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Evaluation of the Antioxidants and Antimicrobial Properties of Two Nigerian Leafy Vegetables

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Abstract The study was carried out on *Senecio biafrae* and *Basella alba* to promote their utilization as a support for promoting healthy diets. Phytochemical screening and determination of reducing power of different concentrations (1-5 mg ml^{-1}) of the aqueous and alcoholic extracts; using ferric reducing antioxidant assay and phosphomolybdate method were carried out. The antimicrobial activities of the extracts against selected pathogen at 0.05g/ml were evaluated by using agar well diffusion method for antibacterial and poisoned food technique for antifungal assays. The results revealed the presence of flavonoid, tannin, terpenoid and saponin in the extracts. Correlation analysis revealed positively strong correlation between the total flavonoid content (TFC) and total phenol content (TPC) with the reducing property. For ferric reduction, the range was TFC (r = 0.944 – 0.967) and TPC (r = 0.937-0.970) for *B.alba* extracts and TFC (r = 0.918 – 0.976) and TPC (r = 0.947 – 0.990) for *S. bifrae* at between 0.01 and 0.05 significant levels. All the fractions showed concentration dependent increase in their total antioxidant property (TAP) with positively strong correlations with corresponding TFC and TPC in the range TFC (r = 0.971 – 0.991); TPC (r = 0.945 -0.980) for *B. alba* and TFC (r = 0.957 – 0.983); TPC (r = 0.966 – 0.991) for *S. biafrae* at 0.01- 0.05 significant levels. The vegetables exhibited mild antibacterial activities against *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Salmonella typhi* compared with streptomycin sulphate used as control but appreciable antifungal activities against (*Fusarium solani*, *Trichoderma rubrum* and *Aspergillus fumigates*) compared with bonlate antibiotic positive control. The vegetables possess appreciable antioxidant and antimicrobial properties for promoting good health, their cultivation and utilization should be encouraged especially in the face of health and economic challenges; and food insecurity in many parts of the world.

Keywords: *vegetables, extracts, phytochemicals, antimicrobial, reducing property*

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1. Introduction

Plants like fruits, vegetables and medicinal plants possess many biologically active compounds, making them potential source of therapeutic agents since ancient times [1,2]. There is increasing interest in the use of natural products because of several lethal diseases which are now very common in modern times; and scientific evidences abound that majority of these chronic conditions are related to diet and life style. There is a wide spread belief now that natural food and medicine are healthier than processed and synthetic products. This is why food based approach and development of new drugs from natural products are considered important interventions in the action plan against chronic diseases. World Health Organization (WHO) therefore encourages countries to identify and exploit traditional medicine and phytotherapy [3]. The presence of phytochemicals in vegetables explains the reason for their use in ethno medicine for the treatment and management of various ailments [4]. Investigations for functional food ingredients and nutraceutical products are important nowadays to promote health and reduce risk of disease. *Senecio biafrae and Basella alba* are among the numerous underutilized indigenous vegetables in Nigeria. *S. biafrae* (with local name "worowo" by Yoruba tribe in Nigeria) is a common undercover crop in cocoa plantations, in south-western Nigeria. Fresh succulent leaves of *Senecio biafrae* are used as food, usually cooked as a leafy vegetable for its unique taste, and flavour, especially among the rural and local population. Studies have established its substantial nutritional and medicinal value [5,6,7].

B. alba, locally called "Amunu-tutu" in southwestern part of Nigeria is a short lived perennial herb which belongs to the family Basellaceae. The young leaves, stem and shoots, which make a succulent, slightly mucilaginous vegetable are used in cooking; they could be eaten cooked as green vegetables or added to soups [8]. *B. alba* has been found to be a good source of calcium, iron, magnesium, vitamin A, vitamin B9 (folic acid), vitamin C and several vital anti-oxidants [2]. Though the consumption of B. alba is more common in Nigeria, it is yet to take its proper place as a potential economy vegetable. Few stands of Basella are commonly cultivated

at the backyard for consumption in many homes. Vegetables can play an important role in improvement of economy and social status of the citizen in addition to their positive effects on human health. Many studies have been carried out on the nutritional values of many vegetables in Nigeria [2,9] but there is need for more information on the antimicrobial properties of many of these vegetables, as an indicator of their possible therapeutic potential. In the present study, attempt was made to screen the alcohol and aqueous extracts of the above mentioned vegetables for phytochemicals, determine their reducing properties and their antimicrobial activities

2. Materials and Methods

2.1. Preparation of Samples and Extracts

The air-dried samples of *B. alba;* a perennial vine which belongs to family Basellaceae and *S. biafrae* also a perennial climbing herb known as English spinach were purchased from local markets in Nigeria, ground and sieve to give 40 mm mesh size powder. Bioactive extract of each powdered vegetable was obtained by weighing 20 g into clean and dried reagent bottle and 400 ml each of distilled water, methanol and ethanol were separately added and subjected to cold maceration process for 24 h to obtain the aqueous extract and 72 h to obtain the alcohol extracts. The extracts were concentrated under vacuum and evaporated using rotary evaporator at low temperature (45°C). The extracts were kept for analyses [10].

