HiLL PUBLISHING

Engineering Advances, 2022, 2(2), 141-146
https://www.hillpublisher.com/journals/ea/
ISSN Online: 2768-7961

Determination of the Metals Contents of Essential Oil from Lemongrass

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How to cite this paper: Samson Onoriode Okpo, Ifeanyichukwu Edeh. (2022) Determination of the Metals Contents of Essential Oil from Lemongrass. *Engineering Advances*, 2(2), 141-146.
DOI: 10.26855/ea.2022.12.001

Received: June 15, 2022
Accepted: July 12, 2022
Published: August 3, 2022

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Abstract

Lemongrass is reportedly been used in some parts of Nigeria for the treatment of fever, convulsion in children, throat inflammations, stomach upset, skin diseases, and ears/eyes infections, pepper soup ingredient, curries, and in preparation of local drinks. Based on this, there is need to assess the metal contents as excess consumption of lemongrass oil or prolong exposure to them could be injurious to health. In this work, lemongrass oil was extracted using Soxhlet apparatuses and its metal contents analyzed using Atomic Absorption Spectrophotometer (AAS). The results obtained were compared with those from similar works from literature and acceptable level in medicinal plants by WHO. The results showed presence of the following metallic elements and their respective concentrations: magnesium (14.159 mg/kg), lead (1.379 mg/kg), zinc (0.844mg/kg), mercury (0.728 mg/kg), chromium (0.530 mg/kg), copper (0.267 mg/kg), iron (0.167 mg/kg), cadmium (0.080 mg/kg), manganese (0.009) and arsenic (no trace). The metal composition is appreciable and tolerable as indicated by the WHO standards except for mercury. Therefore, the concentration of the metals should be constantly monitored to ensure safety of those that consume or apply the lemongrass, and excessive consumption should be avoided in order to prevent associated health challenges such as neuropathy, dementia, Parkinson's disease, and cancer.

Keywords

Arsenic, Extraction, Heavy metals, Lemongrass, Medicinal plants, Soxhlet extractor

1. Introduction

Lemongrass plant belongs to Gramineae (Poaceae) family and genus *Cymbopogon*. According to [1] report, lemongrass has its origin from Africa, Australia, Oceania and Asia where is still being used traditionally in medicinal and other cosmetic commodities till date. Lemongrass has aromatic smell as well possesses both anti-fungal and anti-bacterial characteristics [2]. According to [3], lemongrass extracts has found industrial application in pharmaceutical, cosmetics, food processing and perfumery industries etc. For instance, in India, China, Thailand among other countries, lemongrass is mostly used as food flavoring agent, ingredient in beverages because its ability to aid digestion, boost body immunity and blood circulation. In some parts of Nigeria, lemongrass is reportedly use for the treatment of fever, convulsion in children, throat inflammations, stomach upset, skin diseases, and ears/eyes infections. Particularly, in Isoko part of Nigeria, lemongrass is used as ingredient in pepper soup, curries, and local drink. Lemongrass extract have been reportedly used for treatment of diarrhea, skin infections and painful irregular menstruation in females. In sub-regions of the world, lemongrass is reportedly used to reduce blood pressure [4]. [5] have affirmed the use of lemongrass extracts for local treatment of gastrointestinal discomfort.

The composition of the lemongrass depends on the soil, geographical location and usage of fertilizer in planting the medicinal [6]. Lemongrass contains some minerals such as magnesium, potassium, and calcium which are required in-different proportion for the proper growth, health maintenance, and overall well being. For instance, Magnesium helps the enzymatic function of all cellular life; potassium is required for normal functioning of the brain, and helps to prevent stroke; calcium helps for body metabolism and for the formation of bone and teeth [7-9]. Lemongrass has been reported to have natural ability to adsorbed metallic elements from the soil thereby distributing the elements between the roots and shoot within a certain concentration limit, which the plant uses for its bioprocess and growth [10]. For instance, the species *Cymbopogon citratus* have been used to adsorb CU^{2+}, Ni^{2+}, Pb^{2+}, Cd^{2+} and Zn^{2+}, and *Cymbopogon flexuosus* can remove As^{3+} and Cr^{4+} from aqueous solution [11-15]. Lemongrass may also be contain some toxic metallic elements such as heavy metals like lead, mercury, chromium, cadmium, and arsenic [16]; [17]; [18]. These metals are of great importance to human as they help in maintaining normal human body functions. Despite the numerous advantages of the metals, excess quantity or long exposure and accumulation, especially heavy metals could be substantially dangerous to human body causing multi-organ malfunctioning, acute or chronic poisoning [19-20]. For instance, it could cause permanent disorders or malfunctioning of Central Nervous System [21-24]. Also, excess consumption or exposure to lead (Pb) could cause high blood pressure, cadmium (Cd) causes respiratory disorder, renal failures and cardiovascular problems, an overdose of zinc (Zn) can cause fever, nausea and general weakness and excess consumption of iron especially in children could lead to gastrointestinal and skin problems [25].

