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Evaluation of the Nutritional Status and Phytomedicinal Properties of Dried Rhizomes of Turmeric (*Curcuma longa*)

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Abstract

Turmeric (*Curcuma longa*) belongs to the family *Zingiberaceae* and has long been used traditionally for centuries as a spice and medicinal elixir. Hence, the present study aimed to profile the nutritional and phytomedicinal properties of the plant in order to justify its relevance in traditional phytomedicine and advocate its application in novel pharmacological products. Using standard methods (High Performance Liquid Chromatography, Gas Chromatography-Mass Spectroscopy and Atomic Absorption Spectrophotometry), the dried rhizomes were washed, pulverized and ethanol extracts subjected to proximate, phytochemical, vitamins, amino acid and mineral determinations. Data obtained were analyzed using student's *t*-test in Statistical Package for the Social Sciences version 21. Determined proximate indices indicated moisture content of 9.55%, carbohydrate (57.30%), ash (24.70%), crude fiber (1.12%), proteins (2.15%) and fat (5.32%). Mineral composition analyses showed that *C. longa* rhizomes had higher contents of calcium, magnesium, potassium and sodium in parts per million (ppm) at 38.68 ± 0.114, 19.75 ± 0.001, 9.20 ± 0.002 and 7.06 ± 0.014 respectively. Amino acid profile revealed the presence of both essential and non-essential types with aspartate and glutamate in higher contents at 9.78 g/100 g and 9.65 g/100 g, respectively. Findings showed also the presence of vitamins A, C and D at 254.5 ± 2.19 mg/kg, 19.47 ± 0.16 mg/kg and 10.92 ± 0.92 mg/kg, respectively. Phytochemical analyses showed the presence of phenolic compounds with high retention times. This study thus revealed that *C. longa* possesses various nutritional and pharmacological/medicinal components in considerable quantities and can provide the body with basic nutrients for its therapeutic needs as well as secondary compounds with tremendous phytomedicinal potentials.

Keywords

Curcuma longa, Nutritional, Phytomedicine, Traditional, Rhizomes

1. Introduction

Plants from time immemorial have been a source of supply for the basic nutritional requirements of the body primarily for metabolic and physiological functions. With the rising incidence of food insecurity and scourge of "hidden" hunger of most micronutrients prevalent in the developing countries, more plants that have aforetime not been exploited for their nutritional benefits are receiving more attention. According to Ononamdu *et al.* [1], historically plants have been the basis of the most traditional and modern ethnobotanical treatment systems the world over. A vast array of indigenous plants has been employed in the treatment and management of various ailments and illnesses including plants that have served as mere spices for cooking. Enemor *et al.* [2] noted that evidences are also beginning to emerge that even plant seeds hitherto neglected possess, tremendous nutritional and pharmacological potentials. Such plants have not been sufficiently exploited for their nutritional components and potential phytoethnomedicinal properties, hence the need for this study. Due to the increasing popularity of traditional medicine [1], scientific investigations into the phytochemical components of these plants are progressively been demonstrated by several authors [3]. Despite its numerable use in industries, medicine, pharmacology, food and cosmetology as documented by Prasad and Aggarwal [4], *Curcurma longa* yet continues to top the list of under-exploited plants in the South-east region of Nigeria.

C. longa (turmeric) is a medicinal plant that botanically belongs to *Zingiberaceae* family, explained in studies published by Chattopadhyan *et al.* [5], Jilani *et al.* [6], Olatunde *et al.* [7] and Taoheed *et al.* [8]. Nwaekpe *et al.* [9], Chanda and Ramachandra [10] described the plant as a rhizomatous perennial erect leafy herb that measures up to 1 meter high with a short stem, having oblong, pointed leaves and funnel-shaped yellow flowers. The turmeric plant thrives in temperatures between 20˚C and 30˚C and a considerable amount of annual rainfall. In Nigeria, *C. longa* grows 5 meters above sea level in the Southern coastal plains of the rainforest to the 823 meters above sea level in the Savanna, as reported by Olojede and Nwokocha [11] and it is variously known in local contexts as *atale pupa* in Yoruba; *gangamau* in Hausa; *ohu boboch* in Nkanu East, Enugu; *gigir* in Tiv; and *onjonigho* in Cross River State in studies documented by Nwaekpe *et al.* [9] and Olojede and Nwokocha [11]. The turmeric rhizome is tuberous with a rough and segmented skin and matures beneath the foliage in the ground. The rhizomes are yellowish brown with a dull orange interior and can be ground, when dried, to a yellow powder with a bitter, slightly acrid, yet sweet, taste.

