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PROXIMATE AND MINERAL COMPOSITION OF HAIRY INDIGO LEAVES

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ABSTRACT

Leaves of Hairy indigo *(Indigofera astragalina)* procured from Sokoto state, Nigeria were studied for their mineral composition. The proximate composition revealed the presence of moisture (51.00 ± 0.50 % fresh weight), ash (8.17 ± 0.58 % dry weight, DW), crude lipid (5.0 ± 0.5 % DW), crude fibre (2.67 ± 0.29 % DW), crude protein (8.23 ± 0.11 % DW) and carbohydrate (75.94 ± 0.64%). The energy value was found to be 578.87 kCal/100g. The minerals composition revealed, potassium (14.55 ± 0.17mg/100g), sodium (0.33 ± 0.16mg/100g), calcium (11.49 ± 0.34mg/100g), magnesium (10.89 ± 0.32mg/100g), phosphorus (0.39 ± 0.01mg/100g), copper (0.02 ± 0.00mg/100g), zinc (0.11 ± 0.00mg/100g), iron (20.95 ± 3.84mg/100g) and manganese (0.43 ± 0.01mg/100g). These results releaved that the leaves of Hairy indigo *(Indigofera astragalina)* contained essential nutrients which compete favourably well with those of wild edible leaves in literatures.

Keywords: *Mineral composition, Hairy indigo, Leaves, Indigofera astragalina*

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INTRODUCTION

The conventional food plants provide most nutrients needed for energy, body building, maintenance and regulation of body processes. Due to increasing population, economic crises in most developing nations especially in Nigeria, food insecurity have posed a serious threat to growth, development and survival (Hassan *et al.,* 2007). Most people are now incorporating the non-conventional (wild) food plants in their diets, to provide not only nutrients but also traditional treatment for various ailments. Over the last two decades, studies have revealed that wild or semi-wild plants are nutritionaly important because of high vitamins, minerals, essential fatty acids and fibre contents (Tukan *et al.,* 1998).

Some of these wild plants contain chemical substances that produce a definite physiological action on the human being. About 25% of all prescribed medicines today are substances derived from plants (Ngaski, 2006). Most of these plants are used traditionaly in the treatment of diseases. Among such plants are *Uvaria chamae* (used in the treatment of piles, menorrhegia, epistaxis, haematuria and haemolysis) *Cnestic ferruginea* (used in the treatment of migraine and sinusitis and anaemia for woman with abortion and ovarian problems) and in the treatment of gonorrhea, joint and waist pains, arthritis, rheumatism, stroke and syphilis (Okwu and Ekoaduchi, 2004) and *Cussonia arborea* used for the treatment of sexually transmitted diseases, menstrual pains and severe rashes. Inspite the increasing research into nutrients and medicinal agents of wild edible plants not much has been done about *Indigofera astragalina*.

Indigofera astragalina: Plant taxonomy, Botanical description and Habitat

Taxonomy: *Indigofera astragalina* is commonly known in English as Hairy indigo. In the northern part of the country among the Hausa, it is called "Kaikai koma kan mashekiya", and in the south-west among the Yoruba, it is known as Elu-aja (Mohammad, 2004).

Division: Magnoliophyta
Class: Magnoliopsida
Order: *Fabales*
Family: *Fabaceae*
Subfamily: *Faboideae*
Tribe: *Indigofereae*
Genus: *Indigofera*
Species: *Indigofera astragalina*

Botanical description: *Indigofera astragalina* is an erect hairy plant of about 40 – 70cm in height, with soft stem and green leaves. The leaves are pinnate with 5 – 13 leaflets; leaf size varies from 2 – 5cm long. The flowers are small, reddish – purple in colour and produced racemes of 2 – 10cm long. (Mohammad, 2004).

Habitat: The plant is a herbaceous legume which is simply regarded as weed, it is distributed in southern Africa like in Zimbabwe (Mapfumo *et al.,* 2005), grow well in China and in west Africa; Nigeria and Niger Repulic (Mohammad, 2004). The plant grow well on unfertilized land with annual rainfall of 650 – 800mm and mean annual temperatures of 21^{o}C-32^{o}C (Mapfumo *et al.,* 2005).

