Components and Bioactivity of *Ipomoea batatas* (L.) (Sweet Potato) Ethanolic Leaf Extract

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This work was carried out in collaboration among all authors. Author OTO designed the materials and methods used during this research work. Author OTO performed the statistical analysis and wrote the final draft of the manuscript. Author OOF helps to manage the overall analyses of the study. Author MAYB managed the antioxidant assay protocol and literature searches. All authors read and approved the final manuscript.

ABSTRACT

Sweet potato (SP) popularly known as *Ipomoea batatas*, has played an important role as an energy and a phytochemical source in human nutrition and animal feeding as well as herbal medicine to treat inflammatory and infectious oral diseases in Nigeria. This research aims to evaluate the secondary metabolites (phytochemical), antioxidants and antimicrobial activities as well as proximate analysis and to determine the minerals content of sweet potato ethanolic leaf extracts. The screenings were performed for triterpenes, steroids, alkaloids, anthraquinones, coumarins, flavonoids, saponins, tannins and phenolic acids. The color intensity of the precipitate formation was used as analytical responses to these tests. The antioxidant capacity was evaluated and antimicrobial activity was done by agar well diffusion method. The phytochemical screening showed the presence of secondary metabolites. Alkaloids, saponin, cardiac glycosides, tannin,
1. INTRODUCTION

*Ipomoea batatas* is grown as an annual plant by vegetative propagation using either storage roots or stem cuttings. The stem is cylindrical and its length depends on the growth habit of the cultivar and the availability of water in the soil. The leaves are simple and spirally arranged alternatively on the stem. Their color can be green, yellowish-green, or can have purple pigmentation in part or all of the leaf blades. The storage roots are the commercial part of the sweet potato plant [1]. The color of the smooth skin of the root tuber ranges between yellow, orange, red, brown, purple, and beige. Its flesh ranges from beige to white, red, pink, violet, yellow, orange, and purple. Sweet potato varieties with white or pale yellow flesh are less sweet and moist than those with red, pink, or orange flesh [2].

Sweet potato is used as a staple food, a root vegetable (including its fleshy roots, tender leaves, and petioles), a snack food, animal feed, a source for industrial starch extraction and fermentation, and for various processed products [3]. Sweet potato is high in nutritional value, except protein and niacin. It provides over 90% of nutrients per calorie required for most people [4]. Roots are a valuable source of carbohydrates, vitamins (providing 100% of the recommended daily allowance [RDA] for vitamin A and 49% of the RDA for vitamin C), and minerals (providing 10% of the RDA for iron and 15% of the RDA for potassium [4]).

Several studies from Africa sweet potatoes were found to contain between 100–1,600 micrograms of retinol activity equivalents (RAE) of vitamin A on an average, to meet 35% of all vitamin A needs. In many cases, sweet potatoes contain enough RAE to meet over 90% of vitamin A needs. For those who are involved in strenuous jobs, sweet potato is a good source of carbohydrates and it is rich in vitamins and minerals. For those suffering from stomach cancer, a diet based on the sweet potato is beneficial [5].

Research has also shown that phytoneutrients in sweet potatoes may be able to help lower the potential health risk posed by free radicals [6]. Starch is considered to be the main component of the sweet potato root, followed by simple sugars such as sucrose, glucose, fructose and maltose [7].

Sweet potato leaves are indeed more nutritious than the tuber itself. The leaves contain an appreciable amount of nutrients (crude protein, crude fat, crude fiber, ash, carbohydrates, moisture contents, and energy, vitamins (vitamin A and vitamin C), mineral elements (zinc, potassium, sodium, manganese, calcium, magnesium, and iron), low levels of toxicants (phytic acid, cyanide, tannins and total oxalate), and maybe included in diets to supplement dietary allowances of essential nutrients [8].

Root tuber sweet potato is one of the average calorie starch foods and provides 90 calories/100 g vs. 70 calories/100 g of other types of potatoes (*Solanum tuberosum*). The tuber, however, contains no saturated fats or cholesterol and is a rich source of dietary fiber, anti-oxidants, vitamins, and minerals. Its energy content mainly comes from starch, a complex carbohydrate.
Sweet potato has a higher amylose to the amylopectin ratio when compared to S. turberosum. Amylose raises the blood sugar levels slowly in comparison to simple sugars, and is recommended as a healthy food substance, even for patients with diabetes [9].

The tuber is an excellent source of flavonoids, phenolic compounds such as beta carotene, and vitamin A. A 100 g tuber provides 14187 IU of vitamin A and 8509 IU of b-carotene. The value is one of the highest in the root-vegetables category. These compounds are powerful natural antioxidants. Vitamin A is also required by the body to maintain the integrity of healthy mucus membranes and skin. It is a vita nutrient for visual acuity. Consumption of natural vegetables and fruits rich in flavonoids helps protect from lung and oral cavity cancers. The tubers are packed with many essential vitamins such as pantothenic acid (vitamin B5), pyridoxine (Vitamin B6), and thiamin (vitamin B1), as well as niacin and riboflavin. These vitamins are essential in the sense that the body requires them from external sources in order to be replenished.

