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Proximate, Phytochemical and Antimicrobial Studies on *Solanum macrocarpon* L.

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Authors' contributions

This work was carried out in collaboration between all authors. Author CVI designed the study, carried out the experiment, managed the literature searches and produced the initial draft. All authors performed preliminary data analysis and interpreted the data. All authors read and approved the final manuscript.

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ABSTRACT

Proximate, phytochemical and antimicrobial studies of leaf, fruit and root of *Solanum macrocarpon* L. were evaluated using standard methods. Protein, fat, ash, fibre and moisture as well as bioactive compounds (alkaloid, flavonoid, saponin and tannin) were present in the plant parts but at varied levels. The leaf contained significantly the highest quantities of nutrients and phytochemicals. Antimicrobial screening showed that the leaf had the highest inhibition against the pathogens (*Aspergilus niger* van Tieghem (NR 241), *Staphylococcus aureus* Rosenbach (NR 201), *Candida albican* (C. P. Robin) Berkhout (NR 242) and *Escherichia coli* (Migula) Castellani and Chalmers (NR 202) and the inhibition was dependent on extract concentration. At 50 g/100 ml, the extracts apart from the leaf showed no inhibition against the pathogens. The results indicated that *Solanum macrocarpon* extracts are rich in those nutrients and possessed antimicrobial properties thus justifies the use of the plant as food and could also be used in the treatment of microbial infections.

Keywords: Antimicrobial; phytochemical; proximate and Solanum macrocarpon.

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1. INTRODUCTION

Vegetables are important diet as they are low in cholesterols, low in saturated fats and contain essential fat requirements. They are also good sources of crude fibers and hence good laxative [1]. Vegetables have medicinal values as they help to neutralize stomach acidity and aid digestion [2]. They provide essential mineral elements [1]. Fruits are important sources of vitamins and carbohydrate like fibre and sugar. They are low in calories and naturally sweet. Fruits and their juices are good sources of water too. Nutrients found in fruits and some plant extracts do more than just prevent deficiency diseases. Certain vitamins or vitamin precursors in produce, notably vitamin C, B and carotene, as well as polyphenols are powerful antioxidants [3]. Fruits and vegetables are considered as good source of vitamins and minerals without which human body cannot maintain proper health and develop resistance to disease. Different fruits contain different vitamins, so it is important to eat a variety of fruits. Many fruits have medicinal purposes.

The medicinal values of plants are attributed to the presence of some chemical substances which produce a definite physiological action on the human body [4]. These chemical substances are called phytochemicals [5]. These bioactive compounds are responsible for antimicrobial activity of plant extracts in vitro. Some common examples of phytochemicals are flavonoids, alkaloids, saponins, glycosides, tannins, sterol and phytates [5]. The major global health problem is that microorganisms are developing resistance against antibiotics and this compels researchers to search for new drugs of plant origin. Antimicrobial compounds derived from plants might inhibit bacteria through different mechanisms and provide clinical values for the treatment of infections caused by resistant microbes [6]. Numerous studies have been conducted with the extracts of various plants, screening antimicrobial activity as well as for the discovery of new antimicrobial compounds [7-9]. In an effort to extend the search for new antimicrobial drugs from natural sources, and as a result of the importance of vegetables and fruits to our diet, *Solanum macrocarpon* L member of the family Solanaceae has been evaluated in this study.

Solanum macrocarpon L., popularly known as African egg plant (Hausa- Dauty; Igbo- Afafa or Anara; Yoruba- Igbagba) is a highly valued constituent part of the Nigeria food and indigenous medicine; it is commonly consumed almost on a daily basis by rural and urban families [10]. *Solanum macrocarpon* is cultivated in tropical Africa, tropical Asia and tropical America and throughout the tropical and subtropical area [10]. It is consumed in the various regions of the world where it is found. The parts of the plant that is consumed are the fruits and its young leaves while taste of both the leaves and the fruit are very bitter, they have a high nutrient yield. The roots, leaves and fruits of *Solanum macrocarpon* contain medicinal properties. In Nigeria, the fruit is used as a laxative and as a means to treat cardiac diseases. The flowers are chewed on to ease throat pain. In Kenya, the roots are boiled and the juice is then consumed to kill any hookworms in the stomach. The seeds of *Solanum macrocarpon* crushed to treat tooth ache [11]. The objective of this study was to evaluate the proximate, phytochemical and antimicrobial studies of leaf, fruit and root extracts of *Solanum macrocarpon.*

2. MATERIALS AND METHODS

2.1 Collection of Plant Samples

The plant samples were collected between March–April 2014 from Adazi-nnukwu, in Anaocha Local Government Area, Anambra State. The *Solanum* species was authenticated at Department of Botany, Nnamdi Azikiwe University, Awka where the voucher specimen was deposited.

