In-vitro Antimicrobial Activities and Nutritional Assessment of Roots of Ten Nigerian Vegetables

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Abstract: The leafy parts of the ten test vegetables are consumed for their nutritional values whereas their roots are discarded as waste. This study examined the roots of the vegetables for their therapeutic and nutritional potential with a view to providing information on their economic importance. The plant samples were identified in the University of Ibadan Herbarium (UIH). The test organisms were five clinical isolates. The ethanol (50%) extracts of samples were used for testing antimicrobial activities using agar-well diffusion method. The powdered samples were analysed for their proximate, mineral, phytochemical components using standard methods. Antimicrobial screening indicated that *Crassocephalum rubens* showed the highest (16.50 mm) inhibition against *Escherichia coli* and *Senecio biafrae* had the least (12.0 mm) inhibition at 10^{-3} cfu/ml inoculum concentration. *Only Vernonia amygdalina* (18.00 mm) was active against *Candida albicans*. Crude protein was highest (13.52%) in *Parinari excelsa*. Crude fat was highest (5.11%) in *Senecio biafrae* and *Parinari excelsa* while *Launaea taraxacifolia* had the least (3.57%). Magnesium was highest in *Hibiscus sabdariffa* (990.50 mg/100 g) and *Vernonia amygdalina* had the least (92.00 mg/100 g). Iron was highest in *Parinari excelsa* (26.30 mg/100 g) and least in *Corchorus olitorius* (1.11 mg/100 g). Phytochemical analysis showed that alkaloid was highest in *Telfairia occidentalis* (1.38%) and *Corchorus olitorius* (0.26%) had the least. Saponin was highest in *Telfairia occidentalis* (0.09%) and least in *Corchorus olitorius* (0.03%). In addition to their nutritional and phytochemical components, the plants (80 %) showed significant inhibitory activity against *E. coli* and could be useful in the treatment of diarrhoea, dysentery, cholera and others *E. coli* associated diseases. Also this study has shown that the powdered roots of *V. amygdalina* could be used orally for the treatment of candidiasis. The roots of the vegetables could be useful as cheap source of herbal drugs, food supplements and fodders for livestocks.

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1. Introduction

Vernonia amygdalina Linn., *Launaea taraxacifolia* Wild, *Telfairia occidentalis* Linn., *Corchorus olitorius* Linn., *Celosia argentea* Linn., *Crassocephalum rubens* (Juss.Ex Jacq), *Solanum americanum* Mill, *Parinari excels* Sab, *Hibiscus sabdariffa* Linn., and *Senecio biafrae* (Oliv.&Hiern) J. Moore are common vegetables of southwest Nigeria. Vegetables are important components of a healthy diet, and their sufficient daily consumption could help prevent major diseases (WHO, 2003). They contain many different antioxidant components (Velioglu et al., 1998) and their consumption has been associated with low incidences and mortality rates of cancer (Willet, 1994) and heart disease (Verlangieri et al., 1985). Eating fruits and vegetables also reduces blood pressure, boosts the immune system, detoxifies contaminants and pollutants, and reduces inflammation (Ascherio et al., 1992). A high-level international review of research findings on fruit and vegetable consumption and cancer risk, coordinated by the WHO International Agency for Research on Cancer (IARC), concluded that eating fruit and vegetables may lower the risk of some cancers, particularly cancers of the gastrointestinal tract (WHO, 2003).

The FAO/WHO Expert Consultation on diet, nutrition and the prevention of chronic diseases, recommends the intake of a minimum of 400 g of fruits and vegetables per day (excluding potatoes and other starchy tubers) for the prevention of chronic diseases such as heart disease, cancer, diabetes and obesity as well as for the prevention and alleviation of several micronutrient deficiencies, especially in less developed countries (FAO/WHO, 2003). Vegetables promote intake of essential nutrients from other foods by making them more palatable (Taylor, 1996).

