## Research Article
## Nutritional Evaluation of Some Legumes and Vegetables Cultivated and Consumed in Yola, Adamawa State, Nigeria

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**Abstract:** The study was designed to evaluate the nutritional and anti-nutritional content Legumes and vegetables consumed in Adamawa state. The investigations were carried out on Proximate (Moisture, fibre, Ash, Protein, Nitrogen, fat, carbohydrate and Energy), mineral elements (Na, K, Zn, Cu, Pb and Mn, respectively). Vitamins (vitamin A (retinol), $\beta$-carotene, Vitamin C, Vitamin E, Vitamin $B_1$ and Vitamin $B_2$ and Anti-ntrient composition (phytate, oxalate and Tannins). The percentage moisture ranges between 4.28% for baobab leaves to 12.78% in sesame leaves. Legumes contained higher protein contents, the highest was observed in legumes (ground nut) with 25.40% the percentage for fat and carbohydrates were higher in legumes than in vegetables. Zinc was higher in vegetables (senna leaves and sesame leaves) (5.90 mg/kg) and was absent in one of the legumes (cowpea, red). Lead was only detected in vegetable leaves. It was higher in Sesame leaves with 2.0 mg/kg, lead was not detected in all the other sample used for this research. Vitamin A was only detected in vegetable samples and some legume (cowpea), the values ranges between 7.46 to 37.42 µg/100 g in senna leaves and cowpea (red) respectively. Vitamin C was not detected in the vegetable samples, but was detected in legume samples. Vitamin $B_1$ is higher in vegetable samples (baobab) with 1.32 mg/100 g. Riboflavin ($B_2$) was higher in sesame leaves with 1.01 mg/100 g. The values for phytate ranges between 0.03 mg/100 g in baobab and sesame leaves condiment sample to 5.33 mg/100 g in legume (cowpea, red) respectively. Legumes and vegetables investigated revealed that the anti-nutrient contents were very high especially Oxalate and tannins but lower in phytate.

**Keywords:** Anti-nutrient, legumes, mineral elements, proximate composition, vegetables, vitamins

### INTRODUCTION

The knowledge of nutrient composition of food is quite essential in dietary treatment of disease or in quantitative study of human nutrition. There are different food composition tables that are used in nutritional studies in developing countries, although there are gaps in terms of food and other nutrients. Data on the consumption of food are essential for diversity of purposes in many field of human activity, they are important to spectrum of users ranging from international organization to private individuals (Rand *et al*., 1991). Hence there is no food composition data in north eastern region of Nigeria. Although, there are various food composition tables available for use in developing countries; many of these tables however do not containing sufficient information on food values and several nutrients. Besides, most of these tables contain data that are not recent and have information mostly on raw foods. The gaps may be as a result of minerals content of the soil, fertilizer used, method of processing, the length and method of storage, the moisture content of the sample and the method of analysis (Sanusi and Adebiyi, 2009). The data is

significant in dietary formulations for infants and children which are essential for optimal growth and development and for good health also in the dietary formulation and management of diseases such as scurvy, kwashiorkor or other health threatening conditions like obesity, diabetes and osteoporosis etc., (Osho, 1988; Mariam, 2005).

In every society, every individual and any other living organism needs knowledge about the nutritional content of both raw and processed foods; this is because food contains substances called nutrients. The nutrients build and maintain the body's structure and to supply the energy that powers all vital activities. Food is made up of different nutrients which include proteins, carbohydrates, fats, water, minerals and vitamins. All nutrients are needed by the body and are available through food. Combination of many kinds of food can form a well balance diet. Each nutrient has specific uses in the body. It is the relationship of food to the health of the body that determines nutritional status. Proper nutrition means that all the nutrients are supplied and utilize in adequate amount to maintain optimal health and well-being (Thomas, 2006). The study is significant to spectrum of users ranging from international

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organizations to private individuals. The knowledge of nutritional composition of food is quite essential in dietary treatment in chronic diseases such as cardiovascular (heart) disease, stroke hypertension, diabetes and some form of cancer which account for two thirds of all death and also disease that are associated with deficiency of nutrients in younger children such as osteoporoses and iron deficiency Anemia. Nigeria is witnessing an increase in population growth; National Population Commission (2006) estimated it to be 140,003,542. The high population without corresponding increase in food production and availability to the citizenry can lead to household food insecurity. This is an issue posing serious nutritional problem in Nigeria, particularly among children and lactating mothers. The resultant effect can lead to malnutrition, retarding growth in children and low productivity level among the mothers (Ward-Law and Kessel, 2002). In a related development Maziya-Dixan *et al*. (2003) reported that malnutrition is prevalent in Nigeria to about 76% in children. The survey revealed that 42% of children are stunted, 25% underweight and 9% wasted. The study also revealed that 16.4% of the women malnourished were from dry savannah, 9.9% moist savannah and 9% from humid forest. Malnutrition refers to as insufficient, excessive or imbalanced consumptions of diet by an organism (Deo, 1978).

The problems of low level of food production coupled with low socio-economic capacity of people led to the campaign for increase production, utilization and consumption of traditional foods among the citizenry with the view of reducing the effect of malnutrition (FAO, 1986). There are several food composition tables in the developing countries (Sanusi and Adebiyi, 2009). Whenever using nutrient data, so many factors influences the nutrient contents of foods. These factors include the mineral content of the soil, the diet fed to an animal or the fertilizer used on the plant, the season of harvest, the method of processing, the length and method of storage, the method of cooking, the method of analysis and the moisture content of the sample analyzed (Lupien, 1994). Nutrition is the provision of materials (in the form of food) to the cells and organism that are necessary to support life; it is mainly concerned with nutrient requirement of the body as well as health implication of inadequate or excess of nutrients. The nutrients are supplied to the body through the diet.

