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## **Phytoconstituent Analyses of Selected Wild Edible Plants Constituting Diets of Pregnant Women in Buikwe District, Uganda**

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### **Authors' contributions**

*This work was carried out in collaboration between all authors. Authors AN, JDK and IN designed the study and wrote the protocol. Authors JDK and IN supervised the work. Author AN carried out all laboratory work and performed the statistical analyses. Authors AN, JDK and IN managed the analyses of the study. Author AN wrote the first draft of the manuscript. Authors DO, CM and SN managed the literature searches and edited the manuscript. All authors read and approved the final manuscript.*

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### **ABSTRACT**

Pregnancy is a very critical phase in a woman's life where she has to ensure that she eats the right food, in the right portions and with the necessary nutrient requirements for proper foetal development.

**Aims:** To determine the proximate, mineral and vitamin composition of five wild edible plants

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(WEPs) consumed by pregnant women in Buikwe district.

**Study Design:** Experimental.

**Place and Duration of Study:** Department of Chemistry, Natural Chemotherapeutic Research Institute (Ministry of Health, Uganda) and Department of Chemistry, Uganda Industrial Research Institute (Ministry of Trade, Industry and Cooperatives, Uganda), between March 2016 and August 2016.

**Methodology:** *Solanum nigrum* L. (leaves), *Solanum anguivi* Lam. (fruits), *Aframomum angustifolium* (Sonn.) K. schum. (fruits), *Physalis angulata* L. (fruits) and *Cleome gynandra* L. (leaves) were analysed. Proximate and vitamin analyses were carried out following standard procedures. Minerals were analyzed using Atomic Absorption Spectrophotometer. Total carbohydrate and energy were calculated as crude by difference and using Atwater factors respectively. Species were scored and each species' contribution towards the pregnancy Recommended Dietary Allowance (RDA) calculated.

**Results:** *S. nigrum* had the highest potassium (3042.8±107.39), sodium (44.12±0.86), magnesium (176.71±15.57) and iron (61.37±2.20). *P. angulata* had the highest moisture (1.76±0.00), copper (3.12±0.77), vitamin A (1.86±0.18) and vitamin C (26.27±2.53). *C. gynandra* had the highest crude ash (17.16 ±0.13), protein (35.13±0.04), phosphorous (3349.4±429.4) and calcium (1113.7±79.36). *S. anguivi* had the highest crude fibre (40.19±0.09). *A. angustifolium* had the highest crude fat (3.02±0.01), total carbohydrate (85.91±0.34), energy (410.10±411.59), zinc (55.76±3.87) and manganese (30.19±0.14). There was a significant difference ( $P>.05$ ) in the protein, fibre, potassium, sodium and vitamin A content of all the species. *S. nigrum* and *P. angulata* had the highest mineral (81.67%) and vitamin (105.38%) scores respectively. All values are mg per 100 g of dry sample.

**Conclusion:** Results justify the nutritional significance of the analysed species thus their ability to meet pregnancy nutrient requirements.

**Keywords:** Pregnant women; foetus; nutrition; wild edible plants.

## 1. INTRODUCTION

Pregnancy is a very critical phase in a woman's life and naturally the urge to eat more is experienced by nearly all pregnant women [1]. Nonetheless, a diverse diet with the required nutrients and in their right concentrations is of paramount importance for proper foetal development and the mother's wellbeing [2]. Thus, inadequate maternal nutrition results in intra uterine growth restriction, low birth weights, preterm births, prenatal and infant mortality and morbidity. On the other hand, excessive nutrient intake results in preeclampsia, gestational diabetes, macrosomia, distocia and higher prevalence of cesarean section [3]. Thus streamlining nutritional requirements of pregnant women and providing proper dietary guidelines is paramount. Unfortunately, majority of the pregnant women have resorted to simplification of diets as a result of urbanization and socio-economic changes [4]. In Buikwe district, pregnant women are socio-economically marginalized. They cannot afford proper medical care and their diets are mainly composed of cheap tubers (cassava, yams, maize, sweet

potatoes) which are merely empty calorie foods [5] lacking essential nutrients. This has increased these women's vulnerability to nutritional deficiencies resulting from food insecurity. Nevertheless, Buikwe district is heavily forested and houses Mabira forest which is Uganda's second largest natural forest. Mabira with its high species diversity of 312 tree and shrub species [6], is endowed with a variety of Wild edible plants (WEPs) which can act as a source of essential nutrients for the marginalized pregnant women in this area. The WEPs' role in improving food access, nutrition, health quality and alleviating labor constraints related to food production is acknowledged by [7]. Unfortunately, WEPs are threatened by population pressure in the country and man's activities like clearance of forested areas to set up farmlands [8]. This research generated transformative knowledge thereby providing a solution to dietary nutrient inadequacies among the marginalized pregnant women in Buikwe district. Additionally, scientific validation through chemical analyses helps promote WEPs for wider consumption and acceptability both at national and international level.

