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Nutritional Profile and Health Promoting Properties of *Curcuma Longa* (Linn) (Tumeric).

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ABSTRACT

Turmeric rhizome (*curcuma longa*) is a flowering plant, of ginger family, Zingiberaceae. It is abundantly found in Nigeria, where it is mainly used as a spice in cooking and for various pharmacological and medicinal applications. This study was done to evaluate the nutritional content and health promoting effects of turmeric. Proximate analysis was done using AOAC (2000), Vitamin and Phytochemical analyses were carried out, using standard techniques and procedures, the elemental analysis was conducted using Agilent FS240AA Atomic Absorption Spectrophometer according to the method of APHA 1995. The results showed that turmeric is a good source of carbohydrates (41.07%), proteins (7.35%), fibre (5.21%) and fat (8.20%). It contains high amount of vitamin C (60.4mg/kg) and appreciable amounts of vitamins E (15.4mg/kg), A (5.0mg/kg), B12 (3.9mg/kg) and D (3.1mg/kg),amongst other vitamins present. Minerals such as magnesium (5.8ppm), sodium (5.2ppm), potassium (4.8ppm), calcium (3.0ppm) and iron (1.2ppm) were found in appreciable amounts while Zinc, copper, manganese and chromium were found in trace quantities. Turmeric also contains various pharmacologically active phytochemicals, notably cardiac glycoside (18.45%), Saponin (11.58%), Tannin (11.15%) and Anthocyanin(15.39%), while Flavonoids, Steroid and Alkaloid where found in lower concentrations. The results shows that turmeric is a highly nutritious plant, filled with various nutrients, vitamins, minerals and phytochemicals which can be taken for proper growth and development, prevent and manage various diseases.

Key words: Tumeric, *Curcuma longa*, curcumin, nutrients, minerals, phytochemicals.

INTRODUCTION

Turmeric (*curcuma longa*) is a flowering plant, of ginger family, Zingiberaceae, the rhizomes which are used in cooking (Imtiaz and Sabia, 2016). The plant is a perennial, rhizomatous, herbaceous plant. Turmeric is native to India and Southeast Asia (Daily *et al.,* 2016). It requires temperatures between 20^0c and 30 ^{0}c (68^0f and 86^0 f) and a considerable amount of annual rainfall to thrive. (Naiv and Prabhakaran,2013). The rhizomes are used fresh or boiled in water and dried after which they are ground into a deep orange-yellow powder commonly used as a coloring and flavoring agent in many Asian cuisines, especially for curries, as well as for dyeing, a characteristic, imparted by the principal turmeric constituent "curcumin" (Nelson *et al,* 2017). Curcumin is a bright yellow chemical produced by the turmeric plant. Turmeric powder has a warrn, bitter, black pepper-like flavor and has been long used in Ayurvedic medicine, even though there is no high-quality clinical evidence that its consumption is effective in treating any disease (Nelson *et al* 2017).

Most turmeric is used in the form of rhizome powder to impart a golden yellow color. It is used in many products, dairy products, ice cream, yoghurt, orange juice, biscuits, popcorn, cereals and sauces. It is the principal ingredient in curry powders. (Imitiaz and Sabia, 2016)

Although typically used in its dried powdered form, turmeric also is used fresh like ginger. It is used widely as a spice in south Asian and Middle Eastern cooking. In South Africa, turmeric is used to give boiled white rice a golden color. In Indonesia, turmeric leaves are used for minang. In Thailand fresh turmeric rhizomes are used widely in many dishes such as turmeric soup. In India turmeric is used in a hot drink called "Turmeric latte" or "golden milk", that is made with milk mainly coconut milk (Imitiaz and Sabia, 2016).