In view of this, there is the need to carryout nutritional analysis of indigenous food produced in Adamawa state with the view of formulating food composition table for the state.

## MATERIALS AND METHODS

**Materials:** Six commonly used food as staple food in Adamawa state was used for this research study, namely-legumes used are cowpea (brown and white)

and Ground nuts. The vegetables are baobab leaves, senna leaves and sesame leaves.

**Chemicals:** The chemicals were obtained from M&B lab. Chemical, Dagenham, England.

**Equipment:** Atomic absorption spectrophotometer (Bulk Scientific, USA), soxhlet apparatus extraction unit, hot air ovum (Gallenkamp), muffle furnace (M-525), flame photometer, colourimeter, HPLC (bulk scientific, BLC10/11), Analytical balance (Metler Toledo AB 204).

**Methods:**
**Collection of samples:** Six commonly used foods as staple food in Adamawa state was used for this research study, namely-legumes used are cowpea (brown and white) and Ground nuts. The vegetables are baobab leaves, senna leaves and sesame leaves. All the samples were obtained in Yola market of Adamawa state which is a market where food produced in Yola is sold.

**Proximate analysis of the food samples:**
**Moisture content determination:** The standard method of AOAC (1995) was used to determine the moisture content of the samples.

**Procedure:** Clean crucibles with lids was labeled and dried in an oven at $100^{o}$C for 30 min, cooled in a suitable dessicator containing CaO as a desiccant and weigh to a constant weight. The sample was grinded to fine powder and was mixed to obtain a homogenous sample of large surface area. An analytical balance (Metler Toledo AB 204) was used to obtain the weight of the crucibles with the lids. In each of the crucibles 2.0 g were placed in it, it was then dried in an oven at $100°C$ for 17 h. The samples were removed from the oven and the lids were replaced, the sample was then being transferred to a dessicator containing CaO as desiccant to room temperature ($28\pm1°C$) and was weighed. The process was continued until a constant weight was obtained. Triplicate determinations were carried out on each sample.

**Calculation:** The percentage moisture content was calculated as follows:

$$Moisture\ (\%) = \frac{t-u}{s} \times 100$$

where,
s = Weight of sample for analysis
t = Weight of sample+crucible before drying
U = Weight of sample+crucible after drying
t-U = Loss of weight or moisture content

**Ash content determination:** The ash content was determined by method of AOAC (1990).

**Procedure:** Porcelain crucibles with lids was ignited for 5 min in a muffle furnance (M-525) at $550°C$,

cooled in a Dessicator and weighed. Two grams of each sample was separately weighed into the appropriately labeled crucible and weighed again. Crucible and content was ignited in the muffle furnance (Model M-525) at 550°C for 18 h to light grey ash. Thereafter, they was removed and placed immediately in a dessicator to cool and weighed.

**Calculation:** The difference in weight or loss in weight of the crucible and sample before ashing gave the organic matter content of each diet, while the difference between the weight of the crucibles alone and crucible and ash and gave the weight of the ash of each sample. Values for ash were calculated and expressed in percentages as:

$$Ash\ (\%) = \frac{100\ (X-Y)}{Z}$$

where,
x   = Weight of crucible and content after drying
Y   = Weight of empty crucible
X-Y = Weight of ash
Z   = Weight of sample

**Crude fibre determination:** This was carried out according to the procedure of AOAC (1980). Briefly, 4 g of each moisture-free sample was weight into a 250 mL beaker and 50 mL of 4% $H_2SO_4$ was added followed by distilled water to a volume of 200 mL. This was then heated to boiling and kept boiling for exactly 30 min on a Bunsen flame, with constant stirring using a rubber-tipped glass rod to remove all particles from sides of beaker.

The volume was kept constant by addition of hot distilled water. After 30 min of boiling, the content was poured into a butchner funnel fitted with an ash less what man no. Forty filter paper and connected to a vacuum pump. Beaker was washed several times with hot distilled water and then transferred quantitatively with a jet of hot water. Washing continued on the funnel until the filtrate was acid-free as indicated by litmus paper.

The acid-free residue was transferred quantitatively from the filter paper into the same beaker removing the last traces with 5% NaOH solution and hot water to a volume of 200 mL. The mixture was boiled for 30 min with constant stirring as earlier described, keeping the volume constant with hot water. The mixture was then filtered and washed as earlier described until its alkaline free.

Finally, the resultant residue was washed with two portions of 2 mL 95% alcohol. Residues on filter paper were transferred to a pre-weighed porclain crucible. The content of the crucible was then dried in an oven maintained at 110°C to a constant weight after cooling in a desiccator. Crucible content was then ignited in a

muffle furnance at 550°C for 8 h, cooled and weighed. A triplicate determination was carried out on each sample. The percentage crude fibre was therefore calculated as:

$$Fiber\ (\%) = \frac{y-a}{X}\ X\ 100$$

x = Weight of sample (g)
y = Weight of insoluble matter (g)
a = Weight of Ash (g)

**Crude fat determination:** The method of Pearson (1973) was employed; this method was based on the principle that non-polar components of samples are easily extracted into organic solvents.

