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Phytochemical Screening, Nutritional and Anti-nutritional Composition of Aqueous Rhizome Extract of *Curcuma longa*

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Abstract
Background: *Turmeric (Curcuma longa L.) is widely consumed as a spice and used for treatment of various diseases and conditions including diabetes, cancer, hypercholesterolemia, wounds, jaundice, and inflammation.*
Aim: *This study aims at evaluating the phytochemicals, nutritional and anti-nutritional composition of aqueous rhizome extract of Curcuma longa.*
Materials and Methods: *Experimental analyses for proximate, vitamins, minerals and anti-nutrients composition were performed using standard analytical methods in triplicate and the data were expressed as mean values.*
Results: *The phytochemicals screening of the turmeric extract revealed the presence of flavonoids, tannins, saponins, alkaloids, volatile oil, steroids, glycosides, cardiac glycosides and phenols. The turmeric extract contains significant amount of carbohydrate (56.69%), protein (15.31%), moisture (8.00%), ash (7.00%), lipid (3.50%) and crude fiber (9.50%). The level of vitamin A, C and E in the turmeric extract is 61.1 mg/100g, 24.3 mg/100g and 10.5 mg/100g, respectively. The minerals composition of turmeric extract is potassium (9.97 mg/100g), iron (9.10 mg/100g), calcium (7.66 mg/100g), zinc (4.51 mg/100g), cupper (4.21 mg/100g), manganese (3.30 mg/100g), magnesium (2.29 mg/100g), phosphorus (1.47 mg/100g), selenium (1.19 mg/100g), sodium (1.14 mg/100g), lead (0.03 mg/100g), nickel (0.11 mg/100g) and cadmium (0.02 mg/100g). The anti-nutrients content of turmeric extract is phytate (0.51 mg/100g), oxalate (0.28 mg/100g), cyanide (0.07 mg/100g), saponins (0.98 mg/100g), tannins (0.87 mg/100g) and nitrate (0.12 mg/100g).*
Conclusion: *The aqueous rhizome extract of turmeric contains significant amount of nutrients and several phytoconstituents responsible for its nutritional benefits and medicinal importance.*
Keywords: *Anti-nutrients; Minerals; Nutrients; Phytochemicals; Turmeric; Vitamins*

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I. Introduction

Natural products have been used for nutritional benefits and therapeutic applications. High percentage of the world's population relies on the natural products including plant-based foods for nutritional benefits and remedies. Nutrients and anti-nutrients contents of foods and plants determined their nutritional value. The medicinal use and pharmacological activities of plant-based foods is largely attributed to the presence of phytochemicals or metabolites that play biological and biochemical roles. Plant-based foods contain various nutrients and phytoconstituents attributed to their nutritional value and pharmacological activities. Anti-nutrients are chemical substances found in food that prevent the absorption and reduce the bioavailability of essential nutrients. Level of anti-nutrients in foods can be reduced via several food processing methods to minimize their effect on the essential nutrients. Phytochemicals presence in plants and herbs exhibited significant importance in drug discovery and development[1].

Curcuma longa L. commonly known as turmeric is a rhizomatous herbaceous perennial plant belonging to the family *Zingiberaceae*[2]. Turmeric is widely consumed as spices and used in food industry as colouring agent, coating and as a preservative[3]. It has been used for treatment of various diseases such as diabetes, wounds, hepatic disorders, rheumatism and sinusitis, abdominal pains, menstrual disorders, jaundice, inflammations and cancer[4,5]. In Nigeria, turmeric is locally called Gangamau in Hausa, Atale pupa in Yoruba

and Nwandumo in Igbo. Turmeric has been used traditionally in North Western region of Nigeria as food and for management of many diseases including diabetes, cancer and inflammation.

Turmeric has been reported to demonstrated anti-oxidant scavenging activity, anti-inflammatory, anti-hypertensive, anti-diabetic, anti-microbial, anti-ulcer and anti-cancer activities[5,6]. Studies reported that turmeric contain various essential nutrients including vitamins, minerals and phytochemicals[3,7,8]. Many bio-active compounds such as curcumin, dimethoxycurcumin and bisdemethoxycurcumin were reported for the pharmacological activity of *Curcuma longa*[9,10]. Studies on the phytochemicals screening and nutritional composition of turmeric from different regions in the world have been reported. To the best of our knowledge there is no study on the phytochemicals screening, nutritional and anti-nutritional composition of the turmeric harvested from the North West region of Nigeria that has been reported. To ascertain the nutritional value and phytoconstituents of the turmeric species from this region, this study was conducted to evaluate the phytochemical, nutritional and anti-nutritional composition of aqueous rhizome extract of turmeric.