In Nigeria, turmeric is called *atale pupa* in Yoruba, *gangamau* in Hausa, *nwandnmo* in Igbo, *gigir* in Tiv, *magina* in Kaduna, *turi* in Niger State and *onjonigho* in Cross River. Though it is native to India and parts of Asia, it has been domesticated in Nigeria. It is used in Nigeria, mainly as a food additive and spice, in making juice and as a herbal remedy in traditional and alternative medicine (Akipelu *et al.*, 2021). Turmeric is used to produce the vibrant yellow spice used in dishes. It is used as a natural therapeutic medicine for many diseases. The phytochemical "curcumin", present in this plant shows antioxidant and anti-inflammatory properties (kunnumakkara *et al,* 2017). Curcumin (1,7-bis (4-hydroxy-3- methoxoyphenyl) -1,6-heptadiene-3,5-dione), has the potential of preventing and treating many diseases due to various actions such as antibacterial, anti diabetic, antiviral and anti cancer properties (Sultana *et al.*,2021; Perrone, *et al,* 2015). In recent times, tumeric has been proposed to have several pharmaceutical and medicinal properties; it has found practical applications in traditional medicine, especially in Sub-saharan Africa (Nigeria inclusive). Much needs to be known about the nutritional content of this "wonder" plant and how it can be properly harnessed and used for the prevention, treatment and management of several diseases, hence the need for this research.

MATERIALS AND METHODS

Sample Collection and Preparation

Turmeric rhizhomes *(Curcuma longa)* were bought from Eke Awka market, Anambra state, Nigeria. They were properly identified by a taxonomist in the Botany Department of Nnamdi Azikiwe University, Awka, with a herbarium number NAUH-21. Thereafter, the rhizhomes were washed under running tap water, sliced, shade dried at room temperature and ground into fine powder.

Shade drying of sliced turmeric samples by Anyaoku *et al*., 2023.

Reagents/ chemicals

All reagents/chemicals, distilled and deionised water used, were of analytical standard.

Quantitative Proximate Analysis

The proximate analysis of *Curcuma longa* roots was done using the AOAC (2000).

Estimation of Vitamins

Vitamin A was estimated by the method of Bayfield and Cole (1980), Vitamin E was estimated in the sample by the Emmerie-Engel reaction as reported by Rosenberg, 1992, Vitamin C was analyzed by the spectrophotometric method described by Roe and Keuther (1943) and Vitamin D was assayed according to the method of Brockmann *et al.* (1974).

Elemental/Mineral Analysis

Heavy metal analysis was conducted using Agilent FS240AA Atomic Absorption Spectrophometer according to the method of APHA 1995 (American Public Health Association). Sample digestion was carried out by the method of Adrian, 1973**.**

Quantitative phytochemical determination

Alkaloids were determined using the method of Harborne (1998), Tannin by Van-Burden & Robinson (1981), Saponins by the method described by Obadoni and Ochuko (2001), Flavonoids by the method of Bohm and Kocipai- Abyazan (1994). Phytate content was determined using the method of Young and Greaves (1940) as adopted by Lucas and Markakes (1975). Haemagglutinin level of the sample was determined by the method of Jaffe (1979). Oxalate was determined according to Osagie (1998), while Anthocynanin estimation was done using the gravimetric method of Harborne, 1973.

RESULTS AND DISCUSSIONS

Proximate Analysis

The percentage compositions of some nutrients in turmeric after proximate analysis is shown in table 1. The result reveals that turmeric has substantial amount of water (28.06%) even after drying. It contains appreciable amount of carbohydrate of 41.07%, some amount of fat (8.20%) and protein (7.35%).

Table 1: Percentage composition of nutrients in tumeric

Parameters	(%) composition
Moisture content	28.06
Ash content	10.11
Fat content	8.20
Fibre content	5.21
Protein content	7.35
Carbohydrate content	41.07