Luthra *et al.* [12] noted that *C. longa* is widely used both as spice and coloring agent and is believed by many to possess medicinal properties. There are existing reports that turmeric powder has been applied as traditional medicine against gastrointestinal diseases, especially for biliary and hepatic disorders, diabetic wounds, rheumatism, inflammation, sinusitis, anorexia, coryza and cough. *C. longa* acts as anticancer as reported by Abdel-Lateef *et al.* [13], anti-diabetic, antioxidant, hypolipidemic, anti-inflammatory, antimicrobial, anti-fertility, anti-venom, hepatoprotective, nephroprotective, anticoagulant agent and possesses anti-HIV activity to combat AIDS as described by Akram [14].

While turmeric may be said to be a medicinal elixir based on the range of ailments alluded to its efficacy, much of our insight of its attributes in disease conditions depends on quality scientific evaluations, hence the need to profile the nutritional and bioactive components of the plant, grown on the Nigerian soil, for a better delineation of the properties that make for its claim in pharmacology and traditional medicine while including the plant into the daily fare of the locale.

2. Materials and Methods

2.1. Source of Plant Material and Identification

Fresh rhizomes of *C. longa* used in this work were obtained from Eke Awka market, Awka South Local Government Area, Anambra State, Nigeria and identified by a taxonomist with the Department of Botany, Nnamdi Azikiwe University, Awka, Anambra State.

2.2. Experimental Site

The experimental analyses were carried out at Laboratory of the Department of Applied Biochemistry, Nnamdi Azikiwe University, Awka and Multi-user Science Laboratory, Zaria, Kaduna State.

2.3. Preparation of Plant Material

The harvested rhizomes were carefully washed with clean water. They were then peeled, steamed for 10 minutes to remove the raw odour. It was later dried in the oven at a temperature of 65˚C. After drying, the rhizomes were milled into powder and tightly packaged in a polythene bag kept at room temperature until required for use.

2.4. Determination of Proximate Composition

The crude protein, moisture, crude fiber, and fat contents of the sample were determined according to the methods of Association of Official Analytical Chemists [15]. Determination of ash content was done by ashing at 550˚C for 3 hours. The Kjeldah method was employed to determine the crude protein content. The crude fiber content was determined by digestion method and crude fat content was determined by Soxhlet extraction method. Total soluble carbohy-

drate was determined by the difference of the sum of all the proximate compositions from 100%.

2.5. Determination of Phytochemicals (GC-MS Analysis)

The GC-MS analysis of bioactive compounds from the different extracts of the leaves was done using Agilent Technologies GC systems with GC-7890A/MS-5975C model (Agilent Technologies, Santa Clara, CA, USA) equipped with HP-5MS column (30 m in length × 250 μm in diameter × 0.25 μm in thickness of film). Spectroscopic detection by GC-MS involved an electron ionization system which utilized high energy electrons (70eV). Pure helium gas (99.995%) was used as the carrier gas with flow rate of 1 mL/min. The initial temperature was set at 50˚C - 150˚C with increasing rate of 3˚C/min and holding time of about 10 min. Finally, the temperature was increased to 300˚C at 10˚C/min. One microliter of the prepared 1% of the extracts diluted with respective solvents was injected in a split-less mode. Relative quantity of the chemical compounds present in each of the extracts of *B. luzonica* was expressed as percentage based on peak area produced in the chromatogram.

Identification of Chemical Constituents

Bioactive compounds extracted from different extracts of *B. luzonica* were identified based on GC retention time on HP-5MS column and matching of the spectra with computer software data of standards (Replib and Mainlab data of GC-MS systems).

2.6. Determination of Vitamins

Vitamins A, C and E were determined respectively by the calorimetric, titrimetric and Futter-Mayer colorimetric methods of Kirk and Sawyer [16] with absorbance measured at 325 nm and 410 nm for Vitamins A and E respectively. Vitamins B_1 and B_2 were estimated spectrophotometrically at 216 nm and 242 nm respectively. Vitamins B_3 and B_6 were titrated to greenish blue and green colour end-points using 0.1 ml perchloric acid and 2 - 3 drops of crystal violet as indicator while vitamin B_{12} content was measured spectrophotometrically at 361 nm by the method of Kirk and Sawyer [16]. Vitamins D and K were determined spectrophotometrically at 450 nm and 503 nm respectively using the methods as described by Zakaria *et al.* [17].

2.7. Determination of Minerals

Heavy metal contents were determined using Varian AA240 Atomic Absorption Spectrophotometer according to the methods described by American Public Health Association [18].

2.8. Amino Acid Profile (HPLC Analysis)

Sample proteins were hydrolyzed prior to derivatization. A 0.1 g lyophilized sample was weighed into a 16- × 125-mm screw-cap Pyrex (Barcelona, Spain)

tube, 15 mL of 6N hydrochloric acid was added, and the tube was thoroughly flushed with N_2, quickly capped, and placed in an oven at 110˚C for 24 h (17). After hydrolysis, the tube contents were vacuum filtered (Whatman #541, Maidstone, England) to remove solids, the filtrate was made up to 25 mL with water, and an aliquot of this solution was further filtered through a 0.50-µm pore-size membrane (Millipore, Madrid, Spain). A standard solution containing 1.25 µmol/mL of each amino acid in 0.1N hydrochloric acid was created. Derivatization of sample was done by the method of AOAC as described by Elkin and Griffin [19].