L. taraxacifolia has been used for centuries as a remedy for various ailments such as skin and eye diseases (conjunctivitis), yaws, measles and diabetes. It is rubbed on the limbs of toddlers to facilitate walking (Adebisi, 2004). The roots of *V. amygdalina* and the leaves are used in ethnomedicine to treat fever, hiccups, kidney problems and stomach discomfort (Hamowia, 1994). *T. occidentalis* has been reported in the treatment of anaemia, chronic fatigue and diabetes (Dina et al., 2006). *C. olitorius* is usually recommended for pregnant women and nursing mother because it is believed to be rich in iron (Oyedele et al., 2006). *H. sabdariffa* is used for making a local drink called 'zobo'. Fresh succulent leaves of *S. biafrae* are used as a leafy vegetable in Sierra Leone, Ghana, Benin, Nigeria, Cameroon and Gabon. They are especially popular in southwest Nigeria. They are usually cooked with pepper, tomato and onions (Adebooye, 2004). A root-macerate of *P. excelsa* is taken internally for migraine and stomach pains, and for female sterility (Olowokudejo et al., 2008). *S. americanum* is used as an antiseptic and is given internally for cardalgia (venous congestion) and gripe. An infusion of the plant is used as an enigma in infants having abdominal upsets and freshly prepared extract of the plant is effective in the treatment of cirrhosis of the liver and also serves as an antidote of opium poisoning (Valya et al., 2011). In Ethiopia and Democratic Republic of Congo, the seeds of *C. argentea* are used as medicine for the treatment of diarrhoea, dysentery and muscle troubles (Budin et al., 1996).

The leafy parts of the ten test vegetables form major component of diet as soups in southwest Nigeria whereas their roots are wasted. This study was designed to provide scientific information on the efficacy of their roots in management of infectious diseases and their nutritional potential as food supplements.

2. Materials and Methods

The plants were collected from two different locations: University of Ibadan Campus, Ibadan and a local vegetable market (Oje), Ibadan, Nigeria. The plants were identified at species level in the University of Ibadan Herbarium (UIH). The plant roots were washed, cut into small pieces and air dried. The dry roots were ground into powdered and stored at 4^oC in an air- tight glass jars for further use. The powdered plant sample (50 g each) was extracted in 300 ml of ethanol (50 %) for 2 weeks using cold extraction methods. The extract was concentrated at 40^oC. It was stored in the refrigerator at 4^oC prior to use. 1 g of the extract was dissolved in 10 ml sterile distilled water to obtain a solution of 100 mg/ ml, which was used for the antimicrobial screening.

The organisms were clinical isolates of *Escherichia coli*, *Pseudomonas aeruginosa*, *Candida albicans*, *Streptococcus pyogenes*, and *Staphylococcus aureus* obtained through due process from University College Hospital (UCH) Ibadan. Isolates were maintained in cultures on nutrient agar (Quebec, Canada). The isolates were grown in nutrient broth (Quebec, Canada) for 18 h at 35 ^oC. The inoculum load was adjusted to 1×10^{-3} cfu/ ml via serial dilution method prior to use. 1ml of the inoculum was thoroughly mixed with 19 ml of sterile nutrient agar and poured into sterile Petri dish (100 mm in diameter). The agar was left to solidify and wells were bored in the agar using 6 mm cork borer. The wells were filled with 30 µl of each extract with the aid of a sterile micropipette. A well filled with 50 % ethanol was used as the control experiment in each Petri dish. Also Petri dish containing the text organism in agar without extract was used as control. The plates were incubated at 37^oC for at least 36 hrs. The diameters of the clear zones of inhibitions were measured and the result recorded in millimetres (mm).

The powdered plant samples were analysed for crude protein, crude fat, crude fibre, moisture and ash using the methods described in AOAC (2005).The method of Walsh (1971) was used for digestion of all plant samples. After digestion Calcium (Ca), Magnesium (Mg), Copper (Cu), Zinc (Zn), Iron (Fe), Sodium (Na), Potassium (K), Manganese (Mn) were analysed using Atomic Absorption Spectrophotometer (FC 210/211 VGP Bausch scientific AAS). Phosphorus was determined using Vanadomolybdate (Yellow method.) (AOAC, 2005). Percentage transmittance was determined at 400 nm using Spectronic 20 (Bausch and Lomb) Colorimeter.

