ANALYSES OF SOME LOCAL LEAFY VEGETABLES AS USEFUL SOURCES OF DIETARY MINERALS AND VITAMINS.

A THESIS SUBMITTED TO THE DEPARTMENT OF CHEMISTRY, FEDERAL UNIVERSITY OF TECHNOLOGY, YOLA, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF M.TECH. DEGREE IN INDUSTRIAL CHEMISTRY

BY

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Dec., 2009

DECLARATION

I hereby declare that this research work was carried out and written by me under the supervision of Dr. Dimas Kubmarawa. It has not been presented before in any form for any previous higher degree. References cited have been duly acknowledged.

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Supervisor	Date

CERTIFICATION

This is to certify that the research work, **"Analyses of some local leafy vegetables as useful sources of Dietary Minerals and Vitamins."** has been presented by Adedayo, Sarah Ajoke (M.TECH/CH/06/213) of the department of chemistry Federal University of Technology, Yola and has been read and approved as meeting part of the requirements for the award of Masters of Technology (M.TECH) Degree in Industrial Chemistry.

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DEDICATION

This research work is dedicated to my husband Engr. B. A Adedayo.

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I would like to reiterate my foremost gratitude to the Most High God for His sustenance.

My warm thanks to my supervisor Dr. Dimas Kubmarawa for his assistance, advice, patience, encouragement and the time taken to guide me through this research work.

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TABLE OF CONTENTS

TABLES

ABSTRACT

The leaves of *Hibiscus cannabinus, Balanites aegyptiaca, Haematostaphis barteri, Sesamum indicum, Cassia tora* and *Celtis integrifolia* (consumed largely by rural populace of Adamawa State) were analyzed for vitamins (B_1, B_{12}, E and K) using Flourimetry and Calorimetry and minerals (Calcium, Cobalt, Copper, Iron, Potassium, Manganese, Sodium and Zinc) using Atomic Absorption Spectroscopy and Flame Photometry. Mineral content varied appreciably, *Balanites aegyptica, Celtis integrifolia* and *Cassia tora* leaves contained the highest level of Calcium (3.80±0.90g/100g, 3.70±0.30g/100g and 3.52 ± 0.40 g/100g respectively), potassium, iron and manganese content was highest in *Sesamum indicum* leaves (1.49 ± 0.05g/100g, 0.76 ± 0.20 g/100g and 0.25 ± 0.02g/100g respectively). *Balanites aegyptiaca* leaves contained highest level of cobalt and copper (0.03 ± 0.00 g/100g and 0.04 ± 0.02 g/100g respectively). All the mineral elements determined were present in appreciable amounts. *Haematostaphis barteri, Hibiscus cannabinus, cassia tora* and *Celtis integrifolia* leaves contained the highest level of vitamin K (296.20 ± 0.33 mg/g, 294.4 ± 0.45 mg/g, 288.70 ± 0.52 mg/g and 286.90 ± 0.83 mg/g respectively. Vitamin B_1 was highest in *Hibiscus cannabinus* (0.12mg/g). *Sesamum indicum* leaves contained the highest level of vitamin E (0.10mg/g). Based on this finding, the vegetables could be used as alternative to vitamin and mineral supplements especially vitamin K, Calcium and potassium which helps in blood clotting and bone related problems.

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND OF THE STUDY

1.1.1 Nutritive value of vegetables.

Human beings require food to carry out essential functions which include growth, development and reproduction. It is therefore important to eat a balance diet which provides all the essential nutrients required by the body for energy, body building, maintenance and regulation of body processes. It is being recognized more and more that the most beneficial diet is likely to be most varied

one, drawing protein, dietary minerals and vitamins from as wide a range of source as possible. Diet needs to be balanced not only in terms of food values but also in terms of constituents which aids digestion and absorption of food. Some categories of these constituents also known as essential nutrients are proteins, dietary minerals, carbohydrates, essential fatty and amino acids, vitamins, fibre and water. One of the sources of these essential nutrients is green leafy vegetables. Vegetable is a culinary term which generally refers to an edible part of a plant. It also refers to all part of herbaceous plant eaten as food by humans whole or in part (Whitaker, 2001).

Green leafy vegetables constitute an indispensible constituent of human diet in Africa generally and West Africa in particular (Oguntona and Oguntona,1986). They are generally consumed as part of main meals and snacks or as cooked compliments to the major staples like cassava, cocoyam, guinea corn, rice and plantains. Vegetables are important protective foods and highly beneficial for the maintenance of health and prevention of diseases and also reinforce the resisting ability of the cells to counter bacterial infections due to the fact that they contain valuable food ingredient which is utilized to build and repair body. The variety of green vegetables so utilised are diverse.

Although in many cultures, conventional green vegetables such as cabbage or spinach are not grown at all; the leaves of other crops coupled with the use of wild vegetables provide an ample leafy content to the diet. The leaves of sweet potatoes, cassava, melons, and some beans are all used as vegetables in some parts of the world. In some areas in Nigeria, leaves of baobab tree and in Philippines,

leaves of papaya and cashew nuts trees are cooked and eaten as green vegetables providing considerable amounts of leaf protein. Two important dietary minerals Calcium and Iron found in vegetables are especially useful. Calcium is essential for strong bone and teeth while Iron is needed for blood formation and essential constituent of haemoglobin. Many vegetables contain vitamin A which is essential for normal growth, vitality, good eye sight, healthy skin and protection against diseases. By adding vegetables to a diet consisting only of cereals and beans, the quality of the proteins and its utilisation by the body was improved so much that it was almost equivalent to the best animal protein such as contained in milk (Pacey, 1990).