These vitamins function as co-factors for various enzymes during metabolism. Sweet potato is a rich source of vital minerals such as iron, calcium, magnesium, manganese, and potassium that are essential for enzyme, protein, and carbohydrate metabolism [10].

Shoot. Sweet potato leaves are high in lutein 30 which is said to have a number of benefits for the eye, especially in the prevention of age-related macular degeneration and cataracts. Sweet potato leaves are rich in potent antioxidants and also vitamin C, which helps fight free radicals, thus preventing premature aging and disease. They boost the immune system and help prevent infections and diseases [10].

The polyphenolics present in the leaves showed various kinds of physiological functions, radical scavenging activity, antimutagenic activity, anticancer, antidiabetes, and antibacterial activity in vitro and in vivo, which may help maintain and promote human health. Sweet potato leaves are a physiologically functional food that offers protection from diseases linked to oxidation such as cancer, allergies, aging, HIV and cardiovascular problems [11].

The major phytochemicals present in the leaves of sweet potato are triterpenes/steroids, alkaloids, anthraquinones, coumarins, flavonoids, saponins, tannins, and phenolic acids. Sweet potatoes also contain specific phytochemicals such as quercetin and chlorogenic acid that act to fight cancer and protect the heart. They are rich in beta-carotene, which is an interceptor of free radicals. Carotenoids have antioxidant capabilities and reduce or inhibit mutagenesis in cells and terpenoids reduce low-density lipoprotein (LDL) cholesterol levels and act as anticarcinogens. Thus, eating certain foods such as sweet potatoes may contribute to protective levels against cancers [12].

Plate 1. Photograph of Ipomoea batatas (L.) (Sweet potato) leaves taking from a farm in Akungba Akoko
2. MATERIALS AND METHODS

2.1 Plant Sample

2.1.1 Source and collection of *Ipomoea batatas* (L.) leaves

The leaves of sweet potato used in this research were collected at 6.45a.m from Akungba Akoko in Akoko South West area of Ondo State, Nigeria. The leaf were plucked and kept inside a clean sack bag and transported to the laboratory.

2.1.2 Authentication of *Ipomoea batatas* (Sweet potato) leaves

The plants were authenticated by Dr. Obembe, a botanist at the Department of Plant Science and Biotechnology, Adekunle Ajasin University, Akungba Akoko, Ondo State, Nigeria.

2.1.3 Preparation of *Ipomoea batatas* (Sweet potato) leaves

The leaves of sweet potato after collection were first washed thoroughly with sterile distilled water and appropriately air dried at room temperature for five days to ensure the samples lose most of their moisture content. The leaves were macerated and blended into powdery form using electronic blender at the Department of Microbiology, Adekunle Ajasin University, Akungba-Akoko, Ondo State, Nigeria [13].

2.1.4 Extraction of *Ipomoea batatas* (Sweet potato) leaves

The extraction of the leaves of sweet potato was done, 500 g of each powdered plant sample were weighed into corked containers containing 1500 ml of Ethanol, the mixture were shaken rigorously and left for 5 days. All the mixtures were filtered using sterile Whatman filter papers, and the filtrates were collected directly into sterile crucibles. The filtrates were extracted using rotary evaporator, and the residues obtained were kept at room temperature [14].

2.1.5 Standardization of *Ipomoea batatas* (Sweet potato) leaf extracts

At aseptic condition, the extracts were reconstituted by adding 1 g of each extract to 2.5 ml of Dimethylsulphoxide (DMSO) and 7.5 ml of sterile distilled water, making it 100 mg/ml. 5 ml of distilled water were measured into four sterile test tubes; the serial concentration was prepared to get concentrations of 100 mg/ml, 50 mg/ml, 25 mg/ml and 12.5 mg/ml respectively [14].

2.2 Test Organisms used and Their Sources

The test organisms used were standard strains of pathogenic bacteria; they include strains of *Bacillus cereus*, *Listeria monocytogenes*, *Vibrio cholera*, *Staphylococcus aureus*, *Salmonella typhi*, *Enterococcus faecalis*, *Escherichia coli*, *Klebsiella pneumonia*, *Pseudomonas aeruginosa* and *Aeromonas hydrophila*. The test organisms were obtained and kept on a prepared nutrient agar slant inside McCartney bottles from the stock culture of organisms at the Health Center, Adekunle Ajasin University Akungba and transported at to Microbiology laboratory, Adekunle Ajasin University, Akungba-Akoko Ondo State.

2.2.1 Standardization of test organisms

Slants of the various organisms were reconstituted at aseptic condition, using a sterile wire loop; approximately one isolated colony of each pure culture was transferred in to 5ml of sterile nutrient broth and incubated for 24 hours. After incubation, 0.1 ml of the isolated colony was transferred into 9.9 ml of sterile distilled water contained in each test tube using a sterile needle and syringe and then mixed properly. The liquid now serve as a source of inoculum containing approximately 10^6 cfu/ml of bacterial suspension [15].