The proximate composition of the plant sample (turmeric rhizhomes) is shown in table 1 above. The moisture content of turmeric was found to be approximately 28. 1% (table 1). This result indicates that fresh turmeric sample contain moderate amount of water. This is similar to the result obtained by Abara *et al*., 2021, using fresh turmeric samples. The result from this study deviates from the results of the studies done by Ikeama *et al*., 2014 and Imoru *et al*., 2018 who reported lower moisture content for turmeric. This might be as a result of the fact that they both used processed turmeric samples by applying boiling, oven drying and air drying methods. From the result, fresh turmeric samples therefore might need to be properly dried before storage, to reduce the moisture content in other to reduce microbial activities that will reduce its shelf life. Drying turmeric before storage and would improve its shelf life. Table 1, showed that turmeric has a fat content of 8.20%. This shows that turmeric contains some amount of fat. Turmeric therefore, can be a good source of fat and oil in diets. Other studies reported by Oluwafemi *et al*., 2022 and Enemor *et al.,* 2020 showed that turmeric contains fats in various quantities. The difference in quantities of fat reported in the studies might be attributed to the different species of turmeric used in the studies. The presence of fat in fresh turmeric, implies that proper preservation and storage methods, like washing, sun drying, and air drying, might be required to forestall microbial attack and chemical changes such as rancidity that may affect the organoleptic qualities of turmeric. Addition of turmeric to diet may also supply the body of some essential fat for maintenance of health. The ash content is an indicator of the nutritional value of food, as it refers to the inorganic residue remaining after incineration of organic matter. The ash content of turmeric (table 1) was found to be 10.114%. This shows that turmeric contains reasonable amount of minerals needed in the body. Studies done by Enemor *et al*., 2020, however, reported higher ash content, using fresh turmeric. The study carried out by Oluwafemi *et al*., 2022, using fresh turmeric samples reported lower ash content. This might also be because of differences in the soil factors and geographical locations. From table 1, the protein content of turmeric was found to be 7.35%. This implies the presence of some amount of amino acids in fresh turmeric. Protein is needed for the maintenance of body tissues, growth and development. Therefore, consuming turmeric would provide the body with some amount of protein. This result is similar to what was obtained by Habor, 2020, Imoru *et al*., 2018 and Ikeama *et al*., 2014 who reported the presence of moderate quantities of protein in both unprocessed (fresh) and processed turmeric samples. The carbohydrate content was found to be 40.071% (table 1). This shows that turmeric will be a good source of carbohydrates in the body. This result is similar to what was obtained by Oluwafemi *et al*., 2022, who reported a carbohydrate content of 38.29%. Other studies done by Ikeama *et al*., 2014, Enemor *et al*., 2020 and Habor, 2020 reported the presence of higher amounts of carbohydrates.The slight variation noticed in the carbohydrate content might be related to the differences in species of turmeric used in the different studies. The fibre content from the result (table 1) showed that turmeric contains some amount of fibre (5.208%). Fibre is needed in the body, as it helps in weight maintenance and acts as a laxative, helping to flush out toxins in the body via regular bowel movement. The result is similar to the studies done by Imoru *et al*., 2018 and Habor, 2020 who reported a fibre content of 4.87% and 4.34% respectively. The study carried out by Oluwafemi *et al*., 2022, reported higher fibre content (12.486%).

Vitamin Analysis

The result of the vitamin analysis carried out on turmeric is shown in table 2. The result shows that turmeric has high vitamin C content (60.4mg/kg). It contains substantial amount of vitamin E (15.4mg/kg). Other vitamins found in include vitamin A (5.0mg/kg), vitamin D (3.1mg/kg) and vitamin B12 (3.9mg/kg). Other B-vitamins such vitamins B1, B2,B3 and B6 were found in very trace quantities.

Table 2: Vitamins contents of turmeric in mg/kg

Vitamins	(mg/kg) composition
Vitamin A	5.07393
Vitamin E	15.46078
Vitamin C	60.42963
Vitamin D	3.149254
Vitamin B1	0.0192
Vitamin B2	0.018
Vitamin B3	0.61
Vitamin B6	0.230272
Vitamin B12	3.995807

Analysis of vitamin content (table 2), showed that turmeric has abundant quantity of vitamin C (60.4mg/kg). It also contains reasonable amount of vitamin E (15.4mg/kg) and some quantity of vitamins A (5.0mg/kg) and D (3.1mg/kg). Most B- vitamins were absent except for vitamin B12 which was found in low amount (3.9mg/kg). This is similar to the work done by Adebisi *et al*., 2021 and Imoru *et al*., 2018 which reported turmeric to have little or no amount of vitamins B1, B2 and B3. In the study done by Harbor 2020, turmeric was reported to possess high amount of vitamin C, while Enemor *et al*., 2020 reported high amount of vitamin C and very little or absence of the B-vitamins in turmeric. Vitamin C helps to strengthen the immune system and also a powerful antioxidant. Vitamin C also helps in absorption of Iron. Vitamin E was also found in turmeric. It is a fat soluble vitamin required for proper functioning of many organs in the body. It is an antioxidant, helping to fight free radicals, inflammation and in wound healing. Turmeric may help in maintaining healthy skin and eyes, boost immunity, combat free radicals and help in wound healing and fertility. Vitamin A is best known for its role in vision and eye health. Turmeric may therefore be helpful in vision and maintenance of eye health. The vitamin D content of turmeric may help in development of strong bones and teeth.