Phytochemical analysis of the plant samples was carried out using standard procedures described by Sofowora (1993) and Evans (2002).

All data were expressed as mean ± SD and statistically analysed using One-way Analysis of Variance (ANOVA). The Duncan Multiple Range Test (DMRT) was used to test means for significance. Values were, considered significant at $P < 0.05$.

3. Results and Discussions

The profile of the plants used for this study is presented in Table 1. The habits of the plant were 70% herb, 20% shrub and 10% tree. The plants belong to seven families with Asteraceae being the frequent family. The ethanol extracts of samples showed varied antimicrobial activity (Table 2) against test organisms (1×10^{-3} cfu/ml). 8 out of the 10 extracts were active against *E. coli*. The highest activity of 16.50 mm zone of inhibition was observed for *C. rubens* followed by *C. argentea* (15.00 mm) and *H. sabdariffa* (15.00 mm) *while L. taraxacifolia*, *T. occidentalis* and *S. biafrae* had the least inhibition of 12.00 mm. 20% of the extracts were active against *P. aeruginosa.* The activity of *C. argentea* (12.00 mm) was higher than that of *L. taraxacifolia* (11.00 mm). The remaining eight extracts were inactive against *P. aeruginosa. V. amygdalina* extract was the only active extract against *C. albicans* with 18.00 mm zone of inhibition. *C. rubens* extract was the only active extract against *S. pyogenes* with 16.33 mm zone of inhibition. Three of the ten extracts were active against *S. aureus*. *S. biafrae* had the highest (20.00 mm) activity against *S. aureus*, followed by *H. sabdariffa* (17.00 mm) *and L. taraxacifolia* (16.30 mm) had the least. Overall, *V. amygdalina* was the only extract that displayed antibacterial and antifungal activities. It was active against *E. coli* (14.00 mm) and *C. albicans* (18.00 mm). *L. taraxacifolia* showed antibacterial action against *E. coli* (12.00 mm), *P. aeruginosa* (11.00 mm) and *S. aureus* (16.00 mm). The antibacterial effect of *T. occidentalis* and *C. olitorius* was on *E. coli* only with 12.00 mm and 13.00 mm diameter of inhibition respectively. *C. argentea* showed antibacterial activity against *E. coli*. (15.00 mm) and *P. aeruginosa* (11.00 mm). *C. rubens* displayed antibacterial activity against *E. coli*. (16.50 mm) and *S. pyogenes* (16.33 mm). *S. americanum* and *P. excelsa* were inactive against all isolates. *H. sabdariffa* and *S. biafrae* showed antibacterial activity against *E. coli*. and *S. aureus*.

The plant extracts differ in their inhibitory behaviour against the microorganisms tested. Most of the extracts showed antimicrobial activities against *E. coli* (80%) *and S. aureus* (30%). The inhibitory activity of *T. occidentalis* against *E. coli* agrees with the finding of Oboh et al. (2006) who reported that the ethanol extract of *T. occidentalis* inhibited the growth of *E. coli.* The antibacterial activity of *C. rubens* against *E. coli* agrees with the report of Yehouenou et al. (2011) that the essential oil of the leaves of *C. rubens* showed antibacterial activity against *E. coli*. *S. americanum* showed no inhibition against any of the organisms. This is in contrast to the report of Valya et al. (2011), that the methanol, ethylacetate and chloroform extracts of *S. americanum* leaves were active on *E. coli*, *S. aureus* and *C. albicans*. The variation in results may be attributed to difference in the plant parts and the extraction solvents used. *V. amygdalina* was not active against *S. aureus*, this conforms to the finding of Uzoigwe and Agwu (2011). That *C. olitorius* was inactive against *S. aureus* is in agreement with the finding of Ramadevi and Ganapty (2011), *S. aureus* was resistant to the capsule and root extracts of *C. olitorius.* The observation that *H. sabdariffa* showed no inhibition against *C. albicans* agrees with the report of Olaleye (2007).