2.3 Antimicrobial Screening of *Ipomoea batatas* (Sweet Potato) Leaves

Standard agar well diffusion method was employed for the antimicrobial testing. All the test bacteria, were sub-cultured on sterile Mueller Hinton agar plates, and incubated at 37°C for 18-24 hours. Five distinct colonies for each organism were inoculated onto sterile Mueller Hinton broth and incubated for 3-4 hours. All inocula were standardized accordingly to match the 0.5 McFarland standards, and this standard was used for all susceptibility tests. All the extracts were reconstituted accordingly into concentrations 100, 50, 25, 12.5 mg/ml, using Dimethylsulphoxide (DMSO). The susceptibility testing was investigated by the agar well diffusion method. A 0.1 ml of 1: 10,000 dilutions (equivalent to 10^6cfu/ml) of fresh overnight culture of the clinical isolates grown on Mueller Hinton agar was seeded into Mueller Hinton agar plates.
agiar, and properly mixed in universal bottles. The mixture was aseptically poured into sterile Petri dishes and allowed to set. Using a sterile Cork borer of 6mm diameter, equidistant wells were made in the agar. Drops of the re suspended, (2 ml per well) extracts with concentrations between 100 mg/ml to 12.5 mg/ml were introduced into the wells till it was filled. Levofoxacin 50 mg/ml was used as the control experiment for bacteria, the plates stood on the bench for an hour, to allow pre-diffusion of the extracts before incubation at 37°C for 24 hours for the bacterial isolates. The zones of inhibition were measured to the nearest millimeter (mm) using a standard transparent meter rule [16].

2.4 Antioxidant Screening of Ipomoea batatas (L.) (Sweet Potato) Leaf Extracts

2.4.1 Determination of total phenol of Ipomoea batatas (L.) (Sweet potato) leaf extracts

The total phenol content of the extract determine by the method of [17]. 0.2 ml of the extract was mix with 2.5 ml of 10% Folinciocalteau’s reagent and 2 ml of 7.5% Sodium carbonate. The reaction mixture will be subsequently incubated at 45°C for 40mins, and the absorbance was measure at 700 nm in the spectrophotometer, garlic acid would be used as standard phenol [17].

2.4.2 Determination of total flavonoid of Ipomoea batatas (L.) (Sweet potato) leaf extracts

The total flavonoid content of the extract was determined using a colourimeter assay developed by (18). 0.2 ml of the extract was added to 0.3 ml of 5% NaNO₂ at zero time. After 5 min, 0.6 ml of 10% AlCl₃ was added and after 6 min, 2 ml of 1 M NaOH was added to the mixture followed by the addition of 2.1 ml of distilled water. Absorbance was read at 510 nm against the reagent blank and flavonoid content was expressed as mg rutin equivalent [18].

2.4.3 Determination of ferric reducing property of Ipomoea batatas (L.) (Sweet potato) leaf extracts

The reducing property of the extract was be determined by Pulido et al. [19], 0.25 ml of the extract was mixed with 0.25 ml of 200 mM of Sodium phosphate buffer pH 6.6 and 0.25 ml of 1% KF. The mixture was incubated at 50°C for 20min, thereafter 0.25 ml of 10% TCA was also added and centrifuge at 2000rpm for 10min, 1ml of the supernatant was mixed with 1ml of distilled water and 0.1% of FeCl₃ and the absorbance was measure at 700 nm [19].

2.4.4 Determination of free radical scavenging ability of Ipomoea batatas (L.) (Sweet potato) leaf extracts

The free radical scavenging ability of the extract against DPPH (1, 1- diphenyl-2-picrylhydrazyl) using Gyamfi et al. [20] method. 1 ml of the extract was mixed with 1 ml of the 0.4 m Methanolic solution of the DPPH the mixture was left in the dark for 30 min before measuring the absorbance at 516 nm [20].

2.4.5 Determination of no radical scavenging ability of Ipomoea batatas (L.) (Sweet potato) leaf extracts

Sodium Nitropruside in aqueous solution at physiological pH spontaneously generates NO, which interacts with oxygen to produce nitrite ions that can be estimated by use of Greiss reagent. Scavengers of NO compete with oxygen, leading to reduce production of NO. Briefly 5mM sodium nitroprusside in phosphate-saline was mixed with the extract, before incubation at 25°C for 150min. Thereafter the reaction mixture was added to Greiss reagent. Before measuring the absorbance at 546nm, relative to the absorbance of standard solution of potassium nitrate treated in the same way with Greissreagent [21].

2.4.6 Determination Fe²⁺ chelation of Ipomoea batatas (L.) (Sweet potato) leaf extracts

The ability of the extract to chelate Fe²⁺ was determined using a modified method of Puntel et al. [22]. Briefly, 150 mM FeSO₄ were added to a reaction mixture containing 168ml of 0.1 M Tris-HCl pH 7.4, 218 ml saline and extract and the volume is made up 1 ml with distilled water. The reaction mixture were incubated for 5min, before the additional of 13 ml of 1, 10-phenantroline the absorbance was read at 510 nm [22].