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Economic importance of *Indigofera* species :The genus *Indigofera,* have about 700 species. They occur throughout the tropical and subtropical regions of the world, some of these species, *Indigofera tinctoria* and *Indigofera suffruticosa* are used to produced indigo dyes while some have medicinal values such as *Indigofera articulate* used for the treatment of toothache, *Indigofera oblongifolia, Indigofera suffruticosa,* and *Indigofera aspalthoides* are used as anti – inflammatories for treatment of insect stings, snake bites and swellings; and *indigofera arrecta* extract is used to relieve ulcer pain. Phytochemical investigation of *Indigofera* species shows that they are rich in organic and fatty acids, flavonoids such as rotenoids and coumarins (Yinusa *et al.,* 2007). Study conducted on *indigofera astragalina* shoot revealed the presence of polyphenol, lignin (insoluble fibre), phosphorus, nitrogen and potassium (Mapfumo *et al.,* 2005). Phytochemical screening and anti – microbial study of *indigofera astragalina* extracts revealed the presence of tannins, cardiac glycosides, saponins, resins and alkaloids, and also show activity against *S. aureus* and *E. Coli*, and a very good cholinesterase inhibition (Mohammad, 2004). The importance of these nutrients, phytochemical compounds as well as anti – nutritive factors in nutrition are:

Minerals: Minerals are a large family of nutrients essential to the human body, although some of them are present in the body in very small percentages, probably several parts per million (Tianchi, 1997). They are designated as essential mineral elements because of their metabolic role in the body, and their absence cause deficiency symptoms in animals (McDonald *et al.,* 1995).

Essential mineral elements of nutritional importance are classified into the macro (or major) elements (calcium, phosphorus, potassium, sodium, chlorine, sulphur, magnesium) and the micro (or trace) elements (iron, zinc, copper, molybdenum, selenium, iodine, manganese, cobalt). Both the macro and micro essential mineral elements are believed to have one or more catalytic functions in the cell. Some are firmly bound to the proteins of enzymes, while other are present in prosthetic groups in chelated forms such as cytochromes, haemoglobin, vitamin B_{12} (McDonald *et al.,* 1995). Apart from taking part in various metabolic processes in the body, they also play an important role in the growth, development, immunity regulation, mitotic cell division, propagation and genetic expression of the body. They differ from other nutrients such as proteins, amino acids, carbohydrates, and fats and oils because they cannot be synthesised by human but rather transferred from one form to another, and can only be ingested from food and water (Tianshi, 1997).

In this present research, the authors add to food database by presenting the proximate and mineral composition of hairy indigo leaves.

MATERIALS AND METHODS

Sample collection: Fresh and tender plants of *Indigofera astragalina* were collected from Gwiwa low-cost and Arkilla Federal low-cost areas in Wamakko Local Government Area of Sokoto State. It was identified by a taxonomist in the Botany unit, Department of Biological Sciences, Usmanu Danfodiyo University Sokoto. The leaves were separated from the stalks, washed and sun dried for three (3) days, blended into fine powder using a blender machine, sieved and stored in a covered plastic container for further use. All reagents were of

analytical reagent grade unless otherwise stated. Distilled water was used in the preparation of solutions and dilution unless otherwise stated while the proximate and mineral composition determinations unless otherwise stated were carried out in triplicates.

Proximate analysis: The estimation of the various food parameters in *Indigofera astragalina* plant, was carried out using the methods of AOAC (1990)

Determination of moisture content : This is a measure of the % moisture lost due to drying at a temperature of 105^0C. According to Udo and Ogunwele's (1986) method, 2g of the fresh leaves of *I. astragalina* was weighed (W_1) into preweighed crucible (W_0) and placed into a hot drying oven at 105^0C for 24 hours. The crucible were removed, cooled in a desiccator and weighed. The process of drying, cooling and weighing were repeated until a constant weight (W_2) was obtained. The weight loss due to moisture was obtained by the equation.

