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Bioactive and nutrient composition of *Camellia sinensis* (Tea plant) leaves

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Abstract
Clinical studies have shown the benefits that plant products can offer to health by recognizing the specific nutrients and chemicals in the plants linked with these benefits hence the bioactive and nutritional composition of *Camellia sinensis* leaves were evaluated in this study. The result of the phytochemical content of the aqueous extract and methanol extract showed the presence of flavonoids, alkaloids, steroids, other phenolic compounds and anti-nutrients. Only the aqueous extract had tannins as part of its composition. The proximate analysis showed that fibre had the lowest concentration and carbohydrate had the highest concentration. The most abundant vitamin and element are vitamin C and potassium respectively. The most abundant essential and non-essential amino acids are threonine and arginine respectively. The limiting amino acid is tryptophan. *Camellia sinensis* can be explored to be both a food and a medicinal plant.

Keywords: phytochemical, proximate, vitamins, amino acid, element

1. Introduction
Hippocrates 431 B.C, the father of western medicine made the quote which implied that food be used as medicine and medicine be food when he recognised the value of eating well and the potential of certain foods for good health. In the past years, clinical studies have shown the benefits that different diets can offer to health by recognizing the specific nutrients and chemicals in the plants linked with these benefits. Different nutrients such as the vitamins, minerals offer numerous benefits to humans. Phytochemicals are bioactive substances in plants that act as defence systems against pathogens or protect against diseases. Phytochemicals have been a major focus in investigating the usefulness of plants in preventing or ameliorating different disorders. These phytochemicals include flavonoids, saponins, alkaloids, tannins, saponins, terpenoids [1]. Some of these phytochemicals have shown ameliorative effects to several disorders in man and animals hence are referred to as secondary metabolites [2]. Many phytochemicals have been investigated and found to possess antioxidant, antidiabetic, hepatoprotective, anti-inflammatory activities [3, 4, 5, 6]. Phytochemicals have been isolated from plants and form basis for a lot of synthetic drugs used today. They include flavonoids, alkaloids, kaempferol, saponins, glycosides, phytol, gallic acid [7].
Camellia sinensis is a member of the Theaceae family otherwise known as the tea family. It is abundant in Asia and in Africa it can be found in Kenya, Ghana, Madagascar,and Mambila plateau in Taraba State Nigeria. The leaf is used as green tea and when fermented it is used as black tea. Locally, the Nguroje people in Mambila plateau use the tree bark to treat malaria and typhoid fevers. It has been reported to possess antibacterial, anti-carcinogenic, anti-tumor, antioxidant, antidiabetic and anti-hypertensive activities [8, 9]. This study aims to identify the nutritional composition of *Camellia sinensis* leaves and the phytochemical composition of the aqueous and methanol extract.

2. Methods
2.1 Collection and identification of plants: The fresh leaves were collected from Highland Tea Company farms Mambilla Plateau, Taraba state Nigeria. It was identified by the head botanist Mr Bulus in the factory's laboratory. It was dried with the green tea drier at 120 ^{o}C for

55 minutes and crushed. Five hundred grams of dried leaves of *Camellia sinensis* were extracted with hot water and dried using a freeze drier to make the aqueous extract. Five hundred grams of dried leaves were extracted in methanol, concentrated with a rotatory evaporator and further dried to a paste using a water bath.

2.2 Preliminary qualitative phytochemical screening
Before the tests commenced, two grams (2g) of methanol extract was dissolved in twenty millilitres (20ml) of chloroform, distilled water and 10% H_2SO_4. The solutions were filtered and the three filtrates were used for the screening.

2.2.1 Test for cardenolide (cardiac glycoside)
Kedde A test
Two millilitres of chloroform filtrate was added to a test tube. Three drops of Kedde A reagent was added followed by three drops of Kedde B. the presence of a purple to violet colouration indicates the presence of cardenolides**.**

Keller-Killani test
Two millilitres of chloroform filtrate was added to a test tube. It was treated with two millilitres of glacial acetic acid and one drop of ferric chloride solution. Next, one millilitres of concentrated HCL was added gradually. The presence of a brown ring at the interfaces indicates the presence of cardenolides. A violet ring may appear below the brown ring and a greenish ring may form throughout the acetic acid layer.