## 2. METHODOLOGY

### 2.1 Sample Collection and Preparation

Samples of *S. nigrum* (leaves), *S. anguivi* (fruits), *A. angustifolium* (fruits), *P. angulata* (fruits) and *C. gynandra* (leaves) were collected from the wild in Najjembe sub-county, Buikwe district between January and February 2016. They were cleaned using distilled water in order to remove any contaminants resulting from harvesting and handling. These species were scientifically identified from the Makerere University herbarium. Leaves were air dried for 14 days and fruits were sliced into small pieces and placed in an oven (GallenKamp Hotbox oven, UK) at 40°C for 7 days. The dried samples were dried to constant weight in an oven. Using a grinder (Brook Crompton, Series 2000, UK), they were ground to fine powder. The powdered plant materials were macerated in 80% methanol for 48 hours. The methanolic extracts were concentrated using a rotary evaporator (Büchi, Rotavapor R-200) and allowed to paste using a water bath set at 40°C then stored at 4°C until used for analyses. All the chemicals used were of analytical grade.

### 2.2 Proximate Analysis

Proximate analyses of crude protein, crude lipid, crude fibre, moisture and crude ash were determined using standard analytical methods [9]. Total carbohydrate was calculated as "crude by difference" whereas total energy was calculated using Atwater factors.

#### 2.2.1 Determination of moisture content

The moisture content was determined according to the force draft-air oven method [9]. Petri dishes were weighed using a weighing scale (Metler Toledo, Germany) and weights recorded. Each sample (5 g) was weighed in a petri-dish and heated in an electric oven (GallenKamp Hotbox oven, UK) set at 105°C for 5 hours. After 5 hours, the samples were removed from the oven and transferred to the desiccator to cool for 30 minutes. After 30 minutes, the weight of each sample and petri-dish were taken and then recorded. Moisture calculation:

%Moisture =

$$\frac{\text{Weight of wet sample} - \text{Weight of dry sample}}{\text{Weight of wet sample}} \times 100$$

#### 2.2.2 Determination of crude protein

Crude protein was determined using the Kjeldahl method [9]. The sample (1 g) was weighed in a Kjeldahl flask. One tablet of Kjeldahl catalyst was added to the flask followed by 12 ml of conc. sulphuric acid. The mixture was transferred into a 250 ml digestion tube. A blank was prepared in a similar way. The content was shaken to "wet" the sample. The digestion unit was then turned on and the temperature set at 410°C. Digestion was allowed to run at this temperature for 1 hour until the digestion tube content became colourless. After digestion, the unit was allowed to cool down to 30°C. The cooled digest was diluted with distilled water (50 ml). Boric acid (25 ml) and methyl red (5 drops) were added to the conical flask. Sodium hydroxide (50 ml of 40%) was added to the diluted digest. The distillation apparatus was switched on and timer set at 4 minutes. After distillation, the condensate was allowed to collect in the receiver solution for 3 minutes. Boric hydrogen cyanide solution was titrated into the receiver flask with standard 1M hydrochloric acid. Crude protein calculation:

$$\% \text{ Nitrogen} = \frac{\text{The titre value}}{\text{Sample weight (g)}} \times 0.14$$

$$\text{Crude protein \% (where 6.25 is a constant)} = \% \text{ Total nitrogen} \times 6.25$$

#### 2.2.3 Determination of ash content

The sample (5 g) was weighed into a tarred crucible and placed into a muffle furnace which was ignited for 6 hours at 550°C. When the sample turned white with no black spots, the furnace was turned off, waited for its temperatures to drop at 250°C and the crucibles carefully removed to avoid losing ash that might have been fluty. The crucibles were then transferred using tongs to the desiccator and allowed to cool for 30 minutes. Weight of the sample and crucible were then taken. Percentage ash content calculation:

$$\% \text{ Ash} = \frac{G2 - G1}{W} \times 100$$

Where, G2 = Weight after ashing (sample + crucible): G1 = Tare weight of crucible:  
W = Original sample weight

#### 2.2.4 Determination of crude fat

The Soxhlet method [9] as described by [10] was followed. The sample was weighed in a dry thimble, a pad of cotton wool was inserted into

the thimble to prevent the sample from overflowing through frothing. A beaker (200 ml) was weighed and petroleum spirit (30 ml, boiling point 40-60°C) was added. The sample-containing thimble and the beaker were placed on the Soxtec machine (Soxtec system HT). Boiling was started, thimble was raised and extraction carried out for 45 minutes. Stop corks of the machine were closed, the solvent distilled off and the extracted oil collected in a beaker. The beaker was removed, put in the oven at 100°C for 30 minutes to drive off any water. The beaker was put in a dessicator and allowed to cool before weighing and the percentage fat content calculated. Percentage crude fat calculation:

$$\% \text{ Fat} = \frac{W3 - W2}{W1} \times 100$$

Where,

W3 = Weight of extraction cup + residue weight (g).

W2 = Weight of extraction cup (g).

W1 = Original sample weight (g).