$$\% \text{ moisture} = \frac{W_1 - W_2}{W_1 - W_0} \times 100\% \qquad \text{(i)}$$

where W_0 = Weight of the empty crucible, g
W_1 = Weight of fresh sample + empty crucible, g
W_2 = Weight of dried sample + empty crucible, g

Determination of ash content: This is a measure of the residue remaining after combustion of the dried sample in a furnace at a temperature of 600^0C for 3 hours. According to James (1995), 2g of the powdered leaves sample was weighed (W_1) into preweighed empty crucibles (W_0) and placed into a Lenton furnace at 600^0C for 3 hours. The ash was cooled in a desiccator and weighed (W_2). The weight of the ash was determined by the difference between the powdered leaves sample, preweighed crucible and the ash in the crucible. Percentage ash was obtained by equation ii.

$$\% \text{ Ash} = \frac{W_2 - W_0}{W_1 - W_0} \times 100\% \qquad \text{(ii)}$$

where W_0 = Weight of empty crucible, g
W_1 = Weight of crucible + powdered sample, g
W_2 = Weight of crucible + ashed sample, g

Determination of crude lipids: The crude lipid content in the sample was extracted using Soxhlet extraction procedure, described by Udo and Ogunwele (1986).

The ground sample (2g) was weighed (W_0) into a porous thimble and covered with a clean white cotton wool. Petroleum ether ($200cm^3$) was poured into a $250cm^3$ extraction flask, which was previously dried in the oven at 105^0C and weighed (W_2). The porous thimble was placed into the soxhlet and the rest of the apparatus was assembled. Extraction was done for 5 hours. The thimble was removed carefully and the extraction flask placed in a water bath so as to evaporate the petroleum ether and then dried in the oven at a temperature of 105^0C to completely free the solvent and moisture. It was then cooled in a desiccator and reweighed (W_1). The percentage crude lipid was calculated using the equation below

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$$\% \text{ Crude lipid} = \frac{W_1 - W_2 \times 100}{W_0} \quad \text{(iii)}$$

Where W_0 = Weight of sample, g
W_1 = Weight of flask + oil, g
W_2 = Weight of flask, g

Determination of crude fibre content: Percentage of crude fibre was determined by the method of Udo and Ogunwele (1986), in which 2g of ground sample was weighed (W_0) into a 1 dm^3 conical flask. Water (100cm^3) and 20cm^3 of 20% H_2SO_4 were added and boiled gently for 30 minutes. The content was filtered through Whatmann No. 1 filter paper. The residue was scrapped back into the flask with a spatula. Water (100cm^3) and 20cm^3 of 10% NaOH were added and allowed to boil gently for 30 mins. The content was filtered and the residue was washed thoroughly with hot distilled water, then rinsed once with 10% HCl and twice with ethanol and finally three times with petroleum ether.It was allowed to dry and scrapped into the crucible and dried overnight at 105^{0}C in an air oven. It was then removed and cooled in a desiccator. The sample was weighed (W_1) and ashed at 600^{0}C ^{0}C for 90 mins in a Lenton muffle furnace. It was finally cooled in a dessicatar and weighed again (W_2). The percentage crude fibre was calculated using equation viii.

$$\% \text{ Crude fibre} = \frac{W_1 - W_2 \times 100\%}{W_0} \quad \text{(iv)}$$

where W_0 = weight of sample, g
W_1 = weight of dried sample, g
W_2 = weight of ash sample, g

Determination of crude protein content: The crude protein of the sample was determined using the micro – Kjeldahl method described by AOAC (1990). The principle of this method is based on the transformation of protein and that of the other nitrogen containing organic compounds, other than nitriles and nitrates into ammonium sulphate by acid digestion.

$$\text{Sample nitrogen} + H_2SO_{4(aq)} \xrightarrow{\text{Catalyst}} (NH_4)_2SO_{4(aq)} \quad \text{(v)}$$

$$(NH_4)_2SO_{4(aq)} + 2NaOH_{(aq)} \longrightarrow 2NH_{3(aq)} + 2H_2O + Na_2SO_{4(aq)} \quad \text{(vi)}$$

$$NH_{3(aq)} + H_3BO_{3\,(aq)} \longrightarrow NH^+_{4\,(aq)} + H_2BO^-_{3\,(aq)} \quad \text{(vii)}$$

$$H^+_{(aq)} + H_2BO^-_{3(aq} \longrightarrow H_3BO_{3\,(aq)} \quad \text{(viii)}$$