2.2.2 Test for alkaloids
Dragendoff's test
Two millilitres of acid (10% H_2SO_4) filtrate was transferred to a test tube. Three drops of Dragendoff's reagent was added to the filtrate. A reddish precipitate indicates the presence of alkaloids.

Meyer's test
Two millilitres of acid (10% H_2SO_4) filtrate was transferred to a test tube. Three drops of Meyer's reagent was added to the filtrate and it was shook. A milky precipitate indicates the presence of alkaloids.

Hager's test
Two millilitres of acid (10% H_2SO_4) filtrate was transferred to a test tube. Three drops of Hager's reagent was added to the filtrate and it was shook. A yellow precipitate indicates the presence of alkaloids.

2.2.3 Test for anthraquinone
Two millilitres of chloroform filtrate was transferred to a test tube and one millilitre (1ml) of H_2SO_4 was added followed by one millilitre of dichloromethane. The denser dichloromethane fraction settled at the bottom of the test tube. The dichloromethane fraction was removed carefully and transferred to a clean test tube. One millilitre (1ml) of 10% ammonia was added to the dichloromethane fraction. A rose-pink colouration indicates a positive test.

2.2.4 Test for carbohydrates
Molish test
Two millilitres of aqueous filtrate was transferred to a test tube. To the filtrate, one millilitre (1ml) of alpha naphthol reagent was added. One millilitre of concentrated H_2SO_4 was added gradually with the test tube in a slanting position. A violet-purple or brown colouration at the interface indicates a positive result.

Fehling test
Two millilitres of aqueous filtrate was transferred to a test tube. To the filtrate, 0.5ml of Fehling A and 0.5ml of Fehling B was added and heated for five minutes. A brick red or orange precipitate indicates the presence of free reducing sugars.

2.2.5 Test for phenolic constituents
Ferric chloride ($FeCl_3$) test
Two millilitres of aqueous filtrate was transferred to a test tube. To the filtrate, three drops of ferric chloride was added. A green, dark green, blue-green, blue, blue-black colour indicates a positive result.

Shinoda test
Two millilitres of aqueous filtrate was transferred to a test tube. To the filtrate, a piece of magnesium ribbon was added then one millilitre (1ml) of concentrated H_2SO_4 was added gradually. A pink or rose colouration indicates the presence of flavonoids.

Aluminium chloride ($AlCl_3$) test
Two millilitres of aqueous filtrate was transferred to a test tube. To the filtrate, three drops of 5% aluminium chloride was added. An intense yellow coloration indicates the presence of flavonoids.

Phlobotannin test
Two millilitres of aqueous filtrate was transferred to a test tube. To the filtrate, one millilitre (1ml) of 2% HCL was added and it was allowed to boil for thirty minutes. A red precipitate indicates the presence of phenolic compounds.

2.2.6 Test for saponins
Frothing test
Two millilitres of aqueous filtrate was transferred to a test tube. To the filtrate, five millilitres (5ml) of distilled water was added and shaken vigorously to check for the presence of a persistent froth.

Emulsion test
Two millilitres of aqueous filtrate was transferred to a test tube. To the filtrate, three drops of olive oil was added and shaken vigorously. The presence of an emulsion indicates a positive test.

2.2.7 Test for cyanogenic glycoside
Two millilitres of the aqueous filtrate was transferred to a test tube. Two drops of 2% HCL was added and boiled for 30 minutes. The presence of a red precipitate indicates a positive result.

2.2.8 Test for fixed oil
Two filter papers of the same size were presented. On one paper, olive oil was dropped and the same quantity of aqueous filtrate was dropped on the second filter paper. They were allowed to sit for a while and compared. If the paper with the aqueous filtrate turns translucent like the one with the olive oil, there is a presence of fixed oil in the sample.