2.2. Phytochemical Screening of the Extracts

Phytochemical screening of the extracts were carried out using standard qualitative phytochemical methods described by Harborne [11]. Trease and Evans [12] and Sofowora [13].

2.2.1. Alkaliod Determination

About 0.5ml of each extract was stirred in 5 ml of 1% aqueous HCl on a steam water bath, 1ml 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.

2.2.2. Saponin Determination

The ability of saponin to produce frothing in aqueous solution was used as screening test for saponin. About 0.5 ml of each 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.

2.2.3. Tannin Determination

About 0.5 ml of each 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.

2.2.4. Flavonoid Determination

About 0.5 ml of each extract was stirred with 20 ml of dilute ammonia solution. A yellow colouration was observed, the disappearance of the yellow colour after the addition of 1ml conc. H_2SO_4 indicated the presence of flavonoid.

2.2.5. Steriod Determination

Exactly 20 ml of acetic anhydride was added to 0.5g ml of each extract and filtered, 2 ml of concentrated H_2SO_4 was added to the filtrate. There was a colour change from violet to blue or green which indicate the presence of steroid.

2.2.6. Terpenoid Determination

About 0.5 ml of each extract was mixed with 20 ml of chloroform and filtered. 3 ml of concentrated H_2SO_4 was added to the filtrate to form a layer. A reddish brown colour at the interface was observed which indicated the presence of terpeniod.

2.2.7. Anthraquinone Determination

Borntrager's test was used for the detection of anthraquinone. 0.5 ml of the extract was shaken with 10 ml of benzene, filtered and 5ml 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 indicated the presence of free anthraquinone.

2.2.8. Phlobatannin Detemination

Deposition of red precipitate when 0.5 ml of each of the extracts was boiled with 1% aqueous HCl was taken as the evidence for the presence of phlobatannin.

2.2.9. Cardiac Glycosides Determination

2.2.9.1. Legal's Test

About 0.5 ml of each 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.

2.2.9.2. Salkowski's Test

About 0.5 ml of each extract was mixed with 20 ml of chloroform and filtered. 3ml of concentrated H_2SO_4 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.

2.2.9.3. Keller- killiani's Test

About 0.5 ml of each extract was dissolve in 2ml of glacial acetic acid containing one drop of ferric chloride solution. This was then under layer with 1ml of concentrated H_2SO_4. A brown colouration obtained at the interface indicated the presence of a deoxy sugar, which is a characteristic of cardenolides.

2.2.9.4. Lieberman's Test

Exactly 20 ml of acetic anhydride was added to 0.5 ml of each of the extract and filtered. 2 ml of concentrated H_2SO_4 was added to the filtrate. There was a colour change from violet to blue or green which indicated the presence of steroids nucleous.(i.e aglycone portion of the cardiac glycosides).

2.3. Determination of Ferric Reducing Antioxidant Property (FRAP)

The reducing property of the extract was determined by assessing the ability of the extracts to reduce $FeCl_3$ solution as described by Pulido *et al.*, [14]. Each of the extracts (1-5mg/ml) was mixed with 2.5 ml, 200 mM sodium phosphate buffer (pH 6.6) and 2.5 ml of 1% potassium hexacyanoferrate (III) (- $K_3[Fe(CN)_6]$). The mixture was incubated at 50°C for 20 min, thereafter 2.5 ml, 10 % Trichloroacetic acid was also added and subsequently centrifuged at 650 rpm for 10 min, 5 ml of the supernatant was then mixed with equal volume of water and 1ml of 0.1 % $FeCl_3$. The absorbance was measured at 700 nm, the higher the absorbance, the higher the reducing power.