There has been an increased application of plant extract as well reported health concern arising from their use in the recent times [17]. According to [26-27], mandatory analysis of presence of toxic heavy metallic elements like mercury, lead, arsenic and cadmium in plant extract for human safety and quality control reasons is important. In literature, there has been reported that lemongrass oil/extract possess substantive pharmacological properties, but very little or no information is available on its metal contents as it affects health. Therefore, this study seek to evaluate concentration level of magnesium (Mg), lead (Pb), zinc (Zn), mercury (Hg), chromium (Cr), copper (Cu), iron (Fe), cadmium (Cd), manganese (Mn) and arsenic (As) in oil of lemongrass extracted with ethanol from Nigeria.

2. Materials and methods

2.1. Materials

Fresh lemongrass sample was harvested from a botanical garden located in Ozoro at 5° 32′ 18″ N, 6° 12′ 58″ E, Delta State, Nigeria. The sample was cleaned from dirt and washed with water, and then dried for 4-5 hours. The dried sample leaves were cut to 0.5cm, and stored in air-tight bag prior to use. The solvent used was ethanol and it is of analytical grade.

2.2. Experimental method

2.2.1 Oil extraction

The experiment was performed according to the method described by [28] using 500mL Shuniu GG-17 Soxhlet extractor. About 150g of sample lemongrass was measured with electronic digital balance. The weighed sample was transferred into Soxhlet extractor thimble and 250mL of ethanol was added, into the round bottom flask of the extractor. Heating mantle was regulated and set at temperature of 78^{o}C corresponding to ethanol boiling point. In operation, the apply heat allowed the solvent to vaporize into the extractor thimble containing sample oil as the solvent boils in the round bottom flask. As the liquid gets to overflow level, siphons will withdraw or suck out the mixture from the extractor thimble-holder and discharge it into the distillation flask. The experiment is run for 5times for intervals of 1 hour. Thereafter, experimental setup was dismantled and extracted oil was separated from the ethanol using evaporation process at reduced pressure with rotary evaporator to obtain solvent-free oil. The separated oil was finally stored in air-tight container in dark cupboard for further analysis.

2.3. Atomic Absorption Spectroscopy (AAS) Analysis procedure

The quantitative analysis was performed using AAS machine model Agilent FS240 according to approved standard method. 10g of the oil sample was added into a dish and heated in fume cupboard till there was no smoke coming out. The heated oil sample ash was transferred to desiccators to maintain the moisture content. Thereafter, 0.1 M HCl acid was added to the oil ash. The resulting mixture was filtered and diluted accordingly for quantitative analysis. Suitable salts of metals to be analyzed for were used to formulate standard solutions. Acetylene gas and air mixture was used as fuel-gas. Thereafter, appropriate metallic hollow lamp and their corresponding standard solution were used to obtain calibration curve for the respective metals. All samples and standard were run in thrice and average concentration for suspected metals were noted and recorded accordingly.

2.4. Validation of the metal contents of the lemongrass

The metal content of the lemongrass oil was validated using the results from literature and the specification presented by [29] as shown in Table 1.