Table 1: Profile of vegetables used in this study

Plant	Family	Local name (Yoruba)	Plant habit	Part used
Vernonia amygdalina	Asteraceae	Ewuro	Shrub	Root
Launaea taraxacifolia	Asteraceae	Yanrin	Herb	Root
Telfairia occidentalis	Cucurbitaceae	Ugwu	Herb	Root
Corchorus olitorius	Tiliaceae	Ewedu	Herb	Root
Celosia argentea	Amaranthaceae	Efo-soko	Herb	Root
Crassocephalum rubens	Asteraceae	Ebolo	Herb	Root
Solanum americanum	Solanaceae	Odu	Shrub	Root
Parinari excelsa	Chrysobalanceae	Yinrinyinrin	Tree	Root
Hibiscus sabdariffa	Malvaceae	Isapa	Herb	Root
Senecio biafrae	Asteraceae	Worowo	Herb	Root

Table 2: *In- vitro* antimicrobial activity of the ethanol root extracts of ten vegetables

Plant root extract (100mg/ml)	*E. Coli*	*P. aeruginosa*	*C. albicans*	*S. Pyogenes*	*S. aureus*
	Zones of inhibition (mm)				
Vernonia amygdalina	14.00^{b} ±2.00	0.00^{c} ±0.00	18.00^{a} ±6.08	0.00^{b} ± 0.00	0.00^{c} ±0.00
Launaea taraxacifolia	12.00^{c} ±1.00	11.00^{b} ±1.00	0.00^{b} ±0.00	0.00^{b} ± 0.00	16.33^{b} ±2.52
Telfairia occidentalis	12.00^{c} ±1.00	0.00^{c} ±0.00	0.00^{b} ±0.00	0.00^{b} ±0.00	0.00^{c} ±0.00
Corchorus olitorius	13.00^{bc} ±1.00	0.00^{c} ±0.00	0.00^{b} ±0.00	0.00^{b} ±0.00	0.00^{c} ±0.00
Celosia argentea	15.00^{ab} ±1.00	12.00^{a} ±1.00	0.00^{b} ±0.00	0.00^{b} ±0.00	0.00^{c} ±0.00
Crassocephalum rubens	16.50^{a} ±2.78	0.00^{c} ±0.00	0.00^{b} ±0.00	16.33^{a} ±2.52	0.00^{c} ±0.00
Solanum americanum	0.00^{d} ±0.00	0.00^{c} ±0.00	0.00^{b} ±0.00	0.00^{b} ±0.00	0.00^{c} ±0.00
Parinari excelsa	0.00^{d} ±0.00	0.00^{c} ±0.00	0.00^{b} ±0.00	0.00^{b} ±0.00	0.00^{c} ±0.00
Hibiscus sabdariffa	15.00^{ab} ±1.00	0.00^{c} ± 0.00	0.00^{b} ±0.00	0.00^{b} ±0.00	17.00^{ab} ±3.00
Senecio biafrae	12.00^{c} ±1.00	0.00^{c} ±0.00	0.00^{b} ±0.00	0.00^{b} ±0.00	20.00^{a} ±5.00

Legend: Values are mean ± SD of three replicate. Test values in the same column with same superscripts are not significantly different at P < 0.05. Diameter of cork borer = 6mm.

Table 3 shows the proximate composition of the samples. The crude protein component was highest (13.52%) in *P. excelsa*, followed by *S. biafrae* (12.62%) and *H. sabdariffa* had the least (6.62%). The crude protein content of *P. excelsa* (13.52 %) is high compared to 8.1 % in its seeds as reported by Ogunka-Nnoka and Mepba (2008). The variation may be due to difference in the plant parts used for the experiments. The crude protein in the roots of *T. occidentalis* (8.54 %) is in agreement with the study of Idris (2011) who reported that its leaves had crude protein of 8.72 %. The crude protein content of the root of *S. biafrae* (12.62 %) in this study agrees with that of Adebooye (2000) who reported 11.6-12.3% crude protein for two varieties of *S. biafrae*. Proteins are known to be needed for growth and body building. Crude fat was highest in *S. biafrae* (5.14%), followed by *P. excelsa* (5.11%) and least (3.47%) was in *L. taraxacifolia*. Dietary fats function in increase of palatability of food by absorbing and retaining flavours (Antia et al., 2006). *V. amygdalina* had the highest (39.83%) amount of crude fibre, followed by *T. occidentalis* (38.31%) and *P. excelsa* had the least (16.09%). Crude fibre component in plants could have application in the treatment of diseases such as obesity, cancer and gastro intestinal disorders. *S. biafrae* had the highest (8.72%) amount of ash, followed by *P. excelsa* (6.75%), and *L. taraxacifolia* had the least (2.84%). The ash content is an indication of mineral content. It implies that *S. biafrae* is high in mineral content due to its ash component. There was no significant difference in moisture content of all samples.