2.4.7 ABTS scavenging ability of Ipomoea batatas (L.) (Sweet potato) leaf extracts

A 2,2’-azino-bis(3-ethylbenthiazoline-6-sulphonic acid) (ABTS) scavenging ability. The ABTS
scavenging ability of the extract was determined according to the method describe by Re et al., [23]. The ABTS was generated by reacting an (7 mM). ABTS aqueous solution with K$_2$S$_2$O$_8$ (2.45 mM/L, final conc.) in the dark for 16hours and adjusting the absorbance at 734 nm to 0.700 with ethanol 0.2 ml of the appropriate dilution of the extract was then added to 2.0 ml of ABTS solution and the absorbance was read at 732 nm after 15mins. The TROLOX equivalent antioxidant capacity was subsequently calculated [23].

2.4.8 Hydroxyl (OH) radical scavenging ability of *Ipomoea batatas* (L.) (Sweet potato) leaf extracts

The ability of the extract to prevent Fe$^{2+}$/H$_2$O$_2$ induced decomposition of deoxyribose were carried out using the method of Halliwell and Gutteridge [24]. Briefly, freshly prepared extract (0-100μl) were added to a reaction mixture containing 120μl, 20mMdeoxyribose, 400μl, 0.1 M phosphate buffer pH 7.4, 40μl, 20mM hydrogen peroxideand 40μl, 500μM FeSO$_4$ and the volume was made to 800μl with distilled water. The reaction mixture was incubated at 37°C for 30min and the reaction was stopped by the addition of 0.5 ml of 2.8% TCA, this was followed by the addition of 0.4 ml of 0.6% TBA solution. The tubes were subsequently incubated in boiling water for 20 min. The absorbance measured at 532 nm in spectrophotometer [24].

2.5 Qualitative Secondary Metabolite of *Ipomoea batatas* (L.) (Sweet Potato) Leaf Extracts

2.5.1 Alkaloid determination of sweet potato leaf extracts

About 0.5g of the extract was stirred 5 ml of 1% aqueous HCl on a steam water bath, 1 ml of the filtrate was treated with a few drops of Dragendorf reagent, blue black turbidity was taken as preliminary evidence for the presence of alkaloid [22].

2.5.2 Saponin determination of sweet potato leaf extracts

The ability of Saponin to produce frothing in aqueous solution was used as screening test for Saponin. About 0.5 g of extract was shaken with distilled water in a test tube frothing which persist on warming was taken as preliminary evidence for the presence of Saponin [25].

2.5.3 Tannin determination of sweet potato leaf extracts

To 0.5 g of the extract was stirred with 100 ml of distilled water, filtered and ferric chloride reagent was added to the filtrate a blue black green or blue green precipitate was taken as evidence for presence of tannin [23].

2.5.4 Phlobatannin determination of sweet potato leaf extracts

Deposition of red precipitate when 0.5 g of the extract was boiled with 1% aqueous HCL was taken as evidence for the presence of phlobatannin [25].

2.5.5 Anthraquinone determination of sweet potato leaf extracts

Borntrager’s test was used for the detection of Anthraquinone 0.5 g of the extract was shaken with 10ml of benzene, filtered and 5 ml of 10% ammonia solution added to the filtrate. The mixture was shaken and the presences of pink red or violet colour in the ammonia layer indicate the presence of free Anthraquinone [25].

2.5.6 Flavonoid determination of sweet potato leaf extracts

To 0.5 g of the extract was added 20 ml of dilute ammonia solution, a yellow colouration was observed, the disappearance of the yellow colour after the addition of 1 ml conc. H$_2$SO$_4$ indicate the presence of flavonoid [26].

2.5.7 Steroid determination of sweet potato leaf extracts

To 20 ml of acetic anhydride was added to 0.5 g of the extract and filter, 2 ml of conc. H$_2$SO$_4$ was added to the filtrate. There was a colour change from violet to blue or green which indicate the presence of steroid [25].

2.5.8 Terpenoid determination of sweet potato leaf extracts

To 0.5 g of the extract was added 20 ml of chloroform and filtered 3 ml of conc. H$_2$SO$_4$ was added to the filtrate to form a layer. A reddish brown colour at the interface was observed which indicate the presence of terpeniod [27].
2.5.9 Cardiac glycosides of sweet potato leaf extracts

The followings were carried out to test for cardiac glycosides:

**Legal’s test:** The extract was dissolve in pyridine and a few drops of 2% sodium nitroprusside with few drops of 20% NaOH were added. A deep red colouration which faded to a brownish yellow indicates the presence of cardenolides [27].

**Lieberman’s test:** 20 ml of acetic anhydride was added to 0.5 g of the extract and filter, 2 ml of conc. H2SO4 was added to the filtrate. There was a colour change from violet to blue or green which indicate the presence of steroids nucleous (i.e. aglycone portion of the cardiac glycosides) [27].

**Salkowski’s test:** 0.5 g of the extract was mixed with 20 ml of chloroform and filtered 3 ml of conc. H2SO4 was added to the filtrate to form a layer. A reddish brown colour at the interface was observed which indicate the presence of steroidal ring [27].