2.2 Materials Used for Proximate Study

The following materials were used in the proximate analysis: Dessicator, muffle furnace, spectrometer, silica dish, kjeldahl flask, funnel, soxhlet apparatus, filter paper, thimble, electric oven, grinder, retort stand, test tube and test tube rack, crucible, weighing balance, petri dish. The chemicals used include: Tetrahydrosulphate (vi) acid, Boric acid indicator solution, Sodium hydroxide, Hydrochloric acid, Petroleum ether, Potassium hydroxide, Acetone, Phenolphthaline indicator, Ammonia, Dithezone solution, Carbon tetrachloride, Hydroquinoline, Phenonthroline, Vanado Molybidic acid, Selenium oxide.

2.3 Materials Used for Phytochemical and Antimicrobial Studies

The materials and instruments used included plant specimen, blender (grinder), masking tape,

mortar and pestle, moisture cans, crucibles, Whatman filter paper No 42, burettes, volumetric flasks, beakers, conical flasks, sample tubes, desiccators, spectrophotometer, muslin cloth, oven, measuring cylinder, spatula, electric scale, Bunsen burner (stove), funnels, aluminium foils, test tubes, syringes, pipettes, cotton wools, etc.

2.4 Chemical and Reagents Used

Ethanol (alcohols), concentrated acetic acid, sulphuric acid, diluted ammonia, water, ferric chloride, potassium ferrocyanide, ethyl acetate, hydrochloric acid, petroleum ether, sodium hydroxide, potassium hydroxide (potassium permanganate). Hydrogen peroxide, sodium chloride, copper sulphate, sodium picarate, methyl red, cresol green, folin-cio caltean reagent, folin-dennis reagent, Erichrome black and solechrome dark blue

2.5 Preparation of Plant Samples

The leaves, roots and fruits of *Solanum macrocarpon were* cut into bits with a knife and oven dried at 70℃ for 12 h to remove all moisture. The samples were then ground into fine powder.

2.6 Extraction of Plant Material

2.6.1 Ethanol extraction

The ethanol extract of the plant was prepared by soaking the ground sample of the leaf, root and fruit in 100 ml of ethanol. The concentration of each extract was determined by adding 50 g, 75 g, 100 g, and 150 g in 100 ml of ethanol. The experimental set-up was left for 24 h at room temperature and thereafter filtered using Whatman No 1 filter paper. The extract was then concentrated to 50 ml of the original volume of the extract and stored in an airtight container in a refrigerator at 4℃ until when needed.

2.7 Preliminary Phytochemical Screening

Qualitative phytochemical screening of the extracts was conducted to determine the presence of these phytochemicals: Tannins, saponins, flavonoids and alkaloids. This was done using standard procedure as described by [12].

Quantitative phytochemical test of the extracts was conducted to determine the percent quantitative contents of above phytochemicals using standard procedures described by [12,13,14].

2.8 Test Microorganisms

The following microorganisms: bacterial species (*Staphylococcus aureus* (NR 201)*, Escherichia coli* (NR 204) and fungal species (*Aspergillus niger* (NR 241) and *Candida albican* (NR 242*)* were collected based on their clinical and pharmacological importance.

2.9 Sources of Test Microorganisms

The pure cultures of the microorganisms were obtained from the pathology Department of National Root Crop Research Institute, Umudike, Abia State.

2.10 Antimicrobial Activity

The zone of inhibition of the extracts was determined using the agar diffusion method as described by [15]. Both bacterial and fungal pathogens were grown first in nutritional bath before use. The microorganisms were later sub-cultured in Mueller Hinton Agar. Wells were then bored into the agar medium using a sterile 6 mm cork borer. The wells were then filled up with 0.02 ml of the extract and care was taken not to allow the solution to spill on the surface of the medium. The plates were allowed to stand on the laboratory bench for between 1-2 h for proper absorption of the solution into the medium. The plates were turned inside upside down and the wells labelled with a marker. The plates were incubated aerobically at 37℃ for 24 h. Sensitivity of the organisms to the extract was recorded by measuring the zone of inhibition. The extent of inhibition was expressed in terms of the diameter of the inhibition zone as measured with a transparent metre rule. The effects of the extracts on bacteria and fungi pathogens were compared with those of the standard antibiotic ampicillin and fungabacter for bacteria and fungi as a standard control respectively.