Green leafy vegetables when freshly harvested are best cooked immediately because some of their vitamin contents deteriorate on storage. Vitamins and dietary minerals contained in vegetable can be destroyed or lost through unsuitable cooking methods and therefore, cooking time should be as brief as possible. Vegetable has high moisture content from 72% in cassava leaves to 92-93% in Indian spinach and water leaves (Oguntona and Oguntona, 1986). They also contain cellulose and serve as useful roughage thus promoting normal elimination of waste product. Although leafy vegetables are not good sources of dietary energy because of their high moisture contents they are however rich in dietary minerals and vitamins. Among the nutrients, vegetable may be anti-oxidants, antibacterial, antifungal, antiviral and anticarcinogenic (Whitaker, 2001).

It has been estimated that perhaps over sixty (60) species of green leafy plants are so used in Nigeria (Okoli *et al*., 1988). Some like baobab tree are restricted in their distribution while amarantha are common in all areas of the country. There is also a seasonal variation in the availability of these vegetables, they grow abundantly during the rainy season and are scarce in the dry season except in some areas where dry season farming by irrigation is practiced. Studies by Fafunso and Bassir (1977) estimated per capital daily consumption of fresh vegetables in Nigeria to be 65g while another survey (Oguntona and Oguntona) showed consumption to be high as 360g per day.

The search for lesser known crops, many of which are potentially valuable as human and animal feeds has been intensified to maintain a balance between population growth and agricultural productivity in the tropical and sub-tropical areas of the World (Oyebiodun *et al*.,1983). This has generated considerable interest by recent studies on the chemical composition and nutritional value of lesser known plants in Nigeria. Furthermore, survey of diet related illness like kwashiorkor and protein-calorie malnutrition are attributed to shortage of protein which is readily available in vegetables like peas and beans. The fight against mal-nutrition and undernourishment continues to be a basic goal of development and a variety of strategies are being applied. The strategy based on nutrient-rich food like vegetable is considered essential (Susane, 1996). This is because most leafy vegetables particularly the dark green variety contain pro- vitamin A as do carrots, sweet peppers and some tomatoes , they also supply vitamin C and in many cases Iron and Calcium as well to the diet.

1.2 STATEMENT OF THE PROBLEM

Green leafy vegetables consumed in Nigeria both cultivated and the wild have been the subject of many analytical studies in the past (Victor, 1998; Oke, 1969; Ifon and Bassir, 1979; Faboya, 1983; Barminas *et al*., 1998; and Kubmarawa *et al*; 2008). Considerable information exists on the nutritional, anti-nutritional and proximate composition. The short comings of some of these studies, however, are that they are limited in scope. There are a lot more vitamins and essential dietary minerals other than the ones that have been studied.

1.3 OBJECTIVES OF THE STUDY

(i) Determination of mineral elements in the leaves of *Cassia tora, Hibiscus cannabinus, Sesamum indicum, Balanites aegyptiaca, Haematustaphis barteri* and *Celtis integrifolia.*

(ii) Determination of the different types of vitamins in the above named vegetables.

(iii) Suggest possible industrial applications of the vegetables based on the research findings in (i) and (ii) above.

1.4 SIGNIFICANCE OF THE STUDY

There are over sixty species of green vegetables both in the wild and cultivated in Nigeria that are being used by people in both urban and rural communities (Okoli *et al.,* 1988).

However, there is little information on the chemical composition and nutritive value of some vegetables consumed by some rural communities in Nigeria. The purpose of this research therefore is to assess the nutritive value and chemical composition of these vegetables frequently consumed in Adamawa state especially among the rural communities.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 ESSENTIAL NUTRIENTS

An essential nutrient is a nutrient required for normal body functioning that cannot be synthesized by the body and must be obtained from a dietary source. Some categories of essential nutrients include vitamins, dietary minerals, essential fatty acids and amino acid (Brown and Rogers, 1987).

2.1.1 DIETARY MINERALS

Various minerals have been shown to be essential for man. These can be divided into micro nutrients and trace elements. The element present in largest amount in the body is carbon, hydrogen, oxygen, nitrogen and sulphur, apart from these, the following minerals are required for human health: calcium, chlorine, cobalt, copper, iodine, iron, magnesium, manganese, molybdenum, phosphorus, potassium, selenium, sodium, and zinc (Brown and Rogers, 1987). The roles of these minerals in human diet as follows:

2.1.1.1 CALCIUM

Calcium is essential for living organisms particularly in cell physiology and is the most common metal in many animals. It is an important component of a healthy diet and essential for the normal development and maintenance of bones and teeth; assists in the production of lymphatic fluids, helps in clotting of blood, normal heart action and muscle activity. It also activates enzymes.

A deficiency results in poor bone and tooth formation, retarded growth, rickets and slow blood clotting. Sources of calcium are; dairy products, orange, amaranth,

dark green leafy vegetables and fortified products such as orange juice and soya milk (Ihekoronye and Ngoddy, 1985).

2.1.1.2 COBALT

Cobalt is required in the manufacture of red blood cells and in preventing anaemia. If a normal diet is followed, deficiency is most unlikely. Cobalt is part of the vitamin B_{12} molecule, its function is interwoven with that of vitamin B_{12}.Food sources is pulses and vegetables (Ihekoronye and Ngoddy, 1985)

2.1.1.3 COPPER

Copper is an essential nutrient to all high plants and animals. It is found primarily in the bloodstream as a cofactor in various enzymes. It is essential for the formation of haemoglobin of the red blood cells. Deficiency can often produce anaemia-like symptoms. Sources are liver, kidney, brains, nuts, raisins, cocoa, root crops, dried legumes, cereals, potatoes, vegetables and meat (William, 2003).

2.1.1.4 IRON

Iron is a necessary trace element used by almost all living organisms. It is essential for the formation of haemoglobin of the red blood cells. Its deficiency is associated with low blood level called anaemia characterized by weakness, dizziness, loss of weight. Good sources of dietary iron includes; liver, organ meat, legumes, dried fruits, egg yolk, whole grain, cereals, dark green and leafy vegetables (Ihekoronye and Ngoddy, 1985).