Elemental/Mineral content

The minerals analysis result carried out on turmeric is shown in table 3. The result shows that turmeric contains some amount of Magnesium (5.8ppm), Sodium (5.2ppm), Potassium (4.8ppm) and little amount of iron (1.2ppm). Other minerals such as Zinc, Copper, Manganese, Chromium, Selenium, Molybdenum and Colbalt, were found in trace quantities.

Table 3: Mineral contents of turmeric in (ppm)

parameter	composition (ppm)
Iron	1.243
Ppotassium	4.898
Zinc	0.723
Calcium	3.078
Chromium	0.233
Copper	0.669
Magnesium	5.897
Manganese	0.422
Molybdenum	0.022
Sodium	5.245
Selenium	0.067
Colbat	0.006

The mineral analysis (table 3), shows that turmeric contains some amount of magnesium, potassium, calcium and trace amount of Iron. This is similar to what was obtained by Oluwafemi *et al*., 2022; where turmeric was reported to possess potassium, magnesium, sodium, iron and zinc. Studies carried out by Abara *et al*., 2021, showed that turmeric is a good source of potassium, sodium, calcium, magnesium and phosphorus. In a similar report by Enemor *et al*., 2020, turmeric was shown to possess high amount of calcium and considerable quantity of magnesium and sodium. The variations in the concentrations of minerals across the different studies might be as a result of varying soil factors. Tumeric is a good source of minerals for body development and functions. It may also serve as a 'tonic', for the replacement of lost electrolytes and minerals during dehydration.

Phytochemical content

The phytochemical analysis is shown in table 4. The result showed that turmeric has high saponin (11.58%), it also has high cardiac glycoside (18.41%) and tannin (11.15%). The Alkaloid content is (5.11%), Flavonoid content is (5.14%). Tumeric has high level of anthocyanin (15.39%).The steroid content is (7.06%) while its phenol content is (2.67%). Cyanogenic glycoside in turmeric is (1.89%). Phytate, Haemaglutin and Oxalate levels were quite low (0.65%), (0.69%) and (0.45%) respectively.

Table 4

Phytochemicals in turmeric	
Parameters	Composition (%)
Saponin	11.58
Cardiac glycoside	18.41
Tanin	11.15
Alkaloid	5.11
Flavonoid	5.14

Phytate	0.65
Cyanogenic glycoside	1.89
Oxalate	0.45
Anthocyanin	15.39
Steriod	7.06
Phenol	2.67
Haemaglutin	0.69

The phytochemical analysis of turmeric sample (table 4), showed that turmeric has high concentration of cardiac glycosides (18.41%). This is closely followed by anthocyanin (15.39%), saponin (11.58%) and Tannin (11.15%). It also contains reasonable amount of Steroid, Alkaloid and flavonoids. Other phytochemicals including, Phenol, Phytate, Cyanogenic glycoside, oxalate and Heamaggluttinin, where found in trace amounts. This is in accordance to the work done by Imoru *et al*.., 2018, in which turmeric sample was found to contain high concentration of cardiac glycoside. Cardiac glycosides are groups of compounds widely known for their action in the cardiac tissue. They are derived from plant and animal sources. Apart from their effect on the heart and hypertension, they have ability to induce impairment of cell proliferation or activation of cell death by apoptosis or autophagy (Furst, *et al*., 2017). They are also found to decrease inflammatory symptoms. Turmeric, because of its high concentration of cardiac glycosides can be said to possess these properties and can exert these effects in the body. It could therefore increase heart beat and also act as an anti-inflammatory agent, as well as induce apoptosis. For individuals with cardiac problems such as hypertension, consumption of large amount of turmeric may have negative effect on their health as it may increase heart beat and exert more pressure on the heart. Cardiac glycosides present in turmeric may also interfere with cardiac drugs, to elicit different kind of reactions when taken concomitantly. Therefore, caution is needed when consuming turmeric especially in the elderly and those with cardiac issues. Dose should be monitored as well as individual response to plant. The mechanism by which cardiac glycosides exert inotropic effect on cardiac muscle is known. They inhibit the pumping activity of the Na+/ Ca2+ exchanger, reducing the exchange of extracellular sodium with intracellular calcium, bringing as a consequence, an increase in intracellular calcium (Li and Xie, 2009). However, Turmeric may be beneficial to patients suffering from congestive heart failure because of its high content of cardiac glycoside. Cardiac glycosides are used in the treatment of congestive heart failure. They are steroids, having ability to exert specific powerful action on cardiac muscle. A very small amount can exert a beneficial simulation on diseased heart. They increase the force of heart contraction. Turmeric can be a good source of cardiac glycosides, for isolation and purification, to be used in this regard.