2.11 Statistical Analysis

The results were analyzed using ANOVA. The Duncan's multiple range test significance was used to test the difference among treatments. All analyses were carried out at 5% level of significance.

3. RESULTS AND DISCUSSION

Results are presented in Tables 1-7 and Fig. 1.

The result indicated that the nutrients were present in all the parts investigated but in varied quantities. Moisture, ash, crude fibre, fat and protein were significantly highest in the leaf (85.87±0.01, 1.77±0.04, 1.59±0.03, 0.77±0.01 and 4.78±0.03) respectively (Table 1). The result has shown the leaf to be a better source of these nutrients when compared to other parts. These nutrients provide energy for work and warmth, provide materials for growth and repairs of worn out tissues and keep the organism healthy so that it can fight against diseases [16].

The phytochemical (alkaloid, tannin, saponin and flavonoid) were all present in the plant parts but in varied levels. The leaf contained significantly the highest compositions of the phytochemical (3.17±0.02, 1.85±0.02, 2.30±0.07 and 0.95±0.02) respectively (Tables 2 and 3). The results have shown the leaf to be a better source of these phytochemicals when compared to other parts. Phytochemicals were reported to be responsible for many antimicrobial activities of different plant species [17,18]. Pharmaceutical and therapeutic values of plants and their products lie on the presence of these phytochemicals in them [5,19]. Flavonoids have antioxidant activity; some of the activities attributed to flavonoid include anti-allergic, anti-cancer, anti-inflammatory and anti-viral. Flavonoid functions in defense against herbivores, management of diseases such as malaria, diabetes and hypertension [20,21]. Alkaloids are structurally diverse and derived from different amino acids by various biosynthetic pathways [22]. They have an intense bitter taste and many are extremely poisonous [23]. Tannins have been demonstrated to have antibacterial activity [24]. Similarly, Saponins which are a special class of glycosides have been found to possess antifungal activity [25].

Results also showed that the extracts all had inhibitory effects on assayed pathogens at all concentrations (50 g/ 100 ml, 75 g/ 100 ml, 100 g/ 100 ml and 150 g/ 100 ml) except at 50 g/ 100 ml where the extracts had no inhibition except the leaf (Tables 4-7). This was believed to be true since the antimicrobial activity of plant extracts is shown to be a function of their phytochemicals [26]. *Solanum macrocarpon* extracts all contain the phytochemicals and the phytochemicals are known to have medicinal properties. This result justifies the use of *Solanum macrocarpon* extracts in the treatment of various diseases and ailments. From the study, the leaf showed significantly the highest inhibitory activity against the tested pathogens when compared to root and fruit extracts (Tables 4-7). According to [27] this could be attributed to the presence of higher bioactive compounds in the leaf extract than in the fruit and root extracts. The result revealed the inhibitory effect of the extracts against the pathogens to be in direct proportion to the concentration of the extracts (i.e. as the concentration increases the sensitivity and susceptibility of the test organism increases).

Table 1. Percent proximate analysis of the leaf, root, and fruit of *Solanum macrocarpon*

Proximate contents (%)	Leaf	Root	Fruit
Moisture content	85.87±0.01^{c}	62.62±0.03^{a}	78.77±0.02^{b}
Ash content	1.77±0.04^{c}	0.93± 0.02^{b}	1.64±0.01^{a}
Crude fibre	1.59±0.03^{c}	0.91±0.02^{b}	1.50±0.01^{a}
Crude fat	0.77±0.01^{c}	0.38±0.03^{b}	0.47±0.03^{b}
Crude protein	4.78±0.03^{c}	2.89±0.04^{b}	4.53±0.11^{b}

Results are in mean± standard deviation. Rows with different superscripts are significantly different at (P<0.05)

Table 2. Qualitative phytochemical analysis of the leaf, root, and fruit of *Solanum macrocarpon*

Phytochemical	Leaf	Root	Fruit
Saponin	+	+	+
Tannin	+	+	+
Flavonoid	+	+	+
Alkaloid	+	+	+

Keys: Positive (+ve) = presence
Negative (-ve) = absence

Table 3. The quantitative phytochemical compositions of leaf, root and fruit of *Solanum macrocarpon*

Plant part	Tannin %	Saponin %	Alkaloid %	Flavonoid %
Leaf	1.85±0.020[a]	2.30±0.070[a]	3.17±0.020[a]	0.95±0.020[a]
Root	0.77±0.020[b]	1.67±0.010[b]	0.92±0.020[b]	0.74±0.030[b]
Fruit	0.65±0.040[c]	1.59±.030[c]	0.80±0.020[c]	0.67±0.030[c]
p-value	**	**	**	**