2.4. Determination of Total Antioxidant Property (TAP)

The assay is based on the reduction of Mo (VI) - Mo (V) by the extracts and the subsequent formation of a green phosphate/Mo (V) complex at acidic pH as described by Prieto *et al.*, [15]. Exactly 0.2 ml of the different extracts (1-5mg/ml) was each combined with 3 ml of reagent solution (0.6 M H_2SO_4, 28 mM Na_3PO_4 and 4 Mm $(NH4)_2MoO_4$). The tubes were incubated at 95°C for 90 min and the absorbance measured at 695 nm against the blank after the mixtures have cooled to room temperature. The antioxidant activity was expressed as gallic acid equivalent.

2.5. Determination of Antimicrobial Activity

2.5.1. Determination of Antibacterial Activity

The bacterial isolates used were identified and subsequently maintained as stock strains. Simple susceptibility screening test using agar well diffusion method was employed and each bacterial isolate was suspended in sterile saline and diluted to 10^6 colony forming unit (CFU)/ml. The antibacterial activity of aqueous, methanolic and ethanolic extracts of the vegetables against bacterial isolates (*S. aureus, P. aeruginosa*, and *S. typhi)* was evaluated by using agar well diffusion method [16,17]. Plate count agar (PCA) plates were inoculated with 100 µl of standardized inoculum (1.5 x 10^6 CFU/ml) of each selected bacterium and spread with sterile swabs. Wells of 8 mm size diameter were made with sterile borer into agar plates containing the bacterial inoculum and the lower portion was sealed with a little molten agar medium. About 0.5 ml volume of each of the extracts was poured into a well of inoculated plates. Streptomycin sulphate (10 ug/ml) was used as a positive control which was introduced into a well instead of extract. The solvents; deionized water, methanol or ethanol were used as a negative control which was introduced into a well instead of the extracts. The plates thus prepared were left at room temperature for ten minutes allowing the diffusion of the extract into the agar [18]. After incubation for 24 hrs at 37 ^oC, the plates were observed. If antibacterial activity was present on the plates, it was indicated by an inhibition zone surrounding the well containing the vegetables extracts. The zone of inhibition was measured and expressed in mm.

2.5.2. Determination of Antifungal Activity

The antifungal activity of the vegetables extracts was evaluated against food-associated fungi by using poisoned food technique. Potato dextrose agar (PDA), was weighed (39g) and was dispersed in a litre of deionised water sterilized at 121°C for 15 min, allowed to cool (45°C) before pouring (20 ml) into separated dishes. The fungi; *Fusarium solami*, *Trichoderma rubrum*, and *Aspergillus fumigates* were inoculated on Potato dextrose agar (PDA) plates and incubated for 25°C for 72 h, to obtain young, actively growing colonies of moulds. 0.2 ml of each of the extract was mixed with 20 ml of cooled (45°C) molten PDA medium and allowed to solidify at room temperature for 30 min. Thereafter 10 µl of fungal spores in distilled water was added at the centre of the solidified PDA plates. PDA plates with 10 ug/ml of bonlate were used as positive control. PDA plates with the solvents; deionized water, methanol or ethanol were used as negative control [19] [20]. The inoculated plates were incubated at 25°C and colony mean diameter was measured and recorded after 3 days. Percentage mycelial growth inhibition (% MGI) was calculated as given below:

$$\% \text{ MGI} = \frac{DC - DE \text{ x}100}{DC}$$

MGI = Percentage mycelial growth inhibition
DC = Diameter of fungal colony in control
DE = Diameter of fungal colony in extract.

2.6. Statistical Analysis

Values are presented as the mean ± SD of three replicates. ANOVA and Pearson correlation analyses were performed using the commercial software SPSS 16.0.

3. Results and Discussion

3.1. Phytochemical Screening

The aqueous and ethanol extracts of both *B. alba* and *S. bifrae* tested positive to saponin, flavonoids and steroid. Tannin was present in the aqueous and ethanol extracts of *B. alba* but not in *S. bifrae* while terpenoid was not detected in neither of the aqueous nor ethanol extracts of both vegetables. The methanol extracts of both vegetables were similar to aqueous and ethanol extracts except that they tested negative to steroid (Table 1) and only methanolic extract of *B. alba* tested positive to terpenoid. Oyewole and Kalejaiye, [2] observed the presence of tannin, terpenoid, steroid, saponins and anthraquinone in ethanolic extract of *B. alba* leaves while alkaloid and flavonoid were found to be absent. Ethanol extract of *Senecio biafrae* was also found to contain alkaloids, tannins, saponins, and steroids in very low concentrations in the study carried out by Gbadamosi and Okolosi, [21]. All the extracts tested negative to alkaloids,, anthraquinone and phlobatannin. Cardiac glycosides are class of natural product, which are used to increase the

cardiac contractile force in patients with congestive heart failure and cardiac arrhythmias [22]. Methanol extracts of both vegetables tested positive to Salkwoski test but negative to Lieberman test. All the extracts tested negative to Keller killiani test except the methanol extract of *B. alba* but positive to Legal test. The result of this screening is close to the findings of Ajiboye *et al*. [23] where an aqueous extract of *Senecio biafrae* leaves was found to test positive to steroids, glycosides, alkaloids, phenolic compounds, flavonoids, saponins, phlobatannin and tannins but negative to anthraquinones and terpenes.