Another phytochemical found in pretty high amount was Anthocyanin. They are water soluble vacuolar pigments that exert different colours on plants, depending on their PH. They belong to a parent class of molecules called flavonoids. Its high amount in Turmeric, might contribute to the bright yellowish colour of turmeric. Anthocyannins also have antioxidant and anti-inflammatory activities, making turmeric a potential antioxidant and anti-inflammatory agent.

Table 4, also shows that turmeric contains significant quantity of Saponins. Saponins are triterpene glycosides. They have many characteristics, including antifungal, anti-inflammatory, immunostimulant, hypcholesterol and hypoglycemic activities (Netala *et al.,* 2014). Saponins also have cytotoxic activity (Netala *et al*., 2014). The presence of saponin in turmeric could confer on the plant, antifungal, hypoglycemic, anti-inflammatory and cytotoxic properties. This is in addition to the anti inflammatory effect that "curcumin", the main active ingredient in turmeric contributes (Zhang *et al*., 2019). The mechanism by which saponins exert their hypoglycemic effect can be by restoration of insulin response, increase of plasma insulin levels and induction of the release of insulin from the pancrease (Elekofehinti, 2015). In other studies done by Oluwafemi *et al*., 2022 and Imoru. *et al*, 2018, turmeric was reported to contain saponin in various quantities. Tumeric has been reportedly used for weight reduction especially by young women in Nigeria. It is believed to have anti obesity effect. In south eastern Nigeria, people especially women have used turmeric for weight maintenance and prevention of weight gain. This quality may be attributed to the saponin content of turmeric. Saponins have the ability to induce weight reduction (Zhao *et al*., 2005). Saponins, inhibit Adipogenesis, preventing weight increase via adipocytes (Torres-Fuentes *et al*., 2015). They have the ability to reduce appetite, food intake and leptin levels, via reducing the expression of hypothalamic NPY and serum leptin in high-fat diet rats (kim *et al*., 2009). Saponins can also exert antihyperlipidemic activity, it improves lipid peroxidation and super oxide dismutase activity (Elekofehinti., 2013; Wang *et al*., 2012). Turmeric may be therefore act as a potential natural remedy for weight control. Tannin was also found in reasonable amount in fresh turmeric samples (table 4). Similar studies carried out by Habor, 2020, Imoru *et al*., 2018 and Adebisi *et al*., 2021 reported the presence of tannins in turmeric, but at lower concentrations. Tannins are a class of astringent, polyphenolic biomolecules that bind to and precipitate proteins and various organic compounds, including amino acids and alkaloids (Delimont *et al*., 2017). Tannins have the potential ability to hinder Iron absorption (Delimont *et al*., 2017). In the digestive tract, tannins can easily bind iron present in plant based food, rendering it unavailable for absorption (Delimont *et al*., 2017). The presence of moderate amount of tannin in turmeric as observed in this study (table 4) could therefore make turmeric problematic for people suffering from Iron deficiency, the elderly and malnourished, as its tannin content could prevent the absorption of Iron from diets in the digestive tract. This may lead to continuous low levels of heamoglobin. To combat this problem, it is suggested that turmeric may be taken in between meals and hours after administering hematinics. It should not be taken together with Iron rich foods.