2.3 Analysis of quantitative phytochemical content of the plants

2.3.1 Extraction of the phytochemicals: About 1 g of the extract (aqueous and methanol) was transferred to a test tube and 15 mL of ethanol and 10 mL of 50% m/v potassium hydroxide was added. The water bath was set to 60 °C and the test tube was placed in it for 60 min. The content of the test tube was then transferred to a separation funnel. The test tube was washed with 20ml of ethanol, 10ml of cold water, 10ml of hot water and 3ml of hexane, and also transferred to the separation funnel. The different fractions obtained were combined, washed thrice with 10 mL of 10% v/v ethanol aqueous solution, dried with anhydrous sodium sulphate and then the solvent was evaporated. The final product was solubilized in 1000 µL of pyridine and 200 µL of sample was transferred to a vial for analysis**.**

2.3.2 Quantification by gas chromatography-flame ionization detector (GC-FID): The quantification of the phytochemicals present in the methanol and aqueous extracts of *Camellia sinensis* leaves were done using BUCK M910 gas chromatography equipped with a flame ionization detector. A RESTEK 15 meter MXT-1 column measuring 15m x 250um x 0.15um was used. The injector temperature was up to 280 °C with split less injection of 2 µL of sample and a linear velocity of 30 cm^{-1}, the carrier gas used is Helium 5. 0 pa.s with a flow rate of 40 mL min^{-1}. The oven was initially operated at 200 °C until it heated to 330 °C at a rate of 3 °C min^{-1}. The temperature of 330 °C was maintained for 5 min and the detector operated at a temperature of 320 °C.

2.4 Proximate analysis of *camellia sinensis* leaves

Proximate analysis is done to determine the quantity of major constituents of a sample. These constituents include moisture content, ash content, crude fibre, crude protein, crude fat and carbohydrate. The moisture content was determined by calculating a percentage weight loss obtained by drying 2g of sample in an oven heated at 105 °C till a steady weight was obtained [10]. The ash content was obtained after 2g of sample was burnt in a muffle furnace at 550 °C for 3 hours and cooled in a dessicator. The weight of ash obtained divided by weight of sample and changed to percentage was recorded as the percentage ash content [10]. The crude fat was done using the 'Soxhlet Fat Extraction Method' which involves continuous defatting of sample with petroleum ether. It was allowed to reflux for about 6 hours. The residue obtained after solvent recovery is crude fat and percentage was calculated using its weight in relation to weight of sample. The crude fibre was gotten by: boiling under reflux for 30 minutes with 200ml 1.25g of H_2SO_4 per 100ml of solution, filtering, washing with boiling water, boiling residue for 30 minutes with 200 ml of 1.25g of carbonate free NaOH per 100ml, filtering, drying and incinerating. The weight of fibre divided by weight of sample in percent was used as percentage crude fibre composition [10]. The crude protein was calculated using the nitrogen content of the leaves of *Camellia sinensis* which was in turn gotten by the Kjedahl method [10]. The carbohydrate content was determined by 'Differential method' where the difference gotten from 100% and sum of the percentages of crude protein, moisture, ash, crude fat and crude fibre became the value of carbohydrate content.

2.5 Elemental analysis determination

two grams (2g) of dry sample was digested in a digestion flask with 20ml of acid mixture aqua regia (650ml conc. HNO_3; 80ml perchloric acid; 20ml conc H_2SO_4). It was heated until a clear digest was obtained. The digest was filtered and the filtrate was made up to 100ml mark. The Agilent FS240AA Atomic Absorption Spectrophometer (AAS) was used according to the method by American Public Health Association [11]. To calibrate the AAS, standard metal solutions were injected using acetylene gas followed by an aliquot of the digest. The concentration was read from the AAS.

2.6 Estimation of Amino Acids

The sample was dried to a constant weight, defatted, hydrolyzed, evaporated in a rotary evaporator and loaded into a Technicon Sequential Multi-sample Amino Acid Analyzer (TSM).