### **2.2.5 Determination of crude fibre**

Crude fibre was determined using Acid detergent fibre (ADF) solution following procedures outlined by [11]. Acid detergent fibre solution was prepared by adding 28 ml of 98% sulphuric acid to a beaker and mixing it with distilled water (600 ml). Acetyl trimethyl ammonium bromide- CTAB (12 g) was added and stirred until it dissolved. The acid detergent was made up to 1 L with distilled water and mixed thoroughly. The sample was macerated and weighed (1 g) into a beaker (1 L). The acid detergent solution (100 ml) were added to the beaker followed by decalin (2 ml). The mixture was heated to boiling under reflux for 1 hour. Heating was controlled by adjusting the control knob to minimize foaming. The sample digest was filtered with a crucible previously dried in the oven at 100°C. The beaker was washed with boiling distilled water filtering the content through the same crucible 3 times. The final washing was done with acetone and the residue collected into a clean crucible dried at 100°C for 8 hours in the oven. Crude fibre calculation:

$$\%ADF = \frac{[(a+ADF)-a]}{b} \times 100$$

Where,

a = Weight of crucible, b = Weight of sample and ADF is Acid Detergent Fiber

### **2.2.6 Calculation of total carbohydrate**

Total carbohydrate was calculated as “crude by the difference”

$$\% \text{ Total carbohydrate} = 100\% - (\% \text{ Crude protein} + \% \text{ Crude ash} + \% \text{ Crude lipid} + \% \text{ Moisture}).$$

### **2.2.7 Calculation of total energy**

Energy values were calculated using Atwater factors as:

$$\begin{aligned} & (\text{Crude protein} \times 4 \text{ kcal}) + (\text{Crude fat} \times 9 \text{ kcal}) \\ & + (\text{Total carbohydrate} \times 3.75 \text{ kcal}) = \text{k cal} \end{aligned}$$

Atwater factors: 17 kJ/g (4 kcal/g) for protein, 37 kJ/g (9 kcal/g) for fat, 17 kJ/g (4 kcal/g) for carbohydrates

## **2.3 Vitamin Determination**

### **2.3.1 Determination of vitamin C**

Vitamin C was determined following procedures in [11]. The sample (5 g) was weighed into a clean mortar and macerated with 5% trichloro acetic acid - TCA (5 ml). The extract was transferred into a volumetric flask (50 ml) and made up to volume with TCA. The flask was stoppered, and then shaken to ensure thorough mixing after which the mixture was filtered using a filter paper (Whatman no.1). 2, 6-dichlorophenolindophenol (DCPIP) solution was standardised using ascorbic acid (1.08 mg/ml). Ascorbic acid (2 ml) was titrated with DCPIP until a pink colour that persisted for 3-5 seconds was seen. The extract (5 ml) were pipetted into a clean conical flask and carefully titrated against the standard DCPIP solution until a pink colour that persisted for 3-5 seconds was observed. The volume of DCPIP solution used was read from the burette and used to calculate the vitamin C content of the sample.

Vitamin C content calculation:

$$\text{Vitamin C (mg/100 ml)} = \frac{(Tv \times V \times C \times 100)}{(P \times W)}$$

Where;

V = Volume (ml) of DCPIP solution titrated  
C = Weight (mg) of vitamin C in 1 ml of DCPIP

Tv = Total volume of the extract

P = Pipette volume of extract

W = Weight of sample

### **2.3.2 $\beta$ -carotene determination**

$\beta$ -carotene were determined following procedures outlined by [12].

*$\beta$ -carotene extraction:* Samples were separately weighed out and placed in a mortar; hexane-acetone mixture (5 ml) in a ratio of 1:1 were added. A pestle was used to stir the sample-solvent mixture to facilitate extraction. The extract was then transferred to a 50 ml volumetric flask and extraction repeated 5 times with 5 ml portions of solvent mixture adding the extract of volumetric flask each time to the flask contents. When the sample was free of  $\beta$ -carotene, the volume of the extract was made up to 50 ml with the solvent mixture. The volumetric flask was kept away from light by wrapping it with aluminium foil to prevent photo degradation of  $\beta$ -carotene.

*Concentration of  $\beta$ -carotene:* The extract was placed in a beaker (100 ml) and the beaker heated gently in a water bath in the fume cupboard with the fan on until all the solvent evaporated. The beaker was then removed and allowed to cool after which 2 ml of pure solvent mixture was added to dissolve the residue. The dissolved extract (1 ml) was pipetted and transferred to a packed column of magnesium oxide. A fresh solvent mixture was used to elute the extract from the column. The  $\beta$ -carotene was collected in a 50 ml volumetric flask until the elute turned colourless. The extract was then made up to volume, with the extracting mixture, shaken to dissolve and put in the dark ready for absorbance reading. Capsules of  $\beta$ -carotene (15 mg) were dissolved in 100 ml of hexane to make stock solutions. Using a spectrophotometer (SP 20), the absorbencies of the stock solutions were read at 450 nm. A  $\beta$ -carotene standard curve of absorbance against concentration ( $\mu\text{g/ml}$ ) was plotted. Using a spectrophotometer, absorbencies of the samples were read. By using their absorbencies, the  $\beta$ -carotene concentrations of the samples were read off the previously prepared standard curve. Vitamin A content calculation:

$$\text{Total carotenoid } \mu\text{g/g} = (A \times V \times 104) / (A^* \times W)$$

where;