2.9. Data Analysis

Data was subjected to statistical analyses using Statistical Package for the Social Sciences International Business Machine (SPSS IBM) version 21.0 (SPSS Inc., Illinois Chicago, USA). Data were presented as mean ± SD of triplicate determinations.

3. Results and Discussion

3.1. Proximate Analysis of *C. longa*

The values represented in Table 1 show that the turmeric plant under proximate analysis had 9.55 ± 1.20, 24.70 ± 1.56 and 1.12 ± 0.03 of moisture, ash and fiber respectively. The findings also showed fat, protein and carbohydrates contents of 5.32 ± 1.23, 2.15 ± 0.07 and 57.30 ± 1.69 respectively. Similarly the findings of this study corresponded with that of previous studies on turmeric conducted by Ikpeama *et al.* [20] and Imoru *et al.* [21]. This indicates that the plant could be good sources of carbohydrates and fat when compared to mean carbohydrate values obtained for other species of *Curcuma* such as *C. amada*, *C. leucorrhiza*, *C. pseudomontana* and plants usually employed for culinary purposes, reported in studies conducted by Rajkumari and Sanatombi [22]. The protein content was found to be 2.15% ± 0.07% in the present study. Protein is an essential component of human diet needed for the replacement of tissues, supply of energy and adequate amount of required amino acids for various biosynthetic molecules. Proteins are also required in synthesis of enzymes, hormones and antibodies [23]. Similarly, the high content of ash (24.70 ± 1.56) compares favorably with

Table 1. Proximate analysis of *C. longa*.

Parameters	Mean ± Standard Deviation (%)
Ash	24.70 ± 1.56
Carbohydrate	57.30 ± 1.69
Fat	5.32 ± 1.23
Fiber	1.12 ± 0.03
Moisture content	9.55 ± 1.20
Protein	2.15 ± 0.07

Values are mean ± standard deviation of triplicate determinations.

values obtained for other Curcuma species and suggests that *C. longa* may be a potent source of minerals both major and trace. The crude fiber content of *C. longa* in the present study may suggest its detoxifying ability by removing potential carcinogens from the body, helps in bowel movement and prevents the absorption of excess cholesterol. Fiber adds bulk to food and prevents the intake of excess starchy food and may therefore guard against digestive tract metabolic conditions such as hypercholesteremic and diabetes mellitus [24]. Ayoola and Adeyeye [25] further explained that fiber also softens stool and therefore prevents constipation thus helping to fight colon cancer.

3.2. Vitamin Contents of *C. longa*

The vitamin analysis of the plant as represented in Table 2 showed a high mean content of vitamin A at 254 ± 2.19 followed by vitamins C and D at 19.47 ± 0.16 and 10.92 ± 0.92 respectively. In the same vein, the analysis revealed that the rhizome contained vitamin B_1, B_2, B_3, B_6 and B_{12} at 1.98 ± 0.01, 2.18 ± 0.00, 2.25 ± 0.15, 0.08 ± 0.00 and 1.24 ± 0.00 respectively. Vitamin K was estimated at 7.08 + 0.02 in the plant. These findings corroborate previous studies of nutritional composition carried out on *C. longa* with similar values of Vitamins A, C and E in the rhizomes of the plant documented by Ikpeama *et al.* [20] and Imoru *et al.* [21]. Vitamin A content higher than that obtained for the present study was reported by Imoru *et al.* [21] whereas Ikpeama *et al.* [20] observed a lower value of B_1, B_2 and B_3 than the values of the study. These disparities may be due to the different methods employed in determination of the vitamin contents or differences in soil composition. The presence of vitamins in *C. longa* may elucidate its involvement as an antioxidant and anticancer agent in traditional phytomedicine and further implicate it as an ingredient in novel pharmacology products.

3.3. Mineral Content of *C. longa*

The mineral contents of *C. longa* are presented in Table 3. It contains Ca (38.689

Table 2. Vitamin contents of *C. longa*.

Parameters	Mean ± Standard Deviation (mg/kg)
Vitamin A	254.5 ± 2.19
Vitamin B_1	1.98 ± 0.01
Vitamin B_2	2.18 ± 0.00
Vitamin B_3	2.25 ± 0.15
Vitamin B_6	0.08 ± 0.00
Vitamin B_{12}	1.24 ± 0.00
Vitamin C	19.47 ± 0.16
Vitamin D	10.92 ± 0.92
Vitamin E	0.94 ± 0.01
Vitamin K	7.08 ± 0.02

Values are mean ± standard deviation of triplicate determinations.