**Procedure:** Three grams, (Moist-free) of each sample, was placed into fat free thimbles. These was then weighed plugged with glass wool and introduced into soxhlet extractors containing 160 mL petroleum ether (b.p 60-80°C). Clean dry receiver flask weighed and fitted to the extractors. The extraction unit was then assembled and cold water was allowed to circulate, while the temperature of the water bath was maintained at 60°C. Extraction was carried out for 8 h. At the end of this time, the thimble containing the sample was removed and placed in an oven at 70°C for 3 h and dried to constant weight.

The weight of the dish and the content was then obtained using a standard analytical balance.

**Calculation:** The crude fat was obtained as the difference in weight before and after the exhaustive extraction.
Hence the percentage fat was therefore calculated as:

$$Fat\ (\%) = \frac{X-y}{Z}\ X\ 100$$

where,
x = Weight and thimble and oil
Y = Weight of empty thimble
Z = Weight of sample

**Crude protein determination:** A modified method of micro-Kjeldahl as described by AOAC (1990) was used for crude protein determination. The nitrogen content of proteins varies from 15-18%. Assuming an average value of 16%, then crude protein is estimated as the nitrogen content multiplied by the appropriate factor.

**Equations:** The digestion involves oxidation of the organic matter with sulphuric acid:

$$Organic\ N\ \xrightarrow{Conc.H_2SO_4}\ (NH_4)_2SO_4$$

$$Carbon\ \xrightarrow{Conc.H_2SO_4}\ CO_2$$
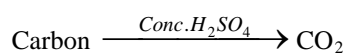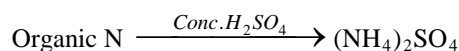
Distillation is carried out on Markham"s steam distillation apparatus. This involves liberation of ammonia by caustic soda, which is trapped in an (excess) acidic buffer and the excess acid titrated with standardized 0.1 M NaOH solution.

**Procedure for digestion:** Three grams each of the de-fatted samples were separately weighed on pre-weighed Whatman ashless filter paper No. 4 and placed in micro-Kjeldahl digestion flask together with few anti-bumping granules. Two grams of catalyst mixture ($CuSO_4$: $Na_2SO_4$: $SeO_2$, 5:1:02 w/w) was added to each flask and then 10 mL nitrogen free concentrated $H_2SO_4$ also added to each flask. The flasks were placed in inclined position on a heating mantle in a fume cupboard. Digestion was started at temperature of 30°C until frothing ceased and then heating was increased to 50°C for another 30 min and finally at full heating (100°C) until a clear solution was obtained. Simmering was continued below boiling point for another 30 min to ensure complete digestion and conversion of nitrogen to ammonium sulphate. After digestion was completed, samples were allowed to cool and then transferred quantitatively to 100 mL volumetric flasks with washing and cooling to room temperature. Volumes were made up to mark with distilled water.

**Distillation:** Ten milliliters of each digested sample was pippetted separately into the Markham steam distillation apparatus, followed by the addition of 20 mL s 40% NaOH solution. Distillation was started and the liberated ammonia was trapped into2% boric acid in a 100 mL conical flask containing 4 drops of mixed indicator (0.1% BCG and 0.1% methyl red in 95% alcohol) to a volume of 50 mL. Titration the ammonia trapped in the boric acid was titrated against 0.01 M Hcl to an end point of light gray color. Titre values were obtained in triplicate for each sample and blanks.

**Calculation:** Percentage nitrogen in the food samples were calculated as follows:

$$\%\text{Nitrogen} = \frac{(a-b) \times 0.01 \times 14.005 \times C \times 100}{D \times E x\ 1000}$$

where,
a = Average titre value for samples
b = Titre value for blank
C = Volume to which the digest was made up to
D = Aliquot taken for distillation
E = Weight of dried samples taken for digestion:

$$\% \text{ Crude Protein} = \%\text{Nitrogen} \times 6.25\ (AOAC, 1975)$$

**Estimation of total carbohydrate:** The total carbohydrate content of the diet samples was obtained by subtracting the sum of percentage crude protein, crude fat, Moisture, Fibre and ash from 100.

**Calculation of caloric value of the food:** When samples of carbohydrate, fat and protein are burnt in a bomb calorimeter, the amount of heat produced (heat of combustion) is always the same for each of these nutrients. It is the maximum amount of energy that the sample is capable of yielding when it is completely burnt or oxidized. Values of 4.1 Kcal/g for carbohydrate, 9.45 Kcal/g for fat and 5.65 Kcal/g for protein have been obtained. However, the net heat of combustion in the human body is slightly different from that in the bomb calorimeter. In the calorimeter, the heat of combustion comes from the energy produced by oxidation of C to $CO_2$, hydrogen to water and nitrogen (from protein) to nitrous oxide. The body is capable of releasing the energy potential of carbon and hydrogen, but cannot use the energy of nitrogen. Therefore the heat from the oxidation of nitrogen cannot be considered available to the body. This amount to 1.3 Kcal a potential of only 4.3 Kcal/g of protein is therefore available to the body (Guthrie, 1989).