The plant samples contained appreciable amount of minerals (Table 4). *C. rubens* had the highest (312.00mg/100g) manganese (Mn), followed by *P. excelsa* (251.00 mg/100g) and *C. olitorius* had the least (2.50 mg/100g). *P. excelsa* had the highest (26.30 mg/100g) amount of iron (Fe), followed by *C. rubens* (13.52 mg/100g) and *C. olitorius* had the least (1.11 mg/100g). Copper (Cu) was highest (3.72 mg/100g) in *S. biafrae* and *V. amygdalina* (0.67 mg/100g) had the least. The highest (63.50 mg/100g) zinc (Zn) content was in *P. excelsa*, followed by *S. americanum* (20.54 mg/100g), and least (0.27 mg/100g) was in *C. olitorius*. *S. americanum* (834.00 mg/100g) had the highest amount of calcium (Ca) followed by *S. biafrae* (761.00 mg/100g) and *P. excelsa* (100.40 mg/100g) had the least. The highest amount of magnesium (Mg) was in *H. sabdariffa* (990.50 mg/100g), followed by *P. excelsa* (614.00 mg/100g) and least (92.00 mg/100g) in *V. amygdalina.* Potassium (K) was highest (557.50 mg/100g) in *C. argentea* and *P. excelsa* had the least (168.00 mg/100g). *P. excelsa* could be used in the management of anaemia based on its iron content. A deficiency of iron can affect vital life processes and leads to anaemia (Ganong, 2003). The potassium content of *C. argentea* was high. Sodium and potassium are important in our diet due to their role in blood pressure regulation (Yoshimura et al., 1991). Calcium and phosphorus are the minerals present in the largest quantity in the structure of the body and bones (Smith et al., 1996). As calcium is needed for growth and maintenance of bone, teeth and muscles; it implies that *S. americanum* can contribute a meaningful amount of dietary calcium. *P. excelsa* is rich in zinc. Zinc is a multifunctional nutrient involved in glucose and lipid metabolism, hormone function and wound healing (Obiajunwa et al., 2005) and it is also associated with proper hair growth (Wang et al., 1985). Manganese was highest in *C. rubens*, it is another microelement essential for human nutrition. It acts as a cofactor of many enzymes (McDonald et al., 1995).

Table 3: Proximate components of the roots of ten vegetables

Plant	%Crude Protein	%Crude fat	%Crude fibre	%Ash	%Dry moisture	%Moisture
Vernonia amygdalina	9.29^{f} ± 0.05	4.03^{cd} ±0.01	39.83^{a} ±0.01	3.27^{ef} ±0.05	90.05^{f} ±0.05	9.95^{f} ±0.35
Launaea taraxacifolia	7.48^{f} ±0.05	3.47^{e} ±0.05	19.27^{f} ±0.05	2.84^{h} ±0.02	90.16^{ef} ±0.05	9.84^{a} ±0.48
Telfairia occidentalis	8.54^{de} ±1.46	3.57^{e} ±0.17	38.31^{b} ±0.09	4.14^{d} ±0.02	90.23^{ef} ±0.01	9.74^{a} ±0.26
Corchorus olitorius	6.91^{g} ±0.01	4.15^{c} ±0.05	23.86^{d} ±0.02	3.14^{f} ±0.02	90.59^{ab} ±0.31	9.41^{a} ±0.01
Celosia Argentea	7.11^{g} ±0.01	5.04^{a} ±0.02	28.47^{c} ±0.05	2.94^{gh} ±0.02	90.66^{a} ±0.05	9.42^{a} ±0.10
Crassocephalum Rubens	11.13^{c} ±0.01	4.65^{b} ±0.35	17.32^{h} ±0.08	5.15^{c} ±0.05	90.46^{c} ±0.04b	9.54^{a} ±0.46
Solanum americanum	8.32^{ef} ±0.08	3.86^{d} ±0.02	18.55^{g} ±0.36	3.24^{ef} ±0.01	90.26^{de} ±0.05	9.74^{a} ±0.26
Parinari excelsa	13.52^{a} ±0.48	5.11^{a} ±0.01	16.09^{i} ±0.74	6.75^{b} ±0.45	90.35^{cde} ±0.05	9.62^{a} ±0.38