II. Materials and Methods

Chemicals

All the chemicals used in this study were of analytical grade and purchased from Sigma-Aldrich (St. Louis, MO, USA), Sigma Aldrich (Irvine, UK), Sigma -Aldrich (Chemie, Steinheim, Germany) and Guangdong Chemical Reagent Engineering, (Guangdong, China).

Plant Material

Fresh turmeric rhizomes were obtained from Gwandu district region in Kebbi state, Nigeria. The plant sample was identified and authenticated (UDUH/ANS/0798) by the Herbarium Officer at Taxonomy Unit, Department of Biological Sciences, Usmanu Danfodiyo University, Sokoto.

Preparation of the Plant Extract

The turmeric rhizomes were thoroughly washed with water, sliced into pieces and then air dried at room temperature for two weeks. The dried rhizomes were pulverized to fine powder using an electric grinding machine. The rhizomes fine powder was stored in air-tight containers for analysis. The extract was prepared using the method of Abubakar *et al.*[11] with some modifications. Five hundred grams (500g) of the powdered rhizomes was extracted in 1.5L of distilled water for 72 hours with intermittent stirring at 1-hour interval. The extract was filtered using Whatman filter paper and concentrated in a rotary evaporator (RV 8, 001000217+, IKA, Germany) at 40°C under reduced pressure for 3 hours. The weight and percentage yield of the extract was recorded and then stored in desiccators until further used. The weight and percentage yield of the extract were 200.5g and 40.1% w/w, respectively.

Phytochemicals Screening

The rhizome aqueous extract of *Curcuma longa* was screened for the presence of various phytochemicals using the standard methods of Mosa *et al.*[12] and Abubakar *et al.*[13] with some modifications.

Proximate Analysis

Proximate parameters (moisture, carbohydrate, crude protein, ash and fiber) were determined using the method of AOAC[14]. All the experiments were performed in triplicate and the results were expressed as the mean and standard error in percentage.

Determination of Vitamins Composition

The composition of vitamin A, C and E in the aqueous rhizome extract of turmeric was determined using the method of AOAC[14]. The experiments were done in triplicate and the results were expressed as the mean and standard error in mg/100g of the sample.

Determination of Minerals Content

The concentration of Ca, Cu, Fe, Mg, Mn, Se, Pb, Ni, Cd, P and Zn in the aqueous rhizome extract of turmeric was determined using atomic absorption spectrophotometer (AA-6300 Model) while K and Na composition was determined using the Flame Photometer (PFP7 500731 Model) according to the method of AOAC[15,16].

Determination of Anti-nutrients Contents

The concentration of phytate in the turmeric extract was determined using the method of Reddy and Love[17]. Cyanide and nitrate contents were estimated according to the method of AOAC[15]. The oxalate level was evaluated by titrametric method as described by Gupta *et al.*[18]. The tannins and saponins contents were determined using the method of AOAC[16] and AOAC[19], respectively.

Statistical Analysis

All the experiments were performed in triplicate. The results were expressed as mean ± SEM. The data were analyzed using Statistical Package for Social Sciences (SPSS) Statistics version 22 software (IBM Corp., Armonk, NY, USA). Significant differences between the mean values were computed by One-way analysis of variance (ANOVA) confidence level (95%) and Tukey-Kramer multiple comparisons test and two-tailed ($p<0.05$) were considered significant.

III. Results

Phytochemicals Composition of the Turmeric Rhizome

Table 1 shows the phytochemical composition of aqueous rhizome extract of turmeric. The turmeric extract showed the presence of more alkaloids, flavonoids, tannins, saponins, steroids and volatile oil. Phenol and cardiac glycosides were presence in moderate amount while glycosides were found in trace amount (Table 1).