Results are in mean± standard error, columns followed by the same alphabet are not significantly different
*** Significant difference exist (p<.05)*

Table 4. Antimicrobial activity of ethanol extracts of *Solanum macrocarpon* at 50 g/ 100 ml of the extracts (zone of inhibition)

Treatments	Zone of inhibition of microbes in ethanol extract (mm)*			
	S. aureus	***E. coli***	***C. albican***	***A. niger***
Leaf	1.23±0.04[b]	1.53±0.11[b]	2.30±0.00[b]	1.80±0.00[b]
Root	-	-	-	-
Fruit	-	-	-	-
Control	12.35±0.11[a]	9.38±0.11[a]	14.25±0.11[a]	16.10±0.12[a]

Control = ampicillin and fungabacter for bacteria and fungi respectively. Values are mean ± standard deviation. Column followed by the same letter are not significantly different at P<.05

Table 5. Antimicrobial activity of ethanol extracts of *Solanum macrocarpon* at 75 g/ 100 ml of the extracts (zone of inhibition)

Treatments	Zone of inhibition of microbes in ethanol extract (mm)*			
	S. aureus	***E. coli***	***C. albican***	***A. niger***
Leaf	3.41±0.04[b]	2.80±0.01[b]	5.26±0.00[b]	4.75±0.00[b]
Root	0.85±000[c]	0.76±0.00[c]	3.52±0.04[c]	1.33±0.01[c]
Fruit	0.60±0.01[d]	0.50±0.00[d]	1.20±0.00[d]	0.94±0.02[d]
Control	15.13±0.17[a]	12.43±0.04[a]	17.50±0.14[a]	19.53±0.12[a]

Control = ampicillin and fungabacter for bacteria and fungi respectively. Values are mean ± standard deviation. Column followed by the same letter are not significantly different at P<.05

Table 6. Antimicrobial activity of ethanol extracts of *Solanum macrocarpon* at 100 g/ 100 ml of the extracts (zone of inhibition)

Treatments	Zone of inhibition of microbes in ethanol extract (mm)*			
	S. aureus	***E. coli***	***C. albican***	***A. niger***
Leaf	6.80±0.04[b]	5.17±0.01[b]	8.75±0.01[b]	7.20±0.00[b]
Root	3.90±005[c]	3.60±0.00[c]	6.25±0.04[c]	4.28±0.04[c]
Fruit	3.75±0.01[d]	3.49±0.00[d]	4.50±0.00[d]	3.82±0.03[d]
Control	19.25±0.35[a]	18.25±0.34[a]	22.65±0.14[a]	23.70±0.14[a]

Control = ampicillin and fungabacter for bacteria and fungi respectively. Values are mean ± standard deviation. Column followed by the same letter are not significantly different at P<.05

Table 7. Antimicrobial activity of ethanol extracts of *Solanum macrocarpon* at 150 g/100 ml of the extracts (zone of inhibition)

Treatments	Zone of inhibition of microbes in ethanol extract (mm)*			
	S. aureus	***E. coli***	***C. albican***	***A. niger***
Leaf	8.62±0.12[b]	7.43±0.04[b]	10.45±0.21[b]	9.53±0.10[b]
Root	4.33±024[c]	5.67±0.10[c]	8.35±0.07[c]	5.72±0.04[c]
Fruit	4.05±0.01[d]	4.75±0.00[d]	6.78±0.04[d]	4.32±0.03[d]
Control	22.25±0.35[a]	21.67±0.10[a]	23.65±0.21[a]	25.00±0.00[a]

Control = ampicillin and fungabacter for bacteria and fungi respectively. Values are mean ± standard deviation. Column followed by the same letter are not significantly different at P<.05

Fig. 1. Habit of *Solanum macrocarpon*
Source: Self collection

4. CONCLUSION

The results indicated that *Solanum macrocarpon* extracts are rich in nutrients, bioactive compounds and possessed antimicrobial properties thus justifies the use of the plant as food and could also be used in the treatment of microbial infections. The leaf contained significantly the highest composition of bioactive compounds and showed significantly the highest inhibitory activity against the tested pathogens thus serves as a better source of these phytochemicals and antimicrobial agent than the fruit and root. The extracts all had inhibitory effects on assayed pathogens at all concentrations (50 g/ 100 ml, 75 g/ 100 ml, 100 g/ 100 ml and 150 g/ 100 ml) except at 50 g/ 100 ml where the extracts had no inhibition except the leaf indicating that only the leaf extract could be used at this concentration.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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