The phytochemicals detected in the extracts of both vegetables in this study have been proved to serve various medicinal functions; saponins are natural antibiotics [21,24,25], tannin promotes healing of wound and contain anti – diabetic properties [26,27] while steroidal compounds are of importance and interest in pharmacy due to their relationship with compounds such as sex hormones [28]. The presence of steroid may enhance the use of the plants as galactogogues by ensuring the synthesis of lactation hormones. The leaves of *B. alba* and *S. biafrae* may be useful as vegetables for expectant mothers or breast feeding mothers to ensure their hormonal balance [2,21,28].

3.2. Antioxidant Properties (FRAP and TAP)

The reducing power of the aqueous and alcohol extracts were assessed based on their abilities to reduce Fe (III) to Fe (II) and the results presented as ascorbic acid equivalent in mg/g. As revealed in Figure 1 and Figure 2, the reducing power of the aqueous extracts of *B. alba* and *S. bifrae* were higher than the alcohol extracts and this correlates to the total flavonoid contents (TFC) as rutin equivalent by reference to standard curve ($y = 8.250x$, $r^2 = 0.998$). The TFC values in mg/g for aqueous extracts of *B. alba* with the range 27.27 ± 0.01 to 139.39 ± 0.01 and *S.biafrae*, which range from 6.06 ± 0.02 to 42.42 ± 0.03 are higher than those of alcoholic extracts which were in the range 0.76 ± 0.02 to 8.49 ± 0.04 and 0.61 ± 0.02 to 4.18 ± 0.03 for B. alba and 0.82 ± 0.01 to 13.33 ± 0.01 and 1.21 ± 0.01to 5.03 ± 0.03 for *S.biafrae*; methanol and ethanol extracts respectively. The higher TFC concentrations observed in the methanolic extracts of *S.biafrae* (0.82 ± 0.01 to 13.33 ± 0.01) than *B.alba* (0.76 ± 0.02 to 8.49 ± 0.04) also correlates with higher reducing property observed in the same extract of *S.biafrae* than *B.alba*. Although, the ethanol extracts of *S. bifrae* gave significantly higher values of TFC ($p \leq 0.05$) with the range 1.21±0.01 to 5.03±0.03 than *B. alba*; 0.61± 0.02 to 4.18 ± 0.03, the opposite was observed in their reducing power. Generally, the reducing power of all the extracts was also positively correlated to the total phenol contents (TPC) in mg/g of DW as gallic acid equivalents by reference to standard curve ($y = 2.327$, $r^2 = 0.9849$). Higher total phenol contents were generally obtained in all the extracts of *S.biafrae* (48.52 ± 0.01 to 64.71 ± 0.01; 42.97 ± 0.01 to 197.66 ± 0.03 and 9.02 ± 0.01 to 51.78 ± 0.03) than *B.alba* (20.41 ± 0.03 to 55.86 ± 0.03; 42.97 ± 0.02 to 83.79 ± 0.16 and 8.16 ± 0.03 to 39.10 ± 0.02) for aqueous, methanolic and ethanolic extracts respectively; the only exception is at 1-2 mg/ml of the methanolic extracts of the two vegetables where there was no significant difference ($p \leq 0.05$) in the concentrations of TPC. In contrast however, the reducing properties of *B.alba* extracts were higher than those of *S.biafrae* except in the ethanol extracts. The observed variances could be due to the fact that different classes of phenolic compounds which exists in plants varies in potency and their solubility in different solvents; despite this, the correlation between the TFC and TPC (Table 2 and Table 3) with the reducing abilities of *B.alba* extracts was positively strong; TFC ($r = 0.944 – 0.967$) and TPC ($r = 0.937$-0.970). Likewise, strong and positive correlations were observed between the reducing power of *S. bifrae* extracts and the TFC ($r = 0.918 – 0.976$) and TPC ($r = 0.947 – 0.990$) at between 0.01 and 0.05 significant levels. This supports the claims that flavonoids and other phenolic compounds of plant origin are powerful antioxidants [29]. The extracts exerted significant reducing abilities compared with the vitamin C standard as shown in Figure 1 and Figure 2.

