditionally used among people in South America, Asia and West Africa for its antiseptic, antifever, antidyspeptic and anti-inflammatory effects. Its essential oils are used in perfumes, they also have antinflammatory and anticancer activity [4]. The oil has also been found to have antiamoebic effect [20], antibacterial effect [21] and antifungal effect [9]. Its therapeutic effect against high blood pressure, heart problem, HIV/AIDS, kidney problem and hair loss has also been reported [22]. All these medicinal/therapeutic functions may be due to the broad spectrum of secondary metabolites (phytochemicals) that it contains [18]. In this research, Lemongrass was analyzed for the presence of phytochemicals. The results as presented in table 1 shows that the methanol extract of Lemongrass contains Flavonoids, Tannins, Saponins, Alkaloids, Cardiac glycosides, while Anthraquinones are absent. The presence of the aforementioned phytochemicals in Lemongrass as reported by us is in consistence with the previous reports [1, 5, 18, 19].

Deficiency or excess of minerals is one of the major causes of health problem in man [23]. Plants are the main source of minerals for human and other animals. Thus, a disease found to be caused or complicated by the deficiency of a particular mineral can be prevented or cured by the supplementation of the deficient mineral. This among many other ways can be achieved by consuming plants or their extracts that are proven to contain the deficient mineral. In this research, the elemental composition of Lemongrass was analyzed and the result as presented in table 2 shows that it contains Cu, Zn, Fe, Pb, Mn, Mg, Al, Cr, Ca, Li, Se, Hg, Na, Cd and K. Lead is a heavy metal that is associated with carcinogenesis and mutagenesis in experimental animals [24]. It is also linked with disorders of the central nervous system. On the other hand, Cd and Hg are toxic metals and have negative effect on both the urinary and respiratory systems. The permissible limit (in food) of Cd, Hg and Pb ranges from 0.05 - 3.00 ppm, 0.10 - 1.00 ppm and 0.01 - 3 ppm respectively [24, 25, 26, 27]. In this research, the level of Cd, Hg and Pb in Lemongrass was found to be 0.006, 0.033 and 0.097 ppm respectively. These are all within the permissible limits stated above. Hence, their concentrations in the Lemongrasss analyzed is negligible to be concerned about.

Iron is an important trace element. It is a component of hemoglobin and is involved in metabolism of lipids, carbohydrates and protein. It is also a cofactor. Its deficiency may lead to anemia [23, 28]. Zinc is needed for normal secretion of insulin, wound healing, normal growth and development and behavioral development. It is also a cofactor. Deficiency results to loss of appetite, growth retardation, skin change, and immunological abnormality [29]. Copper is another essential microelement but may be toxic in excess. In this research, its concentration (0.282 ppm) is less than the permissible amount (3 ppm) [23], thus, within the safety limit. Copper is required for absorption and incorporation of Iron into hemoglobin, it serves as a cofactor of enzyme such as superoxide dismutase and cytochrome c oxidase. Its deficiency results to anemia, demyelination, degeneration of the nervous system, defects in pigmentation and reproduction failure [29]. Manganese is a micro-element that serves as a cofactor of enzymes of the oxidoreductases, lyases and ligases class [30]. Selenium, sometimes referred to as essential toxin, is an important microelement that plays important role in preventing liver necrosis. It is a cofactor of the antioxidant enzyme glutathione peroxidase [23]. Calcium is vital for bones and teeth health. It is needed for cardiac muscle and nerve impulses, blood and milk clotting. Magnesium on the other hand is required by enzymes of glycolysis associated with ATP and ADP. Almost 55% to 60% of total magnesium is associated with bones while the rest is found in muscle and extracellular fluids. Deficiency can lead to muscle irritability and convulsions [28], gastrointestinal abnormalities and renal dysfunction [29]. Potassium is involved in muscular activities, acid-base balance and neuromuscular activities. It is part of certain metabolic enzymes, like pyruvate kinase and has important role in cardiac function [31]. Trivalent chromium is required for maintaining normal glucose metabolism in

laboratory animals; it acts as a cofactor for insulin. Experimental chromium deficiency has been induced in several animal species, resulting in impaired glucose tolerance in the presence of normal concentration of circulating insulin, and in severe cases, in a diabetes-like syndrome [29]. Our result in this research, as earlier stated shows that Lemongrass contains the above aforementioned essential elements in moderate amounts, thus, its usage may avail us with all the health benefits mentioned above.

Amino acids are essential for the synthesis of body protein and other nitrogen-containing compounds. Protein and other nitrogenous compounds are being degraded and resynthesized continuously. Several times, more protein is turned over daily within the body than ordinarily consumed, indicating that reutilization of amino acids is a major feature of the economy of protein metabolism. This process of recapture is not completely efficient, and some amino acids are lost by oxidative catabolism. Metabolic products of amino acids (urea, creatinine, uric acid, and other nitrogenous products) are excreted in the urine; nitrogen is also lost in feces, sweat and other body secretions. Therefore, a continuous supply of dietary amino acids is required to replace these loses, even after growth has ceased [29]. The result of amino acid analysis in this research as presented in table 4, reveals that Lemongrass contains all the essential amino acids (Histidine, Isoleucine, Leucine, Lysine, Methionine, Phenylalanine, Threonine, Tryptophan and Valine). These are amino acids that are not synthesized by mammals and are therefore, dietarily essential or indispensable nutrients [29]. Thus, Lemongrass could serve as a good source of amino acids. The presence of amino acids in Lemongrass was earlier reported [1, 5].

In recent times, there is an increasing interest in the exploration of natural antioxidants from plants. In this research, the antioxidant potential of Lemongrass was determined using DPPH method, and has been observed to increase proportionally with increase in the concentration of the extract. The antioxidant potential has increased from 55.60±1.72% at 50 µg/ml to 92.19±0.36% at 1000 µg/ml. It also has a very high EC_{50} of 45.00 µg/ml. Our finding is corroborated by the report of many researchers who have also confirmed the antioxidant activity of Lemongrass [18, 22]. Its antioxidant activity may not be unconnected with the Flavonoids it contains. The antioxidant activity of Flavonoids has been confirmed by many researchers [32, 33].

Conclusion

The present research shows that Lemongrass contains flavonoids, tannins, saponins, alkaloids, cardiac glycosides and phenols. These are phytochemicals whose therapeutic effects have been established, thus, the plant may serve as source of these phytochemicals. The results reveal that Lemongrass contains non-essential amino acids, as well as, all the essential amino acids, thus could serve as source of these amino acids which are essential to life. The results of the research also reveal the presence of macro and micro-minerals in the plant, which are essential or play complimentary role in metabolism. Finally, the antioxidant activity of the plant has further been established by this research.

Author's Contribution

All Authors have contributed equally during the research.

Conflict of Interest: There is no conflict of interest among the authors.

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