2.1.1.5 MANGANESE

Manganese is found as a free element in nature often in combination with iron and many minerals. Manganese (II) ions functions as co-factors for a number

of enzymes. It helps the body utilize biotin, thiamine, ascorbic acid and choline. It also helps the bone to be strong and healthy, helps the body to synthesize fatty acids and cholesterol, maintain normal blood sugar level and it is also an anti oxidant. Deficiency is associated with nausea, vomiting, poor glucose tolerant, skin rash, loss of hair colour, low cholesterol level and in infants leads to paralysis, convulsion, blindness and deafness. Sources are pineapple, raspberries, spinach, beans, banana, carrots, and milk among others (Ensansa and Clegg, 2002).

2.1.1.6 POTASSIUM

Potassium is isolated from potash and occurs naturally bound to other elements in sea water and many minerals. It is an essential micronutrient in human nutrition. It is the major cation inside animal cells thus important in maintaining fluid electrolyte balance in the body. It is also important in allowing muscle contraction and sending of nerve impulses in animals, influences osmotic balance between cells and the intestinal fluid thereby keeping cells alive. Deficiency symptoms include muscle weakness, decreased reflex response and respiratory paralysis. Food sources rich in potassium include; orange juice, potatoes, bananas, soybeans, avocadoes, apricots and green leafy vegetables which is the richest source and meat (Brown and Rogers, 1987).

2.1.1.7 SODIUM

Sodium is a component of many minerals, an essential element for animal life. It helps regulate fluid balance and acid-base balance. It also helps in osmosis, it regulates muscle and nerve irritability, it is also used for glucose absorption. Symptoms of sodium deficiency that is combined with loss of water are muscle

cramps, exhaustion, nausea. High source of sodium are in most cases processed foods, salt, meat, poultry, fish, eggs and milk (Donatelle, 2005).

2.1.1.8 ZINC

Zinc is necessary for a healthy immune system and fighting skin problems such as acne, boils and sore throat. It is also needed for cell division and helps the tissue of the hair, nail and skin to be in top form. Zinc also performs the following functions; growth and maintenance of muscles, normal growth for children, sexual development, synthesis of collagen and protein. Deficiency in zinc will result in an underperforming immune system, open to infections, allergies, night blindness, loss of smell, falling hair, skin problems, sleep disturbance, fertility problem in men and women. Food sources of zinc are; muscle meat, poultry, fish, sea food, grains, nuts, eggs, seeds, and brewer's yeast (Valko and Morris, 2005).

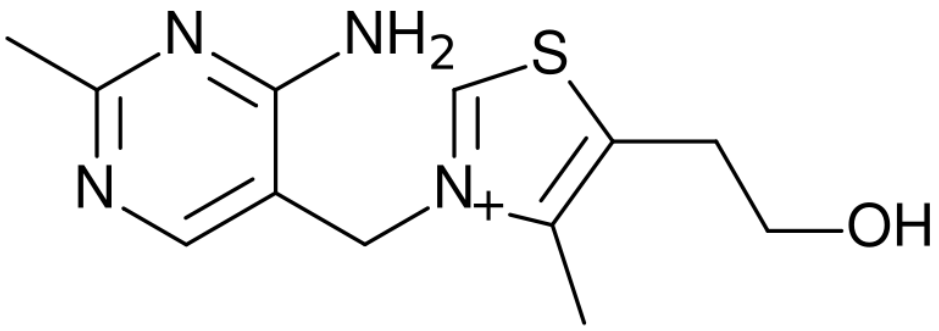
2.2 VITAMINS AS NUTRIENT SOURCE

A vitamin is an organic compound required in tiny amounts for essential metabolic reaction in living organisms; they are also natural substances found in plant and animals. In humans, there are thirteen vitamins, which can be divided into two main groups; Fat soluble and water soluble. The fat soluble Vitamins are A, D, E and K. These Vitamins are absorbed through the intestinal tracts with the help of lipids. The water soluble Vitamins are C and B complex (8 in number). These Vitamins are easily absorbed by the body. Dietary supplements often containing vitamins are used to ensure that adequate amount of nutrients are obtained on a daily basis if optimal amounts cannot be obtained through a varied

diet (Brown and Rogers, 1987). Out of the thirteen vitamins mentioned above, only five are found in vegetables, these are Vitamins A, B_1, C, E & K. Similar research has been carried out on vitamins A & C, as a result, this research work is based on Vitamins B_1, B_{12}, E & K.

2.2.1 VITAMIN B_1 (THIAMINE)

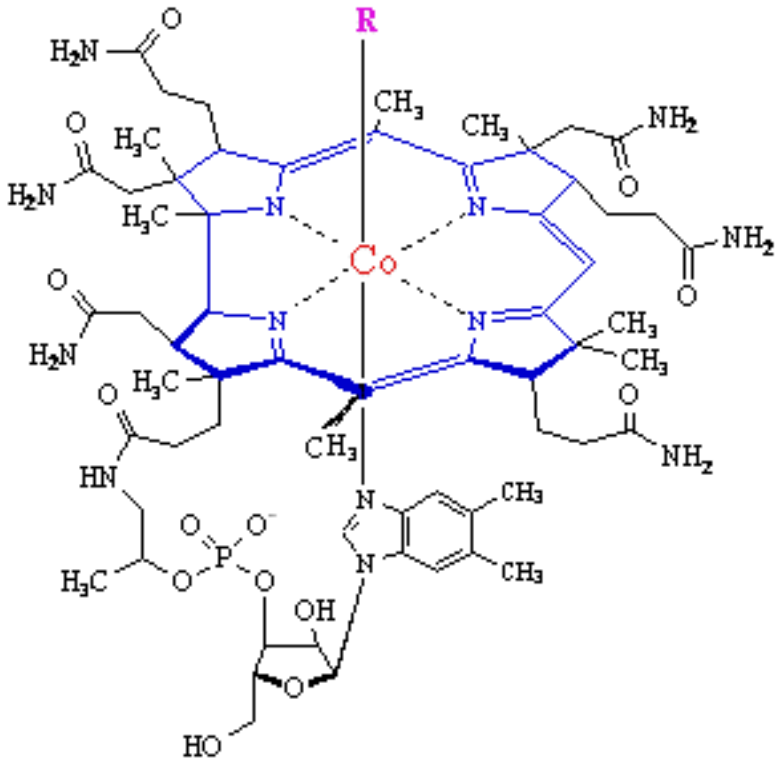
Thiamine plays an important role in helping the body metabolize carbohydrates and fats to produce energy for cell respiration, normal functioning of heart and nervous system. Thiamine deficiency can lead to, beriberi, loss of appetite, irritability, less resistance to fatigue and constipation. Good sources of thiamine: green peas, spinach, liver, yeast, potatoes, legumes, kidney, meat and dried vegetables (Ihekoronye and Ngoddy, 1985).