Table 3. Mineral composition of *C. longa*.

Parameter	Mean ± Standard Deviation (ppm)
Aluminum	0.187 ± 0.003
Arsenic	1.496 ± 0.005
Cadmium	0.000 ± 0.000
Calcium	38.689 ± 0.114
Chromium	0.295 ± 0.004
Cobalt	0.114 ± 0.006
Copper	0.153 ± 0.009
Iron	0.708 ± 0.001
Lead	0.374 ± 0.002
Magnesium	19.750 ± 0.001
Manganese	1.446 ± 0.044
Mercury	0.126 ± 0.003
Nickel	0.226 ± 0.003
Potassium	9.204 ± 0.002
Selenium	0.000 ± 0.000
Sodium	7.060 ± 0.014
Vanadium	0.000 ± 0.000

Values are mean ± standard deviation of triplicate determinations.

± 0.114) as the highest element followed by Mg (19.75 ± 0.001) and K (9.204 ± 0.014). The rhizome also contains some heavy metals in considerable quantities such as Pb (0.374 + 0.002), Ar (1.496 ± 0.005), Ni (0.226 ± 0.003) and Hg (0.126 ± 0.003). These contents are significant of the nutritive value of *C. longa*. Calcium, as a micronutrient, plays a part in the regulation of muscle contraction and relaxation and is implicated in strong bones and teeth development [20] [26]. Normal extracellular calcium concentration is necessary for blood coagulation as explained by Ogidi *et al.* [23] and Okaka and Okaka [27]. The magnesium content of the plants was found to be 19.75 ± 0.001, considerably high in support of previous works on the plant. In a research publication by Hartwig [28], magnesium plays fundamental roles in genomic stability and DNA repair processes. Magnesium activates over 300 different enzymes and thus participates in many metabolic processes, which makes it a pivotal micronutrient, as well as functions in electrolyte transport across cell membranes [29] [30]. Several studies showed that magnesium ions are important for maintaining cell homeostasis because they are essential to the stabilization of cell membranes, especially in the red blood cells where they help maintain membrane integrity through the action of the potassium and calcium pumps [30] [31] [32]. With such significant roles and its presence in the plant, this may elucidate the involvement of the plant in phytomedicine as a blood purifier.

Potassium content which was also observed to be high (9.204 ± 0.014) in this study supported previous reports [33] of its presence in most agricultural plants. It helps to maintain body weight and regulate water and electrolyte balance in the blood and tissues thereby controlling blood pressure [34]. It is also involved

in regulating muscle contraction and nerve impulse transmission [20]. Sodium was also found to be a mineral constituent of the dried rhizomes under analysis (7.06 ± 0.014) and its presence may have implicative functions in treatment of heart diseases as was indicated by Ogidi *et al.* [23].

Trace amount of manganese (1.446 ± 0.044) was observed in the plant as shown by the present study. Manganese is involved in activating enzyme-catalyzed reactions such as decarboxylations, phosphorylations, reductions and hydrolysis reactions. Manganese regulates blood sugar levels, the production of energy and cell reproduction. It may be involved as a cofactor in enzymes of oxidative stress such as superoxide dismutase.

The presence of heavy metals such as lead, mercury, arsenic, nickel and mercury as observed in the present study may probably explain the role of the plant in phytoremediation or the bio-concentration of these metals in the soil from where the plant rhizome were obtained. It may also indicate the degree of environmental contamination in the farm area though the amounts sequestered in the dried rhizomes under study are minimal compared to amounts obtained in areas of dense environmental pollution or plants of phytoremediation. Since heavy elements may have little or no beneficial biochemical roles or biological functions, its presence may be for the benefit of the plant in secondary metabolic processes requiring the elements.

3.4. Amino Acid Profile of *C. longa*

The amino acid profile of the plant is presented in Table 4. Eighteen out of the

Table 4. Amino acid profile.

Amino acid	Concentration (g/100 g of Protein)
Alanine	2.34
Arginine	6.55
Aspartate	9.78
Cystine	2.74
Glutamate	9.65
Glycine	3.64
Histidine	4.76
Isoleucine	2.85
Leucine	2.65
Lysine	3.85
Methionine	1.50
Phenylalanine	5.75
Proline	3.69
Serine	3.74
Threonine	3.57
Tryptophan	1.79
Tyrosine	2.92
Valine	4.75

Values are mean ± standard deviation of triplicate determinations.

twenty amino acids were identified in the analysis. Amino acid composition of protein isolates is an indicator of their nutritive value. The concentrations of essential amino acids and non-essential amino acids of isolated protein were present. The isolated protein contained ten essential amino acids and eight non-essential amino acids of the twenty amino acids. These data showed that the plant had a complete protein fraction. Of the essential amino acids present, arginine (6.55 g/100 g) was found maximum while glutamate (9.65 g/100 g) was presented maximum as a non-essential amino acid in the isolated protein. Overall, aspartate (9.78 g/100 g) was found in higher concentration followed by glutamate (9.65 g/100 g) and arginine (6.55 g/100 g). In a previous study, Enemor *et al.* [2] indicated that the presence of the essential amino acids in the plant under analysis may demonstrate its potential and involvement in body building activities, cell proliferation and stabilization of protein complexes in wound healing. **Figure 1** shows the chromatogram obtained for the amino acid profiling of *C. longa*.