**Keller-killiani’s test:** 0.5 g of the extract was dissolve in 2 ml of glacial acetic acid containing one drop of ferric chloride solution. This was then under layer with 1 ml of conc. H2SO4 a brown obtain at the interface indicate the presence of a deoxy sugar. Characteristic of Cardenolides. A violet ring may appear below the brown ring while in the acetic acid layer; a green ring may form just above the brown ring and gradually spread throughout this layer [25].

2.6 Quantitative Secondary Metabolites Determination of *Ipomoea batatas* (L.) (Sweet Potato) Leaf Extracts

2.6.1 Tannin determination

Finely ground sample (0.2 g) was weighed into a 50ml sample bottle. 10 ml of 70% aqueous acetone was added and properly covered. The bottle were put in an ice bath shaker and shaken for 2hours at 30°C. Each solution was then centrifuge and the supernatant store in ice. 0.2 ml of each solution was pipetted into the test tube and 0.8 ml of distilled water was added. Standard tannin acid solutions were prepared from a 0.5 mg/ml of the stock and the solution made up to 1 ml with distilled water. 0.5 ml of Folinciocateau reagent was added to both sample and standard followed by 2.5 ml of 20% Na2CO3 the solution were then vortexed and allow to incubate for 40minutes at room temperature, its absorbance was read at 725 nm against a reagent blank concentration of the same solution from a standard tannic acid curve was prepared [27].

2.6.2 Determination of total flavanoid

The total flavonoid content of the extract was determined using a colourimeter assay developed by Bao et al. [18]. To 0.2 ml of the extract was added 0.3 ml of 5% NaNO3 at zero time. After 5min, 0.6 ml of 10% AlCl3 was added and after 6min, 2 ml of 1M NaOH was added to the mixture followed by the addition of 2.1 ml of distilled water. Absorbance was read at 510 nm against the reagent blank and flavonoid content was expressed as mg rutin equivalent [25].

2.6.3 Determination of saponin

The spectrophotometric method of Brunner [28] will used for Saponin determination. 2 g of the finely grinded sample will be weighed into a 250 ml beaker and 100 ml of Isobutyl alcohol or (But-2-ol) will be added. Shaker will be used to shake the mixture for 5hours to ensure uniform mixing. The mixture will now be filter with No 1 Whatman filter paper into 100 ml beaker containing 20ml of 40% saturated solution of magnesium carbonate (MgCO3). The mixture obtain again will be filter though No 1 Whatman filter paper to obtain a clean colourless solution. 1ml of the colourless solution will be taken into 50ml volumetric flask using pipette, 2 ml of 5% iron (iii) chloride (FeCl3) solution will be added and made up to the mark with distill water. It would be allow standing for 30min for the colour to develop. The absorbance is read against the blank at 380nm [28].

2.6.4 Determination of alkaloid

Sample (5 g) was weighed into a 250 ml beaker and 200 ml of 10% acetic acid in ethanol was added and allowed to stand for 4 min. this was filtered and extract was concentrated on a water bath to one quarter of the original volume. Concentrated ammonium hydroxide added dropwise to the extract until the precipitation was completed. The whole solution was allowed to settle and the precipitated was collected and wash with dilute ammonium hydroxide and then filtered. The residue is then alkaloid which was dried and weighed [29].

\[
\%\text{Alkaloid} = \frac{W_3 - W_2}{W_1} \times 100
\]
2.6.5 Determination of cardiac glycosides

The procedure described by Sofowora [30] was used. 10 ml of the extract pipetted into a 250 ml conical flask. 50 ml chloroform was added and shaken on vortex mixer for 1 hour. The mixture was filtered into 100 ml conical flask. 10 ml of pyridine and 2 ml of 29% sodium nitroprusside were added and shaken thoroughly for 10 min. 3 ml of 20% NaOH was added to develop a brownish yellow color. Glycosides standard (Digitoxin). A concentration which range from 0 – 50 mg/ml were prepared from stock solution the absorption was read at 510 nm [30].

2.6.6 Determination of terpenoid

The procedure described by Sofowora [30] was used. Finely grounded sample (5 g) was weighed into a 50 ml conical flask. 20 ml of chloroform: methanol (2:1) was added, the mixture was shaken thoroughly and allowed to stand for 15 min at room temp. The suspension was centrifuged at 3000 rpm the supernatant was discarded and the precipitate was re-washed with 20 ml chloroform: methanol (2:1) and then re-centrifuge again the precipitate was dissolve in 40 ml of 10% SDS solution. 1 ml of 0.01 M ferric chloride was added and allowed to stand for 30 min before taken the absorption at 510 nm.

2.6.7 Determination of steroid

A quantitative determination of steroid was determined by weighing a 5 g of the finely powdered sample into 100 ml conical flask and 50 ml of pyridine was added to it, and shake for 30 min at room temperature, 3 ml of 250 mg/ml metallic copper powder or copper (1) oxide and allow to incubate for 1 hr in the dark and the absorbance was measure at 350 nm against reagent blank [30].