Table 1: Phytochemicals composition of the turmeric rhizome

Phytochemical	Turmeric Extract
Alkaloids	+++
Flavonoids	+++
Tannins	+++
Glycosides	+
Saponins	+++
Steroids	+++
Phenol	++
Cardiac glycosides	++
Volatile oil	+++

+++ = Highly present, ++ = Moderately present, + = Fairly present

Proximate Composition of the Turmeric Rhizome

The proximate composition of aqueous rhizome extract of turmeric is shown in figure 1. The turmeric extract contains 56.69% carbohydrate, 15.31% protein, 8.00% moisture, 7.00% ash, 3.50% lipid and 9.59% crude fiber (Fig. 1).

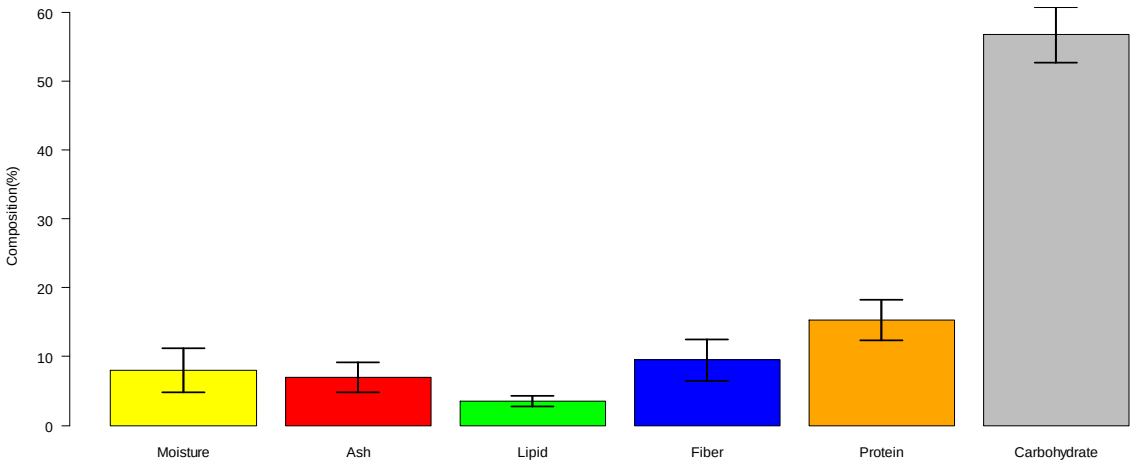

Figure 1: Proximate composition of the turmeric rhizome

Values are mean ± SEM (n = 3)

Vitamins Composition of the Turmeric Rhizome

Fig. 2 shows the anti-oxidant vitamins composition of the aqueous rhizome extract of turmeric. The result revealed that the turmeric extract contains high significant amount vitamin A up to 61.1 mg/100g approximately. The concentration of vitamin C and E in the turmeric extract is approximately 24.3 mg/100g and 10.5 mg/100g, respectively (Fig. 2).

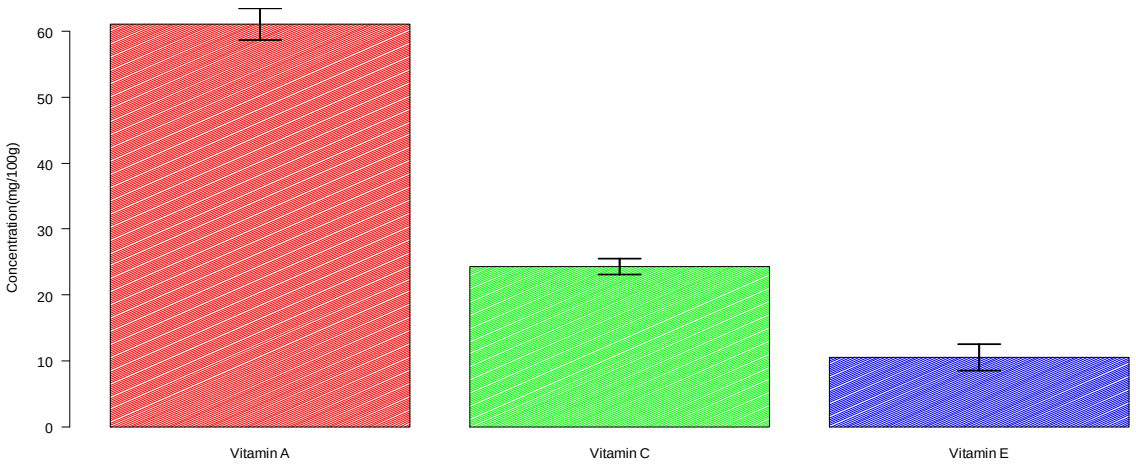

Figure 2: Vitamins composition of the turmeric rhizome
Data are expressed as mean ± SEM (n = 3)