3.5. Phytochemical Composition of *C. longa*

The present study identified several phenolic compounds with varying retention times as obtained by GC-MS analysis presented in **Table 5**. **Figures 2-5** show

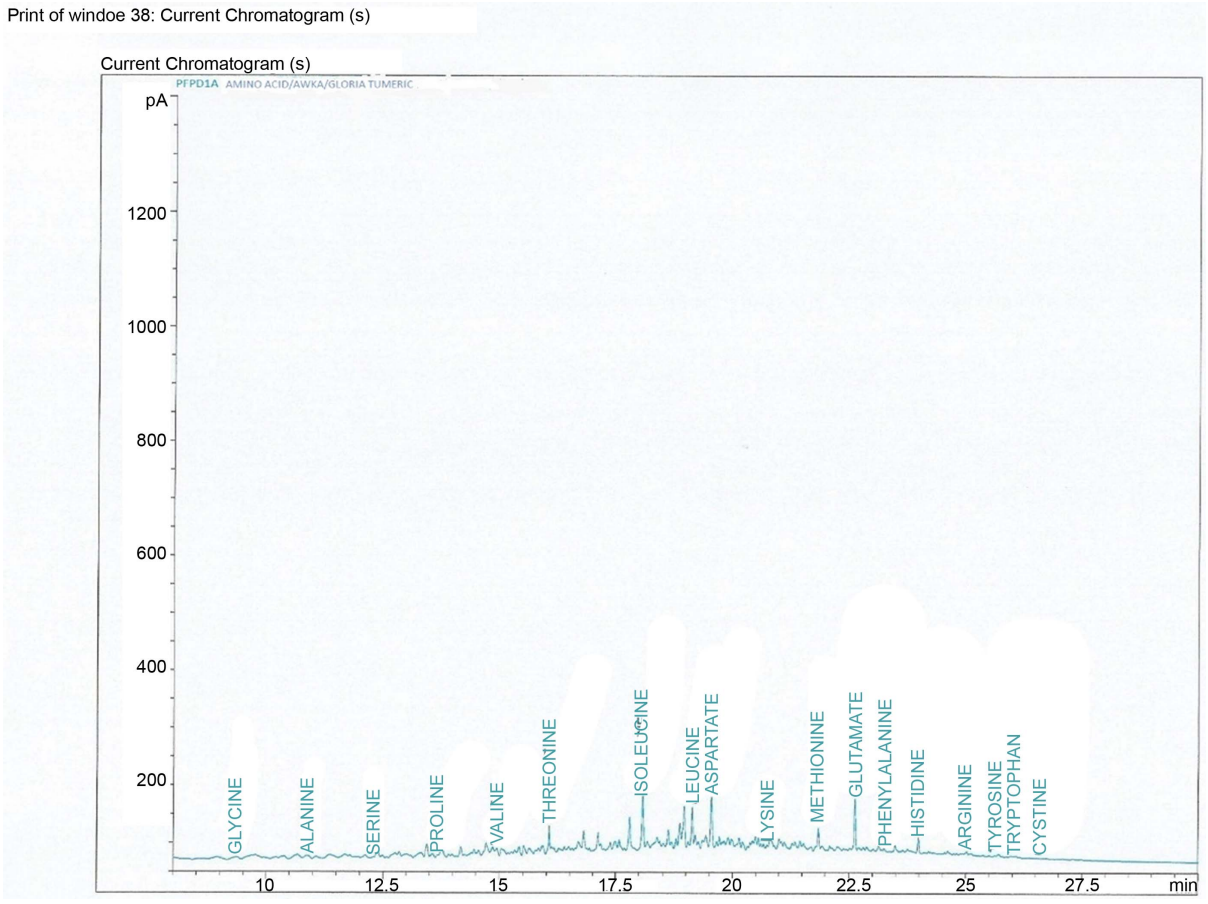

Figure 1. Amino acid chromatogram of *C. longa*.