2.7 Proximate Analysis of Ipomoea batatas (L.) (Sweet Potato) Leaf Extracts

The proximate parameters (moisture, dry matter, ash, crude fats, proteins and fibers, nitrogen, carbohydrates and energy values) were determined using Association of Official Analytical Chemists (AOAC) methods.

2.7.1 Determination of moisture content

Determination of moisture content was done by drying samples in oven (Wise Ven, WON-50, Korea) at 110°C until constant weight was attained [31].

2.7.2 Nitrogen estimation

Nitrogen estimation was carried out by the micro-Kjeldahl (BUCHI, KjelFlex K-360 and Switzerland) method with some modification [32].

2.7.3 The crude protein

The crude protein was subsequently calculated by multiplying the nitrogen content by a factor of 6.25. The energy value estimation was done by summing the multiplied values for crude protein [32].

2.7.4 Crude fat and carbohydrate

Crude fat and carbohydrate respectively at Water Factors (4, 9 and 4). Crude fat was determined by Soxhlet apparatus using n-hexane as a solvent [32].

2.7.5 The ash value

The ash value was obtained by heating samples at 550°C in a muffle furnace (Wise Therm, FHP-03, Korea) for 3 hours [32].

2.7.6 The carbohydrate content

The carbohydrate content was determined by subtracting the total crude protein, crude fiber, ash content and crude fat from the total dry matter [33].

2.7.7 Crude fiber was estimated

Crude fiber was estimated by acid-base digestion with 1.25% H2SO4 (v/v) and 1.25% NaOH (w/v) solutions [33].

2.8 Determination of Mineral Content of Sweet Potato Leaves

The atomic absorption spectrophotometer (AAS) was used for the analyses of the following metals: Mg, Fe and Ca while the Flame Photometer was used in the analyses of K and Na. Using AAS, a known amount of the sample was placed in a dish and heated with bunsen burner in a fume cupboard until there was no smoke emitted. This was transferred to the dessicator other for it to cool after which 0.1 MHCl solution was added to the ash. The resulting solution was filtered and distilled.
Suitable salt of the metal metals in questions were used to make their standards, lamps were fixed and the analyses were done. Using the flame photometer, the diluents of sample was aspirated into the jenway Digital flame photometer using the filter corresponding to each mineral element. All of these were carried out using the method of [33].

3. RESULTS

Fig. 1 shows the diameter (in mm) of the zones of inhibition of bacterial growth at different concentrations (100 mg/ml, 50 mg/ml, 25 mg/ml and 12.5 mg/ml) of sweet potato leave extract, The zones of inhibition were recorded. The extract showed the highest antibacterial activity to *Salmonella typhi*, with 25 mm zones of inhibition. The extracts also showed moderate antimicrobial activity to *Listeria monocytogens*, *Staphylococcus aureus*, *Vibrio cholera* and *Pseudomonas aeruginosa*, all with 20mm zones of inhibition. However, the leaves extract had the lowest antimicrobial activity to *Enterococcus faecalis*, with 7mm diameter. Tetracycline was used as the control and it was positive for all the tested clinical isolates, the zones of inhibition of the control ranged from 17 to 30mm with *Staphylococcus aureus*, *Vibrio cholera* and *Pseudomonas aeruginosa* having the highest zone of inhibition of 30mm diameter.

Table 1 shows the qualitative secondary metabolites analysis of sweet potato leaf, it was evident that sweet potato leaf contains (positive test) Saponin, Tannin, Flavonoid, Steroid, Alkaloid and Cardiac glycoside and was absent (negative test) to Phlobatannin and Anthraquinone. The reported health benefits of *Ipomoea batatas* leaves may be attributed to these phytoconstituents that might be of medicinal value.

Fig. 2 shows the quantitative phytochemical analysis of Sweet potato leaf. For all the parameters tested. Alkaloid content of the sweet potato leaf was 13.649%. Cardiac glycosides, saponin, tannin, steroids and terpenoids was 8.271, 2.545, 4.726, 0.276 and 6.888 mg/ml respectively.

Fig. 3 presents the quantitative Antioxidants present in sweet potato extracts. Flavonoids, phenol, FRAPP, Oxalate and phylate were 0.852, 9.209, 3.7143.151 and 15.656mg/g respectively and DPPH, OH Radicals, Fe$^{2+}$ chelation and NO Radical were 53.034, 18.719, 24.703 and 28.054% while the ABTS is 0.009μmol/g.

Fig. 4 Present the proximate analysis of Sweet Potato Leaf the result revealed that the mineral content, 32.98%, Ash content, 5.863%, protein content, 14.953% and carbohydrate, 45.16%.
The mineral content of Sweet Potato leaf was presented in Fig. 5. Fig. 5 revealed the presence of Calcium 28.4ppm, Magnesium 36.92ppm, iron 1.21ppm, Sodium 48.78ppm and Potassium 43.90ppm.