Minerals Composition of the Turmeric Rhizome

The minerals content of aqueous rhizome extract of turmeric is shown in Table 2. The turmeric extract demonstrated highest significant levels of potassium (9.97 mg/100g), iron (9.10 mg/100g) and calcium (7.66 mg/100g) than the other minerals. The extract also contains significant amount of zinc (4.51 mg/100g), cupper (4.21 mg/100g), manganese (3.30 mg/100g) and magnesium (2.29 mg/100g). Phosphorus (1.47 mg/100g), selenium (1.19 mg/100g) and sodium (1.14 mg/100g) were found in moderate amount. However, the extract contains a trace amount of lead (0.03 mg/100g), nickel (0.11 mg/100g), and cadmium (0.02 mg/100g) (Table 2).

Table 2: Minerals composition of the turmeric rhizome

Mineral	Concentration (mg/100g)
Sodium	1.14 ± 0.030
Potassium	9.97 ± 0.020
Phosphorus	1.47 ± 0.040
Selenium	1.19 ± 0.005
Calcium	7.66 ± 0.060
Magnesium	2.29 ± 0.020
Iron	9.10 ± 0.010
Manganese	3.30 ± 0.006
Zinc	4.51 ± 0.008
Copper	4.21 ± 0.007
Lead	0.03 ± 0.001
Nickel	0.11 ± 0.005
Cadmium	0.02 ± 0.001

Values are expressed as mean ± SEM (n = 3)

Anti-nutrients Content of the Turmeric Rhizome

Fig. 3 shows the concentration of the anti-nutrients in aqueous rhizome extract of turmeric. The turmeric extract demonstrated significant (p<0.05) highest concentration of saponins (0.98 mg/100g) and tannins (0.87 mg/100g) compared to the other anti-nutrients. In comparison to the cyanide and nitrate, the extract exhibited significant (p<0.05) levels of phytate (0.51 mg/100g) and oxalate (0.28 mg/100g). However, trace levels of cyanide (0.07 mg/100g) and nitrate (0.12 mg/100g) were found in the extract (Fig. 3).