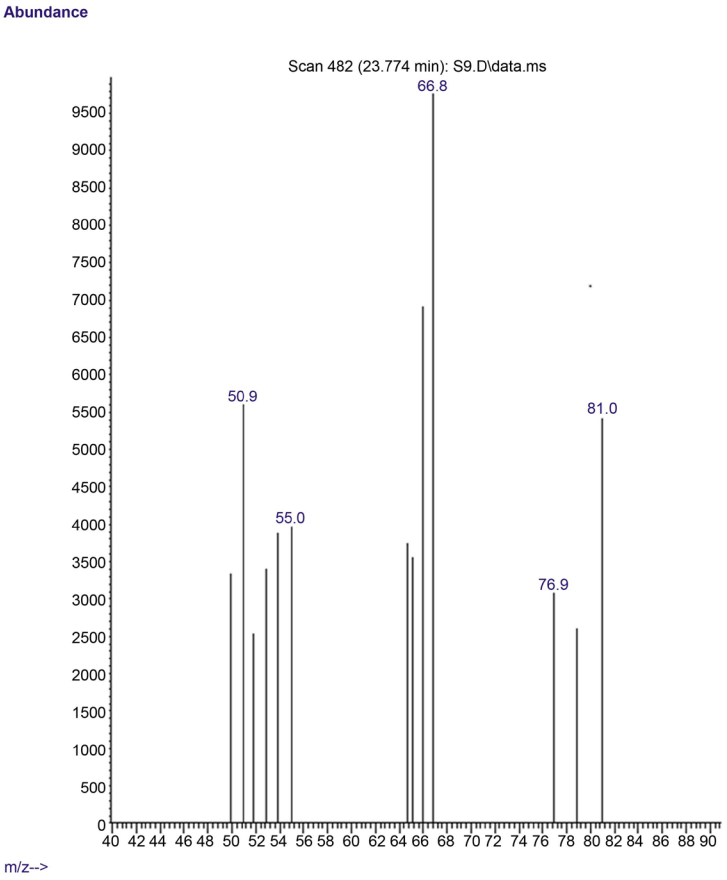

Figure 2. GC-MS chromatogram of *C. longa*.

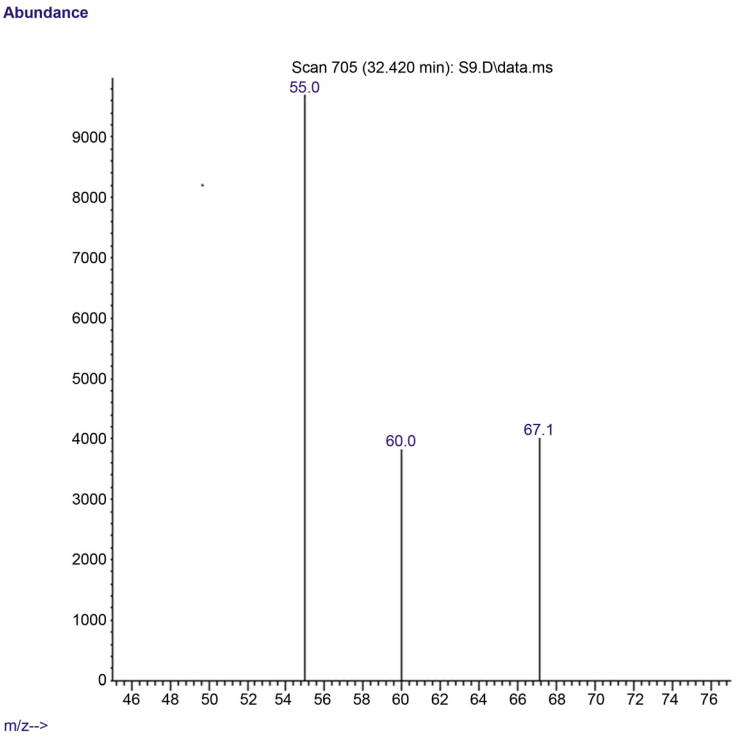

Figure 3. GC-MS chromatogram of *C. longa*.

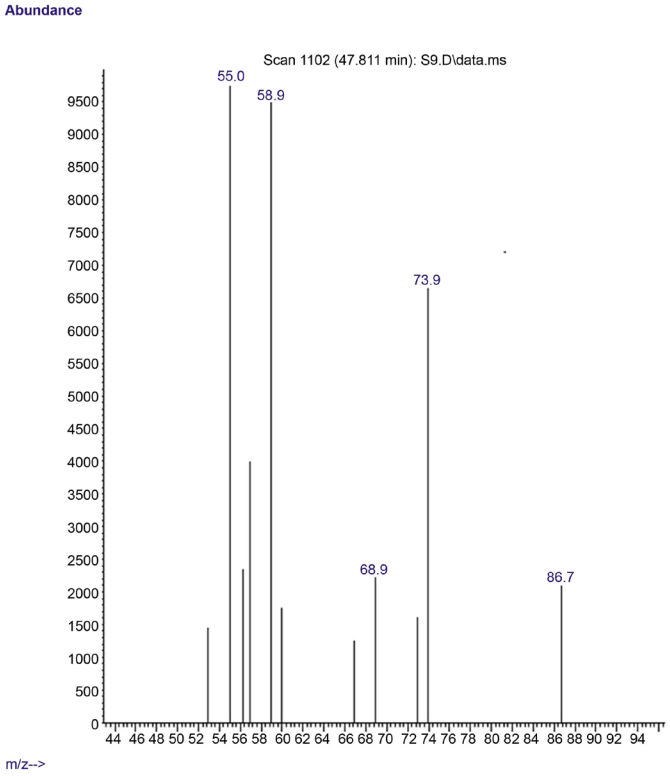

Figure 4. GC-MS chromatogram of *C. longa*.