The sample (2g) was weighed along with 20cm^3 of distilled water into a micro – Kjeldahl digestion flask. It was shaken and allowed to stand for sometime. One tablet of selenium catalyst was added followed by the addition of 20cm^3 concentrated sulphuric acid. The flask was heated on the digestion block at 100^{0}C for 4 hours until the digest became clear. The flask was removed from the block and allowed to cool. The content was transferred into 50cm^3 volumetric flask and diluted to the mark with water.

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An aliquot of the digest (10cm^3) was transferred into another micro-Kjeldahl flask along with 20cm^3 of distilled water, and placed in the distilling outlet of the micro – Kjeldahl distillation unit. A conical flask containing 20cm^3 of boric acid indicator was placed under the condenser outlet. Sodium hydroxide solution (20cm^3, 40%) was added to the content in the Kjeldahl flask by opening the funnel stopcock. The distillation start and the heat supplied was regulated to avoid sucking back. When all the available distillate was collected in 20cm^3 of boric acid, the distillation was stopped. The nitrogen in the distillate was determined by titrating with 0.01M of H_2SO_4; the end point was obtained when the colour of the distillate changed from green to pink.

Crude protein is a measure of nitrogen in the sample. It was calculated by multiplying the total nitrogen content by a constant, 6.60. This is based on the assumption that, proteins contain about 16%N which includes both true protein and non – protein N and does not make a distinction between available or unavailable protein (Udo and Ogunwele, 1986). The crude protein was calculated using eqn. ix

$$\% \text{ crude protein} = \%N \times 6.60 \qquad \text{(ix)}$$

The nitrogen content of the sample is given by the formula below.

$$\%N = \frac{Tv \times Na \times 0.014 \times V1}{G \times V_2} \times 100 \qquad \text{(x)}$$

where Tv = Titre value of acid (cm^3)
Na = Concentration or normality of acid
V_1 = Volume of distilled water used for distilling the digest (50cm^3).
V_2 = Volume of aliquot used for distillation (10cm^3)
G = Original weight of sample used, g

Determination of carbohydrates : The method of James (1995) was adopted where the total proportion of carbohydrate in the leaves sample was obtained by calculation using the percentage weight method. That is by subtracting the % sum of food nutrients: % protein, % crude lipids, % crude fibre and % ash from 100%. This is done by using the equation below.

$$\%\ CHO = 100\% - (\%\ cr\ protein + \%\ cr\ lipid + \%\ cr\ fibre + \%\ ash) \qquad \text{(xi)}$$

Determination of energy value : In this method, the calorific value of sample is determined by means of an oxygen bomb calorimeter. This determination involves the complete combustion of a known weight of a sample in a closed vessel called bomb containing oxygen gas at a pressure of 25 atmospheres (Verma, 2003).

The ground sample (1g) was weighed into the capsule of the bomb and put into the bomb. The firing wire (nickel – chromium fuse wire), 10cm was arranged on the sample so as to ignite the sample when current was passed through. Then oxygen gas was introduced into the bomb until the pressure inside rose to 25 atmospheres. One and half litre of water was measured into the bucket (calorimeter) and the bomb was submerged into the water

and the rest of the apparatus was assembled. The stirrer was switched on for 5mins before ignition and the initial temperature (T_1) was taken. The current flew and combustion of the sample began. The temperature in the thermometer was observed and the maximum temperature (T_2) reached was recorded.