A = Absorbance

A\* = Absorbance coefficient of  $\beta$ - carotene in petroleum ether (2592)

W = Sample weight (g)

$$V = \text{Total volume of extract (ml)}$$

$$\text{Carotenoid } \mu\text{g}/100 \text{ g} = ((A \times \text{volume (ml)} \times 104) / (A^* \times \text{sample weight (g)}) \times 100$$

### **2.4 Mineral Determination**

Minerals were determined by the atomic absorption spectrophotometric method as described by [11] and [9].

#### **2.4.1 Preparation of the digestion mixture**

Selenium powder (0.42 g) and lithium sulphate (14 g) were weighed into a beaker, to which 350 ml of 30% hydrogen peroxide were added and mixed. Conc. sulphuric acid (420 ml) slowly added while cooling in an ice bath. The sample (0.2 g) was added into a digestion tube followed by 5 ml of digestion mixture. The mixture was digested at 360°C for 2 hours until the solution turned colourless. The contents were allowed to cool then 25 ml of distilled water were added and shaken until no more sediment dissolved. The volume was made up to 50 ml with water and shaken. They were allowed to settle and the clear solution decanted off for zinc, calcium, Iron, sodium, phosphorous, copper, manganese, magnesium and potassium analyses.

#### **2.4.2 Preparation of the stock standard solution**

The sample (0.3 g) was weighed into a digestion tube. The digestion mixture (4.4 ml) was added to the tube and to two reagent blanks for each batch of the sample and allowed to react at room temperature for 2 hours. Digestion was done at 110°C for 1 hour. The tubes were then removed from the digester and allowed to cool. After 10 seconds, 3 successive portions of 1 ml of hydrogen peroxide were added and carefully mixed by swirling the tubes after each addition. The tubes were returned to the block digester and temperatures adjusted to 330°C until the colour of the contents changes from brown to yellow. The tubes were removed from the block digester and allowed to cool at room temperature. The contents were transferred to a 50 ml volumetric flask and made up to the mark with deionised water.

After digestion, the samples were passed through atomic absorption spectrophotometry (PerkinElmer; AA analyst 700; U.S.A) using different lamps and calibrated or different micronutrients. Potassium and sodium was determined through flame photometer after acid

digestion [13]. Phosphorus was determined spectrophotometrically using the vendates solution [13].

### 2.5 Species Recommended Dietary Allowance (RDA) Contribution

Mineral and vitamin scores were computed as described by [14] in order to establish the species RDA percentage contributions in 100 g of dry sample. Species mineral/ vitamin scores were calculated as geometric means of individual minerals/vitamins combined. A graph of geometric means against species was plotted.

Calculation:

$$\frac{IMS}{IVS} = \frac{\text{Individual mineral/ individual vitamin content}}{\text{RDA}} \times 100$$

Where;

IMS = Individual mineral score;  
 IVS = Individual vitamin score;  
 RDA = Recommended Dietary Allowance [15].

### 2.6 Nutrition Data Analysis

All determinations were done in triplicate. Nutritional values were entered in Microsoft Excel v. 2007 and cleaned. One way ANOVA facilitated by SPSS v 16 was used to determine the differences between means of variables at a confidence interval of 95%,  $P = .05$ . Results were given as mean  $\pm$  standard deviation.

## 3. RESULTS AND DISCUSSION

### 3.1 Proximate Composition

Proximate composition results are presented in Table 1. Additionally, results of the species pregnancy RDA percentage contribution of individual proximate macronutrients per 100 g of dry sample are presented in Table 2. Moisture ranged from (0.46–1.76)%. Moisture content denotes shelf life. High moisture means a shorter shelf life due to faster microbial contamination [16] and low moisture indicates a longer shelf life [17]. Crude ash ranged from (6.57–17.16) g/ 100 g. Ash content denotes mineral content. Species

with high ash content can be used as mineral supplements [18]. Crude protein ranged from (9.81–35.13) g/100 g. The protein RDA during pregnancy is 71 g/day [19]. *C. gynandra* and *S. nigrum* meet half of the protein RDA thus, doubling the consumed portion to 200 g can meet the RDA. Proteins provide the basic building blocks necessary for formation of enzymes, antibodies, muscle and collagen thus very important for healthy foetal development. Protein deficiency during pregnancy is not a common occurrence except in extreme cases. Crude fat content ranged from (0.17–3.02) g/ 100 g. The pregnancy fat RDA is 69 g (1 g of fat = 9 calories) [19] which is 30% of the pregnancy calorific RDA - 2070 kcal [20]. The species RDA contribution is just too little to meet the pregnancy fat RDA thus supplementation required. During the prenatal period, lipids are essential for the formation of cell membranes and hormones [21]. Furthermore, dietary intake of fat increases absorption of fat soluble vitamins (A,D,E,K) and precursors such as vitamin A and pro-vitamin A carotenoids. Moderation of fat during pregnancy is paramount to avoid undesired weight gain which can result in caesarian deliveries.