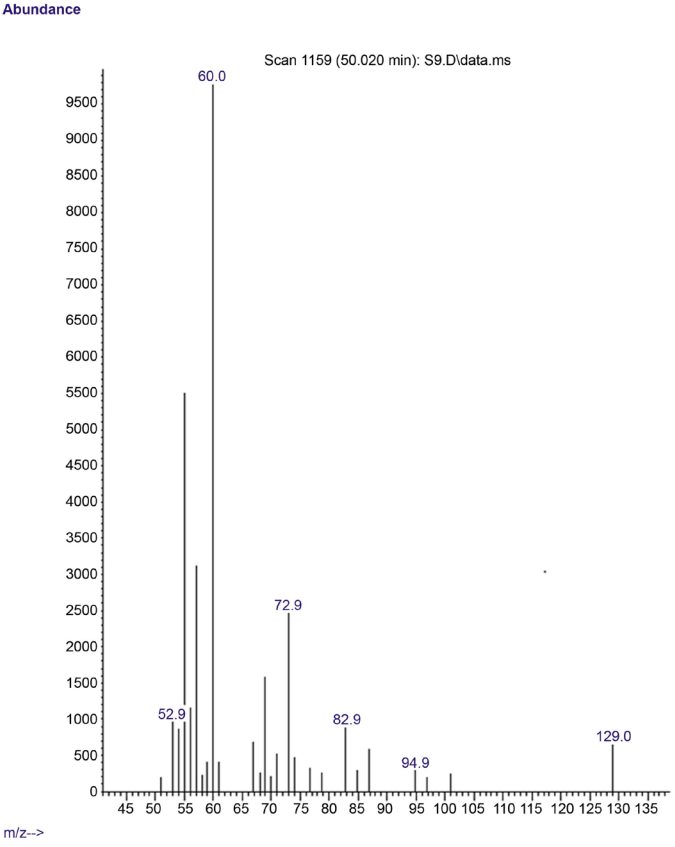

Figure 5. GC-MS chromatogram of *C. longa*.

Table 5. Phytochemical composition of *C. longa*.

Areas	Phenolic Compound	Retention Time (RT)
3.48	1-Azabicyclo [3.1.0] hexane 0-Allyihyfroxylamine Pyridine, 2,3,4,5-tetrahydro	55.176
1.14	Butylamine 0-Allyihyfroxylamine Hydrazine, 1,2-dimethyl-	55.874
1.16	Urea Oxalic acid. Butyl cyclobutyl ester Formic acid hydrazide	56.611
0.78	2-butanamine, (S) – Formic acid hydrazide Carbonyl sulfide	59.960
0.70	Propanamide Carbonyl sulfide Hydrazine, 1,1-dimethyl	57.503
0.71	Urea Thiirane Thiirane	58.355
0.74	Bicyclo [1.1.0] butane 1,3-Butadiene 1,3-Butadiene	58.588
0.70	O-Allylhydroxylamine Urea Thiirane	59.053
1.29	Bicyclo [1.1.0] butane 1,3-Butadiene 1,3-Butadiene	59.247
0.84	Propanal, oxime Aminoacetonitrile Ethyl isocyanide	59.519
0.79	Azetidine Methane, Isocyanato – Methane, Isocyanato -	59.674
1.48	Propanal, oxime Aminoacetonitrile Aminoacetonitrile	59.945
1.13	2-Butanamine, (s)- O-Allylhydroxylamine Thiirane	60.449
1.11	Nitric acid, heptyl ester Amyl nitrite (E)-2-Butenylcyclopropane	60.604
0.79	1,2-Dimethyl cyclopropane 3-Methylbut-2-en-l-ylpivalate Aziridine, 1-ethenyl-	60.875
0.91	Ethyl isocyanide Thiirane Thiirane	61.108