Another 1g of the sample was taken and whole procedure was repeated. The caloric value was calculated using equation below

$$\text{The calorific value of the sample (cal/g)} = \frac{tW - e_3}{m} \quad \text{(xii)}$$

where $t = T_2 - T_1$
and T_2 = final temperature of the water
T_1 = initial temperature of the water
W = standardisation factor (2420) calories.
e_3 = length of the wire used L
and $L = (10 - X) \times 2.3\ cm^3$
m = mass of the sample used
X = length of wire left after combustion

Mineral analysis: The triple acid digestion method of Sahrawat *et al.* (2002) was employed. The dried leaves sample (2.0g) was weighed into a micro-Kjeldahl digestion flask to which $24cm^3$ of mixture of concentrated HNO_3, H_2SO_4, and 60% $HClO_4$ (9 : 2 : 1 v/v) were added. The flask was put on a heating block and digested to a clear solution, cooled and the content tranferred into a $50cm^3$ volumetric flask and made-up to the volume mark with water. The solution was used for determination of mineral elements; calcium, magnesium, pottasium, iron, copper, manganese, zinc and phosphorus.

Minerals analysis using atomic absorption spectrometry (AAS): calcium, magnesium, pottasium, iron, copper, manganese and zinc were analysed using atomic absorption spectrometry (AAS). The method gives a good precision and accurancy (Ojeka and Ayodele,1995). The principle of the method is based on nebulising a sample solution into an air acetylene flame where it is vapourised. Elemental ions were then atomised and the atoms then absorb radiation of a characteristic wavelength from a hallow-cathode lamp. The absorbance measured, is proportional to the amount of analyte in the sample solution. As mentioned already, the level of each element in the sample solution was determined by reference to a calibration curve.

Determination of phosphorus: The clear supernatant solution ($2cm^3$) after digestion was placed into $50cm^3$ volumetric flask. $2cm^3$ of extracting solution was added, followed by $2cm^3$ of ammonium molybdate solution. Then distilled water was added to make-up to $48cm^3$. The content was properly mixed, and $1cm^3$ of dilute stannous chloride solution was added and mixed again. $1cm^3$ of distilled water was added to make-up to $50cm^3$ mark and left to stand for 5mins. The % absorbance on the the spectrophotometer at 660nm wavelength was used to determine the conc. of phosphorus (Bray and Kurtz, 1975).

Determination of vitamin C : The principle of this method is based on reduction of the dye (2,6 – dichlorophenol indophenol) by an acid solution of ascorbic acid. In the absence of interfering substances, the capacity of an extract of a sample to reduce a standard solution of the dye as determined by titration is directly proportional to the ascorbic acid content. The sample (100g) was dissolved in $10cm^3$ of 6% metaphosphoros acid HPO_3 to form a slurry. The slurry (10g) was dissolved into $100cm^3$ of 6% metaphosphoric acid and allowed to stand for 2mins. The mixture was filtered using muslin cloth. Then $10cm^3$ aliquot of the filtrate was immediately titrated with the standard solution of 2,6 – dichlorophenol indophenol to a faint pink end point which persisted for 15 seconds. The vitamin C content was determined by equation xvii below, (Mukoshy, 1995) and average of the results was recorded.

$$\text{mg ascorbic acid /100g of sample} = \frac{V \times T}{W} \times 100\% \qquad \text{(xiii)}$$

Where V = $10cm^3$ of aliquot used for titration with the dye (2,6 –dichlorophenol indophenol).

T = Ascorbic acid equivalent of dye solution (mg/cm^3); W = weight of the sample in aliquot titrated

RESULTS AND DISCUSSION

The results of the various analyses conducted on the sample are presented in Tables 1 and 2.

Table 1: Proximate composition of *Indigofera astragalina* leaves

Parameter	**Level (**%drymatter+ SD)
Moisture (% wet weight)	51.00±0.05
Ash	8.17±0.58
Crude Lipid	5.0±0.50
Crude Protein	8.23±0.11
Crude Fiber	2.67±0.29
Carbohydrate	75.94+0.64

Values expressed as: Mean±SD; The calorific value is 578.87 kcal/100g

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Table 2: Mineral compositions of *I. astragalina* leaves

Parameter	Concentrations (mg/100g Dry matter)
Potassium	14.55 ± 0.17
Sodium	0.33 ± 0.16
Calcium	11.49 ± 0.34
Magnesium	10.89 ± 0.32
Phosphorus	0.39 ± 0.01
Copper	0.02 ± 0.00
Zinc	0.11 ± 0.00
Iron	20.95 ± 3.84
Manganese	0.43 ± 0.01
[Ca] / [P]	29.46
[K] / [Na]	44.09