Table 1. Phytochemical screening of aqueous and alcohol extracts

Extracts	Aqueous		Methanol		Ethanol	
	B. alba	*S. biafrae*	*B. alba*	*S. biafrae*	*B. alba*	*S. biafrae*
Alkaloids	-	-	-	-	-	-
Saponnin	+	+	+	+	+	+
Tannin	+	-	+	+	+	-
Flavonoid	+	+	+	+	+	+
Steroid	+	+	-	-	+	+
Terpenoid	-	-	+	-	-	-
Anthraquinone	-	-	-	-	-	-
Phlobatannin	-	-	-	-	-	-
CARDIAC GLYCOSIDES						
Legal test	+	+	+	+	+	+
Salkwoski test	-	-	+	+	-	-
Keller killiani	-	-	+	-	-	-
Lieberman	+	+	-	-	+	+

+ = Present
- = Absent.

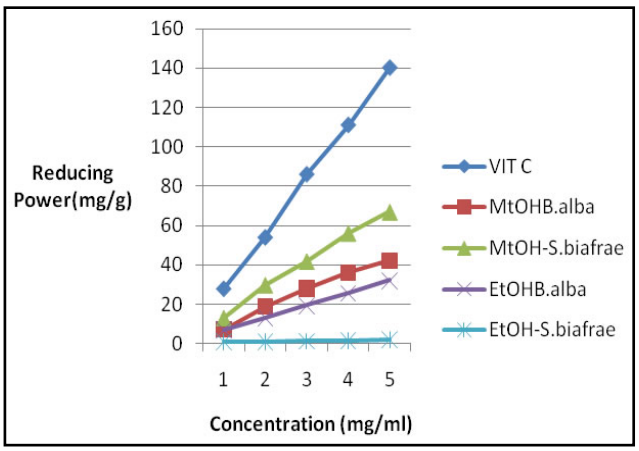

Figure 1. Ferric reducing antioxidant property (Alcohol extracts)

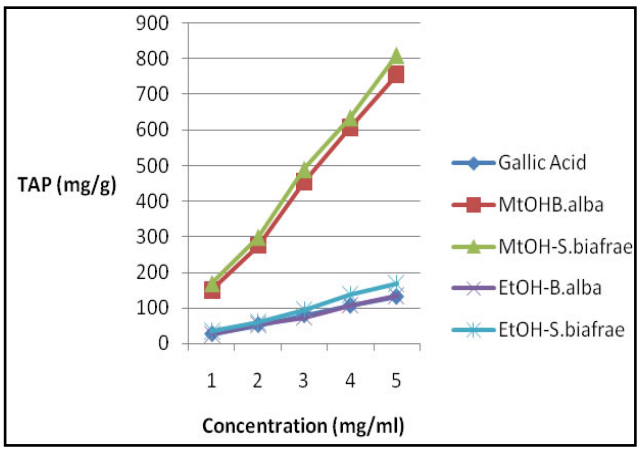

Figure 3. Total Antioxidant Property (Alcohol extracts)

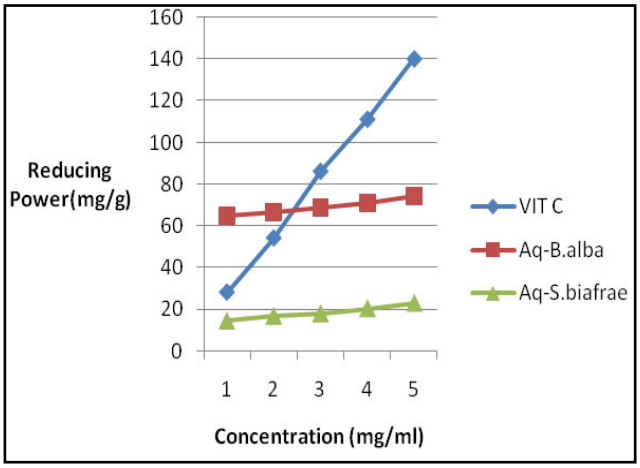

Figure 2. Ferric reducing antioxidant property (Aq extract)