Crude fibre ranged from (14.74–40.19) g/100 g. Pregnancy fibre RDA is 28 g/day [19]. *S. anguivi* meets almost one and half times the RDA. Therefore, if consumed on a daily basis it can meet the mother's fibre RDA without any supplementation. Fibre is not very important for foetal development but a high fibre diet significantly increases the comfort of the mother by helping her prevent constipation, a common side-effect of pregnancy. Furthermore, dietary fibre lowers blood serum cholesterol levels [22] reducing risks of gestational hypertension and diabetes [20]. Low fibre diets can result in hemorrhoids and diverticulitis. Total carbohydrate (CHO) ranged from (63.36–85.91) g/ 100 g. The pregnancy RDA for CHO is 135 g [19]. *S. anguivi* (100 g) and *A. angustifolium* (100 g) meet almost half the RDA. Thus if quantity consumed is doubled to 200 g, then they can be sufficient or they can be eaten in combination with cereals and root tubers. Carbohydrate is required for rapid foetal development and optimum functioning of the brain, digestive and immune systems [23]. Furthermore, CHO is broken down to form glucose which is a source of energy required by the mother to be available to the foetus all the time. Diabetic mothers are recommended to regulate the amount of dietary CHO consumed as this has negative effects on

their pregnancy because their insulin levels are low. Carbohydrate deficiency causes depletion of the body's tissues [24].

Energy content ranged from (395.48–410.10) kcal/100 g. The pregnancy energy RDA is 2070 kcal/day during the first trimester same as that of a non pregnant woman. She then experiences an increase in energy requirements of 370 kcal during the second trimester and 480 kcal during the third trimester [20]. The analysed species meet so little of the pregnancy energy RDA thus need to be eaten in combination with tubers. The extra energy requirements during the second and third trimesters facilitate the growth of the foetus, placenta and various maternal tissues in the uterus, breasts and fat stores [20,25]. Therefore in order to meet the additional calorie requirements, many pregnant women resort to adding small snacks between meals [26]. Eating smaller amounts of food more frequently also helps curb down reflux and nausea which are some of the uncomfortable side-effects of pregnancy [27].

### 3.2 Mineral and Vitamin Composition

Table 3 presents the mineral and vitamin composition results. Additionally, Table 4 presents the species pregnancy RDA percentage contribution of individual minerals and vitamins

per 100 g of dry sample. The potassium (K) and sodium (Na) content ranged from (274.73–3042.8) mg/ 100 g and (11.53–44.12) mg/100 g respectively. The K and Na pregnancy RDA is 1.5 g (1500 mg) and 4.7 g (4700 mg) respectively [28]. *S. nigrum* meets half the K RDA thus doubling the consumed portion to 200 g can meet the RDA. Expansion of the maternal blood volume by up to 50% [29] increases the mother's Na and K electrolytes requirements in order to keep extra fluid in the right chemical balance of 3Na+: 2K+ ions. Potassium and Na are very essential for osmotic pressure maintenance [30] and prevention of gestational hypertension.

Phosphorous (P) content ranged from (415.65 – 3349.4) mg/ 100 g. During pregnancy, P levels remain constant thus an RDA of 700 mg/d is maintained through the three trimesters [31]. *C. gynandra* meets four and a half times the RDA, *S. nigrum* meets two and a half times, *S. anguivi* meets almost two and a half times and *P. angulata* meets twice. Thus if these species are consumed on a daily basis in reduced quantities they can meet the P pregnancy RDA without any supplementation. Phosphorous is needed for the growth, maintenance and repair of all tissues and cells, and for the production of genetic building blocks – DNA and RNA [32]. Dietary deficiency is rare because most foods contain P [33].