4. DISCUSSION

This study investigates the antimicrobial activities of the different concentration of the ethanolic leaf extract of sweet potato against some selected clinical isolates, the results it was observed at concentration 100 mg/ml, the extract was active against all the tested isolates. However, the extract shows the highest antimicrobial activity against *Salmonella typhi* with a 25 mm zone of inhibition. It was observed the plant extract is potent antimicrobial activity against *Listeria monocytogen*, *Staphylococcus aureus*, *Vibrio cholera* and *Pseudomonas aeruginosa*, at 20 mm zone of inhibition at 100 mg/ml concentration. This results implies the extracts from *Ipomium batata* (sweet potato) leaf extract can be regarded as a potent antimicrobial agents, this suggest that infections caused by these group of microorganisms can be treated with this plant. This study revealed that the extract shows the lowest activity against *Enterococcus faecalis*. At concentration 12.5 mg/ml with 7.00 mm. However, at concentration of 100 mg/ml, the activity of the plant extract against *Enterococcus faecalis* (11 mm), this shows with increased dose of the extract, it may be very active against Enterroccocal infections, this was reported in the previous study which revealed an antimicrobial activity for three different cultivars of sweet potato leaves against *Escherichia coli O157:H7*, *Bacillus cereus* and *Staphylococcus aureus* by the use of a lyophilized leaf powder and Tryptone Soya Broth medium [34].

Table 1. Qualitative secondary metabolites analysis of *Ipomoea batatas* (L.) (Sweet potato) leaf extracts

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Water</th>
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<tbody>
<tr>
<td>Saponin</td>
<td>+ve</td>
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<tr>
<td>Tannin</td>
<td>+ ve</td>
</tr>
<tr>
<td>Phlobatannin</td>
<td>- ve</td>
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<tr>
<td>Flavonoid</td>
<td>+ ve</td>
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<td>Steroid</td>
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<tr>
<td>Terpenoid</td>
<td>+ ve</td>
</tr>
<tr>
<td>Alkaloid</td>
<td>+ ve</td>
</tr>
<tr>
<td>Anthraquinone</td>
<td>- ve</td>
</tr>
</tbody>
</table>

Cardiac glycosides

<table>
<thead>
<tr>
<th>Legal test</th>
<th>+ ve</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keller kiliani test</td>
<td>+ ve</td>
</tr>
<tr>
<td>Salkwoski test</td>
<td>+ ve</td>
</tr>
<tr>
<td>Lieberman test</td>
<td>+ ve</td>
</tr>
</tbody>
</table>

Key: + represent positive results, - represent negative results

![Ipomoea batatas (L.) (Sweet Potato) Ethanolic Leaf Extract](image)

*Fig. 2. Quantitative secondary metabolite (Phytochemical) analysis of *Ipomoea batatas* (L.) (Sweet potato) Ethanolic Leaf Extract*
From the qualitative secondary metabolites screening and colour test of *Ipomoea batatas* (sweet potato) ethanolic extracts leaf, it was found that the leaf extract of sweet potato contains terpenoid, flavonoid, tannin, saponin, steroids and alkaloid. These compounds are common in medicinal plants [35].

Alkaloid and flavonoid are compounds which have medicinal properties and are widely used. This result is also in line with the phytochemical studies of the plant done by [35].

The flavonoid content has been widely investigated in *Ipomoea* species. Recently, anthocyanins, catechins, flavonols, and proanthocyanidins from sweet potato leaves were identified and quantified using high performance liquid chromatography combined with a photodiode-array detector [36]. Flavonoids were also found in mature and immature tubers of *I. mauritiana* [37]. Moreover, the presence of flavonoids in *Ipomoea* spp. can be useful as a chemotaxonomic approach for assessing the status of these species. Saponins were also identified in Sweet potato tubers as triterpene,
saponins [38]. Tannins were previously verified in Sweet potato leaves as antinutrient components [39].

Due to the radical scavenging, antimutagenic, antidiabetes, and antibacterial properties of these organic acids, recent papers has been devoted to investigating these compounds in sweet potato [36]. A higher content of phenolic acids was found in sweet potato leaves as compared with those of major commercial leafy vegetables [40]. Therefore, present study's results confirm sweet potato leaves can be also considered a high source of phenolic substances (e.g., flavonoids, phenolic acids, tannins, and tocopherols) with a potential medicinal use as previously demonstrated for tubers [40].

A relative antioxidant activity was obtained for the ethanolic extract from sweet potato leaves as compared to ascorbic acid. This shows potential in reducing the phosphomolybdenum complex, compared to ascorbic acid. This shows potential medicinal use as previously demonstrated for tubers [40].

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Carbohydrate also serves as stored forms of energy as glycogen in liver and muscles. It also provides major source of energy and responsible for breaking-down of fatty acids and preventing ketosis [43].

Protein is used for building and repairing of body tissues, regulation of body processes and formation of enzymes and hormones. Proteins also aid in the formation of antibodies that enable the body to fight infection. Proteins serve as a major energy supplier [44]. Proteins are responsible for the formation of bones, teeth, hair and the outer layer of skin and they help maintain the structure of blood vessels and other tissues. The result reveals that the protein content of Ipomoea batatas leaves (14.95%). The concentration is relatively lower compared to the 35.9% reported by Ekuagbere [44]. The result revealed that the leaves Ipomoea batatas leaves is a good source of protein.

