Evaluation of the Polyphenolic, Nutritive and Biological Activities of the Acetone, Methanol and Water Extracts of *Amaranthus asper*

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**Abstract:** The nutritional, phytochemical, antioxidant and antibacterial activities of the acetone, methanol and water extracts of the leaves of *Amaranthus asper* were investigated using standard analytical methods in order to assess the numerous potential of the plant leaves. The proximate analysis showed that the leaves of this plant contained moisture, ash, crude protein, crude lipid, crude fibre, energy and carbohydrate. Elemental analysis in mg/100 g (DW) indicated that the leaves contained sodium (0.0373), potassium (2.872), calcium (2.504), Magnesium (0.569), Iron (419), Zinc (26), phosphorus (0.177), Copper (18), Manganese (91), and Nitrogen (1.78). The chemical composition in mg/100 g (DW) for alkaloid, saponins, and phytate were 0.3, 7.0 and 9.25 respectively. Comparing the nutrient and chemical constituents with recommended dietary allowance (RDA) values, the results reveal that the leaves contain an appreciable amount of nutrients, minerals, and phytochemicals and low levels of toxicants. At 1mg/ml, the acetone extract caused 98.2% ABTS radical scavenging inhibition while the methanol, water and BHT caused inhibition at 95.4, 97.1 and 99.3% respectively. The result for DPPH scavenging activity was close to that of ABTS. The plant was also rich in the different polyphenols analyzed in this study. The ferrous reducing antioxidant power (FRAP) values for acetone extract (1084.9) is much higher than that of methanol (143.5), water (42.4), BHT (63.5), and catechin (972.02) but lower than those of ascorbic acid (1632.1) and quercetin (3107.3). The methanol extract has antibacterial activity against all the Gram-positive organisms used in this study. This study has to some extent validated the need for the use of the leaves of *Amaranthus asper* for nutritional and medicinal purposes.

**Keywords:** Antibacterial properties, antioxidant activities, polyphenolics, *Amaranthus asper*, nutritional value.

**INTRODUCTION**

Most developing countries depend on starch-based foods as the main staple food for the supply of both energy and protein. This accounts in part for protein deficiency which prevails among the populace as recognized by Food and Agricultural Organization [1, 2]. In Nigeria, as in most other tropical countries of Africa where the daily diet is dominated by starchy staple foods, vegetables are the cheapest and most readily available sources of important proteins, vitamins, minerals and essential amino acid [2]. Many of the local vegetable materials are under-exploited because of inadequate scientific knowledge of their nutritional potentials. Many workers [3-7] have reported the compositional evaluation and functional properties of various types of edible wild plants in use in the developing countries. Though several works reporting compositional evaluation and functional properties of various types of edible wild plants in use in the developing countries abound in literature, much still need to be done.

*Amaranthus asper* L, popularly called “Amaranth or pigweed”, is an annual herbaceous plant of 1-6 feet high. It belongs to the family Amaranthaceae. Other synonyms for this plant are *A. hybridus* and *A. albus*. The leaves are alternate petioled, 3-6 inches long, dull green, and rough, hairy, ovate or rhombic with wavy margins. The flowers are small, with greenish or red terminal panicles. Taproot is long, fleshy red or pink. The seeds are small and lentilcellular in shape; with each seed averaging 1-1.5 mm in diameter and 1000 seeds weighing 0.6-1.2 g. It is rather a common species in waste places, cultivated fields and barnyards [2]. In Nigeria, *A. hybridus* leaves combined with condiments are used to prepare soup [8]. In Congo, their leaves are eaten as spinach or green vegetables [9]. These leaves boiled and mixed with a groundnut sauce are eaten as salad in Mozambique and in West Africa [10, 11]. *A. hybridus* has been shown to contain large amount of squalene, a compound that has both health and industrial benefits [12-14]. Despite the use of this plant for such purposes, there is little information on the nutritional and chemical composition of *A. asper* leaves.