It is also note worthy to mention, that tannins can irritate the GIT, leading to nausea when taken in an empty stomach (Mathews, 2010). This may particularly affect people with more sensitive digestive systems. Taking turmeric on an empty stomach may therefore cause stomach irritation and nausea, similar to what is observed when taking ordinary tea on an empty stomach. To combat the problem, turmeric may be taken with food or adding milk. The protein and carbohydrates in the food would bind with some of the tannins, minimizing its ability to irritate the digestive system. Also reducing the quantity at one sitting would also be of benefit (Hussain *et al*., 2019).

Studies have shown that turmeric possesses antioxidant, anti inflammatory, antibacterial and antiviral effects (Hewlings and Kalman, 2017; Zhang *et al*., 2019; Abdulrahman *et al*., 2020, Jennings and Parks, 2020). This property might be linked to its tannin content. In a study carried out by Myoung *et al*., 2013, tannins were reported to possess antioxidant and anti infalammatory activities. Tannic acid like many other flavonoids and phenolics has a strong antioxidant capacity invitro. The presence of catecholic B-ring is typical of most tannins and the key factor determining their antioxidant capacity (Quideau *et al*., 2011). Tannins and flavonnoids are proposed to act as antioxidants via H-atom transfer or single-electron transfer mechanisms (Quideau *et al*., 2011).

The ability of turmeric to act as an antioxidant and anti inflammatory agent may be related to its tannin content. Turmeric, may find application in the treatment and management of inflammatory conditions such arthritis, rheumatism, fibroid etc. It could also be used in the management of diseases related to antioxidant deficiency, such as diabetes mellitus and cancer (Pand *et al*., 2017). It may also be used in the prevention of antioxidant deficiency, inflammation and in stress management. The report that turmeric may act as an antibacterial, antifungi and antiviral agent, (Abdulrahman *et al*., 2020, Teow, *et al*., 2016 and Jennings and Parks, 2020) may be attributed to the ability of tannin in turmeric to act as an anti microbial agent. Tannic acid inhibits the bacteria attachement to surfaces (Belhaoes, *et al*., 2020). A lack of bacteria adhesion to the surface results in cell death. Moreover, the sugar and amino acid uptake are inhibited by tannic acid which limits the bacteria growth (Pandey and Negi, 2018). The antiviral activity of tannins is related to inhibition of receptor binding and the influence on their activity. As tannin binds to the cell receptor, it inhibits the viruses' attachment to different types of surfaces. It also inhibits the attachment of proteins to the cells which are necessary for metabolic processes (Belhaoues *et al*., 2020). Tannins pass through the bacterial cell wall up to the internal membrane and interfere with metabolism of the cell and results in their destruction. Turmeric may be potentially beneficial as an anti microbial agent to be used as an anti bacterial, antiviral and antifungal agent. It may find application as an adjunct in the treatment of bacterial infections such as *H.pylori* and *E.coli* etc as well as in viral infections such as Influenza, common cold , SARS, HIV and more recently COVID-19 (Maren *et al*., 2021).