The structure of Thiamine

2.2.2 VITAMIN B_{12} (COBALAMIN)

Cobalamin helps maintain nerve cells and red blood cell. It is needed to make DNA. Deficiency occurs as a result of an inability to absorb it from food and in strict vegetarians. Symptoms are; stomach and intestinal disorders, anaemia, dementia, weakness, constipation, loss of appetite, weight loss, poor memory. Cobalamin is naturally found in foods that come from animals including fish, meat, poultry, egg milk and its products (Folate, 1996).

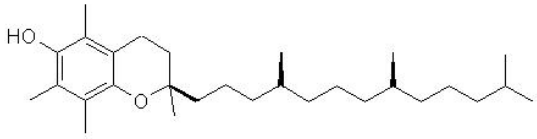


The structure of Vitamin B_{12}

2.2.3 VITAMIN E (α TOCOPHEROL)

It is a powerful biological antioxidant which protects the cells against effect of free radicals which can damage cells and may contribute to the development of cardiovascular diseases and cancer. It also plays role in immune function, DNA

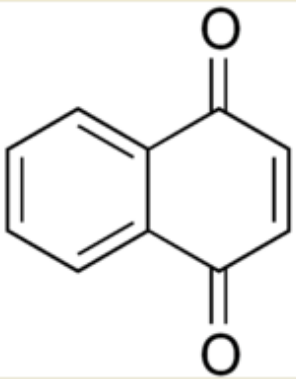
repair and other metabolic processes (Farell and Roberts, 1994). Its deficiency may result in the following; poor transmission of nerve impulses, muscle weakness, degeneration of the retina and infertility. Sources are vegetable oils, nuts, green leafy vegetables, wheat germ oil, almonds, sun flower seeds and peanut butter (Tanyel and Mancano, 1997).



The structure of Tocopherol

2.2.4 VITAMIN K (NAPHTHOQUINONE)

It is mostly required for blood coagulation, bone metabolism and vascular biology. It is used as prophylactic measure to prevent late–onset haemorrhage disease. Vitamin K deficiency results in slow clotting of blood and haemorrhagic disease in new born. Its deficiency may however occur by disturbed intestinal uptake or by accidental intakes of its antagonists. It is found in green leafy vegetables such as spinach, lettuce, cabbage, pumpkin, cauliflower and cereals (Ihekoronye and Ngoddy, 1985).



The structure of Naphthoquinone

2.3 VEGETABLES

2.3.1 *Balanites aegyptiaca (Desert date)*

The common name is desert date while the Hausa name is aduwa. It is a tree reaching a height of 10-12 meters with a dark brown bark, shoots have strong green spines the fruit is a drupe. The species are found wild in Adamawa and Borno states (Bokhari and Ahmed, 1979) and in all dry lands of Africa. It is common in Israel, Jordan, the Arabian Peninsula, Pakistan and India. Flowers appear in April and the fruit ripe and fall in December-January. The tree is tolerant to drought. The green leaves are eaten by humans and animals. The wood is used for making tool handles, camel saddles, candle sticks etc. The seeds are rich in protein and contain 41% oil which is edible. The fruit is rich in vitamin A and the kennels vitamin B (Baumer, 1983). It has a calorific range of 514 kcal/100g – 567kcal/100g. The pulp of fruits contain an average of 10.9% moisture, 2.7% ash, 1.4% protein, 0.29% oil, 36% sugar, 16% alcohol – insoluble solids, 93mg/100g calcium, 15mg/100g iron, 57mg/100g phosphorus (http:ecoport.org/eplant).

The seed contains 38.2% oil and the following mineral element expressed in mg/100g dry weight: Magnesium 437, Calcium 240, phosphorus 630, Iron 30 and Manganese 90. The phyto chemical investigation of the back has demonstrated the presence of furanocoumarin. Bark also contains saponins (Eromosele *etal*.,1994)

2.3.2 *Haematustaphis barteri (Blood plum)*

The common name is Blood Plum and the Hausa name is jinin kafiri. The tree is found wild in Adamawa and Borno states. The fresh tender leaves are

edible. The red-purple fruit which has oily seed is edible (Bokhari and Ahmed, 1979). The compositions are as follow: oil 54.5%, crude protein 4.11%, crude fibre 2.4%, ash 1.0%, moisture 9.0% and carbohydrate 29.0% (Eromosele *et al*., (1994).

2.3.3 *Hibiscus cannabinus (Kenaf)*

The common name of this vegetable is kenaf while the Hausa name is rama. It is an annual herbaceous plant which is tall with a woody base, it is widely grown in tropical and sub tropical climates. It grows well during rainy season. Kenaf leaves which are acidic are eaten by both plants and animals. It is either cooked, used as a pot herb or as additives to soup, powdered leaves are used as purgatives. The seeds yield edible oil, which is high in omega antioxidant and used for cosmetics, industrial lubricants, bio-fuel, manufacture of soap, linoleum paints and vanishes. The blast fibre is used for fuel insulation, clothing, paper, packing material, organic filler for blending of plastics, injection moulding and various types of mats and containers (Mabberly, 1987).