One noticed with dismay the fact that few vegetables species were consumed in South Africa by the general populace. Although 32 plants were documented as wild vegetables species utilized in Transkei, Eastern Cape Province (about 120 kilometers from Alice), their nutritional qualities were not reported. The interview conducted during the course of our research in Alice and its surrounding villages indicated that many of these species, though known, are considered as weeds and were not eaten by the people. This is in spite of the fact that these vegetables grow spontaneously and in abundance around the rural homesteads. Reports of studies carried out on wild vegetables in different parts of the world as already indicated show that many wild
vegetables had higher protein, mineral and vitamin contents than the cultivated vegetables like spinach and cabbage. The consumption of vegetables has also been linked to reduction in the incidence of oxidative-stress related diseases such as cancer, diabetes, [15-17] and neurodegenerative diseases, including Parkinson’s and Alzheimer’s diseases [18] as well as inflammation and problems caused by cell and cutaneous aging [19, 20]. This is due to beneficial health functionality of phenolic antioxidants present in them.

Also, natural products from microorganisms have been the primary source of antibiotics, but with the increasing acceptance of herbal medicine as an alternative form of health care, the screening of medicinal plants for active compounds has become very important because these may serve as promising sources of novel antibiotic prototypes [21-23]. It has been shown that in vitro screening methods could provide the needed preliminary observations necessary to select crude plant extracts with potentially useful properties for further chemical and pharmacological investigations [24].

*Amaranthus asper* was one of the wild vegetables identified and the study was therefore aimed at assessing its nutritional quality and possible biological activities.

**MATERIALS AND METHODS**

**Plant Collection and Extract Preparation**

Fresh plant material of *Amaranthus asper* was collected in November 2006 from the wild around the University of Fort Hare campus (Alice, South Africa). The area falls within the latitudes 30°00′-34°15′ S and longitudes 22°45′-30°15′ E. It is bounded by the sea in the east and the drier Karoo (semi-desert vegetation) in the west [25]. These areas consist of villages which are generally classified as rural and poor. Prof. D.S. Grierson of the Department of Botany, University of Fort Hare, authenticated the species. A voucher specimen was prepared and deposited in the herbarium of the University of Fort Hare. A voucher was the tannic acid equivalent (mg/g).

**Determination of Total Phenolics**

Total phenol contents in the extracts were determined by the modified Folin-Ciocalteu method [27]. An aliquot of the extract was mixed with 5 ml Folin-Ciocalteu reagent (previously diluted with water 1:10 v/v) and 4 ml (75 g/l) of sodium carbonate. The tubes were vortexed for 15 sec and allowed to stand for 30 min at 40°C for color development. Absorbance was then measured at 765 nm using the Hewlett Packard UV-VS spectrophotometer. Samples of extract were evaluated at a final concentration of 0.1 mg/ml. Total phenolic content were expressed as mg/g tannic acid equivalent using the following equation based on the calibration curve: 

\[ y = 0.1216x, R^2 = 0.9365, \]  

where x was the absorbance and y was the tannic acid equivalent (mg/g).

**Determination of Total Flavonoids**

Total flavonoids were estimated using the method of Ordon ez et al. [28]. To 0.5 ml of sample, 0.5 ml of 2% AlCl₃ ethanol solution was added. After one hour at room temperature, the absorbance was measured at 420 nm. A yellow color indicated the presence of flavonoids. Extract samples were evaluated at a final concentration of 0.1 mg/ml. Total flavonoid content were calculated as quercetin (mg/g) using the following equation based on the calibration curve: 

\[ y = 0.0255x, R^2 = 0.9365, \]  

where x was the absorbance and y was the quercetin equivalent (mg/g).