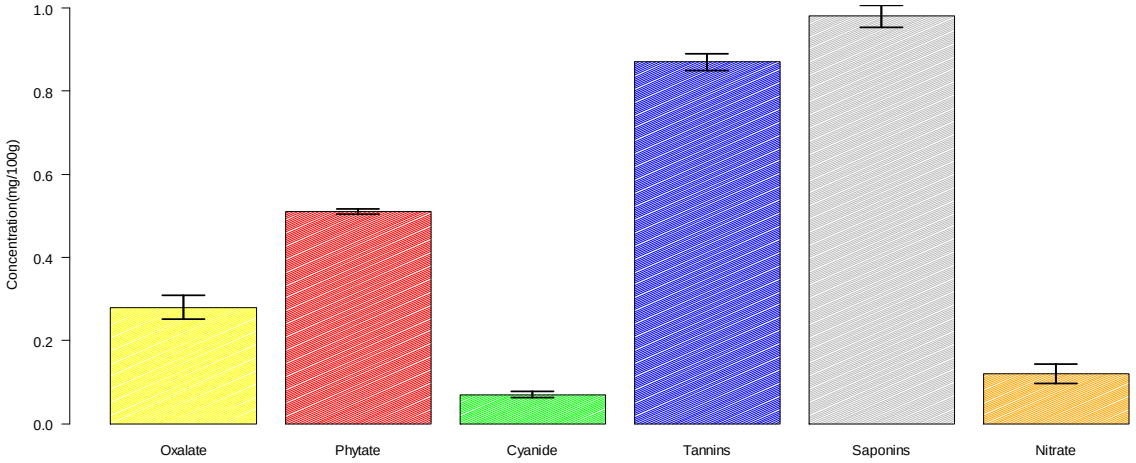

Figure 3: Anti-nutrients content of the turmeric rhizome

IV. Discussion

In this study the result of phytochemical screening revealed that aqueous rhizome extract of turmeric demonstrated the presence of many phytoconstituents including flavonoids, Tannins, saponins, alkaloids, volatile oil, steroids, glycosides, cardiac glycosides and phenols. These phytochemicals have been documented to possessed pharmacological activities and therapeutic applications[20]. Alkaloids from different plants extracts have been reported with analgesic activity[21]. Study by Ballard and Marostica[22] showed that flavonoids isolated from different plants extracts exhibited antioxidant activity scavenging activity, anti-cancer, anti-malarial, anti-hypertensive and anti-ulcer activity. Saponins have been reported to lower blood cholesterol level and as a source of steroidal hormones[23]. Tannins presence in many plants has been used as a wound healing agents, astringents agents and in treatment of gastrointestinal diseases[23,24]. Cardiac glycosides from different plants extracts have been used in the treatment of cardiovascular diseases and their complications including congestive heart failure and cardiac arrhythmia[25]. Plant steroids are essential precursors for biosynthesis of sex hormones and steroidal drugs such as corticosteroid[26]. Studies showed that phenolic compounds demonstrated pharmacological activities such as anti-ulcer, anti- inflammatory, cytotoxic and antitumor, anti-spasmodic, and anti-depressant activities[27]. Volatile oils are used in industries as antioxidants and preservatives, and have therapeutic applications including pain relievers, depression, antimicrobial and anxiety[28,29].

The result of this study showed that the turmeric extract contains high significant amount of carbohydrate suggesting that turmeric is good source of carbohydrates. The result is in agreement of with the study by Uzomba *et al.*[30] and Ikpeama *et al.*[31] who reported higher value of carbohydrate contents in different rhizome extract of turmeric. In this study it was found that aqueous rhizome extract of turmeric demonstrated significant amount of protein. Plant protein is important in child feeding, production of enzyme, hormones and human serum albumin[32]. The percentage of moisture content in the turmeric extract obtained in the current study is in agreement with the study reported by Ikpeama *et al.*[31] and Imoru *et al.*[8]. The low moisture content of the turmeric extract could be attributed to its long shelf life and lesser prone to microbial attack. The present study revealed that the rhizome extract of turmeric contains significant amount of ash content. Ash is a crucial factor in measuring the mineral content of the food stuffs[33]. This suggests that the turmeric extract could be a good source of minerals. In this study low lipid content was found in the turmeric extract signifying that the turmeric extract may be less prone to coronary heart disease and low risk of hypertension. However, the result of this study showed that aqueous rhizome extract of turmeric contains significant amount of crude fiber. Study shows that dietary fiber can reduce the prevalence of coronary heart diseases, obesity, type 2 diabetes and cancer[34].

In this study, the aqueous rhizome extract of turmeric demonstrated the presence of vitamin A, C and E. In humans vitamin A has many biological functions including vision, gene expression, immune function, antioxidant activity, cell reproduction and regeneration[35]. Vitamin C is an antioxidant vitamin which in human plays vital roles in reduction incidence of cancer, blood pressure, immunity and immune system, drug metabolism, urinary hydroxyproline excretion and tissue regeneration[36]. Study showed that vitamin C deficiency is associated with the risk of scurvy, common cold, asthma, capillary fragility, gout, gingivitis, musculoskeletal injury, seasonal allergies and increase in blood pressure[37]. Vitamin E has been reported with multiple functions

as a supplement, potent natural antioxidant[38], wounds healing agent, immune system enhancer[39] facilitates vasodilatation of blood vessels and anti-clotting agent in blood vessels[40].

The result of present study showed that the turmeric extract contains high amount of iron and calcium. Iron is an essential component of certain enzymes and proteins including hemoglobin, and myoglobin[41]. It plays important role in formation of hemoglobin, transport of oxygen, oxidative processes, cellular growth and many catalytic reactions[41]. Iron facilitates oxidation of many metabolites and help in the management of obesity and its associated complications[42]. Calcium plays an essential role in blood clotting, formation of bone and teeth and as a co-factor in certain enzymatic reactions[43,44]. Sodium and Potassium plays a vital role in acid-base balance regulation, maintenance of osmotic pressure and membrane potentials, muscles contraction and nerve impulses transmission[45]. In this study the turmeric extract demonstrated a high and low level of potassium and sodium, respectively. The K^+/Na^+ ratio is an important factor associated with hypertension and its complication particularly cardiovascular disease[46]. The high and low level of potassium and sodium obtained in this study indicated that the turmeric extract might have important role in lowering blood pressure.