The seeds contain radium, thorium and rubidium and fatty oil like groundnut oil (Reed, 1976). It also contains moisture 9.6%, ash 64%, fatty oil 20.4%, Nitrogeneous matter 21.4%, saccharifiable matter 15.7%. The seed oil contains oleic acid 45.3%, linoleic acid 23.4%, palmitic acid 14.0% and stearic acid 6.0%. The dry pressed cake contains proteins 33.0%, oil 6.0%, crude fibre 17.4%, ash 60.0%, N-free extract 37.6%. The following amino acids have been identified in the acid hydrolysates of the proteins albunin 15.38%, arginine 6.23%, tyrosine 1.80%, and lysine 3.05%. Fresh stems from India contains crude protein 15.0%, crude fibre 19.9%, ash 82.0%, N-free extract 51.1%, Calcium 2.08% and

Phosphorus 0.5%. Dry leaves contain crude protein 13.1%, crude fibre 11.6%, ash 11.8%, N-free extract 61.4 %, calcium 3.31% and phosphorus 0.35% (Reed, 1976).

2.3.4 *Sesamum indicum (Sesame or Ridi)*

Its common name is Sesame and the Hausa name is ridi. It is a flowering plant in the genius *Sesamum*, an annual plant widely naturalized in tropical regions around the world. Numerous wild relatives occur in Africa and in India. It is cultivated and used in over fifteen states of Nigeria (Falusi,1999). It is economically and nutritionally important according to (WHO/FAO, 1973). The leaves are edible and eaten as potherb (Zohary et al.,2000) and can also be used for cold infections, acute diarrhoea, dysentery kidney and urethra infections. Seeds are rich in oil and are sometimes added to bread and hamburger buns. The seeds are also rich in manganese, copper, calcium, vitamin A, B and E; it is also a rich source of unsaturated fatty acids (Bown, 1995). The seeds also contain 21.5% protein, 60.8% fat, 8.9% carbohydrate and 3.4% ash (Reed, 1976).

2.3.5 *Cassia tora (Foetid Cassia)*

The common name is foetid cassia, sickle serna, and the Hausa name is tafassa. Cassia tora is an annual plant that grows wild in north, central and South America, Asia, Africa and Oceania. Useful parts are leaves, roots and shoots which are eaten and are used medically in Asia. It is beneficial to the eye. The leaves are used for skin diseases, fever, congestion, illness and headache.

(http://en.wikipeida.org/wiki/sennaobtusitolla,,2007)

Barminas et al 1998 reported the mineral element content of C*assia tora* on mg/100g dry weight basis as follows : phosphrous 802.6 ± 184.9, calcium 860.4 ±

196.4, iron 20.4 ± 4.3, manganese 4.8 ± 0.1, copper 1.8 ± 1.2, zinc 20.9 ± 8.4 and magnesium 396.8 ± 116.6. Values are mean SD for three determinations.

2.3.6 *Ceiltis integrifolia (Dunki)*

The Hausa name is Dunki. It belongs to the *Ulmaceae* family. It is common in Savanna areas in Nigeria. It is also found in Senegal, Uganda, Sudan and Arabia. It is usually found in drier Savanna regions often along rivers or streams and is locally abundant. The tree grows up to 24-30m high, 5m in girth, branching low down with a spreading rounded crown. The bark is grayish and fairly smooth flaking off in large thin hand plates. The twigs and young foliage are short and hairy. The leaves are 3.5 to 9cm long by 2.5cm broad, they are unsymmetrically ovate, shortly acuminate, the upper edge usually much more rounded than the lower but meeting the stalk at the same level. The flowers which are grayish in colour and unusually unisexual appear between December to April. The fruits are fleshy drupes and are edible. The wood is light yellow and soft (Keay., 1989). The main constituents of the leaves are gamma amino butyric acid (GABA), sugars, gallic acid and leucocyanidin (Muazu, 1997). The deficiency of GABA may lead to convulsions. The leaves are used in treating epilepsy among the Hausa/Fulani tribes in northern Nigeria (Muazu and Kaita, 2008).

2.4 COMPARATIVE REPORTS

Green leafy vegetables consumed in Nigeria both cultivated and wild have been the subject of many analytical studies (Osagie and Eka, 1999). Research

report carried out by many scientists on proximate composition of Nigerian leafy vegetables. The composition of *Sesamum indicum* are as follows, moisture 80%, protein 4.5g, total fat 0.6g, crude fibre 2.0g, and ash 3g. That of *Hibiscus cannabinus* are: moisture content (8.05%), protein (5.8g) total fat and crude fibre are (3.0g) and ash (1g) respectively (Oguntona and Oguntona, 1986). Another research carried out by Barminas *et al* (1998) on mineral composition of non-conventional leafy vegetables gave the composition of *Cassia tora* leaves as follows: Phosphorus (802.6±184.9); Magnesium (396.8±116.6); Calcium (860.4±196.4); Iron (20.4±4.3); Manganese (4.8±0.1); Copper (1.8±1.2) and Zinc (20.9±8.4) (mg/100g dry weight). Calcium has the highest composition which could serve as rich source of this mineral. It is closely followed by phosphorus. Eromosele *et al.*, (1994) reported that the seeds of *Balanites aegyptiaca* contain 38.2% oil; magnesium (437), calcium (240), phosphorus (630), iron (30) and manganese (90) mg/100g. Kubmarawa *et al*., (2008) reported that *Hibiscus cannabinus, Balanites aegyptiaca, Haematostaphis barteri and Sesamum indicum* contain Vitamin C, Calcium, Magnesium, Zinc, Iron and Phosphorus as indicated in the table overleaf:

Table 2.1 Vitamin C and Mineral Element Content of the Vegetables (g/100g dry weight)

Vegetables	*Hibiscus cannabinus*	*Balanites aegyptiaca,*	*Haematostaphis barteri*	*Sesamum indicum*
Vitamin C	0.078 ± 0.00	0.172 ± 0.004	0.1117 ± 0.01	0.064 ± 0.000
Calcium	1.48 ± 0.21	3.78± 0.07	1.73 ± 0.14	1.78 ± 0.01
Magnesium	0.96 ± 0.04	0.86 ± 0.04	0.70 ± 0.04	0.39 ± 0.12
Zinc	0.07 ± 0.00	0.02 ± 0.01	0.06 ± 0.01	0.05 ± 0.00
Iron	0.03 ± 0.00	0.07 ± 0.01	0.11 ± 0.07	0.05 ± 0.07
Phosphorus	0.25 ± 0.02	0.19 ± 0.02	0.13 ± 0.12	0.38 ± 0.24

Values are mean ± SD for three determinations (Kubmarawa *et al*.,2008).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Reagents

All the chemical reagents used for this research work are of analytical grade and were used without further purification.