Hibiscus sabdariffa	6.62 ^{g} ±0.3	3.83 ^{d} ±0.23	21.27 ^{e} ±0.77	3.45 ^{e} ±0.05	90.45 ^{bcd} ±0.05	9.55 ^{a} ±0.45
Senecio Biafrae	12.62 ^{b} ±0.04	5.14 ^{a} ±0.01	19.25 ^{f} ±0.05	8.72 ^{a} ±0.05	90.56 ^{ab} ±0.04	9.44 ^{a} ±0.09

Legend: Values are mean ± SD of three replicate. Test values in the same column with same superscripts are not significantly different at P <0.05.

Table 4: Mineral compositions of the roots of ten vegetables (mg/100g)

Plant	Mn	Fe	Cu	Zn	Ca	Mg	K	Na	P
Vernonia amygdalina	*7.60 ^{f} ±0.20	2.21 ^{f} ±1.00	0.67 ^{g} ±0.31	3.15 ^{e} ±0.05	341.00 ^{f} ±1.00	92.00 ^{g} ±0.10	230.0 ^{e} ±0.50	325.00 ^{de} ±5.00	63.40 ^{d} ±1.00
Launaea taraxacifolia	12.30 ^{d} ±0.100	7.41 ^{c} ±0.05	1.33 ^{edf} ±0.70	8.34 ^{c} ±0.01	307.00 ^{g} ±2.00	180.0 ^{f} ±10.00	443.0 ^{c} ±10.00	511.00 ^{b} ±1.00	80.90 ^{c} ±0.30
Telfairia occidentalis	4.50 ^{g} ±0.50	2.08 ^{fg} ±2.00	1.61 ^{cde} ±0.01	8.60 ^{c} ±0.20	295.00 ^{g} ±5.00	307.0 ^{d} ±3.00	254.50 ^{d} ±45.50	334.00 ^{cd} ±1.00	135.57 ^{a} ±14.45
Corchorus olitorius	2.50 ^{h} ±0.50	1.11 ^{h} ±1.00	1.06 ^{efg} ±0.04	0.27 ^{f} ±0.03	616.33 ^{c} ±4.73	157.5 ^{f} ±42.50	233.17 ^{e} ±1.61	306.00 ^{d} ±6.00	70.00 ^{d} ±10.00
Celosia argentea	9.90 ^{e} ±0.10	4.89 ^{d} ±11.00	1.91 ^{bcd} ±0.09	6.29 ^{d} ±0.05	266.00 ^{h} ±34.00	531.0 ^{c} ±1.00	557.50 ^{a} ±42.50	356.00 ^{c} ±44.00	105.00 ^{b} ±5.00
Crassocephalum rubens	312.00 ^{a} ±2.00	13.52 ^{b} ±50.00	2.16 ^{bc} ±0.04	6.16 ^{d} ±0.04	383.00 ^{e} ±17.00	310.50 ^{d}±0.50	185.00 ^{f} ±15.00	155.00 ^{f} ±5.00	43.80 ^{e} ±0.50
Solanum americanum	100.09 ^{c} ±1.00	4.38 ^{e} ±5.00	2.51 ^{b} ±0.49	20.54 ^{b} ±0.46	834.00 ^{a} ±1.00	209.0 ^{e} ±1.00	236.00 ^{e} ±5.00	345.00 ^{cd} ±5.00	63.40 ^{d} ±0.10
Parinari excelsa	251.00 ^{b} ±1.00	26.30 ^{a} ±10.00	3.65 ^{a} ±0.35	63.50 ^{a} ±0.50	100.40 ^{i} ±0.10	614.0 ^{b} ±1.00	168.00 ^{f} ±1.00	824.00 ^{a} ±1.00	113.80 ^{b} ±0.50
Hibiscus sabdariffa	13.60 ^{d} ±0.50	1.27 ^{h} ±5.00	0.93 ^{fg} ±0.01	3.24 ^{e} ±0.01	582.00 ^{d} ±1.00	990.5 ^{a} ±0.50	287.17 ^{d} ±12.59	62.20 ^{g} ±0.10	24.10 ^{e} ±1.00
Senecio biafrae	8.90 ^{ef} ±1.10	1.83 ^{g} ±1.00	3.72 ^{a} ±0.50	8.50 ^{c} ±0.50	761.00 ^{b} ±1.00	415.0 ^{c} ±5.00	495.00 ^{b} ±45.00	37.50 ^{h} ±2.50	50.27 ^{e} ±0.14