Continued

1.09	Azetidine, 1-methyl Azetidine, 2-methyl Isobutylamine	61.379
1.41	Thiirane Hydrazine, 1,2-dimethyl – Formic acid hydrazide	61.573
0.97	1,4-pentadiene Cyclobutane, methylene – Cyclobutane, methylene -	61.883
1.48	Pyridine, 2,3,4,5-tetrahydro – 1-Azabicyclo [3.1.0] hexane Acetonitrile, hydroxyl -	62.426
1.04	Oxirane, 5-hexenyl- Chloro-methyl-methoxy-amine Chloro-methyl-methoxy-amine	62.542
1.16	1-methyl-3-butenyl 3-methyl-3 hydroxybutyl ether Acetic acid, (aminooxy) – Hydrazine, 1,2-dimethyl -	62.814
2.60	1,4,2,5 Cyclohexanetetrol 11-(2-Cyclopenten-1-yl) undecanoic acid, (+) – 2-Hepten-1-o1, (E)-	63.202
1.70	1,5-Pentanediol, 3-methyl- 3-Buten-1-o1, 3-methyl- (Aminomethyl) cyclopropane	63.628
2.59	1-Hexene, 6-bromo- Sucrose 2-Heptenal, (E)-	63.861
1.82	Oxirane, 2,2'-(1,4-butanediyl) bis- 5-Hexen-2-o1 3,4-Hexanediol, 2,5-dimethyl -	64.209
2.42	Pentanoic acid, 4-methyl Amyl nitrite Oxirane, 2,2'-(1,4-butanediyl) bis-	64.558
3.42	1,2: 4,5:9, 10-Triepoxydecane Oxirane, 2,2'-(1,4-butanediyl) bis- 1,5-Hexadiene, 3-methyl	64.830
3.33	Cyclobutanone, 2-methyl -2-oxiranyl Hexane, 1,6-dichloro- Sec-Butyl ethyl carbonate	65.062
1.24	2-Propanamine, N-hydroxy- $CH_3ON(CH\#)_2$ 2,3-Epoxyhexanol	65.256
2.17	4-Cyclopentene -,3-diol, trans- 1,2:4, 5:9,10-Triepoxydecane Peopanamide	65.605
1.06	4-Cyclopentene-1,3-diol, cis- 2H-Pyran, 2-(3-butynyloxy) tetrahydro- 2-Methylenecyclohexanol	57.774

Continued

1.31	Thiirane Hydrazine, 1,1-dimethyl- Hydrazine, 1,1-dimethyl-	58.007
1.28	$CH_3ON\ (CH_3)_2$ Urea Hydrazine, 1,1-dimethyl-	58.101
0.95	2-Butanamine, (S) Isobutylamine Isobutylamine	58.123

the GC-MS chromatograms obtained after the analysis of the dried *C. longa* plant for secondary antimetabolites. They include the flavonoids, sterols and tannins. Phenolic compounds are ubiquitously distributed phytochemicals synthesized through the shikimic acid and phenylpropanoid pathways and have been linked to the potentiating effects of human health through the prevention of several diseases due to their antioxidant property. More specifically in a study documented by Huang *et al.* [35], these may allude the bioactivities of the plant responsible for its chemo-preventive properties such as antioxidant, anti-carcinogenic, anti-inflammatory effects and also contribute to their inducing apoptosis by arresting cell cycle, regulating carcinogen metabolism and ontogenesis expression, inhibiting DNA binding and cell adhesion, migration, proliferation or differentiation and blocking signaling pathways. For example, Subramani and Casmir [36] explained that the flavonoids prevent the oxidation of low-density lipoprotein, lowers the blood levels of cholesterol and triglycerides thereby reducing the risk for the development of atherosclerosis. Okwu [37] also reported the ability of the plant to have vaso-dilatory and inhibitory effects on platelet aggregation thereby preventing coronary heart. On the other hand, saponins have been reported to have beneficial effects on blood cholesterol levels. They bind with bile salts and cholesterol in the intestinal tract and cause a reduction of blood cholesterol by preventing its re-absorption. As noted by Oakenfull and Sidhu [38], the non-sugar part of saponins also has antioxidant activity which may help to reduce risk of heart diseases.

4. Conclusion

The results of this research work showed that the dried, ground rhizomes of *C. longa* are rich in phytochemicals, proximate, vitamin, amino acids and minerals in appreciable quantities and the presence of these secondary metabolites may explain its efficacy in disease treatment and management with pharmacologic activities as anti-inflammatory, antioxidant, anti-cancer among others. It is worthy of recommendation that this plant as a nutraceutical be incorporated with other such valuable species like ginger in fruit juices, milk shakes and protein shakes for provision of its essential nutrients. This way, through the findings of this study, *C. longa* will be exploited and further utilized pharmacologically.

Authors' Contributions

This work was carried out in collaboration between all authors. Author VHAE designed and supervised the study while GCI carried out the experimental analyses. Authors OGF, OCE and COO managed the analyses of the study and the literature searches. Author UCO wrote the protocol and first draft of the manuscript. All authors read and approved the final manuscript.

Conflicts of Interest

The authors declare that no conflict of interests exists.

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