Values expressed as: Mean ± SD

Proximate analysis: The result revealed that the moisture content, (51.00 ± 0.50%) is higher than those of some common Nigerian leafy vegetables such as *Xanthosem sagittifolum* (14.7%), *Gnetum buchholsianium* (33.8%), *Vernonia amygdaline (*27.4%,) *Adansonia digitata* (9.5%) (Tunde, 1998), but lower compared to moisture content within the range of 58.0 – 90.64% reported in some other Nigerian green leafy vegetables (Ladan *et al.,* 1996). *I. astragalina* leaves has relatively average moisture content but that can also show some possible microbial activities during storage (Hassan and Umar, 2004)

The ash content 8.17± 0.58% indicates that the leaves are rich in mineral elements. The value obtained is higher compared to 1.8% reported in sweet potato leaves (Asibey – Berko and Tayie, 1999), and 5% in *Tribulus terrestris* leaves , but lower than 19.61% in *Amaranthus hybridus* leaves (Nwaogu *et al.,* 2000), 10.83% in water spinach leaves and 18.00% Balsam apple leaves (Hassan and Umar, 2004).

The leaves contained 5.0 ± 0.5% crude lipid, which is lower than 11% in water spinach leaves , 12% in *Senna Obtusfolia* , but higher when compared to spinach leaves (0.3%) and Chaya leaves (0.4%) and 1.60% in *Amaranthus hybridus* leaves (Nwaogu *et al.,* 2000). Crude Lipids are the principal sources of energy but should not exceed the daily recommended dose of not more than 30 calories so as to avoid obesity and other related diseases. One gramme of lipid provides 8.37kcal (Asibey – Berko and Tayie, 1999), which indicates that 100g of *I. astragalina* leaves lipid should provide about 42kcal.

The crude protein content of 8.23 ± 0.11% obtained in present study is higher compared to 6.30% in water Spinach, 4.6% in *Momordica foecide* leaves consumed in Swaziland, but lower compared with 11.29% in balsam apple leaves (Hassan and Umar, 2006), 24.85% in sweet potatoes leaves, and *Piper guineeses* and *Talinum triangulare* with values of 29.78% and 31.00% respectively (Akindahunsi and Salawu, 2005). The recommended dietary allowance (RDA) for children, adult males, adult females, pregnant women, and lactating mothers are 28,63,50,60,65g of protein daily (Ganong, 2003). For

100g of *Indigofera astragalina* leaves to provide 8.23g of proteins, then it indicates that the leaves are a poor source of daily proteins.

The crude fibre content of 2.67% is low compared to 7.20% in sweet potatoes leaves ,13% in *Tribubus terrestris* (Tsaida) leaves, 29.00% in balsam apple leaves (Hassan and Umar, 2006), but the value is within the range of 0.70 – 12.0% for most leafy vegetables. Dietary fibre helps to reduce serum cholesterol level, risk of coronary heart disease, colon and breast cancer and hypertension (Ganong, 2003). The recommended daily allowance (RDA) for fibre is 18 – 35g, that means 100g of *I. astragalina* cannot provide the daily fibre requirements of the body.

The carbohydrate content of the leaves is considerably high 75.94± 0.64% compared to some other leafy vegetables like *Tribulus terrestris* (*"*Tsaida*"),* 55.67% , 54.20% in water spinach leaves and within the range with 75% in sweet potato leaves (Asibey – Berko and Tayie, 1999) but lower than 82.8% in *Corchorus tridens* leaves (Asibey – Berko and Tayie, 1999). Carbohydrate and lipid are the principal sources of energy, the carbohydrate content per 100g of *I. astragalina* provide 578.87 kcal of energy, this indicates that the leaves of this plant can contribute meaningfully to the daily energy requirement for an adult which is 3000kcal/day (Hassan *et al.,* 2006). The calorific value of *I. astragalina* leaves is 578.87kcal/100g on dry weight which is high compared to 248.8 – 307.1kcal/100g reported in some Nigeria leafy vegetables (Isong *et al.,* 1999). This is expected because of the high carbohydrate content of 75.94%. For that, *Indigofera astragalina* can serve as a good source of energy for the body.