**Calculation:** Based on these values, the factors 4, 9 and 4 representing the approximate amount of energy available to the body per gram of carbohydrate, fat and protein respectively (physiological fuel value) were used in arriving at the caloric values of the diets analyzed as follows:

Total caloric value = Sum (gram of each nutrient in diet×factor)

**Assay of anti-nutritional factors in the food samples: Determination of phytate:** This was achieved using the method of AOAC (1990). Phytate was extracted using dilute HCl and then extract mixed with $Na_2$ EDTA-NaOH solution and placed in an ion-exchange column. The extracted phytate is diluted with 0.7 mL NaCl solution and wet-digested with $H_2SO_4/HNO_3$ mixture to release phosphate, which is measured colorimetrically after reacting with ammonium molybdate solution. The amount of phytate in original sample is obtained as hexaphosphate equivalent.

**Procedure:** Two grams of each diet sample was separately weighed into labeled 150 mL Erlenmeyer flasks. Exactly 40 mL of 2.4% HCl was added to each sample, covered and shaken vigorously on an MSE orbital shaker for 3 h at room temperature. Meanwhile, a column was prepared by adding 3 mL of distilled $H_2O$ to the slurry of 0.5 g-anion exchanger resin AG 1-x 4 chlorides obtained from BIO-Rad laboratories. This was allowed to settle and then washed with 15 mL of 0.7 M NaCl solutions, followed by 15 mL of distilled water.

Samples were removed from the shakers and filtered through Whatman filter paper No. 42. One millilitre of each filtrate was separately mixed with 1.0 mL $Na_2$ EDTA-NaOH reagent in a 25 mL volumetric flask. Mixtures were diluted to the mark with distilled water, mixed and transferred quantitatively to the prepared column. The first eluent from the column was discarded. The Column was washed with 15 mL 0.1 M NaCl, which was also discarded. The column was then washed with 15 mL 0.7 M NaCl and fraction collected into a digestion flask. Concentrated $H_2SO_4$ (0.5 mL) and 3.0 mL concentrated $HNO_3$ were added to the flask. Before the next sample was added to the column, 15 mL of distilled water was passed through it. Mixtures in flasks were digested on micro-Kjeldahl rack at 50°C until active boiling ceased and thick yellow vapour was given out. Heating continued for another 10 min before burner was turned off. Flasks were allowed to cool to room temperature. Exactly 10 mL-distilled water was added to flask and swirled to dissolve the digests. All solutions were separately transferred quantitatively to labeled 50 mL volumetric flasks. (2.0 mL) molybdate solution was added to each sample, mixed thoroughly, then followed by 1.0 mL sulfonic acid reagent and mixed again. The solutions were then diluted to volume with more distilled water. Mixtures were allowed to stand for 15 min and absorbance read at 640 nm. A blank solution was prepared by mixing 1 mL 2.4% Hcl with 1.0 mL $Na_2$EDTA-NaOH reagent and diluted to 25 mL with distilled water before pouring into column and treated as samples Preparation of Standard Curve. A standard curve was prepared by pipetting 1.0, 3.0, 5.0, 7.0 mL phosphate standard solution containing 80, 240, 400 and 560 μg phosphorus, respectively, into labeled 50 mL volumetric flasks. Twenty milliliter distilled water was added to each flask, mixed thoroughly, followed by 2.0 mL Molybdate solution with continuous mixing. (1.0 mL) sulfonic acid solution was added mixed well, diluted to volume with distilled water and mixed again. Absorbances of the solutions were read at 640 nm. A standard curve was generated. Triplicate determinations were carried out on all the samples and standards.

**Calculation:** Phytate concentration in the diet samples was extrapolated from the generated standard curve and expressed as mg/100g sample.

**Determination of total oxalate:** Total oxalate in the diet samples was assayed using the method of AOAC (1990).

Oxalate is precipitated as insoluble calcium oxalate, which was collected by centrifuging. The precipitate is dissolved in an excess of hot dilute $H_2SO_4$ and the oxalate titrated (in hot) with standardized $KMnO_4$.

**Procedure:** Two gram of the powdered diet samples was separately weighed into labeled 250 mL beaker and

150 mL distilled water and 55 mL 6 M HCl added. Two drops of alcohol was added and mixture boiled for 15 min, cooled and transferred quantitatively into 500 mL volumetric flask, diluted to volume with distilled water and mixed again. Mixture was allowed to stand overnight, mixed thoroughly and then filtered through No. 42 Whatman filter paper.

Exactly 25 mL of the filtrates was separately pipetted into labeled 50 mL flasks and then 5 mL tungstophosphoric acid added, mixed and let to stand for 5 h. Mixtures was filtered through Whatman filter paper and 20 mL of filtrates was pipetted again into centrifuge tubes followed by ammonium hydroxide solution drop wise until a pH of 4.5 was achieved using indicator paper. Five mL acetate buffer (pH 4.5) will then be added to maintain a constant pH. Mixtures was allowed to stand again overnight at room temperature, after which they was centrifuged for 15 min at 1700 rpm to compact the precipitate. Supernatants were carefully decanted and calcium oxalate precipitates washed three times with centrifugation and decantation using cold washing liquid (12.5 mL HoAc, diluted to 250 mL with distilled water). Precipitates were re-dissolved in 5 mL dilute $H_2SO_4$ (1:9 v/v). The dilute $H_2SO_4$ also served as the blank solution. All mixtures were then heated in a boiling water bath for 15 min and the hot solutions titrated with 0.01 N $KMnO_4$ until a persistent pink color was obtained.