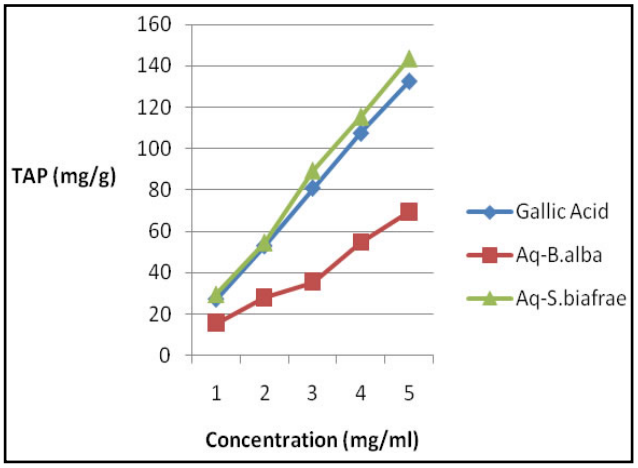

Figure 4. Total Antioxidant Property (Aqueous extract)

MtOHB.alba = Methanol extract of B.alba
EtOHB.alba = Ethanol extract of B.alba
MtOH S. biafrae = Methanol extract of S. biafrae
EtOH S. biafrae = Ethanol extract of S. biafrae
Aq. B.alba = Aqueous extract of B.alba
Aq. Biafrae = Aqueous extract of biafrae.

Table 2. Pearson's correlation coefficient between total phenol content and antioxidant assays

TPC		Samples	Pearson correlation	
			FRAP	TAP
Aqueous	r value	*B. alba*	.970**	.945*
	p value		.006	.015
	r value	*S. biafrae*	.947*	.966**
	p value		.015	.008
Methanol	r value	*B. alba*	.937*	.959**
	p value		.019	.010
	r value	*S. biafrae*	.958*	.985**
	p value		.010	.002
Ethanol	r value	*B. alba*	.948*	.980**
	p value		.014	.003
	r value	*S. biafrae*	.990**	.991**
	p value		.001	.001
Control			.991**	.992**
			.001	.001

**Correlation is significant at 0.01 level (2-tailed), * Correlation is significant at 0.05 level (2-tailed)
TPC = total phenol content.

Table 3. Pearson's correlation coefficient between total flavonoid content and antioxidant assays

TFC		Samles	Pearson correlation	
			FRAP	TAP
Aqueous	r value	*B. alba*	.946*	.989**
	p value		.015	.001
	r value	*S. biafrae*	.918*	.957*
	p value		.028	.011
Methanol	r value	*B. alba*	.967**	.991**
	p value		.007	.001
	r value	*S. biafrae*	.961**	.983**
	p value		.009	.003
Ethanol	r value	*B. alba*	.944*	.971**
	p value		.016	.006
	r value	*S. biafrae*	.976**	.963**
	p value		.005	.009
Control			.968**	.988**
			.007	.002

**Correlation is significant at 0.01 level (2-tailed), * Correlation is significant at 0.05 level (2-tailed)
TFC = total flavonoid content.

Total Antioxidant Property assay assessed the reducing power of the extracts based on their abilities to reduce Mo (VI) to Mo (V) and the results presented in Figure 3 and Figure 4 as gallic acid equivalent in mg/g. *B alba* and *S. bifrae* exhibited strong reducing capability on Mo (VI) in the aqueous and alcohol extracts compared with the gallic acid standard. Methanol extracts exerted better reducing power on Mo (VI) to Mo (V) transformation in this study than the aqueous and ethanol extracts in agreement with the trend observed for the TPC. Stronger ability to reduce Mo (VI) exhibited by the extracts of *S. biafrae* also agrees with the trend observed for TPC. All the fractions showed substantial and concentration dependent increase in their reducing properties with positively strong correlations with corresponding TFC and TPC in the range TFC (r =0.971 – 0.991); TPC (r = 0.945 -0.980) for *B. alba* and TFC (r = 0.957 – 0.983); TPC (r = 0.966 – 0.991) for *S. biafrae* at 0.01- 0.05 significant levels (Table 2 and Table 3). 3 1.66 (µg vit E equivalent/100 µg) was obtained for chloroform extract of *Coccinia grandis* in a study carried out by Umamaheswari and Chatterjee [30].