In the current study the turmeric extract demonstrated significant amount of zinc, cupper, manganese and magnesium. Zinc plays a vital role in protein synthesis, DNA synthesis, immune response, cell division and replication and wound healing[47]. It has been reported that zinc demonstrated protective effect against aging and accelerated healing process by virtue of its antioxidant properties[48]. Study showed that cupper serve as an important structural component for maintenance of strength of skin, connective tissue and epithelial cells[48]. It plays a vital role in the synthesis of melanin, hemoglobin, myelin, and maintenance of normal functioning of thyroid gland[48]. Manganese serves as a cofactor and activator of many enzymes including decarboxylases, transferases, and hydrolase[45]. It plays a role in lipid and carbohydrate metabolism, absorption of calcium, and regulation of blood sugar[49]. It helps in the formation of bones and connective tissues and blood clotting[50]. Magnesium plays a crucial role in many biochemical processes. It functions as cofactor in more than 300 enzymatic reactions[51]. It involves in the metabolism of protein and nucleic acid, production of energy, contraction of muscle and nerve function[51].

However, phosphorus and selenium were found in moderate amount in the present study. Phosphorus is a structural component of RNA and DNA and plays a role in bone mineralization, homeostasis process and ATP synthesis[52]. Moreover, a trace amount of lead, nickel and cadmium were found to be present in the turmeric extract. Although, lead, nickel and cadmium have certain biological functions their toxic effect on various organs and tissues have been reported and documented. Thus, the presence of many important minerals in the turmeric extract indicated that consumption of turmeric could help in protection against many minerals deficiency associated diseases.

Anti-nutrients have been reported to elicit toxic effects in both human and animal models[53]. In this study a low level of oxalate was found in the turmeric extract. Consumption of foods containing high levels of anti-nutrients may cause toxic effect in the body. Oxalate hinders the absorption of calcium ion resulting to unavailability of the calcium for various functions in the body[54,55]. Oxalate binds to plasma calcium ion to form Calcium-oxalate complexes which accumulate to kidney stones[56]. It has been reported that high levels of oxalate in foods causes irritation in the mouth and the lining of the gut[57]. The result of this study showed a lowest level of cyanide in the turmeric extract. Cyanide has toxic effects on cardiovascular, respiratory and the central nervous system[58]. Elevated level of cyanide is associated with cerebral damage and lethargy[58].

Phytates bind strongly to several minerals including calcium, copper, iron, zinc, magnesium and molybdenum forming insoluble complexes that are poorly absorbed from gastrointestinal tract[59,60]. The complexes formed lower the bioavailability of minerals in the body[60]. The chelating property of phytate renders it a most effective anti-nutrient in foods and cause deficiency of minerals in animal and human nutrition[61]. Consumption of high phytate rich foods causes serious effects in infants, pregnant and lactating women[62]. Phytates inhibit the activity of digestive enzymes including amylase, pepsin and trypsin[63]. In the present study, the turmeric extract demonstrated low level of phytate.

Tannins interferes the digestion of many food substances resulting to poor absorption of important nutrients[64]. Tannins bind strongly to proteins and form complexes which inhibit the activity of many digestive enzymes leading to low availability of proteins[65]. Low level of tannins was found in this study. High concentrated saponins is characterized by a bitter taste which is the main factor limiting the use of saponins[57]. Saponins have many toxic effects in biological system including decreasing of enzymes activities, binding of minerals and reducing the bioavailability of nutrients[66]. Saponins interfere with protein digestion and absorption of vitamins and minerals in the gut leading to development of leaky gut[67]. In the current study, the turmeric extract exhibited low concentration of saponins.

V. Conclusion

The extract of turmeric rhizome contains various phytochemicals and essential nutrients with trace amount of anti-nutrients. The presence of these bioactive metabolites and essential nutrients implies that turmeric rhizome has nutritional value and medicinal properties. Thus, this study suggested that turmeric rhizome could be consumed for nutritional and health benefits.

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Conflict of Interest

The authors declare no conflict of interest.

Authors' Contribution

The laboratory experiments were conducted by Jabir Aliyu Danyaya, Zayyanu Abdullahi Fatima Ahmad Abubakar and Abdulhakim Zubairu. Ibrahim Abubakar and Abdulsalam Umar Sahabi performed the statistical analyses of the results. Original draft of the manuscript was written, edited and reviewed by Ibrahim Abubakar. All the authors read, revised and approved the final version of the manuscript.

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