**Calculation:** The volume of $KMnO_4$ used to titrate the hot solution of each sample was used to calculate the oxalate content of each sample as follows:

$$\text{Mg oxalate/100g sample} = \frac{\text{mL of 0.01N KMnO}_4 \times 1350}{\text{Weight of sample taken}}$$

where,

1350 = 0.45 (mg oxalic acid equivalent to 1 mL 0.01 N $KMnO_4$) × [(30/20) × (50/25) dilution factors] ×100 (to convert to 100 g sample)

**Determination of tannins:** The method of AOAC (1980) was also used in this determination.

**Procedure:** Two grams residues of petroleum ether extracts as earlier described was boiled with 300 mL distilled water for 2 h, cooled and diluted to 500 mL with more water and then filtered. Twenty five milliliter of the filtrates was transferred separately into 2 L porcelain dish. Twenty mL indigo solution and 750 mL distilled water added, followed by 1 mL of $KMnO_4$ (earlier standardized with 0.1 N oxalic acid) at a time until the blue solution turned green; then few drops until solution became golden yellow. A triplicate analysis was carried out on all the samples. Mixture of

20 mL indigo solution and 750 mL distilled water was titrated with $KMnO_4$ as blank.

**Calculation:** The difference between the sample and the blank titre values was multiplied by the factor of 0.006235* to obtain the concentration of tannin in the samples:

*1 mL oxalic acid solution = 0.006235 querci tannic acid

**Determination of the mineral content:** Two grams of powdered food sample was weighed into a porcelain crucible and preheated to 600°C for 4 h. The crucible was then being transferred directly to desiccators and was allowed to cool. The weight of the ash was noted.

**Digestion:** The ash was treated with a few milliliters of 5 N HCl and a few drops of concentrated $HNO_3$ and boiled. This was then cooled, filtered and the filtrate then makes up to 100 mL in a standard volumetric flask with de-ionized water. This solution was for the determination of Pb, Mn, Zn and Cu. by atomic absorption analysis. The procedure was carried out five times. Mineral elements such as Na and K were determined using flame photometer.

**Assay of vitamins content:**
**Determination of vitamins A and E:** The method of HPLC (High Performance Liquid Chromatography) was used in the determination of Vitamin A and E, briefly, analysis was performed by injecting 20 uL of carefully prepared sample into a bulk scientific (USA) BLC 10/11-model HPLC Equiped With UV-325 nm and UV 254 nm detectors for fat soluble vitamins. AC18, 4.6×150 mm, 5um column and a mobile phase of 95:5 (methanol: water) was used at a flow rate of 1.00 mL/min and an ambient operating temperature. A 01 mg of mixed standards were analyzed in a similar manner for identification. Peak identification was conducted by comparing the retention times of authentic standards and those obtained from the samples. Concentrations were calculated using a four way calibration curve.

**Estimation of ascorbic acid:**
**Sample analysis:** Two grams of the samples was extracted in 4% oxalic acid and makeup to known volume (100 $cm^3$) and centrifuge and Ascorbic acid contents were estimated by method described by AOAC (1990). Briefly 5 $cm^3$ of the working standard solution was pipetted out into 100 $cm^3$ conical flask and l0 mL of 4% oxalic acid was added and titrated against the dye solution. The end point was the appearance of pink color, which persists for a few minutes. The amount of dye consumed is equivalent to the amount of ascorbic acid present in the test sample.

**Thiamin estimation (flourimetric analysts):** Two grams of the sample were grinded in a mortar and 30 mL of hydrochloric acid was added by portions. The content was thoroughly mixed and filtered using filter paper.

This analysis comprises of three (control, test sample and standard), for each sample both fresh and dried. To the first (control), 5 mL of hydrochloric acid solution was transferred to the sec l (sample). To 1 mL of the extract of the sample and 4 mL of hydrochloric acid was transferred.

To the third (standard) 5 mL of thiamin solution was transferred. (1.5 mL) of oxidizing mixture was poured into each phial and mixed, gently to homogeneity. Then 5 mL of butanol was added to each phial and stopper-using flask shaker and shaken vigorously for 5 min. The phials were then allowed to stand until the contents were separated into two layers. Then 0.5 mL of ethanol was added cautiously to further clarify the butanolic phase. The cleared butanolic layer was cautiously decanted into a flourimeter cell and successive measurement of the fluorescence intensity for the three (test sample, control and standard) solutions of all the samples sativa were recorded.

**Vitamin $B_2$ (riboflavin) determination:** This assay was based on the method of AOAC (1990). Vitamin $B_2$ occurs in natural products almost entirely in combined form as riboflavin-5-phosphoric acid ester (flavine mononucleotide) and linked to protein as a constituent of "yellow enzymes". Extraction with hot dilute acid (steam bath or water bath) splits vitamin $B_2$-protein complex. Protein is precipitated with excess acetone or methanol, while riboflavin stays in solution without being absorbed by the precipitated protein and other impurity. Dry samples such as cereal products and feeding stuffs, are first of all powdered and then defatted by extraction with ether or light petroleum.

**Extraction:** Powdered moisture free samples were defatted using light petroleum ether (40-60°C) for 8 h. One gram each of the defatted samples was weighed into a 50 mL conical flask and shaken with 120 mL of 0.1 N Hcl on a water bath set at 70°C for 90 min. Fifteen mL of acetone was added and shaken for 5 min. Mixtures were filtered through No. 1 Whatman filter paper. Excess acetone in the filtrate was evaporated on water bath until odour-free. Each extract was diluted to 10 mL with distilled water, 1 mL of glacial acetic acid added and then shaken.