2.7 Estimation of vitamins

Vitamin A was estimated by the method of Bayfield and Cole [12] based on the spectrophotometeric estimation of the colour produced by vitamin A acetate or palmitate with TCA and carried out in the dark to avoid the interference of light. Vitamin E was estimated in the sample samples by the Emmerie-Engel reaction as reported by Rosenberg [13] based on the reduction of ferric to ferrous ions by Vitamin E, which, with 2,2'-dipyridyl, forms a red colour. Vitamin C was analysed by the spectrophotometric method [14]. Absorbate is converted into dehydroascorbate on treatment with activated charcoal, which reacts with 2,4-dinitrophenyl hydrazine to form osazones. These osazanes produce an orange coloured solution when dissolved in sulphuric acid, whose absorbance can be measured spectrophotometrically at 540nm. For Vitamin B_1 and B_2**,** 1g of sample was weighed into a conical flask and dissolved in 100ml of deionized water. This was shaken thoroughly, heated for 5 minutes and allowed to cool and filtered. The filtrate was poured into cuvette and their respective wavelength for the vitamins set to read the absorbance using spectrophotometer**.** Vitamin B1 was read at 261nm and vitamin B2 was read at 242 nm. For vitamin B_3, 5g of sample was dissolved in 20ml of anhydrous glacial acetic acid and warmed slightly. 5ml of acetic anhydride was added and mixed and 2 drops of crystal violet solution was added as indicator. It was **t**itrated with 0.1M perchloric acid to a greenish blue colour. For vitamin B_6, 5g of sample was dissolved in a mixture of 5ml of anhydrous glacial acetic acid and 6ml of 0.1m mercury II acetate solution and 2 drops of crystal violet was added as indicator. It was **t**itrated with 0.1m perchloric acid to a green colour end point. Vitamin B_{12} was determined spectrophotometrically by coupling reactions with pyridine**.** Vitamin D was assayed according to the method of Brockmann and Chen [15] based on the formation of a yellow colour by reaction of the vitamin with a chloroform solution of trichloroacetic acid.

3. Results

Chromatogram of GC-FID of aqueous and methanol extracts showing retention time in minutes are shown in Figure 1 and 2 respectively.

The qualitative phytochemical result of the methanol extract of *Camellia sinensis* leaves is presented in Table 1.