**Determination of Total Proanthocyanidins**

Total flavonols in the plant extracts were estimated using the method of Kumaran and Karunakaran [20]. To 2.0 mL of sample (standard), 2.0 mL of 2% AlCl₃ ethanol and 3.0 mL (50 g/L) sodium acetate solutions were added. The absorption at 440 nm was read after 2.5 h at 20°C. Extract samples were evaluated at a final concentration of 0.1 mg/ml. Total flavonoid content were calculated as quercetin (mg/g) using the following equation based on the calibration curve: 

\[ y = 0.0255x, R^2 = 0.9812, \]  

where x was the absorbance and y was the quercetin equivalent (mg/g).

**Determination of Total Proanthocyanidins**

Determination of proanthocyanidin was based on the procedure reported by Sun et al. [29]. A volume of 0.5 ml of 0.1 mg/ml of extract solution was mixed with 3 ml of 4% vanillin-methanol solution and 1.5 ml hydrochloric acid; the mixture was allowed to stand for 15 min. The absorbance was measured at 500 nm. Extract samples were evaluated at a final concentration of 0.1 mg/ml. Total proanthocyanidin content were expressed as catechin equivalents (mg/g) using the following equation based on the calibration curve: 

\[ y = 0.5825x, R^2 = 0.9277, \]  

where x was the absorbance and y is the catechin equivalent (mg/g).
Determination of Antioxidant Activity

**ABTS Radical Scavenging Assay**

For ABTS assay, the method of Re et al. [30] was adopted. The stock solutions included 7 mM ABTS⁺ solution and 2.4 mM potassium persulfate solution. The working solution was then prepared by mixing the two stock solutions in equal quantities and allowing them to react for 12 h at room temperature in the dark. The solution was then diluted by mixing 1 ml ABTS⁺ solution with 60 ml methanol to obtain an absorbance of 0.706 ± 0.001 units at 734 nm using the spectrophotometer. Fresh ABTS⁺ solution was prepared for each assay. Plant extracts (1 ml) were allowed to react with 1 ml of the ABTS⁺ solution and the absorbance was taken at 734 nm after 7 min using the spectrophotometer. The ABTS⁺ scavenging capacity of the extract was compared with that of BHT and percentage inhibition calculated as ABTS radical scavenging activity (%) = [(Abscontrol - Abs sample) / Abscontrol] x 100 where Abscontrol is the absorbance of ABTS radical + methanol; Abssample is the absorbance of ABTS radical + sample extract /standard (Fig. 1).

**DPPH Radical Scavenging Assay**

The effect of extracts on DPPH radical was estimated using the method of Liyana-Pathirana and Shahidi [31]. A solution of 0.135 mM DPPH in methanol was prepared and 1.0 ml of this solution was mixed with 1.0 ml of extract in methanol containing 0.02–0.1 mg of the extract. The reaction mixture was vortexed thoroughly and left in the dark at room temperature.
temperature for 30 min. The absorbance of the mixture was measured spectrophotometrically at 517 nm. Ascorbic acid and BHT were used as references. The ability to scavenge DPPH radical was calculated by the following equation: 

\[
\text{DPPH radical scavenging activity (\%)} = \frac{(\text{Abs}_{\text{control}} - \text{Abs}_{\text{sample}})}{\text{Abs}_{\text{control}}} \times 100
\]

where \(\text{Abs}_{\text{control}}\) is the absorbance of DPPH radical + methanol; \(\text{Abs}_{\text{sample}}\) is the absorbance of DPPH radical + sample extract/standard.