**Assay:** Standard solutions of riboflavin were prepared by accurately weighing out 50, 100, 200, 400 and 600 mg riboflavin and dissolving in 10 mL distilled water to give concentration of 5, 10, 20, 40, 60 mg/mL, respectively. To 10 mL of both sample extracts and

standard solutions of riboflavin, 0.5 mL of 4% $KMnO_4$ solution was added with shaking and allowed to stand for exactly 2 min. To this 0.5 mL of 3% $H_2O_2$ solution was added and shaken vigorously to expel excess oxygen. Solutions that were turbid or had precipitates of $KMnO_4$, were centrifuged before absorbance of the resultant yellow color solution was measured at 444 nm.

**Calculation:** Absorbance obtained for the different concentrations of standard riboflavin were used to plot a calibration curve, while the vitamin $B_2$ concentration of each sample extract was read from the linear curve.

**Data analysis:** All the data were expressed as mean±standard deviation. The proximate and mineral element was carried out five times and vitamins and anti-nutrients was determined in triplicates and was analyzed using one-way ANOVA and the difference in means was compared using the Duncan's multiple test and was processed using SPSS 17.0 software version for windows computer software package and p<0.05 was considered statistically significant.

**RESULTS AND DISCUSSION**

The proximate composition of one species of ground nut and two species of cowpea is shown in Table 1, the mineral element composition was shown in Table 2, the vitamin composition in Table 3 and the anti-nutrient composition in Table 4. The percentage moisture content ranged from 6.40 to 11.56% (p<0.05). It was higher in cowpea (red), then followed by cowpea (white) and the lowest was seen in ground nut. The

range obtained for each component was within the range of values reported for some selected ground nut varieties by Duke (1981) and Henshaw (2008) (11.60%). High moisture/water content predispose them to bacterial and fungal attack, as a result for the value of the moisture not being too high, it can also be stored for a long period of storage time. The protein content ranges between 18.60 to 25.40%. The presence of high protein in these samples suggested that these samples are good sources of protein. Dietary proteins are needed for the synthesis of new cell wall, repair of worn out tissues, hormones, enzymes, antibodies and other substances required for healthy functioning and development of the body and its protection and also for the treatment of protein-energy malnutrition (Omoruyi *et al.*, 1994). The lipid or fat content obtained from this analysis was ranging between 0.61 and 52.30% (p<0.05) for legumes. The highest value was seen in ground in ground nut which was comparable with the values obtained by Asibuo *et al.* (2008) and Alayande *et al.* (2012) (52.25%). Cowpea has been to be low in their lipid content. Lipids provide strong energy and also help in the transport of fat soluble vitamins such as vitamin A, D, E and K. Also Fats contribute substantially to the energy value of foods as well as provide essential fatty acids for optimal neurological, immunological and functional developments in children (Guthrie, 1989). The ash content analyzed was found to be 3.69% for Cowpea (white), 4.20% in Cowpea (red) and 5.88% in ground nut. The range of values obtained falls within the range of values quoted by Ologhobo and Fetuga (1988) and Yeshajahu (1991) (3.42%). Legumes had high ash content in samples suggesting

Table 1: Proximate composition of the commonly consumed legumes and vegetables

| Sample | Moisture (%) | Ash (%) | Fibre (%) | Nitrogen (%) | Protein (%) | Fats (%) | CHO (%) | Energy (KCAL) |
|---|---|---|---|---|---|---|---|---|
| Cowpea (white) (*Vigna unguiculata*) | 11.40±0.30[a] | 3.69±0.27[c] | 11.14±0.65[b] | 3.65±0.12[b] | 22.80±0.76[b] | 1.14±0.09[b] | 49.87±1.12[b] | 320.84±44.10[c] |
| Cowpea (red) | 11.56±0.21[a] | 4.20±0.08[b] | 13.33±0.32[a] | 2.97±0.08[b] | 18.60±0.47[c] | 0.61±0.37[c] | 51.76±0.54[a] | 357.10±2.83[b] |
| Groundnut | 6.40±0.32[b] | 5.88±0.32[a] | 2.68±0.54[c] | 4.07±0.08[a] | 25.40±0.49[a] | 52.30±0.27[c] | 7.32±1.15[c] | 601.78±2.83[a] |
| Baobab leaves (*Adamsonia digitata*) | 4.28±0.19[c] | 3.76±0.38[c] | 16.69±0.24[b] | 2.96±0.03[a] | 18.52±0.20[a] | 11.38±0.15[a] | 45.34±0.50[b] | 357.90±1.90[a] |
| Senna leaves (*Hibiscus cannabinus*) | 12.40±0.12[b] | 11.80±0.01[a] | 11.62±0.19[c] | 2.14±0.03[c] | 13.34±0.19[c] | 2.23±0.11[b] | 48.57±0.40[a] | 268.03±0.38[b] |
| Sesame leaves (*Cassia tora*) | 12.78±0.11[a] | 9.83±0.08[b] | 26.97±0.12[a] | 2.50±0.00[b] | 15.62±0.17[b] | 2.03±0.02[c] | 32.76±0.10[c] | 211.80±0.82[c] |

Values are expressed as mean±standard deviation for five determinations; Values with different superscript down the column are significantly different from each other at p<0.05; CHO: Carbohydrates