Legend: Values are mean ± SD of three replicate. Test values in the same column with same superscripts are not significantly different at P <0.05.

The samples contained varied quantities of alkaloids, tannins, carotenoids, saponins, flavonoids, steriods, cardenolides, anthraquinones and glycosides (Table 5). The percentage alkaloids was highest in *T. occidentalis* (1.38%) followed by *V. amygdalina* (1.27%) and least (0.26%) in *C. olitorius*. Tannin was highest in *T. occidentalis* (3.42%), followed by *V. amygdalina* (2.92%) and least (0.38%) in *C. olitorius*. *P. excelsa* had the highest (0.07%) amount of β carotene and least (0.02%) in *L. taraxacifolia; C. olitorius; C. rubens and S. americanum* with no significant difference between them. Flavonoid was highest (0.01%) in *L. taraxacifolia* and least (0.001%) in *V. amygdalina*. *T. occidentalis, C. olitorius, C. argentea, C. rubens, S. americanum* contained no flavonoid. Steroid was highest (0.09%) in *V. amygdalina,* followed by *T. occidentalis* (0.05%) and least (0.01%) in *Parinari excelsa. H. sabdariffa, S. americanum, C. rubens, C. argentea,* and *C. olitorius* contained no steroid. The amount of cardenolide *was* highest in *V. amygdalina* (0.643%) and lowest in *L. taraxacifolia* (0.11%) while *C. rubens* contained no cardenolides. The amount of qlycoside was highest in *T. occidentalis* (0.004%) and *V. amygdalina* had the least (0.003%) while *L. taraxacifolia, C. olitorius, C. argentea*, *C. rubens, S. americanum and H. sabdariffa* had no glycoside. The roots of *T. occidentalis* could have healing properties due to its high tannin content. Tannins have been reported to hasten the healing of wounds and inflamed mucous membrane (Okwo and Okwo, 2004). Flavonoids have been shown to have anti-mutagenic, antibacterial, anti-inflammatory, antiallergic, antiviral, anti-neoplastic, anti-thrombotic and vasodilatory activity (Alan and Miller, 1996). *Launaea* taraxacifolia is a good source of flavonoids. Much of the protective effect of vegetables has been attributed to phytochemicals, which are the non-nutrient plant compounds such as the carotenoids, flavonoids, isoflavonoids, and phenolic acids (Boyer and Liu, 2004). Flavonoids, carotenoids and phenol indeed play an important part in the function of antioxidation and antiproliferation (Larson, 1988). Saponin is used in the manufacturing of shampoos, insecticides and various drug preparation and synthesis of steroid hormones (Okwu, 2003).