Minerals : The result of minerals analysis of *I. astragalina* leaves in Table 3.3, imply that iron content is higher in the leaves compared to other minerals while copper has the lowest content. The potassium content of *I. astragalina* 14.55 ± 0.17mg/100g is higher compared with 6.42 mg/100g found in *Diospyros mespiliformis (L.)* but lower compared to 220.00 ± 7.8mg/100g in *cassia siamea* leaves (Ngaski, 2006). The level was below the range reported in some green leafy vegetables consumed in Sokoto (Ladan *et al*., 1996). This indicates that *I. astragalina* is not a rich source of potassium. The K/Na ratio in the diet assist in the prevention of hypertension and arterioscherosis and for normal protein retention during growth stages the level should be within the range of 3 – 4 but K/Na in *I. astragalina* is 44.09, which is above the range. The ratio can be adjusted by addition of salt during cooking. The recommended daily allowance (RDA) of potassium is 2000mg far adults (NRC, 1989), and the leaves contribute 0.7% to R.D.A, meaning the leaves cannot provide the body with the dietary potassium.

The sodium content of *I. astrgaalina* leaves 0.33±0.16 mg/100g is low compared with 5.00±0.6 mg/100g reported in *Tribus. terrestris* leaves (Hassan *et al*., 2005) and 45mg/100g in *Senna obtusfolia*t falls within the range of 2 – 150mg/100g for vegetables (Lintas, 1992). The sodium content is low. It contributes 0.06% to RDA while the RDA value for sodium for adult is 500mg (NRC, 1989) Despite the low sodium content in *I. astragalina* leaves, it could be a good source of food for hypertensive patients.

The calcium contents in the leaves 11.49±0.34 mg/100g is high compared with the calcium content 3.05mg/100g of *Diosypyros mesipiliformis (L)*. Hassan *et al*., (2004) but

lower than 941mg/100g in *Momordica balsamina L.* leaves (Hassan and Umar, 2006) and 17.95±2.00mg/100g in *Cassia siamea* leaves (Ngaski, 2006). The RDA values of calcium for adult men with 3000 kcal/day; recommended energy intake is 1,200mg (NRC, 1989) and *I. astragalina* can only contribute 0.91% to the RDA. This values implies that for calcium which is needed for growth and maintenance of bone, teeth and muscles, *I. astragalina* can not contribute meaningful amount of dietary calcium. The phosphorus content of the leaves 0.39±0.01 mg/100g is low when compared with the P content of *Diospyros mespiliformis (L)* 1.0mg/100g and 166 – 460mg / 100g found in some green leafy vegetable consumed in Sokoto (Ladan *et al*., 1996), and 180.00±0.04mg/100g in *cassia siamea* leaves (Ngaski, 2006). The RDA value for phosphorus is 120mg for adult males (NRC, 1989). *I. astragalina* leaves is a poor source of phosphorus since it contributes 0.26% to RDA and phosphorus, like calcium is required for growth, maintenance of bones, teeth and muscles (Turan *et al*., 2003).

Magnesium is an important mineral element in connection with circulatory diseases such as ischemic heart disease and calcium metabolism in bone (Ishida *et al*., 2000, Hassan and Umar, 2006). The magnesium content of the leaves is 10.89 ± 0.32mg/100g which is high compared with 2.56mg/100g in *Diospyros mespiliformis* (Hassan *et al*., 2004) and low compared with the magnesium content 23.18±0.4 of *Amaranthus hybridus* leaves (Nwaogu *et al*., 2000) and 400.00±00.00 mg/100g in *Cassia siamea* leaves (Ngaski, 2006). The RDA value for magnesium for adults male is 350mg (NRC, 1989) and *I. astragalina* contribute 3.1% to the RDA. This implies that the leaves are a poor source of magnesium.