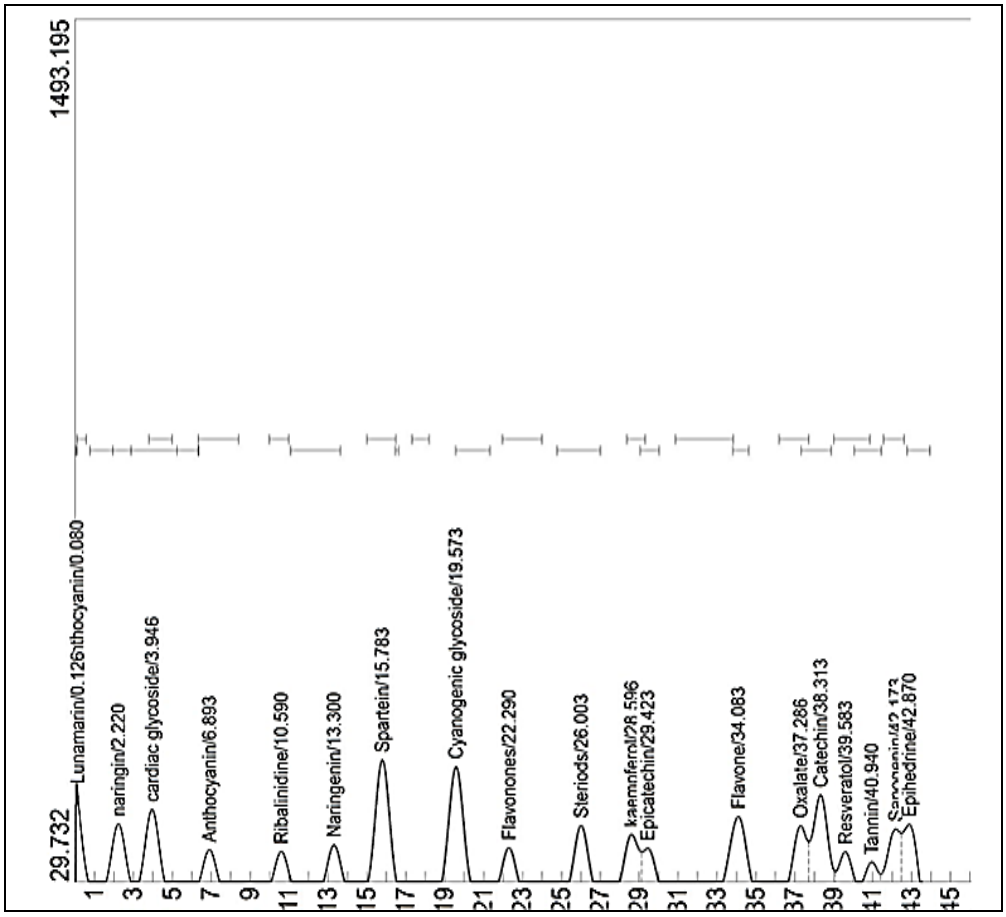

Fig 1: Chromatogram of GC-FID of aqueous extract

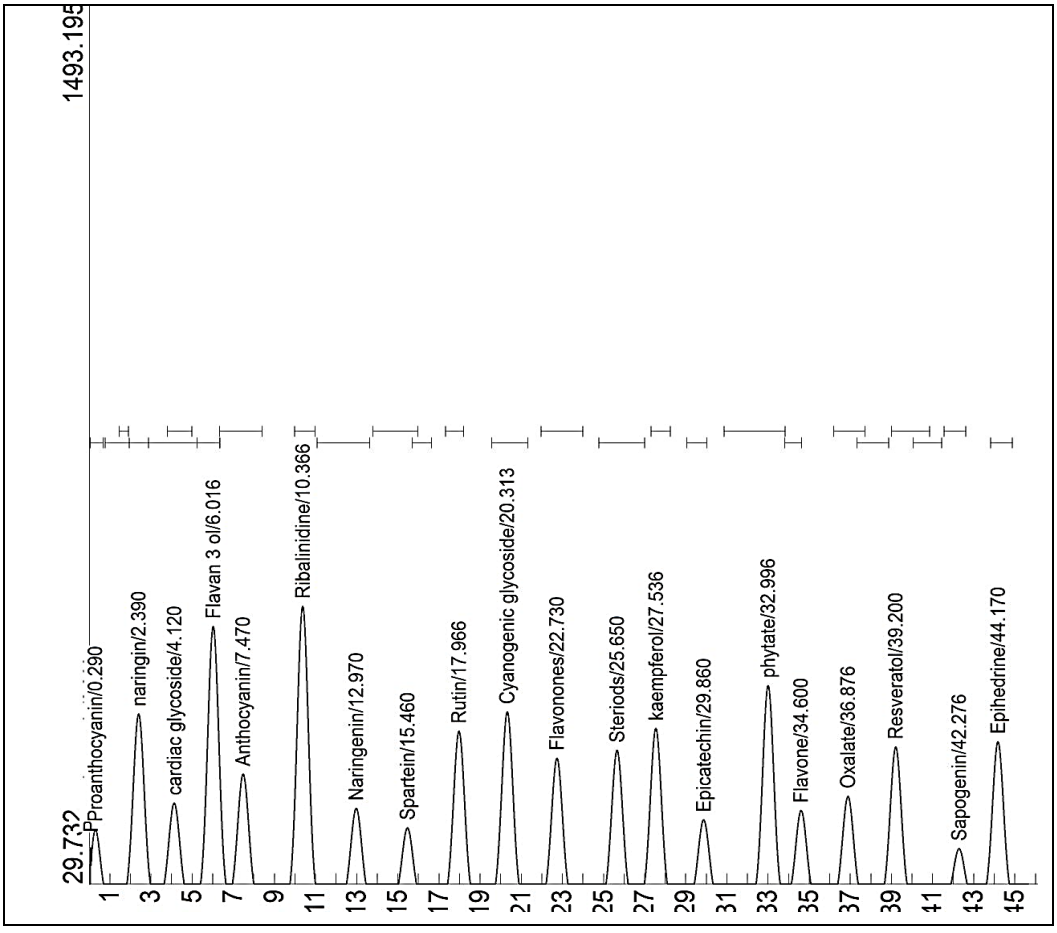

Fig 2: Chromatogram of GC-FID of methanol extract

Table 1: Qualitative phytochemical screening of *Camellia sinensis* methanol extract