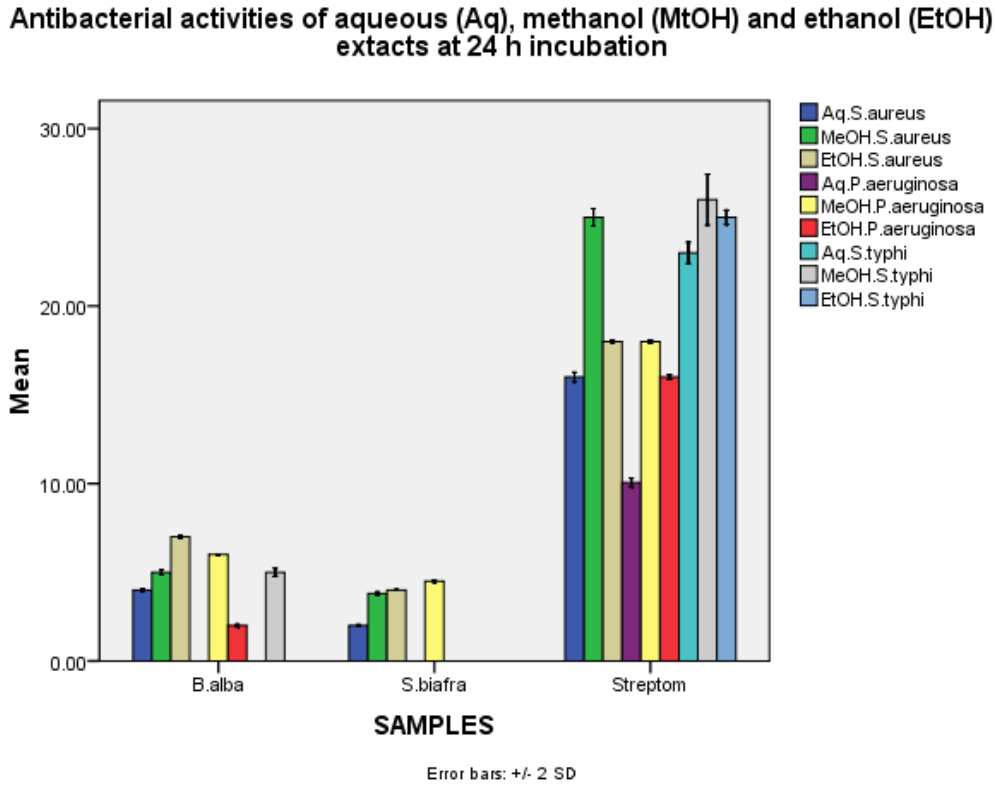

Figure 5. Antibacterial property

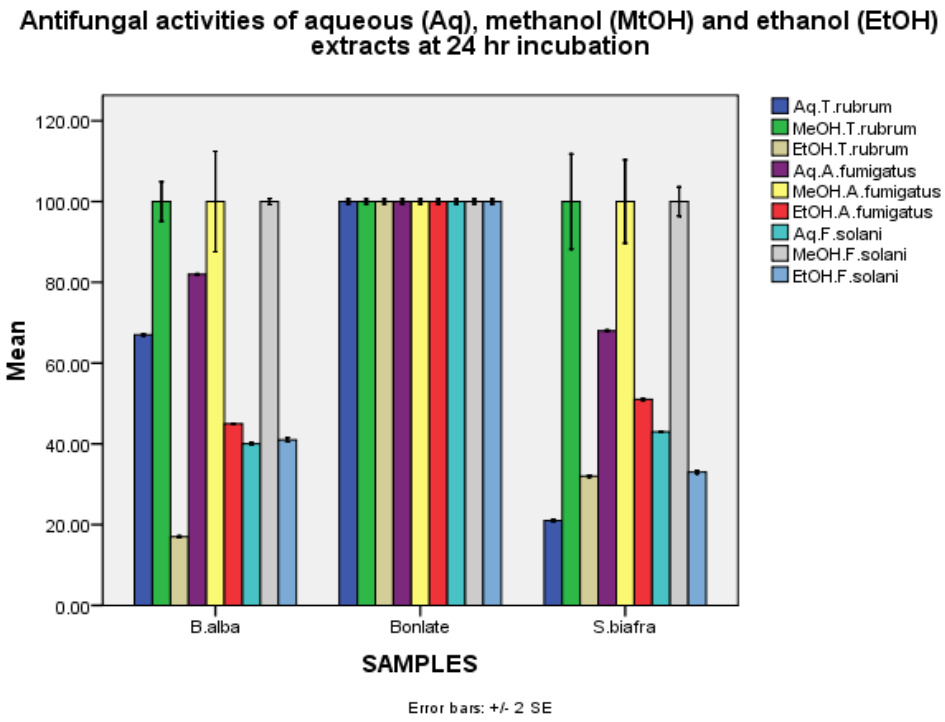

Figure 6. Antifungal property

3.3. Antimicrobial Activities of Vegetables Extracts

The antibacterial activities of leaves extracts of *S. biafrae* and *B. alba* are shown in Figure 5. The results showed that the aqueous extracts of *S. biafrae* and *B. alba* had no inhibitory activity against *P.aeruginosa* and *S. typhi* but *S. aureus* was inhibited by the aqueous extracts of both vegetables. This observation may be attributed to the fact that aqueous extracts of *S. biafrae* and *B. alba* are effective against gram positive bacteria than gram negative bacteria. Ethanolic extract of *B.alba* had the highest activity against *S. biafrae* when compared with the other extacts of *B. alba* and *S. biafrae*. The results also showed that both *S. biafrae* and *P.aeruginosa* were susceptible to ethanolic extract of *B.alba* while *S. typhi* was resistant. This is similar to the findings of Oyewole and Kalejaiye [2], and Sushila *et al*., [31]. Oyewole and Kalejaiye [2] reported that *S. aureus, P.aeruginosa* and *E.coli* were susceptible to the ethanolic extract of the leaves of *B.alba*. Among the extracts of *S. biafrae*, methanolic extract had the highest inhibitory effect on *P.aeruginosa*.

The results of the antifungal properties of the extracts of *S. biafrae* and *B. alba;* presented in Figure 6 showed that the methanolic extracts of both vegetables had 100 % mycelia growth inhibition against *T. rubrum, A. fumigates* and *F. solani*. The aqueous extract of *S. biafrae* had the lowest mycelia growth inhibition against *T. rubrum* when compared with other extracts of *S. biafrae* in this study; and *T. rubrum* was least susceptible to the extracts of both vegetables. It can be deduced from the results of this study that the vegetables extracts displayed higher susceptibility to fungi than bacteria, but both *B. alba* and *S. biafrae* demonstrated similar antifungi properties.

B.alba extracts contained stronger antibacterial compounds than *S. biafrae*, both *S. biafrae* and *B. alba* extracts however showed appreciable antimicrobial activities. Their extracts may be developed as antifungal agents for treatment of infections as well as food preservatives.

4. Conclusion