Steroids are biologically active organic compounds with four rings arranged in a specific molecular configuration. Plant steroids possess many interesting medicinal and pharmaceutical activities. They act as an antitumor, antibacterial and anti inflammatory (Sun *et al*., 2005; Nazrullaer *et al*., 2000). Table 4, shows that turmeric contains some amount of steroid. A similar study carried out by Oluwafemi *et al*., 2022, reported also the presence of steroids in turmeric. The anti inflammatory mechanism of action of steroids is diverse. One of them includes acting as a non-redox inhibitor of 5-lipoxygenase, hence inhibiting leukotriene biosynthesis in a dose dependent manner (Shah *et al*., 2009). Steroids act as tumor suppressors by triggering Apoptosis (Liagre *et al.,* 2004). The presence of steroids in turmeric may also contribute immensely to the widely reported anti inflammatory and anti cancer effects of turmeric. It may also confer on turmeric, some cardiotonic properties, as steroids have been reported to affect heart muscle contraction (concepcion *et al*., 2000). Another phytochemical found in turmeric was flavonoid (table 4). Flavonoids are a class of secondary poly phenolic secondary metabolites found in plants and thus commonly consumed in human diets. They have been shown to possess antioxidant, hepato protective, anti bacterial, anti inflammatory, anti cancer and anti viral activities. Studies carried out by Harbor, 2020 and Oluwafemi *et al*., 2022 reported the presence of flavonoids in turmeric. The functional hydroxyl groups in flavonoids mediate their antioxidant effects by scavenging free radicals and/or by chelating ions (Kumar *et al*., 2013). The chelation of metals could be crucial in the prevention of radical generation which target biomolecules (Kumar *et al*., 2013). They thus have health promoting properties especially against cancer, age related diseases and infections. Several flavonoids have been shown to possess antibacterial activity. They have multiple cellular targets. One molecular action is to form complex with proteins through non-specific forces such as hydrogen bonding and hydrophobic effects as well as covalent bond formation. Thus, their mode of antimicrobial action may be related to their ability to inactivate microbial adhesions, enzymes, cell envelope, transport proteins etc. Lipophilic flavonoids may also disrupt microbial membranes (Mishra *et al*., 2009). The anti inflammatory mechanism of flavonoids may include acting as inhibitors of the production of prostaglandins, a group of powerful pro-inflammatory signaling molecules (Agati *et al*., 2012). They also may act as anticancer through down regulation of mutant P53 protein, cell cycle arrest, tyrosine kinase inhibition, inhibition of heat shock proteins, estrogen receptor binding capacity and inhibition of expression of Ras proteins (Davis and Matthew, 2000). The antiviral activity of flavonoids is mostly related to its inhibition of various enzymes associated with the life cycle of viruses (Zandi *et al*., 2011). Having flavonoids as one of the phytochemicals vividly present in turmeric, suggests that this plant has pharmacological and medicinal potentials in the prevention and management of wide range of diseases, ranging from microbial infections, cardiovascular diseases, cancer, inflammations such as arthritis and rheumatism amongst others.

Alkaloids were also identified in turmeric (table 4). They are a class of basic naturally occurring organic compounds that contain at least one Nitrogen atom (Begley and Tadhg, 2009). This is accordance with the work done by Imoru *et al*., 2018, which reported higher concentration of Alkaloids in turmeric. Alkaloids are known to have analgesic effect through inhibition of peripheral as well as central nervous system mechanisms (Shoab *et al*., 2016). They also possess anti cancer cell growth and induce cell cycle arrest (Liu *et al*., 2017). Alkaloids also have many other activities including anti bacterial effects especially against *S. aureus* and *E.coli* (Gurrapu and Mmidala, 2017) and Anti malarial effects (Uzor, 2020), to mention but a few.

Turmeric is thus, naturally loaded with lots of biologically active phytochemicals which have numerous pharmacological and medicinal properties as elucidated above. Alkaloids in turmeric may confer on the plant, some analgesic effects and may be effective in alleviating pains especially resulting from inflammations and wounds. It may also find application as a herbal remedy in the prevention of malaria and treatment.

Phenol was found in turmeric in a low concentration in this study. Other studies carried out by Ikeama *et al*., 2014 and Harbor, 2020 also reported lower concentration of phenols in turmeric. Phenols like many other phytochemicals are also potent antioxidant agents and are effective in prevention of various oxidative stress associated diseases (Rasmussen *et al*., 2005). Its presence in turmeric may contribute to the antioxidant and anticancer effects of turmeric.

Other phytochemicals analysed in this study, such as Cyanogenic glycoside, Oxalate, Haemagglutinin were observed to be in very low in concentration in turmeric (table 4). They may therefore not play major significant role in the medicinal and pharmacological uses of turmeric.

From the result above discussion, turmeric is indeed a "wonder' plant. It is rich in many biologically active phytochemicals, minerals, vitamins, protein, fats and carbohydrates. It is therefore, a promising plant that can offer enormous health benefits in pharmacology and medicine for the prevention, treatment and management of various diseases.

However, caution is advised, in the use of turmeric as some phytochemicals abundant in this plant such as cardiac glycosides, tannins and saponin may have some negative effects in the body as already highlighted in the discussion above.

CONCLUSION

Tumeric is rich in various nutrients, minerals, vitamins and phytochemicals. It may find applications in the prevention and management of various diseases especially antioxidant deficient and age related diseases such as diabetes, cancer, arthritis etc. Further studies are however recommended, on how this special plant can be harnessed, through isolation and processing of bioactive components which may include the identification and removal of dangerous phytochemicals that may hinder its use and bioavalability

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