Cardiac glycoside	
Kedde A	-
Keller-Killani	-
Alkaloids	
Dragendorff's test	+
Meyer's test	-
Hager's test	-
Anthraquinone	
Free anthraquinone	-
Combined anthraquinone	-
Carbohydrate	
Molisch test	+
Fehling test	+
Triterpenoids	
Liebermann-Buchard test	+
Salwoski test (steroidal nucleus)	-
Saponins	
Frothing test	+
Emulsion test	-
Phenolic compounds	
$FeCl_3$ test (general)	+
Shinoda test for flavonoids	-
$AlCl_3$ test for flavonoids	+
Phlobatannin	-
Fixed oil	-
Cyanogenic glycoside	+

The qualitative phytochemical result of the methanol extract showed the presence of alkaloids and triterpenoids only when Dragendorff's test and Liebermann-Buchard tests were used respectively. It showed the presence of carbohydrate, saponins with frothing test, phenolic compounds and cyanogenic glycosides. The quantitative phytochemical contents of the aqueous and methanol extract of *Camellia sinensis* leaves are presented in Table 2.

Table 2: Phytochemical content of aqueous and methanol extract of *Camellia sinensis* leaves.

Compound (unit)	Class of phytochemical	Aqueous extract (ug/ml)	Aqueous extract (% composition)	Methanol Extract (ug/ml)	Methanol Extract (% composition)
Proanthocyanin	Flavonoid	0.6555	0.499	3.3560	1.823
Naringin	Flavonoid	8.1487	6.200	15.2971	8.309
Cardiac glycoside	Steroids	4.9875	3.794	3.9668	2.155
Anthocyanin	Flavonoid	3.8558	2.933	7.2515	3.939
Ribalinidine	Alkaloid	1.8511	1.408	8.4042	4.565
Naringenin	Flavonoid	2.0505	1.560	2.6381	1.433
Sparteine	Alkaloid	22.8287	17.368	8.9020	4.835
Cyanogenic glycoside		16.8464	12.817	17.1472	9.314
Flavonones	Flavonoid	4.0494	3.081	8.2102	4.460
Steroids	Steroids	11.5463	8.784	17.2023	9.344
Kaempferol	Flavonoid	2.8114	2.139	5.2994	2.879
Epicatechin	Flavonoid	6.1264	4.661	8.2188	4.464
Flavone	Flavonoid	5.6400	4.291	3.6120	1.962
Oxalate		10.0267	7.628	11.0392	5.996
Resveratrol	Phenolic compound	3.1971	2.432	7.7774	4.225
Sapogenin	Triterpene or Steroids	9.6969	7.377	5.7253	3.110
Epihedrine	Alkaloid	7.7671	5.909	13.5351	7.352
Lunamarin	Alkaloid	5.2833	4.020		
Catechin	Flavanoid	2.1778	1.657		
Tannin	Tannin	1.8942	1.441		
Flavan 3 ol	Flavonoid			10.5576	5.735
Rutin	Flavonoid			7.0369	3.822
Phytate				18.9224	10.278

In the total phytochemicals present in aqueous extract 45% of them were flavonoids, alkaloids were 20%, steroids 15%, other phenolic compounds 5%, tannins 5% and anti-nutrients 10%. In the total phytochemicals present in methanol extract 50% of them were flavonoids, alkaloids 15%, steroids 15%, other phenolic compounds 5% and anti-nutrients 15%.

The concentration of phytochemicals in the aqueous extract increased in the order: Proanthocyanin (0.499%) < Ribalinidine (1.408%) < Tannins (1.441) < Naringenin (1.56%) < Catechin (1.657%) < Kaempferol (2.139%) < Resveratol (2.432%) < Anthocyanins (2.933%) < Flavonone (3.081%) < Cardiac glycosides(3.794%)

< Lunamarin (4.02%) < Flavone (4.291%) < Epicatechin (4.661%) < Epihedrine(5.909%) <Naringin (6.2%) < Sapogenin (7.377%) < Oxalate(7.628%) < Steroids (8.784%) < Cyanogenic glycoside (12.817%) < Sparteine (17.368%).