Aqueous and alcohol extracts of *B.alba* and *S. biafrae* generally demonstrated concentration dependent effectiveness in their reducing power and antimicrobial properties; and there was positively strong correlation between the reducing properties and the total phenol and total flavonoid contents of the extracts. Their reducing ability is an indication of the antioxidant potential of the flavonoids and other phenolic compounds present in these vegetables. Large scale cultivation and utilization of these vegetables could be of great health benefit and economic potential.

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Statement of Competing Interests

The author has no competing interests.

List of Abbreviations

TPC = Total phenol content
TFC = Total flavonoid content
MtOHB.alba = Methanol extract of *B.alba*
EtOHB.alba = Ethanol extract of *B.alba*

MtOH *S. biafrae* = Methanol extract of *S. biafrae*

EtOH *S. biafrae* = Ethanol extract of *S. biafrae*

Aq. B.alba = Aqueous extract of *B.alba*

Aq. *biafrae*= Aqueous extract of *biafrae*

Aq. *S. aureus* = Antibacterial activity of Aqueous extract against *S. aureus*

MtOH. *S. aureus* = Antibacterial activity of methanol extract against *S. aureus*

EtOH *S. aureus* = Antibacterial activity of ethanol extract against *S. aureus*

Aq. *P.aeruginosa* = Antibacterial activity of Aqueous extract against *P.aeruginosa*

MtOH *P.aeruginosa* = Antibacterial activity of methanol extract against *P.aeruginosa*

EtOH *P.aeruginosa* = Antibacterial activity of ethanol extract against *P.aeruginosa*

Aq. S.typhi = Antifungal activity of Aqueous extract against S.typhi

MtOH S.typhi = Antifungal activity of methanol extract against S.typhi

S.typhi = Antifungal activity of ethanol extract against S.typhi

Aq. *T.rubrum* = Antibacterial activity of Aqueous extract against *T.rubrum*

MtOH.*T.rubrum* = Antibacterial activity of methanol extract against *T.rubrum*

EtOH *T.rubrum* = Antibacterial activity of ethanol extract against *T.rubrum*

Aq. *A.fumigatus* = Antibacterial activity of Aqueous extract against *A.fumigatus*

MtOH *A.fumigatus* = Antibacterial activity of methanol extract against *A.fumigatus*

EtOH *A.fumigatus* = Antibacterial activity of ethanol extract against *A.fumigatus*

Aq. *F.solami* = Antifungal activity of Aqueous extract against *F.solani*

MtOH *F.solami* = Antifungal activity of methanol extract against *F.solani*

EtOH *F.solami* = Antifungal activity of ethanol extract against *F.solani*

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