**Total Antioxidant Activity (FRAP Assay)**

A modified method of Benzie and Strain [32] was adopted for the FRAP assay. The stock solutions included 300 mM acetate buffer (3.1 g \(\text{C}_2\text{H}_3\text{NaO}_2\cdot 3\text{H}_2\text{O}\) and 16 ml \(\text{C}_2\text{H}_4\text{O}_2\)), pH 3.6, 10 mM TPTZ (2, 4, 6-tripyridyl-triazine) solution in 40 mM HCl, and 20 mM \(\text{FeCl}_3\cdot 6\text{H}_2\text{O}\) solution. The fresh working solution was prepared by mixing 25 ml acetate buffer, 2.5 ml TPTZ, and 2.5 ml \(\text{FeCl}_3\cdot 6\text{H}_2\text{O}\) solution. The temperature of the solution was raised to 37 °C before using. Plant extracts (150 \(\mu\)L) were allowed to react with 2850 \(\mu\)L of the FRAP solution for 30 min in the dark condition. Readings of the colored product (ferrous tripyridyltriazine complex) were taken at 593 nm. The standard curve was linear between 200 and 1000 \(\mu\)M \(\text{FeSO}_4\). Results are expressed in \(\mu\)M Fe (II)/g dry mass and compared with that of BHT, ascorbic acid and catechin.

**Proximate Analysis**

The recommended methods of the Association of Official Analytical chemists (AOAC, 1999) were used for the determination of moisture, ash, crude lipid, crude fibre and nitrogen content.

**Mineral Analysis**

The automated procedure for determining cations in the plant material utilizes the reaction between a particular cation and molybdenovanate to form a complex. The complex is then measured colorimetrically at 420nm. The elements comprising sodium, calcium, potassium, magnesium, iron, zinc, copper, manganese, potassium, nitrogen and phosphorus were determined in this way.

**Anti-nutrient Analysis**

Determination of alkaloid and saponins were as described by Obadoni and Ochuko [33]. Phytate was estimated by the method of Wheeler and Ferrel [34].

**Bioassay**

The bacterial cultures used in this study were obtained from the Department of Biochemistry and Microbiology, Rhodes University, South Africa. They consisted of five Gram-positive and five Gram-negative strains (Table VI). Each organism was maintained on nutrient agar plates and was recovered for testing by growth in nutrient broth for 24 hrs. Before use, each bacterial culture was diluted 1:100 with fresh sterile nutrient broth [35].

Test organisms were streaked in a radial pattern on sterile nutrient agar plates containing filtered extracts at final concentrations of 0.1, 0.5, 1.0, 2.5 and 5.0 mg/ml [23, 36]. Plates containing only nutrient agar and another set containing nutrient agar and the respective solvents served as controls. After inoculation, the plates were incubated at 37°C for 24 to 48 hours. Each treatment was performed in triplicate and complete inhibition of bacterial growth was required for an extract to be declared bioactive. The antibacterial activities of the extracts were compared to those of streptomycin and chloramphenicol.

**Statistical Analysis**

The experimental results were expressed as mean ± standard deviation (SD) of three replicates. Where applicable, the data were subjected to one way analysis of variance (ANOVA) and differences between samples were determined by Duncan’s Multiple Range test using the Statistical Analysis System (SAS, 1999) program. \(P\) Values < 0.05 were regarded as significant and \(P\) values < 0.01 as very significant.

**RESULTS**

**ABTS**

At 0.05mg/ml, the acetone extract caused 96.5% ABTS radical scavenging inhibition while the methanol, water, and BHT caused inhibition at 61.8, 79.1 and 89.8% respectively. At 1mg/ml, the results were 98.2, 95.4, 97.1 and 99.3% for acetone, methanol, water and BHT respectively.

**DPPH**

At 0.05mg/ml, the acetone, methanol, water, BHT and ascorbic acid caused DPPH radical scavenging activity at 72.5, 53.5, 46.0, 93.1 and 99.8% respectively while at 1mg/ml, the results were 93.5, 85.4, 70.5, 90.1 and 100% for acetone, methanol, water, BHT and ascorbic acid respectively.

**Polyphenolic Contents**

With respect to the total polyphenol, the acetone extract has higher content of this constituent than that of methanol and acetone. The flavonoid contents of the water extract is higher than those of acetone and methanol at 1.15, 0.80 and 0.96 respectively. The methanol extract had higher content of proanthocyanidins relative to acetone and water extracts at 2.42, 1.9 and 0.73 respectively. In the case of total flavonol, methanol extract also have higher contents than acetone and water extracts i.e. 0.96, 0.43 and 0.43, respectively (Table 1).