The concentration of phytochemicals in the methanol extract increased in the order: Naringenin (1.433%) < Proanthocyanin (1.823%) < Flavone (1.962) < Cardiac glycosides (2.155%) < Kaempferol (2.879%) < Sapogenin (3.11%) < Rutin (3.822%) < Anthocyanins (3.939%) < Resveratol (4.225%) < Flavonone (4.46%) < Epicatechin (4.464%) < Ribalinidine (4.565%) < Sparteine (4.835%) < Flavan 3 ol (5.735 %) < Oxalate (5.996%) < Epihedrine (7.352%) < Naringin (8.309%) < Cyanogenic glycoside (9.314%) < Steroids (9.344%)Phytate < (10.278%).

The result of proximate analysis of *Camellia sinensis* leaves is presented in Table 3.

Table 3: Proximate analysis of *Camellia sinensis* leaves

Composition	Percentage concentration (%)
Carbohydrate	64.893 ± 0.516
Protein	11.725± 0.247
Moisture	11.302 ± 0.467
Ash	5.406 ± 0.035
Fat	4.946 ± 0.177
Fibre	1.729 ± 0.141

Values are expressed as mean ± standard deviation (SD), n=2.

The result from the proximate analysis show that the compositions increase in the order: Fibre (1.729%) < Fat (4.946%) < Ash (5.406%) < Moisture (11.302%) < Protein (11.725%) < Carbohydrate (64.893%).

Elemental analysis, vitamins composition, amino acid composition and chemical score are shown in tables 4,5,6,7 respectively.

Table 4: Elemental analysis of *Camellia sinensis* leaves

Parameters	Composition in ppm
Iron	1.029
Magnesium	4.933
Lead	0.064
Cadmium	0.008
Silver	0.059
Zinc	0.145
Copper	0.582
Manganese	0.224
Cobalt	0.007
Sodium	0.507
Potassium	4.988
Molybdenum	0.483
Vanadium	0.033
Selenium	1.092
Calcium	3.983
Nickel	0.017
Arsenic	0.012
Chromium	0.011
Mercury	0.122

Table 5: Vitamins composition of *Camellia sinensis* leaves

Vitamin	Composition in mg/kg
A	7.6809
B1	0.02832
B2	0.0144
B3	0.5978
B6	0.1758
B12	4.0271
C	71.0407
D	1.4471
E	16.1471

Table 6: Amino acid composition of *Camellia sinensis* leaves

Components	Type of amino acid	Amount (mg/100g protein)
Glycine	Non-essential	3.2334
Alanine	Non-essential	3.3893
Serine	Non-essential	2.2783
Proline	Non-essential	3.1789
Valine	Essential	4.1562
Threonine	Essential	4.2500
Isoleucine	Essential	4.1004
Leucine	Essential	1.1788
Aspartate	Non-essential	1.1487
Lysine	Essential	2.3152
Methionine	Essential	1.3720
Glutamate	Non-essential	4.1790
Phenylalanine	Essential	5.2678
Histidine	Essential	2.1899
Arginine	Non-essential	4.9772
Tyrosine	Non-essential	3.3788
Tryptophan	Essential	0.0375
Cysteine	Non-essential	0.2857
Total essential amino acids		24.8678
Total non-essential amino acids		26.0493
Total sulphur containing amino acids		1.6577
Total aromatic amino acids		8.6841

Table 7: Comparison of essential amino acid present in *Camellia sinensis*, with WHO reference protein pattern (McGilvery and Goldstein, 1983; FAO/WHO/UNU, 1991) [48, 49].

Amino acid (g/100 g protein	Reference pattern (g/100g protein)	Chemical score (%)
Valine	4.81	86.41
Threonine	3.47	122.48
Isoleucine	4.19	97.86
Leucine	7.03	16.77
Lysine	5.17	44.78
Methionine	1.53	89.67
Phenylalanine	3.01	175.00
Histidine	1.77	123.72
Tryptophan	1.10	3.41

Discussion

The quantitative phytochemical screening of the methanol and aqueous extract of *Camellia sinensis* using GC-FID showed that the extracts are rich in alkaloids and flavonoids. Sparteine is known for its anti-arrhythmic and anti-convulsant activity [16]. Anthocyanins are anti-diabetic and delays cataract in experimental rats [17]. Anthocyanins were found to prevent body fat accumulation [18], exhibit anticancer, antioxidant [19] and cardioprotective effects through its anti-inflammatory activity [20].