Table 5: Phytochemical compositions of the roots of the ten vegetables

Plant	Alkaloids (%)	Tanninss (%)	βCarotene (µg/100g)	Saponins (%)	Flavonoids (%)	Steriods (%)	Cardenolides (%)	Anthraquinones (%)	Glycosides(%)
Vernonia amygdalina	*1.27^{a} ±0.22	2.92^{b} ±0.02	0.04^{ab} ±0.02	0.08^{a} ±0.01	0.001^{e} ±0.00	0.09^{a} ±0.005	0.64^{a} ±0.002	0.006^{a} ±0.002	0.003^{ab} ±0.001
Launaea taraxacifolia	0.35^{de} ±0.04	0.41^{g} ±0.11	0.02^{b} ±0.01	0.04^{c} ±0.00	0.01^{a} ±0.00	0.04^{c} ±0.01	0.11^{e} ±0.001	0.00^{c} ±0.00	0.00^{c} ±0.00
Telfairia occidentalis	1.38^{a} ±0.01	3.42^{a} ±0.02	0.05^{ab} ±0.03	0.09^{a} ±0.01	0.00^{f} ±0.00	0.05^{b} ±0.001	0.56^{b} ±0.001	0.00^{c} ±0.00	0.004^{a} ±0.002
Corchorus olitorius	0.26^{e} ±0.04	0.38^{e} ±0.06	0.02^{b} ±0.01	0.03^{c} ±0.01	0.00^{f} ±0.00	0.00^{e} ±0.00	0.17^{d} ±0.00	0.00^{c} ±0.00	0.00^{c} ±0.00
Celosia argentea	0.62^{b} ±0.02	0.84^{c} ±0.04	0.05^{ab} ±0.03	0.07^{ab} ±0.01	0.00^{f} ±0.00	0.00^{e} ±0.00	0.13^{de} ±0.00	0.00^{c} ±0.00	0.00^{c} ±0.00
Crassocephalum Rubens	0.29^{e} ±0.05	0.62^{e} ±0.02	0.02^{b} ±0.01	0.04^{c} ±0.02	0.00^{f} ±0.00	0.00^{e} ±0.00	0.00^{f} ±0.00	0.00^{c} ±0.00	0.00^{c} ±0.00
Solanum americanum	0.33^{e} ±0.01	0.54^{f} ±0.02	0.02^{b} ±0.01	0.05^{bc} ±0.03	0.00^{f} ±0.00	0.00^{e} ±0.00	0.17^{d} ±0.05	0.004^{ab} ±0.002	0.00^{c} ±0.00
Parinari Excelsa	0.48^{cd} ±0.01	0.49^{f} ±0.05	0.07^{a} ±0.01	0.09^{a} ±0.01	0.002^{d} ±0.001	0.01^{d} ±0.002	0.22^{c} ±0.005	0.003^{b} ±0.001	0.002^{b} ±0.001
Hibiscus sabdariffa	0.56^{bc} ±0.04	0.74^{d} ±0.02	0.05^{ab} ±0.03	0.08^{a} ±0.01	0.008^{b} ±0.00	0.00^{e} ±0.00	0.15^{de} ±0.05	0.00^{c} ±0.00	0.00^{c} ±0.00
Senecio Biafrae	0.37^{de} ±0.02	0.53^{f} ±0.01	0.05^{ab} ±0.03	0.07^{ab} ±0.01	0.004^{c} ±0.00	0.003^{de} ±0.001	0.26^{c} ±0.05	0.003^{b} ±0.001	0.002^{b} ±0.001

Legend: Values are mean ± SD of three replicate. Test values in the same column with same superscripts are not significantly different at $P < 0.05$.

4. Conclusion

The study provides important information on economic value of roots of the ten vegetables. The roots showed significant antimicrobial activity especially against *E. coli* and *S. aureus* in addition to their nutritional and phytochemical components. The powdered roots of *V. amygdalina* could be used for the treatment of candidiasis, diarrhea, dysentery and other *E.coli* implicated infections. Although the root of *P. excelsa* showed no antimicrobial activity against all test organisms, it could serve as food supplement due to its high protein, iron and ß-carotene components. The roots could be useful as cheap source of herbal drugs, food supplements and fodders for livestocks instead of discarding them as wastes.

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