Copper plays a role in haemoglobin formation and it contributes to iron and energy metabolism . The copper content of *I. astragalina* is 0.02±0.00mg/100g which is higher compared to 0.01mg/100g in *Diospyros mespiliformis* (Hassan *et al*., 2004(b)) but lower when compared with 1.28±0.1mg/100g in *T. terrestris* leaves (Hasan *et al*., 2005) and 0.50± 0.90mg/100g in *Cassia siamea* leaves (Ngaski, 2006). The RDA values for copper is 1.5 – 3 mg for a male adult (NRC, 1989) and 1.33 – 0.67% are contributed to the RDA by *I. astragalina*. This means that the leaves are also a poor source of copper.

The zinc content of *I. astragalina* leaves 0.11±0.00mg/100g was found to be higher compared to 0.02mg/100g in *Diospyros mespiliformis* (Hassan *et al*., 2004), 0.10±0.00mg/100g in *T. terrestris* leaves but lower when compared to 6.85±1.00mg/100g in *Cassia siamea* leaves (Ngaski, 2006) and 6.3 – 25.5mg/100g in some famine foods of the Republic of Niger . Zinc plays a vital role in gene expression, regulation of cellular growth and participates as a co-factor of enzymes responsible for carbohydrates, proteins and nucleic acids metabolism. The RDA value of zinc for a male adult is 12 – 15mg (NRC, 1989) *I. astragalina* leaves can contribute 0.9 – 0.71% zinc to the RDA. This implies that the leaves are a poor source of zinc.

Manganese is another microelement essential for human nutrition. It acts as in activator of many enzymes (McDonald *et al*., 1995). The Manganese content in *I. astragalina* is 0.43 ± 0.01mg/100g which is lower than 0.98 – 38.0mg/100g reported in some locally green leafy vegetables and 11.6mg/100g in Balassam apple (*Momordica Balsamina L.*) leaves (Hassan and Umar, 2006) but higher than the manganese content in lettuce (0.3mg/100g) and in cabbage (0.2mg/100g) (Turan *et al*.,2003). The RDA value for

Manganese is 2 – 5mg/100g for a male adult (NRC, 1989). *I. astragalina* leaves can contribute 12.5 – 8.6 % of manganese to the RDA. Despite the low value, but compare to others (K,Na,Ca,Mg,P and Zn contents), *I. astragalina* is a good source of manganese.

Iron is required for haemoglobin formation and its deficiency leads to anaemia (Turan *et al*., 2003). The iron content of *I. astragalina* is 20.95±3.84 mg/100g which is higher than 2.80±0.7 mg/100g in *T. terrestris* and in some cultivated vegetables such as spinach (1.6mg/100g) lettuce (0.7mg/100g) and cabbage (0.3mg/100g) (Turan *et al*., 2003) but lower than 70.00±0.80mg/100g in *Cassia siamae* (Ngaski, 2006) and 84.4mg/100g in *Helminthostachys sp*. The RDA value for iron for a male adult is 10 – 15mg (NRC, 1989). The leaves of *I. astragalina* can contribute 209 – 139.7% of iron to the RDA. This shows that about 50g of *I. astragalina* can provide the daily iron requirement for a male adult when the anti – nutritive agents are ignored. The leaves of *I. astragalina* are rich sources of iron, and could be of good use to pregnant women, lactating mothers. Generally for women since they loss some quantity of blood during monthly menstruation, it could help in the nourishing of their bodies.

Vitamin C is an excellent antioxidant and free radical scavenging nutrients protecting cells from damage by oxidants . The vitamins C content is 21.13mg/100g in the leaves is higher when compared with 10mg/100g in *Diospyrus mespiliformis* (Hassan *et al*., 2004), but lower when compared with 54mg/100g in orange juices . The RDA of vitamins C is 60mg/day for a male adult (Ganong, 2003). Ascorbic acid in the body increase iron absorption from the intestine and it is also required for connective tissue metabolism especially the scar tissues, bone and teeth (Hassan *et al*., 2004). The leaves of *I. astragalina* can actually provide the daily needs of vitamins C.

CONCLUSIONS

The *Indigofera astragalina leaves* may not provide all the nutrients required by man, yet it contains some essential nutrients like vitamin C and iron. They also have a high calorific value. *I. astragalina* leaves are quite safe for consumption.

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