Table 2: Mineral elements composition of the commonly consumed legumes and vegetables

| Sample | Na (mg/kg) | K (mg/kg) | Zn (mg/kg) | Cu (mg/kg) | Mn (mg/kg) | Pb (mg/kg) |
|---|---|---|---|---|---|---|
| Cowpea (white) | 2.40±0.007[a] | 178±2.91[a] | 3.80±0.020[a] | 0.24±0.007[a] | N.D | N.D |
| Cowpea (red) | 1.70±0.03[c] | 122±1.58[c] | N.D | N.D | N.D | N.D |
| Groundnut | 2.30±0.05[b] | 145±2.91[b] | 2.30±0.007[b] | 0.20±0.020[b] | 0.12±0.02 | N.D |
| *Adamsonia digitata* | 3620.40±0.05[b] | 46.40±0.09[b] | 5.80±0.040[a] | 34.40±0.020[a] | 3.36±0.02[c] | 1.90±0.32[a] |
| *Hibiscus cannabinus* | 3610.90±0.08[b] | 48.32±0.09[a] | 5.90±0.060[a] | 34.40±0.030[a] | 5.50±0.20[a] | 1.90±0.03[b] |
| *Cassia tora* | 4011.50±0.03[a] | 27.60±0.22[c] | 5.90±0.010[a] | 34.70±0.020[a] | 4.90±0.06[b] | 2.00±0.11[c] |

Values are mean±standard deviation for five determinations; Values with different superscript down the column are significantly different from each other at p<0.05

Table 3: Vitamin composition of the commonly consumed legumes and vegetables

| Sample | Vitamin A (µg/100 g) | Vitamin C (mg/100 g) | Vitamin E (mg/100 g) | Vitamin B1 (mg/100 g) | Vitamin B2 (mg/100 g) |
|---|---|---|---|---|---|
| Cowpea (white) | 30.22±0.12[b] | 0.079±0.03[b] | 0.31±0.03[c] | 0.72±0.01[b] | 0.18±0.01[a] |
| Cowpea (red) | 37.42±0.01[a] | 0.089±0.02[a] | 0.38±0.01[b] | 0.67±0.02[b] | 0.12±0.02[b] |
| Groundnut | N.D | 0.045±0.04[c] | 9.14±0.05[a] | 1.00±0.30[a] | 0.13±0.04[b] |
| *Adamsonia digitata* | 16.47±0.02[a] | ND | 24.68±0.22[a] | 1.32±0.20[a] | 0.85±0.02[b] |
| *Hibiscus canabinus* | 7.46±0.04[c] | ND | 18.88±0.30[c] | 0.90±0.01[c] | 0.20±0.01[c] |
| *Cassia tora* | 13.78±0.03[b] | ND | 23.36±0.02[b] | 1.13±0.04[b] | 1.01±0.01[a] |

Values are mean±standard deviations for three determinations; Values with different superscript down the column are significantly different from each other at p<0.05; Values are expressed as mean±standard deviation for five determinations; Values with different superscript down the column are significantly different from each other at p<0.05

Table 4: Anti-nutrients composition of the commonly consumed legumes and vegetables

| Sample | Phytate (mg/100 g) | Oxalate (mg/100 g) | Tanin (mg/100 g) |
|---|---|---|---|
| Cowpea (white) | 4.26±0.03[ab] | 144±0.02[b] | 558±0.12[a] |
| Cowpea (red) | 5.33±0.01[a] | 270±0.01[a] | 543±0.01[b] |
| Ground nut | 3.11±0.02[b] | 97±0.10[c] | 522±0.03[c] |
| *Adamsonia digitata* | 0.03±0.03[b] | 197±0.02[c] | 149±0.12[a] |
| *Hibiscus cannabinus* | 0.13±0.01[a] | 570±0.01[a] | 102.3±0.01[b] |
| *Cassia tora* | 0.03±0.02[b] | 422±0.10[b] | 96.0±0.03[c] |

Values are mean±standard deviations for three determinations; Values with different superscript down the column are significantly different from each other at p<0.05

that legumes are rich in mineral elements. The crude fibre content of legumes was analyzed and was found to be 2.68% in ground nut, 11.14% in cowpea (white) and 13.33% in cowpea (red). The values obtained falls within the range of values reported by Gibney (1989) and Alayande *et al*. (2012) (12.25%). The fibre content in relation to diet is adequate, exerting a major influence on the metabolism of the Gastrointestinal Tract (GIT) and its deficiency is linked to appendicitis, diverticular disease and haemorrhoids (Gibney, 1989). Fibre also slows down the release of glucose into the blood and decreases intercolonic pressure, hence the risk of colon cancer (Gibney, 1989). The carbohydrate of the legumes ranges between 7.32 to 51.76%. The lowest was observed in ground nut and highest is observed in Cowpea (red), the low carbohydrate in ground nut suggested that ground nut are not good sources of carbohydrate.

The proximate composition of commonly consumed vegetables revealed that the moisture content ranges between 4.28 to 12.78% (p<0.05). The presences of low moisture in these soup condiment samples suggested that the soup condiment samples would be kept well for a long period of time. The crude fibre content of soup samples ranges between 11.62 and 26.97%. The lowest was seen in baobab leaves and the highest was observed in sesame leaves. The values are comparable with that of Aletor and Omodara (1994). However the crude fibre is higher in Sesame leaves than in the other samples used for this study. The protein content between 13.34 to 18.52% in Senna and Baobab leaves. The results showed that, the protein content of the samples were lower than those obtained by Onibi *et al*. (2008). The Ash content of the vegetable samples ranges between 3.76-11.80%, the values were lower than those obtained by Ayssisiewede *et al*. (2012).