Table 1. Metal concentrations of lemongrass oil from literature and acceptable level in medicinal plants by WHO

Heavy Metals	Conc. of metals Ethopia	Conc. of metals Indian	Conc. of metals in medicinal plant (mg/kg) WHO
Magnesium(Mg)	23.9-36.3	0.76-0.79	2000
Lead (Pb)	0.13-0.20	0.14	10
Zinc (Zn)	0.59-1.07	2.23	50
Mercury (Hg)			
Chromium (Cr)			
Copper (Cu)	1.48-2.5	0.05-0.07	20-150
Iron (Fe)	10.35-22.3	1.5-1.98	261-1239
Cadmium (Cd)			
Manganese (Mn)	10.0-12.7	0.19-0.27	20-150
Arsenic (As)			
	[6]	[30]	[29]

3. Results and Discussion

3.1. Determination of the metal concentration of lemongrass oil

The lemongrass oil was extracted using the Soxhlet extraction and then analyze using the atomic absorption spectroscopy (AAS) as described in Section 2 to ascertain the metal content of the oil. The result obtained is presented in Fig. 1 and it revealed that the oil contains some metals including magnesium(Mg), lead(Pb), zinc(Zn), mercury(Hg), chromium(Cr), copper(Cu), iron(Fe), cadmium(Cd), manganese(Mn) and arsenic (As) at different concentrations. The metallic content of the oil can be attributed to the soil and location of the plant [31]. Since the sample was obtained from a garden and was grown without fertilizer, there was no contribution of the metallic composition from fertilizer.

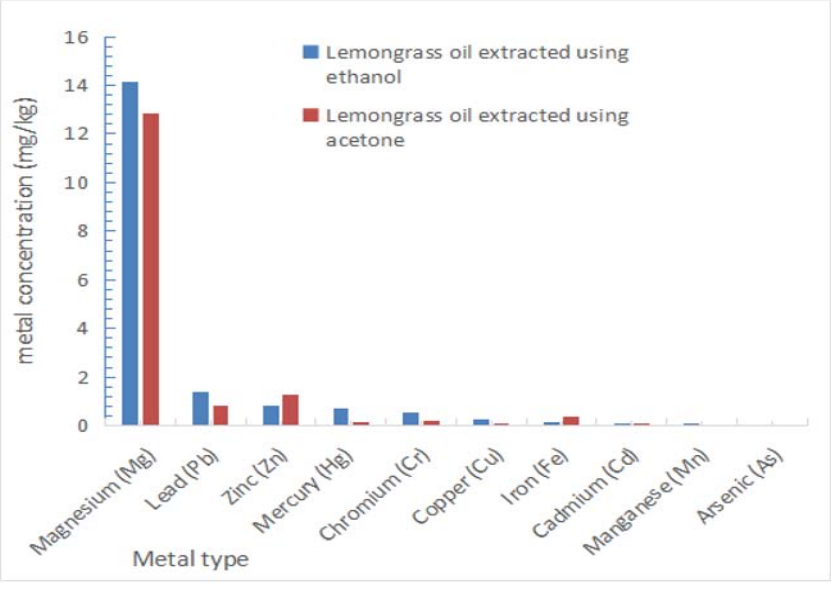

Figure 1. Metal concentrations of lemongrass oil extracted by Soxhlet extraction with ethanol and acetone solvents obtained using AAS.

Magnesium (Mg):

The concentrations of the magnesium obtained from both solvents: ethanol and acetone are 14.159mg/kg and 12.819mg/kg, respectively. These concentrations are lower than that obtained by [6] and greater than the one from [30]. The disparity could be due to the soil, geographical location or even the use of fertilizer to enhance the growth. Despite the difference, the magnesium concentration is within the standard concentration recommended by WHO (Table 1). The lemongrass when used for soup or medicinal application can help to enzymatic function.

Zinc (Zn):

The concentration of Zinc from the solvent extraction using ethanol was 0.844mg/kg and that from acetone was 1.259 mg/kg. The concentration of zinc obtained from the extraction using ethanol is within the range presented by [6] but that from acetone was slightly higher. The concentrations were higher than that presented by [30] but within the specification by [29] (see Table 1 and Fig. 1). The reason for the disparity could be the same with magnesium.

Copper (Cu):

The copper concentration obtained using ethanol as solvent was 0.267mg/kg and that from acetone was 0.094mg/kg. Comparing the results with the literature shows that both concentrations from solvents are lower than that obtained by [6] and were greater than those presented by [30], but below the range (20-150mg/kg) specified by the [29] (Table 1 and Fig. 1). The variation in result could be attributed to climatic condition, application of fertilizer and the nature of soil [6]. The results show that the lemongrass oil is deficient in copper and if used in food or may not contribute sufficiently to the copper need of the body.