**Table 1. Polyphenol Contents of the Acetone, Methanol and Water Extracts of the Leaves of Amaranthus asper (n= 3, X ± SEM)**

<table>
<thead>
<tr>
<th>Phenolics</th>
<th>Acetone</th>
<th>Methanol</th>
<th>Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total polyphenol</td>
<td>22.77 ±0.95*</td>
<td>13.89 ±1.62*</td>
<td>7.25± 1.43</td>
</tr>
<tr>
<td>Flavonoids</td>
<td>0.80 ±0.04</td>
<td>0.96 ±0.11</td>
<td>1.15 ±0.03*</td>
</tr>
<tr>
<td>Proanthocyanidins</td>
<td>1.90 ±0.43*</td>
<td>2.42 ±0.37*</td>
<td>0.73 ±0.31</td>
</tr>
<tr>
<td>Total Flavonol</td>
<td>0.43 ±0.03</td>
<td>0.96 ±0.25*</td>
<td>0.43 ± 0.14</td>
</tr>
</tbody>
</table>

*aExpressed as mg tannic acid/g of dry plant material.
*bExpressed as mg quercetin/g of dry plant material.
+cExpressed as mg quercetin/g of dry plant material.
+dExpressed as mg quercetin/g of dry plant material.
+ indicates that this value is significantly different from the other at \(P<0.05\)
Total Antioxidant Power (FRAP)

The ferrous reducing antioxidant power (FRAP) values for acetone extract (10.84.9) is much higher than that of methanol (143.5), water (42.4), BHT (63.5), and catechin (972.02) but lower than those of ascorbic acid (1632.1) and quercetin (3107.3) (Table 2).

<table>
<thead>
<tr>
<th>Extracts</th>
<th>FRAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetone</td>
<td>1084.91 ± 122.7</td>
</tr>
<tr>
<td>Methanol</td>
<td>143.48 ± 11.59</td>
</tr>
<tr>
<td>Water</td>
<td>42.39 ±14.53</td>
</tr>
<tr>
<td>Ascorbic acid</td>
<td>1632.1 ± 16.95</td>
</tr>
<tr>
<td>BHT</td>
<td>63.46 ± 2.49</td>
</tr>
<tr>
<td>Catechin</td>
<td>972.02 ± 0.61</td>
</tr>
<tr>
<td>Quercetin</td>
<td>3107.29 ± 31.28</td>
</tr>
</tbody>
</table>

Expressed in units of μmol Fe (II)/g.

Proximate analysis

The proximate analysis showed the percentage moisture content, ash content, crude protein, crude lipid, crude fibre and carbohydrate of the leaves as 70.5, 18.5, 11.13, 4.0, 17.5 and 48.8%, respectively while its calorific value is 275.9 Kcal/100 g (Table 3).

<table>
<thead>
<tr>
<th>Constituents</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>70.48 ±5.48</td>
</tr>
<tr>
<td>Ash</td>
<td>18.5± 0.4</td>
</tr>
<tr>
<td>Protein</td>
<td>11.13± 0.11</td>
</tr>
<tr>
<td>Fat</td>
<td>4.0 ± 0.2</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>48.84 ±2.1</td>
</tr>
<tr>
<td>Crude fibre</td>
<td>17.53 ± 1.87</td>
</tr>
<tr>
<td>Energy (kcal)</td>
<td>275.88 ±3.2</td>
</tr>
</tbody>
</table>

Antibacterial Assay

The methanol extract of this plant has activity against all the Gram positive organisms used in this study at 5mg/ml concentration. The acetone extract on the other hand has activity against Bacillus cereus (1mg/ml), Micrococcus kristinae (1mg/ml), Staphylococcus aureus (5mg/ml) and Streptococcus pyogenes (2mg/ml). The water extract only has activity against Micrococcus kristinae (1mg/ml) and Escherichia coli (2mg/ml) (Table 6).