**Table 1. Proximate composition of the five wild edible plants**

Parameter	Species				
	<i>C. gynandra</i>	<i>S. nigrum</i>	<i>S. anguivi</i>	<i>P. angulata</i>	<i>A. angustifolium</i>
Moisture (%)	1.24±0.00 <sup>a</sup>	1.75±0.00 <sup>a</sup>	0.46±0.03 <sup>d</sup>	1.76±0.00 <sup>a</sup>	1.25±0.54 <sup>a</sup>
Ash (g/100 g)	17.16±0.13 <sup>a</sup>	13.44±13.44 <sup>be</sup>	6.57±0.34 <sup>c</sup>	8.75±1.05 <sup>d</sup>	6.97±0.92 <sup>eb</sup>
Crude protein (g/100 g)	35.13±0.04 <sup>a</sup>	33.20±0.08 <sup>d</sup>	18.38±0.73 <sup>c</sup>	21.59±0.27 <sup>d</sup>	9.81±0.22 <sup>e</sup>
Crude fat (g/100 g)	0.17±0.01 <sup>a</sup>	1.69±2.25 <sup>ab</sup>	0.81±0.03 <sup>ab</sup>	0.32±0.33 <sup>a</sup>	3.02±0.01 <sup>b</sup>
Crude fibre (g/100 g)	15.92±0.39 <sup>a</sup>	14.74±0.06 <sup>b</sup>	40.19±0.09 <sup>c</sup>	23.96±0.03 <sup>d</sup>	17.59±0.73 <sup>e</sup>
Total CHO (g/100 g)	63.36±0.11 <sup>a</sup>	63.60±2.69 <sup>a</sup>	80.35±0.06 <sup>b</sup>	75.90±0.53 <sup>c</sup>	85.91±0.34 <sup>d</sup>
Energy (kcal/ 100 g)	395.48±0.49 <sup>a</sup>	402.46±9.81 <sup>ab</sup>	402.19±0.25 <sup>ab</sup>	397.40±2.34 <sup>a</sup>	410.10±411.59 <sup>b</sup>

Note: Values are means of three determinations ± Standard deviation (SD) (n = 3)

Total CHO was calculated as "crude by difference". Energy was calculated using Atwater factors

Superscripts a, b, c, d, e = differences in means of variables. Similar superscripts = No significant difference P≤.05: different superscripts = Significant difference P>.05

**Table 2. Species pregnancy RDA percentage contribution of individual proximate macronutrients per 100 g of dry sample**

Parameter	Species pregnancy RDA percentage contribution per 100 g of dry sample				
	<i>C. gynandra</i>	<i>S. nigrum</i>	<i>S. anguivi</i>	<i>P. angulata</i>	<i>A. angustifolium</i>
Protein	49.48	46.76	25.89	30.14	13.82
Fat	0.25	2.45	1.17	0.46	4.38
Fibre	56.86	52.64	143.53	85.57	62.82
Total CHO	36.2	36.34	45.91	43.37	49.1
Energy	19.1	19.44	19.43	19.2	19.81

Calcium (Ca) content ranged from (23.58–1113.7) mg/100 g. The mother's Ca absorption increases early in pregnancy [29] resulting in increased Ca requirements. Thus the Ca RDA during the first and second trimester (1300 mg/d) is higher than that in the third trimester (1200 mg/d) [34] despite its importance during bone formation [26]. Therefore, consuming adequate amounts of Ca while pregnant may not affect the baby's bone density but it will protect the mother's bones from losing too much of the Ca that she would have given to her baby if dietary Ca is not enough [26]. *C. gynandra* meets three quarters of the Ca RDA and *S. nigrum* meets half the RDA thus increasing consumed quantity to 125 g and 200 g respectively is sufficient. Calcium is important for normal heart and muscle functions, blood clotting and immune defenses [35]. Although Ca deficiency is rare in pregnancy, it appears in cases of hypoparathyroidism and in individuals who are unable to eat a diet rich in dairy products [36]. Hypertensive disorders during pregnancy are a result of low Ca and magnesium concentrations [37].

Magnesium levels ranged from (13.35– 176.71) mg/100 g. There is no increase in Mg requirements during pregnancy thus the RDA remains 220 mg/ day throughout the three trimesters [34]. *S. nigrum* meets three quarters the Mg RDA and *C. gynandra* meets half thus increasing consumed quantity to 125 g and 200 g respectively is sufficient. Magnesium is a co-factor in over 300 enzymes in the body [26] and essential for building strong bones and teeth and transmission of nerve impulses [35]. During pregnancy, dietary Mg inadequacy causes preeclampsia, miscarriages, fetal growth retardation and preterm delivery [38]. Furthermore, Mg inadequacy increases the mother's risk to gestational diabetes and type 2 diabetes[39].

Copper (Cu) ranged from (0.74-3.12) mg/ 100 g. The pregnancy RDA for Cu is 800 µg/d [40]. *P. angulata* meets three and a half times the Cu RDA, *S. anguivi* meets twice, *S. nigrum* meets one and a half times and *C. gynandra* meets almost one and a half times. Thus reducing consumed quantity to 28 g, 50 g, 67 g and 66 g respectively is sufficient to meet the RDA without causing any toxicity. Fetuses and neonates chronically deprived of Cu during gestation and early life are characterized by severe connective tissue abnormalities, skeletal defects, and lung abnormalities [41]. Copper is involved in free radical eradication, energy production and

connective tissue formation [42]. Severe Cu deficiency results in growth and mental retardation, teratogenesis, and fetal death [43]. Fortunately, Cu deficiency due to marginal intake and Cu antagonistics such as zinc supplements are more common than chronic Cu deficiency. Thus, following proper dietary guidelines for Cu intake is enough for the mother to prevent Cu deficiency.