3.2 Sampling and Sample Treatment

Young tender leaves of *Balanites aegyptiaca*, *Cassia tora*, *Haematotaphis barteri, Hibiscus cannabinus, Celtis integrifolia* and *Sesamum indicum* were collected in September 2008 from Jimeta and Yola markets and from farm lands/wild in Adamawa State. The samples were collected twice within the same period. Each of the samples was destalked as practiced locally, washed with distilled water, air dried for some days. It was grounded into fine powder using stainless steel mortar and pestle, sealed in polythene bags and labeled appropriately for analysis.

3.3 Analysis of Minerals

3.0g of the powdered sample was weighed and pre-treated with 20ml concentrated nitric acid and allowed to stay overnight. 10ml per-chloric acid was added and heated gently, then vigorously until clear solution was obtained.

The solution was allowed to cool and then transferred to a 100ml volumetric flask and made up to mark with distilled water (Onwuka, 2003). The solution was then

filtered and stored in plastic bottles for the determination of Zn, Ca, Cu, Co, Fe, Mn, K, Mn and Na using atomic absorption spectrophotometry (Model 969 501361 v 5.50) with cathode lamps that match the different elements. Appropriate dilutions were made for each element. Potassium and sodium were determined using flame photometer

Calibration curves were constructed for each element using standard solution by plotting absorbance versus concentration. By extrapolation, the concentrations of the metals in sample digests were obtained.

Preparation of Standard Solution.

The method described by Onwuka, (2005) was adopted. Working standards for each element were prepared from their salts and further dilutions of 1000ppm stock solutions were made as follow:

Calcium: dissolved 2.497g of oven-dried $CaCO_3$ and dilute to 100ml with de-ionized water. This solution contains 1000mg Ca^{2+} ions. From the stock solution, Calcium standard solutions with the following concentrations were prepared: 0.5, 1.0 and 2.0 ppm.

Cobalt: 1.0g of cobalt was weight and dissolved in 10ml Conc. HCl, the solution was boiled and evaporated almost to dryness in a water bath. De-ionized water was added and transferred to a 100ml volumetric flask and made up to mark. Cobalt standard solutions were prepared from the stock solutions with the following concentrations 0.0, 1.0, 2.0 and 3.0 ppm.

Copper: A stock solution containing 100mg/ml of Cu^{2+} ions was prepared by dissolving 2.682g of $CuCl.2H_2O$ in de-ionized water and finally diluted to 1000ml. Standard solutions of concentration 0.5, 1.0 and 2.0 ppm were prepared from the stock solution.

Iron: A stock solution containing 1000ml of Fe^{3+} ions was prepared from 1.0g of pure ions wire. The wire was dissolved in 100ml conc. HNO_3, boiled on a water bath and diluted to 1000ml with distilled water. From this stock solution, standard solution of concentration 0.5, 1.0 and 2.0 ppm were prepared.

Sodium: A stock solution containing 1000ml of sodium ions is prepared by dissolving 2.542g of oven-dried NaCl in de-ionized water and subsequently diluted to mark. From this solution, standard solutions with concentrations 0.0, 2.0, 4.0 and 6.0 ppm were prepared.

Potassium: A stock solution containing 1000ml K^+ ions was prepared by dissolving 1.907g of KCl in water. The solution is made to mark with distilled water. From this stock solution, standard solutions with concentrations 0.0, 5.0, 10.0 and 15.0 ppm were prepared.

Manganese: A stock solution of manganese was prepared by dissolving 1.5825g of MnO_2 in water and finally diluted to 1000ml using distilled water. Standard solutions of concentrations 0.0, 1.0, 2.0 and 3.0 ppm were prepared from the stock solution.

Zinc

A stock solution containing 1000ml of zinc ion was prepared by dissolving 1.0g of zinc ribbon in 10ml of concentrated HCl. The solution was evaporated almost to dryness and made up to mark in 1000ml volumetric flask using distilled water. Working standards of 0.1, 0.2, and 0.4, ppm were prepared from the stock solution by serial dilution using the relationship $C_1V_1 = C_2V_2$ where;

C_1 = Concentration of the stock solution. C_2 = Concentration of the standard solution to be prepared. V_1 = Volume of stock solution taken for use.

V_2 = Volume standard solution to be prepared.

A calibration curve was plotted for each of the metals and the concentrations of metals in samples were extrapolated from the respective plots. Concentration for the metals was calculated thus: Concentration in g/100g = (mg/l x 100)/1000 (Onwuka, 2005).

3.4 ANALYSES OF VITAMINS

3.4.1 DETERMINATION OF VITAMIN B_1 (THIAMINE)

10g of leaf samples were weighed and transferred to a 25ml glass-stoppered cylinder, 10ml of 10% Sodium hydroxide solution and 0.1ml of 0.1% Potassium ferricyanide solution were added. The mixture was stirred for 10 minutes after which it was extracted with 13ml of Isobutyl alcohol. It was centrifuged and 10ml

of the supernatant solvent was transferred to the cell of the fluorimeter and the reading noted (Jacobs, 1999).