Ribalinidine has anti-oxidant properties due to its free radical scavenging ability [21]. Ephedrine provides relief to chest tightness, shortness of breath, wheezing caused by bronchial asthma [22, 23]. Resveratrol possesses anti-arrhythmic, anti-obesity and cardio-protective abilities [24, 25]. It was also reported to have anti-cancer activities [26] and reduced oxidative damage to the liver in a case of ethanol intoxication [27]. Catechins are known for their antioxidant properties and a study [28] reported their anti-microbial, anti-cancer properties as well as the potential of preventing cardiovascular diseases and improving blood pressure. Epicatechins likewise possess antioxidant and anti-inflammatory [29]. Kaempferol exhibits anti-cancer [30], antioxidant [50], anti-inflammatory [32] and anti-micobial [33] activities. Flavanones in citrus fruits like naringenin reduce the incidence of cardiovascular disease risk [34], reduces cholesterol and exhibits anti-inflammatory, anticancer and antiulcer activities [35, 36]. Naringin is the glycosidic form of naringenin possesses cardioprotective and hepatoprotective abilities [37]. Continual treatment with naringin was found to promote recovery of traumatic brain injury in rats due to its antioxidant and anti-inflammatory activities [4]. Cardiac glycosides have anti-cancer activities [5]. A review [3] reported that plant steroids possess antihelminthic, antibacterial, anti-tumor activities and are involved in growth hormone regulation.Studies have shown that lunamarin has radical scavenging function as well as anti-amoebic activity [6, 38]. Phosphorus is stored as phytate in grains as well as some fruits and vegetables. Phytates are salts of phytic acids and are found in high concentrations in foods rich in fibre. It has been reported to exhibit metal chelating, antioxidant and anti-inflammatory activities. Tannins are polyphenols which have been reported to have antioxidant, antimicrobial, antivirus activities [39, 40, 41].

Fibre from dietary sources protects the beneficial flora in the intestine of humans and promotes growth. High fibre intake aids digestion and reduces the risk of colon cancer [42, 43]. The moisture content is a representation of the water activity of the plant. Low moisture content provides protection against microbial spoilage thus improving shelf life [44]. Ash content indicates the quantity of non-carbon compounds in the sample which is mostly the minerals. Fat is important because of their energy value and its role in provision of fat- soluble vitamins and essential fatty acids. Dietary fats have been reported to increase absorption and retention of flavours thereby increasing palatability of food [45]. Protein is important for growth and repair of damaged tissues. The most abundant vitamins are Vitamins C and E which are antioxidant vitamins [46, 47]. The three most abundant elements are potassium, magnesium and calcium which are macro minerals. Potassium is an electrolyte in the body as well as a cofactor for several enzymes. The body uses magnesium for metabolic processes like energy production, biomolecule synthesis, and as a structural component of cell membranes and chromosomes. Calcium is essential for bone and tooth development as well as cell signaling. Tables 6 and 7 show the amino acid profile and chemical scores of *Camellia sinensis* leaf protein, respectively. Essential amino acids account for 24.8678mg/100g, while non-essential amino acids account for 26.0493mg/100g. Tryptophan is the first limiting amino acid with a protein score of 3.41%. Leucine with a protein score of 16.77%, is the second limiting amino acid. Every 100 g of this protein contains 24.8678g of essential amino acids, 26.0493g non-essential amino acids, 1.6577g of sulphur-containing amino acids and 8.6841g of aromatic amino acids (Table 7).

Conclusion

The top five most abundant phytochemicals in the aqueous extract are sparteine, cyanogenic glycoside, steroids, oxalate, sapogenin. The top five most abundant phytochemicals in the methanol extract are phytate, steroids, cyanogenic glycoside, naringin, epihedrine. Most of the compounds present in the samples were flavonoids compounds have been reported have antioxidant, anti-inflammatory and anticancer activities. The most abundant vitamin and element are vitamin C and potassium respectively. The most abundant essential amino acid is threonine whereas arginine is the most abundant non-essential amino acid. The limiting amino acid is tryptophan. *Camellia sinensis* can therefore be explored as both food and as a nutraceutical.

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