Iron (Fe):

The concentrations of iron were 0.167 and 0.353 mg/kg obtained from the extraction using ethanol and acetone, respectively (Fig. 1).The results when compared with those presented in Table 1 are lower and including those from literature are lesser than the specification by [29]. With these results, it is evident that the lemongrass oil is deficient in iron and may not contribute this element appreciably to the desired application. Iron is very vital for blood building and its shortage can cause anemia.

Lead (Pb):

The lead (Pb) concentration from both solvents: ethanol and acetone are 1.379 and 0.840, respectively (Fig. 1).These concentrations though greater than those from [6] and [30] are still within the permissive limit by [29] (see Table 1). Lead is a heavy metal and excessive intake of it can trigger continuing symptoms of poisoning for human beings and other living organisms, though some living organisms possess ability to take in and accumulate lead in their structure. Cumulative chronic intoxications can occurs from regular intake of products slightly contaminated with lead. Exposure to lead and its associate compounds can cause diabetic nerve pains and polyneuropathy in adults, gout, hypertension cognitive impairments in children [26]. A major source of Lead (Pb) is the use of petrol by automobiles which accounts for about 80% of Lead (Pb) in the atmosphere, with about 50% of this falling to the ground within a distance of 100 metres from the road while the remainder is distributed widely in the biosphere [32]. The lemongrass oil obtained from this work, contains a tolerable amount of lead might not give rise to an immediate effects as described above.

Mercury (Hg):

The mercury concentrations were 0.728 and 0.145mg/kg obtained from the ethanol and acetone extracts, respectively. These concentrations are higher than those reported by [6, 30], and 5.0μg/g prescribed by [29]. With this, there is the possibility that the lemongrass oil will be harmful if consumed, as mercury is a toxic element. According to [33] report, mercury exposure beyond normal limit can result to adverse health conditions, and [34] reported that mercury gets deposited in vital body organs which include brain, nervous system, heart, liver, kidneys, and bone marrow among others. Mercury is also among the major causes of neuropathy, dementia, Parkinson's disease, cancer in human etc.

Chromium (Cr):

The concentration of chromium was 0.201- 0.530 mg/kg. Chromium is required by humans at low concentration. It could become toxic to humans when the concentration level exceeds maximum allowable limits. It helps to synthesize glucose-tolerance -factor [35]; [36]. Overdose may also cause cancer.

Cadmium (Cd):

The concentration of cadmium was 0.08 -0.09mg/kg, comparing this with the permissible value of 0.3 μg/g by [29] shows that the lemongrass oil is limited in cadmium. This could be because; fertilizer was not used in growing the lemongrass as phosphate fertilizer is known to influence cadmium concentration in addition to sewage sludge application and combustion of fossil fuel [37]. The result is good and that means that lemongrass oil would be devoid of the hazardous effect of cadmium, as it can accumulate in the kidneys thereby causing damage to important cells and body mechanisms [38].

Manganese (Mn):

The highest concentration of manganese was 0.009 mg/kg and this is lower than those obtained by [6] and [30], and the specification 20-150 mg/kg prescribed by [29]. This means that there might be no appreciable Mn contribution to the body from the application or consumption of lemongrass oil. Manganese is needed by most biological system. [38]

reported that manganese deficiencies can leads to severe skeletal, reproductive abnormalities in mammals as well weakening of brain, lungs for unwarranted exposure and neurological disorder.

Arsenic (As):

There was no trace of arsenic detected in the sample within the condition considered and with the method used. But, concentration of arsenic (As) above the permissible value of $0.2\mu g/g$ is very hazardous as it could cause lungs, skin, liver, and bladder cancer.

4. Conclusions

The study revealed that the lemongrass contains some metallic elements including magnesium, zinc, copper, iron, lead, mercury, manganese, chromium and cadmium at different concentrations. The concentrations of most of these metals are within the permissible limits by WHO except that of mercury. While of some metals such as magnesium, Zinc, copper and iron, are beneficial, the presence of heavy metals such as lead, mercury, chromium, cadmium and manganese can pose a serious health challenge on consumption or prolong exposure. Therefore, excess consumption or application of the lemongrass must be avoided and regular monitoring through analysis of the metal composition of the lemongrass is encouraged to engender health and safety.

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