DISCUSSION

Polyphenols are the major plant compounds with antioxidant activity. This activity is believed to be mainly due to their redox properties [37], which play an important role in adsorbing and neutralizing free radicals, quenching singlet and triplet oxygen, or decomposing peroxides. The results strongly suggest that phenolics are important components of these plants, and some of their pharmacological effects could be attributed to the presence of these valuable constituents.

The antioxidant potentials of the extracts of the leaves of this plant were estimated from their ability to reduce TPRZ-Fe (III) complex to TPTZ-Fe (II). According to recent reports, a highly positive relationship between total phenols and antioxidant activity appears to be the trend in many plant species [27].

Proton radical scavenging is an important attribute of antioxidants. ABTS, a protonated radical, has characteristic absorbance maxima at 734 nm which decreases with the scavenging of the proton radicals [38]. Higher concentrations of the extracts were more effective in quenching free radicals in the system.

The effect of antioxidants on DPPH is thought to be due to their hydrogen donating ability [39]. The DPPH radical scavenging abilities of the acetone extract at 1mg/ml was significantly comparable to those of ascorbic acid (100%) and BHT (100), showing that the extract has the proton-donating ability and could serve as free radical inhibitors or scavengers, acting possibly as primary antioxidants. The results for methanol (85.4) and water (70.5) are not as high. The scavenging of the ABTS radical by the extracts at 1mg/ml was found to be slightly higher than that of DPPH* radical. Factors like stereoselectivity of the radicals or the solubility of the extract in different testing systems have been reported to affect the capacity of extracts to react and...
Senna obtusfolia, Amaranthus incurvatus, M. balsamina (48.8% DW) is higher than 20, 23.7 and 39.05% reported for DW in some edible green leafy vegetables of Southern India reported for Africa [49, 50]. However, it compares favorably with 4.20% lipid content (4.0% DW) is low compared to reported values A. asper protein requirement of the local people. requirement may nonetheless go a long way in meeting the good source of protein. Though, the protein content of (29.78% DW) and E. coli the plant extracts were active against the Gram-positive and the plant is presented in Table 6. It has just been shown that the antibacterial activity of the extracts of the leaves of (20.5% DW), but lower than those of I. batatas (24.85% DW), Amaranthus candatus (20.5% DW), Piper guineeses (29.78% DW) and T. triangulare (31.00% DW) [4, 44, 47]. According to Pearson [48], plant food that provides more than 12% of its calorific value from protein is considered good source of protein. Though, the protein content of A. asper leaves is 11.13 and is slightly lower than this requirement may nonetheless go a long way in meeting the protein requirement of the local people.

A. asper leaf is a poor source of lipid because the crude lipid content (4.0% DW) is low compared to reported values (8.3 - 27.0% DW) in some vegetables consumed in West Africa [49, 50]. However, it compares favorably with 4.20% reported for Calchorus africanum leaves and 1.85 - 8.71% DW in some edible green leafy vegetables of Southern India and Nigeria [51, 52]. The carbohydrate content of the plant (48.8% DW) is higher than 20, 23.7 and 39.05% reported for Senna obtusfolia, Amaranthus incurvatus, M. balsamina leaves, respectively [6, 53]. This is however; lower than reported values for Corchorus tridens (75.0% DW) and sweet potatoes leaves (82.8%) [54]. The recommended dietary allowance (RDA) values for children, adults, pregnant and lactating mothers are 130 g, 130, 175 and 210 g, respectively [2]. It implies that 40, 40, 30 and 25% of their respective daily requirement can be met when 100 g dried leaves are consumed.