The cured fat content of sweet potato (Ipomoea batatas) leaves was 0.319%, which was low in amount when compared to those of groundnut (43%) [46], Alinum triangulare (5.09%), Amaranthus hybridus (4.80%) [47] and calabash seed (43%) [44], this study showed that, the Ipomoea batatas leaves is a good source of protein.

The proximate analysis of sweet potato (Ipomoea batatas) leaves revealed that it contain an appreciable amount of carbohydrate (45.16%) [42], for every 100 g of Ipomoea batatas leaves, it should contain 45.16 g of carbohydrate.

Fig. 5. Mineral content analysis of Ipomoea batatas (L.) (Sweet potato) ethanolic leaf extract
The crude fiber content of Sweet potato (Ipomoea batatas) leaves is 0.725%. This value is higher than that of Gnetum africanum (0.60), M. ureans (0.40) and Parinari polyantra [49]. The substantial amount of fiber in all the vegetables shows that they can help in keeping the digestive system healthy and functioning properly. Fiber aids and speeds up the excretion of waste and toxins from the body, preventing them from sitting in the intestine or bowel for too long, which could cause a build-up and lead to several diseases, reduce serum cholesterol level, hypertension, diabetes, breast cancer and constipation [50,51]. Thus, the Ipomoea batatas leaves could be valuable sources of dietary fiber.

The ash content 5.863% indicates that the leaves are rich in mineral elements. The value obtained is higher compared to 1.8% reported in sweet potato leaves [52], 10.83% in water spinach leaves and 5% in Tribulus terrestris leaves, but lower than 19.61% in Amaranthus hybridus leaves [53] and 18.00% Balsam apple leaves [54]. The ash content is a reflection of the amount of mineral elements present in the samples; therefore, the Ipomoea batatas leaves contained a good amount of minerals.

The mineral composition of sweet potato (Ipomoea batatas) leaves was evaluated in the present study. Potassium is necessary for the proper functioning of all living cells and is thus present in all plant and animal tissues. Epidemiological studies and studies in animals subject to hypertension indicated that, diets high in potassium can reduce the risk of hypertension and possibly stroke. The present study reveals the potassium content of Ipomoea batatas leaves (43.90ppm). Thus, the Ipomoea batatas leaves could serve as a good source of potassium for the hypertensive patient especially pregnant women that are prone to high blood pressure toward the period of delivery.

Sodium is an essential element that is necessary for humans to maintain the balance of the physical fluids system. It is also required for nerve and muscle functioning. Sodium content of Ipomoea batatas leaves was (48.78ppm) which shows a close agreement with the values reported for bitter leaf 50.20ppm and soybean 47.85ppm [55].

Magnesium is an important mineral element in connection with circulatory diseases such as ischemic heart disease and calcium metabolism in bone [50,51]. The magnesium content of the leaves is 36.92ppm which is high compared with 12.03ppm in Diospyros mespiliformis [56], 16.99ppm of Amaranthus hybridus [53] and lower than 65.99ppm in Cassia siamea leaves [57].

Calcium is an important component of a healthy diet and a mineral necessary for life. It plays an important role in building strong and dense as well as in the keeping of healthy bones and teeth both early and later in life. Calcium content of Ipomoea batatas leaves was 28.40ppm. It is higher than the values obtained for spinach 8.5ppm, bitter leaf 17.65ppm, okra 7.24ppm but less than soybean 65.24ppm [58]. Thus, the Ipomoea batatas leaves could serve as a good source of calcium for building strong and dense as well as in the keeping of healthy bones and teeth.

Iron is required for haemoglobin formation and its deficiency leads to anaemia [58]. The iron content of sweet potato (Ipomoea batatas) leaf was found to be 28.40ppm which is higher than 4.21ppm in T. terrestris leaves [49] but lower than 39ppm in Helmin thostachys sp. The leaves of Ipomoea batatas is rich sources of iron [60], and could be of good use to pregnant women, lactating mothers. Generally for women since they loss some quantity of blood during monthly menstruation, it could help in the nourishing of their bodies.

5. CONCLUSION

In conclusion, the ethanolic extract of sweet potato leaves had antibacterial activity against all the tested clinical isolates which suggest that sweet potato leaf extract can be a potential therapeutic agent against most of the clinical infections caused by the isolates. Ipomoea batatas leaves are an important plant not only as food but also as medicine, due to the presence of various phytochemical constituents. The result of the mineral composition also reveals its high content of minerals such as Ca, Zn, K, Mg and Fe indicating its relevance and indispensable roles in solving many mineral related problems in the consumers. Some of these minerals are useful in patient suffering from bone thinning, adult rickets, bone fraction, bone leaching or bone weakening. The high carbohydrate content provides major source of energy and responsible for breaking down of fatty acids and preventing ketosis.
DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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