The iron (Fe) content ranged from (6.13 – 61.37) mg/ 100 g. The pregnancy RDA for Fe is 27 mg/day [40]. *S. nigrum* meets twice the Fe RDA and *C. gynandra* meets one and a half times thus reducing consumed quantity to 50 g and 67 g respectively is sufficient without causing any toxicity. Iron is a co-factor for enzymes involved in oxidation-reduction reactions and an essential component of haemoglobin [44]. Most importantly, Fe is essential for normal neurodevelopment in the fetus. Consuming Fe with a source of vitamin C improves its absorption [35] and helps the mother to reduce the amount of extra Fe she needs to take. Iron deficiency results in anemia [35] and can cause maternal mortality [45]. Foetal iron deficiency results in impaired memory and changes in temperament during infancy.

Manganese (Mn) ranged from (4.45 – 30.19) mg/ 100 g. The pregnancy RDA for Mn is 2 mg/day [40]. *A. angustifolium* meets fifteen times the Mn RDA, *S. nigrum* meets six times, *C. gynandra* meets five and a half times and lastly *S. anguivi* and *P. angulata* each meets twice the RDA. Thus reducing consumed quantities is sufficient enough to meet the RDA without causing toxicity. Manganese is necessary for normal brain and nerve function. Being a component of the antioxidant enzyme superoxide dismutase (SOD), it helps fight free radicals [46] that can damage cell membranes and DNA.

The zinc (Zn) levels ranged from (0.84 – 55.76) mg/ 100 g. The pregnancy Zn RDA is 11 mg/d [40]. *A. angustifolium* meets five times the Zn RDA thus if quantity consumed is reduced to 20 g is sufficient without causing toxicity. Zn is very important during the first trimester, because during this time foetal organs are being formed and the immune system is being developed [47]. Zn is also an antioxidant and a component of many proteins, hormones and enzymes [35]. Zinc deficiency results in congenital abnormalities, abortions, intrauterine growth retardation, premature birth [48], and preeclampsia [49]. Furthermore, it affects the



immune response because it reduces T cell function and development [50].

Vitamin C content ranged from (3.15–26.27) mg/ 100 g. The pregnancy RDA for vitamin C is 55 mg/day [34]. *P. angulata* meets almost half of the RDA whereas the rest of the species' RDA contribution is quite insignificant. Therefore supplementation is a prerequisite. Vitamin C is an antioxidant which regenerates oxidized vitamin E and reduces formation of nitrosamines in the stomach. It also enhances Iron absorption and helps the body to use Ca and other nutrients to build bones and blood vessel walls plus increasing resistance to infection [51].

Vitamin A ranged from (0.17–1.86) mg/ 100 g. The pregnancy vitamin A RDA is 800 µg/day [34]. *P. angulata* meets twice the RDA thus

reducing consumed quantity to 50 g is sufficient without causing toxicity. Vitamin A is required for maintenance of epithelial cells, mucous membranes, and the skin. It is also needed for immune system function and provides resistance to infections. Vitamin A deficiency in pregnancy is associated with premature birth, intrauterine growth retardation and low birth weight [52].

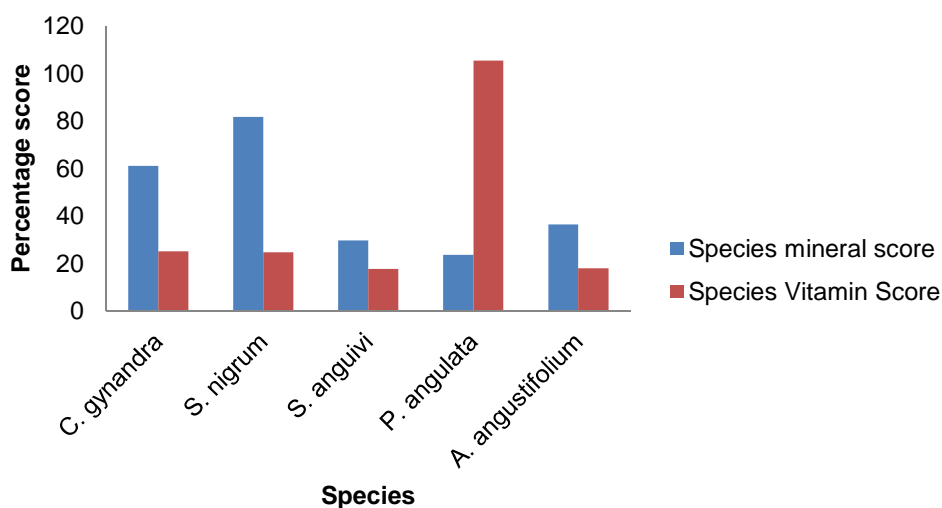
### 3.3 Species Mineral and Vitamin Scores

Fig. 1 presents the species mineral and vitamin scores. The species mineral and scores ranged from (23.59–81.67)% and (17.73–105.38)% respectively. *S. nigrum* is the richest source of minerals (K, Na, P, Ca, Mg, Cu, Fe, Mn, Zn). This corresponds with its high ash values. Additionally, *A. angulata* is the richest source of vitamins (A and C).