The crude fibre content (17.5% DW) is high when compared to Ipomea batatas (7.20%), T. triangulare (6.20%) P. guineeses (6.40%), Corchorus olitorius (7.0%) Vernonia amarygdalina (6.5%) [4, 44]. Adequate intake of dietary fibre can lower the serum cholesterol level, risk of coronary heart disease, hypertension, constipation, diabetes, colon and breast cancer [12, 55]. The RDA of fibre for children, adults, pregnant and lactating mothers are 19 – 25, 21-38, 28 and 29 g, respectively. The estimated calorific value (275.9 kcal/100 g DW) in A. asper leaves compare favourably to 248.8–307.1 Kcal/100 g DW reported in some Nigerian vegetables [2, 44, 56]. Asibey–Berko and Tayie [54] also reported comparable energy content in some Ghanaian green leafy vegetables. Thus, the calorific value agreement with general observation that vegetables have low energy values [57].

The mineral composition of A. asper is as shown in Table 4. The Na/K ratio in the body is of great concern for prevention of high blood pressure. Na/K ratio less than one is recommended [58]. Hence, consumption of A. asper would probably reduce high blood pressure diseases because its Na/K is less than one. Iron content of the leaves (419 mg/100 g) is very high when compare with the value reported in I batatas (16.00 mg/100 g) [44]. Iron is an essential trace element for haemoglobin formation, normal functioning of the central nervous system and in the oxidation of carbohydrates, protein and fats [2, 59]. The Zinc content (26 mg/100 g) compares favourably to most values reported for green leafy vegetables in literatures [6, 60]. Zinc is involved in normal function of immune system.

Analysis of the antinutrient contents of the plant showed that alkaloid (0.3mg/100g) saponins (7.0mg/100g) and phytate (9.3mg/100g) were present. The alkaloid content (0.3mg/100 g) is lower than the values reported for the leafy vegetables Aspilia Africana, Bryophyllum pinnatum), Cleome rutidosperma and Emilia cocinea consumed in

### Table 6. Antibacterial Activity of the Leaves Extracts of Amaranthus asper

<table>
<thead>
<tr>
<th>Bacterial species</th>
<th>Gram +/-</th>
<th>Minimum inhibitory concentration (mg/ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Acetone</td>
</tr>
<tr>
<td>Bacillus cereus</td>
<td>+</td>
<td>1.0</td>
</tr>
<tr>
<td>Staphylococcus epidermidis</td>
<td>+</td>
<td>na</td>
</tr>
<tr>
<td>Staphylococcus aureus</td>
<td>+</td>
<td>5.0</td>
</tr>
<tr>
<td>Micrococcus kristinae</td>
<td>+</td>
<td>1.0</td>
</tr>
<tr>
<td>Streptococcus pyogenes</td>
<td>+</td>
<td>2.0</td>
</tr>
<tr>
<td>Escherichia coli</td>
<td>-</td>
<td>na</td>
</tr>
<tr>
<td>Salmonella pooni</td>
<td>-</td>
<td>na</td>
</tr>
<tr>
<td>Serratia marcescens</td>
<td>-</td>
<td>na</td>
</tr>
<tr>
<td>Pseudomonas aeruginosa</td>
<td>-</td>
<td>na</td>
</tr>
<tr>
<td>Klebsiella pneumoniae</td>
<td>-</td>
<td>na</td>
</tr>
</tbody>
</table>

Na=not active.
Nigeria [2, 61, 62]. The saponin content (7.0 mg/100 g) is much less than the value reported for some medicinal plants used in Nigeria. Though the phytate (9.3mg/100g) is higher than the value reported for\textit{I. batatus} and\textit{G. africana} leaves [44, 49] is still within the tolerable limits and can easily be detoxified by soaking, boiling or frying [2, 63-65].

The results of this study showed that the leaves of\textit{A. asper} contain appreciable amount of proteins, fat, fibre, carbohydrate and calorific value, mineral elements, polyphenols, and generally low level of toxicants. Its antioxidant and antibacterial activities further lend credence to the biological value of this plant. Thus, it can therefore be concluded that\textit{A. asper} leaves can contribute significantly to the nutrient requirements of man and should be used as a form of nutrients to supplement other major sources. Its medicinal value is also of great interest.

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