3.4.2 DETERMINATION OF VITAMIN E (α TOCOPHEROL))

10g of leaf samples were weighed into a long neck flask containing 200ml of absolute alcohol to which 3ml of freshly prepared Potassium hydroxide solution and a pinch of pyragallol was added. The mixture was heated on a water bath and refluxed for an hour. The alcohol was kept vigorously boiling during this process. The saponified mixture was cooled quantitatively and transferred to a separating funnel with 50ml of water. It was extracted three times with 50ml portions of ether. The combined ether extract was first washed with water and was then shaken with freshly prepared Potassium hydroxide solution after which it was dried over anhydrous sodium sulphate and evaporated under vacuum in an atmosphere of Carbon dioxide. The residue was dissolved in 25ml of ethyl alcohol and 1ml of 0.2% Ferric chloride solution was added in absolute ethyl alcohol and mixed. 1ml of 0.5% solution of a, a′-dipyridyl in absolute ethyl alcohol was added and mixed, the volume was made up to 25ml. A blank was prepared in a similar manner. The solution was allowed to stand for 10 minutes and the colours were compared in a photometer with a standard solution prepared from pure tocopherol treated with same amount of reagents. The reading was taken at 520nm. The known and unknown were corrected for the blank determination (Jacobs, 1999).

3.4.3 DETERMINATION OF VITAMIN K (NAPHTHOQUINONE)

Dried 10g of leaf sample was weighed and 10ml of butyl alcohol solution was added. It was then reduced using phenosafranine as indicator. The resulting Vitamin hydroquinone was then treated with an excess of butyl alcohol solution of sodium 2,6 – dichlorobenzene-oneindophenol in the absence of air. The decrease in colour is proportional to the quinone originally present (Jacobs, 1999).

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 MINERAL ELEMENT CONTENT OF THE SAMPLES

The mineral element compositions of the six vegetables studied on dry weight basis are shown in Table 4.1 below.

Table 4.1 Mineral Element Content of the Vegetables (g/100g dry weight)

Mineral Elements	*Hibiscus cannabinus (Rama)*	*Balanites aegyptiaca (Aduwa)*	*Haematostaphis barteri (Jinin kafiri)*	*Sesamum indicum (Ridi)*	*Cassia tora (Tafasa)*	*Celtis integrifolia (Dunki)*
Ca	3.14 ± 0.41	3.80 ± 0.90	1.65 ± 0.02	2.90 ± 0.44	3.52 ± 0.40	3.70 ± 0.30
Co	0.02 ± 0.00	0.03 ± 0.00	0.01 ± 0.00	0.02 ± 0.00	0.02 ± 0.00	0.01 ± 0.00
Cu	0.04 ± 0.02	0.04 ± 0.02	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	0.03 ± 0.01
Fe	0.46 ± 0.03	0.25 ± 0.11	0.24 ± 0.20	0.76 ± 0.20	0.22 ± 0.07	0.22 ± 0.12
K	1.25 ± 0.01	1.30 ± 0.19	1.34 ± 0.01	1.49 ± 0.05	0.76 ± 0.06	1.44 ± 0.01
Mn	0.23 ± 0.03	0.12 ± 0.00	0.11 ± 0.00	0.25 ± 0.02	0.10 ± 0.00	0.13 ± 0.10
Na	0.14 ± 0.01	0.22 ± 0.01	0.23 ± 0.02	0.10 ± 0.00	0.10 ± 0.00	0.07 ± 0.01
Zn	0.03 ± 0.01	0.03 ± 0.02	0.03 ± 0.02	0.05 ± 0.02	0.04 ± 0.01	0.02 ± 0.01

Values are mean ± SD for three determinations

Calcium which is essential for development of teeth and bone is comparatively higher in *Balanites aegyptiaca* (3.80 g/100g) in comparison to *Solanum africana* (3.6g/100g) (Aletor *et al*; 1995). This value is higher than is obtainable in most leafy vegetables, *Balanites aegyptiaca* therefore could serve as a rich source of this mineral compared to common vegetables (Friederike and Clause, 1996). The values of calcium obtained for *Celtis integrifolia* and *Cassia*

tora are 3.70g/100g and 3.52g/100g respectively. These values are higher than those of *Amaranthus hybridus* (2.78g/100g) (Ifon and Bassir, 1979) and Crassocephalum (2.80g/100g) (Aletor *et al*., 1995). *Haematostaphis* barteri has the least value of calcium (1.165g/100g) since the recommended daily calcium intake varies from 1.2g to 1.5g per day (Donatele, 2005) depending upon the stage of life, a meal containing a modest serving of *Balanites aegyptiaca* (100g per day) is enough to supply an adult's daily calcium needs (Sceranio *et al*., 1995).

The level of potassium in these vegetables ranged from 0.76g/100g to 1.49g/100g with *Sesamum indicum* having the highest value (1.49g/100g). This range is much lower than the values of this element in *Basella rubra* (5.80g/100g) (Aletor *et al*., 1995) and *Amaranthus hybridus* (4.29g/100g) (Ifon and Bassir, 1979). A diet rich in this vegetable therefore will be good in maintaining fluid electrolyte balance in the body thereby keeping cells alive.

The levels of iron in these vegetable samples ranged from 0.22g/100g in *Cassia tora* and *Celtis integrifolia* to 0.76 g/100g in *Sesamum indicum*. These values are higher than the 0.11g/100g in *Amaranthus hybridus* (being one of the most common vegetables consumed in Nigeria) and 0.07g/100g in *Crassocephalum biafrea* (Aletor *et al*., 1995). Iron is important in the diet of both pregnant and lactating mothers as well as infants, the convalescent and the elderly (Awoyinka, *et al*., 1995) its dietary deficiency which is associated with low blood level called anemia characterized by weakness and dizziness (Ihekoronye and Ngoddy, 1985)

could be prevented by regular consumption (100g/day) of these vegetables in diets since the tolerable upper intake level for adults is 0.04g/day (Durupts, *et al*., 2000).