Mineral elements were analyzed, potassium was seen as the most abundant mineral element in all the legumes and manganese was not detected in all the legumes used for this research. Potassium is essential for normal muscular functioning of the heart, proper nerve stimulation, regulation of water balance and osmotic pressure. It also helps to maintain acid-base balance. Deficiency results in muscle weakness, loss of appetite, nausea, drowsiness etc., (Alayande *et al*., 2012). The concentration of sodium was found to be 2.40 mg/kg in cowpea (white), 1.71 mg/kg in cowpea (red) and 2.31 mg/kg in ground nuts, the values were generally higher than the ones obtained by Oke (1966). Zinc (Zn) was not detected in cowpea (red), 3.80 mg/kg in cowpea (white) and 2.30 mg/kg in ground nuts. The values obtained was higher than the quoted values by Awolabi *et al*. (2012). Zinc function as a co-factor and is a constituents of many enzymes like lactate dehydrgenase, alcohol dehydrgenase, glutarmic dehyrogenase, alkaline phosphatase, carbonic anhydrse, carboxypeptidase, superoxide dismutase, retinase reductase, DNA and RNA polymerase. Zinc dependent enzymes are involved in micronutrient metabolism and cell replication (Hays and Swenson, 1985; Arinola, 2008).

The sodium content of vegetable samples ranges between 3620.40 to 4011.50 mg/kg in baobab leaves sesame leaves respectively. It was higher in Sesame leaves and lower in Baobab leaves, however, the values were greater than those quoted by Ayssisiewede *et al*. (2012). Also potassium was higher compared to other researches. The values range between 48.1 to 27.6 mg/kg which was lower in sesame leaves and higher in Baobab leaves. The Zinc content of the vegetable samples ranged between 5.8 to 5.9 mg/kg. The lowest was seen in Baobab leaves. The result showed that there has no significance difference among the vegetable

samples. Some trace amount of lead was detected in all the samples as 1.90 mg/kg was detected Baobab leaves and *Hibiscus cannabinus* and relatively higher in Sesame leaves.

The vitamin content of the legumes was analyzed, the vitamin A (retinol) content ranges between 30.22 to 37.42 µg/100 g in cowpea (white) and was absent in ground nut. Vitamin A is important in preventing dim-light vision. B-carotene was not detected in all the samples used for this analysis. Vitamin $B_1$ (thiamin) ranges between 0.12 to 1.00 mg/100 g. The highest was seen in cowpea (red) and the lowest is observed in ground nut. The vitamins content of the legumes was generally low; this may be because of the length of storage of the food sample. The vitamin composition of the soup condiment samples was analyzed and the results showed that vitamin A in µg/100 g ranges between 16.47 to 7.40 µg/100 g (p<0.05) as shown in Table 3. The highest was observed in Baobab leaves and the lowest was seen Senna leaves. Also vitamin C was detected in Baobab leaves and was not detected in sanna and Vitamin E was detected in all the samples; 24.68 mg/100 g was detected in Baobab leaves, 18.88 mg/100 g in senna and 23.36 mg/100 g in sesame leaves.

The ant-nutrient content of legumes and vegetables are presented in Table 4. Our findings revealed that Phytate was present in all the legume samples, the values ranges between 3.11 mg/100 g in Ground nuts to 5.33 mg/100 g in cowpea (red). 144 mg/100 g of oxalate was seen in Cowpea (white), 270 mg/100 g is seen in Cowpea (red) and the lowest was seen in ground nuts with 97 mg/100 g. Tannin values range between 522 to 558 mg/100 g. Cowpea (white) has the highest tannin content. The anti-nutritional factors in the vegetables samples investigated in this research were phytate, oxalate and tannins. The phytate content ranges between 0.13 to 0.03 mg/kg (p<0.05). The highest was observed in Senna leaves and the lowest was seen in Baobab and sesame leaves. The values obtained agreed with the values reported by Ayssisiewede *et al*. (2012).

## CONCLUSION

The main objective of this study is to provide useful and current information on the nutrient composition (proximate, mineral element and vitamins) and the anti-nutritional factors (phytate, oxalate and tannins) of some selected commonly consumed food namely legumes and vegetables in Adamawa state has been achieved. The study showed that sodium, zinc and lead were higher in the vegetables and was low in legumes. Lead was not detected in legumes. But lead was detected in vegetables. Our findings revealed that the level of anti-nutritional factors was found to be high in a legume which has also led to the observation that the levels of some anti-nutritional factors may not affect the availability and utilization of nutrients. It was observed that legumes are good sources of vitamin A.

## RECOMMENDATIONS

It is recommended for further study on the following:

- Carry out proximate composition on other commonly consumed food samples in Adamawa state in order to obtain a comprehensive food composition data of Raw and processed as eaten in Adamawa state.
- Determine the amino acid profile of the commonly consumed food samples in the state.
- Determine other mineral element of the commonly consumed food in the state in order to obtain a comprehensive food composition table for the state.
- Determine other anti-nutritional factors of the commonly consumed food to ascertain the factors that may be responsible for availability and bi-availability of nutrients.

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