**Table 3. Mineral and vitamin composition of five wild edible plants**

Parameter (mg/ 100 g)	<i>C. gynandra</i>	<i>S. nigrum</i>	<i>S. anguivi</i>	<i>P. angulata</i>	<i>A. angustifolium</i>
Potassium	274.73±15.40 <sup>a</sup>	3042.8±107.39 <sup>b</sup>	1356±23.13 <sup>c</sup>	2227.1±49.67 <sup>d</sup>	1589.1±22.01 <sup>e</sup>
Sodium	30.79±0.99 <sup>a</sup>	44.12±0.86 <sup>b</sup>	11.53±0.15 <sup>c</sup>	17.89±0.23 <sup>d</sup>	17.34±0.12 <sup>e</sup>
Phosphorous	3349.4±429.49 <sup>a</sup>	2094±155.70 <sup>bcd</sup>	1694.2±38.61 <sup>cbd</sup>	1612.8±96.80 <sup>dbc</sup>	415.65±12.37 <sup>e</sup>
Calcium	1113.7±79.36 <sup>a</sup>	787.77±211.19 <sup>b</sup>	145.42±15.39 <sup>cde</sup>	28.63±3.70 <sup>dce</sup>	23.58±0.79 <sup>ecd</sup>
Magnesium	145.46±78.32 <sup>ab</sup>	176.71±15.57 <sup>ab</sup>	100.01±4.19 <sup>ad</sup>	13.35±9.28 <sup>cd</sup>	65.67±21.66 <sup>d</sup>
Copper	1.162±0.35 <sup>a</sup>	1.39±0.48 <sup>a</sup>	1.67±0.92 <sup>a</sup>	3.12±0.77 <sup>b</sup>	0.74±0.29 <sup>a</sup>
Iron	48.06±0.91 <sup>a</sup>	61.37±2.20 <sup>b</sup>	6.13±0.16 <sup>cde</sup>	6.19±0.19 <sup>dce</sup>	4.66±0.11 <sup>ecd</sup>
Manganese	11.54±0.07 <sup>a</sup>	12.07±0.19 <sup>a</sup>	4.79±0.08 <sup>b</sup>	4.45±5.77 <sup>cb</sup>	30.19±0.14 <sup>d</sup>
Zinc	3.91±0.23 <sup>ab</sup>	4.02±0.28 <sup>a</sup>	0.84±0.10 <sup>b</sup>	0.96±0.12 <sup>ab</sup>	55.76±3.87 <sup>c</sup>
Vitamin C	4.20±0.91 <sup>ae</sup>	8.14±0.46 <sup>b</sup>	8.14±0.91 <sup>cb</sup>	26.27±2.53 <sup>d</sup>	3.15±0.79 <sup>a</sup>
Vitamin A RAE	0.66±0.02 <sup>a</sup>	0.33±0.02 <sup>b</sup>	0.17±0.05 <sup>c</sup>	1.86±0.18 <sup>d</sup>	0.45±0.06 <sup>e</sup>

All parameters are presented in mg/ 100 g dry weight (dw)



**Fig. 1. Species mineral and vitamin scores**

**Table 4. Species pregnancy RDA percentage contribution of individual minerals and vitamins per 100 g of dry sample**

Minerals and vitamins	Species pregnancy RDA Percentage contribution				
	<i>C. gynandra</i>	<i>S. nigrum</i>	<i>S. anguivi</i>	<i>P. angulata</i>	<i>A. angustifolium</i>
Potassium	5.85	64.72	28.85	47.38	33.81
Sodium	2.05	2.94	0.77	1.19	1.15
Phosphorous	478.48	299.14	242.03	230.4	59.38
Calcium	85.67	60.59	11.19	2.2	1.81
Magnesium	66.12	80.32	45.46	6.07	29.85
Copper	145.65	173.75	208.75	390	92.5
Iron	178	227.29	22.7	22.92	17.26
Manganese	577	603.5	239.5	222.5	1509.5
Zinc	35.54	36.54	7.64	8.73	506.91
Vitamin C	7.64	14.8	14.8	47.76	5.72
Vitamin A	82.5	41.25	21.25	232.5	56.25

#### 4. CONCLUSION

*S. nigrum* (leaves), *S. anguivi* (fruits), *A. angustifolium* (fruit pulp), *P. angulata* (fruits) and *C. gynandra* L. (leaves) can sustainably meet the nutrient requirements of both the mother and developing foetus. This is because they contain the necessary nutrients in good concentrations which can meet the pregnancy RDAs. Furthermore, the fact that these species are available, accessible cheap and nutritious strengthens and justifies the argument that they are the best option to improve the dietary quality for the rural pregnant woman in Buikwe district. Nevertheless other factors remaining constant, maternal diet and absorption, delivery of the nutrients to the uterus and placenta, and placental transfer and foetal uptake influence nutrient availability to the developing foetus.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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