Manganese content was highest in *Sesamum indicum, Hibiscus cannabinus* and *Celtis integrifolia* (0.25g/100g, 0.23g/100g and 0.13g/100g) respectively. A diet rich in these vegetables therefore will help keep the bone strong and healthy, protect the cells from free radical damage and also prevent the adverse effect of Manganese deficiency which results in paralysis of infants, convulsions, loss of hair colour and bones and low cholesterol level (Ensansa and Clegg, 2002).

Sodium is a dietary element needed by the body to function properly. Its recommended daily intake is 100mg/day. It helps to control electrical charges that occur between cells, keeps blood from clotting and its pressure within normal ranges (Donatelle, 2005). This dietary element is present in appreciable amounts in all the six vegetable samples analyzed with the highest value in *Haematostaphis barteri* (0.23g/100g). This value is much lower than those obtained in most common vegetables.

The concentration of cobalt, copper and zinc were rather low, but they will still supplement other sources of these minerals and regular consumption may help in preventing adverse effects of dietary deficiencies of these mineral elements which is associated with anemia, low immunity and infertility problem in both men and women (Valko and Morris, 2005).

The vitamin content of the six vegetable samples analyzed on mg/g are shown in Table 4.2 overleaf.

Table 4.2 Vitamin Content of the Vegetables (mg/g)

Vegetables	Vitamin B_1	Vitamin E	Vitamin K
Hibiscus cannabinus	0.12 ± 0.002	0.08 ± 0.002	294.4 ± 0.45
Balanites aegyptiaca	0.08 ± 0.002	0.06 ± 0.00	240.4 ± 0.45
Haematostaphis barteri	0.04 ± 0.00	0.08 ± 0.002	296.20 ± 0.33
Sesamum indicum	0.08 ± 0.002	0.10 ± 0.00	250.4 ± 0.50
Cassia tora	0.06 ± 0.00	0.02 ± 0.00	288.70 ± 0.53
Celtis integrifolia	0.06 ± 0.00	0.08 ± 0.00	286.90 ± 0.83

Values are mean ± SD for three determinations.

All the vegetable samples studied contained very high amounts of vitamin K, the values ranged from 240.4 mg/g to 296.20mg/g with *Haematostaphis barteri* having the highest value (296.40mg/g). Vitamin K is found mostly in green leafy vegetables among other sources, it is required for blood coagulation and bone metabolism, regular consumption of any of these vegetables therefore will help in preventing the adverse effects of its deficiency which results in slow clotting of blood (Ihekoronye and Ngoddy, 1985).

Vitamin E is a fat soluble vitamin which is a powerful antioxidant which protects cell membranes against the damaging effects of free radicals (Farell and

Roberts, 1994). This vitamin is present in appreciable amounts in all the six vegetable samples analyzed, *Sesamum indicum* having the highest value (0.10mg/g or 10mg/100g). The daily dietary intake of vitamin E for adults is 15mg/day while for lactating mothers is 19mg/day, a diet containing any of these vegetables may supplement other sources of this vitamin which may help prevent infertility (Tanyel and Muncano, 1997).

Values of vitamin B_1 in the vegetable samples studied ranged from 0.04 (4mg/100g) in *Haematostaphis barteri* to 0.12 mg/g (12mg/100g) in *Hibiscus cannabinus*. These values are high in comparison to the values of this vitamin in *Adansonia digitata* (0.40 mg/100g or 0.0004mg/g) (Addy, 1978) (Oguntona, 1985) and *Manihot utilisima* (cassava leaves) (0.25 mg/100g or 0.0025mg/g) (West *et al*., 1988). A meal containing a modest serving of this vegetable is enough to supply the daily vitamin B_1 needs of an adult which can prevent the effects of its deficiency called beri-beri (Ihekoronye and Ngoddy, 1985).

Vitamin B_{12}, was also analyzed in the vegetable samples but no trace of it was found, probably because it is naturally found in foods that come from animals (Folate, 1996).

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The results from this research indicate that *Hibiscus cannabinus, Balanites aegyptiaca, Haematostaphis barteri, Sesamum indicum, Cassia tora* and *Celtis integrifolia* are rich in nutrients. The mineral and vitamin composition of these local leafy vegetables studied which is largely consumed by the rural populace of Adamawa State could be rich sources of minerals and vitamins especially calcium, potassium, iron and vitamin K which are highest in *Balanites aegyptiaca, sesamum indicum* and *Haematostaphis barteri* respectively. Significant contribution regarding the recommended daily allowance (RDA) for the nutrients may be met by these vegetables. These vegetables will play an important role in the diet with regards to the prevention of bone and teeth problems and blood clotting. Earlier studies on *Hibiscus cannabinus, Balanites aegyptiaca, Sesamum indicum and Haematostaphis barteri* suggests that their anti-nutritional contents are lower than is obtainable in most common Nigerian vegetables, which implies that the overall nutritional value of these vegetables will not be affected. This further suggests these local vegetables are not inferior to the common conventional vegetables.

5.2 RECOMMENDATION

There is the need to study the effect of preservation by drying on nutrients in these vegetables. Research should also be made on pro-vitamin A carotenoids and total carotenoids contents, this is important in view of the fact that its deficiency is associated with blindness and the campaign to eradicate it. There is the need also to study other B complex vitamins especially vitamin B_9 (folic acid) whose deficiency is associated with birth defects. Seasonal variation of trace mineral composition should also be studied so as to determine the complete nutritional contribution of these vegetables to human nutrition.

REFERENCES

Addy, E.O.H (1978) Studies on the nutritive values of leaves and fruits of the Baobab tree (*Adansonia digitata*) M.Sc (Biochemistry) Thesis. ABU Zaria.

Aletor; M.V.A and Adeogun, O.A (1995) Nutrient and anti-nutrient components of some tropical leafy vegetables *Food Chem* 53: 375-376.

Alias, C. and Linden G. (1999). Food Biochemistry, Aspen Publishers, Gaithersburg Maryland. pp 105-109

Awoyinka, A.F Abegunde, V.O and Adewusi, S.R.A (1995) Nutrient content of young cassava leaves and assessment of their acceptance as a green vegetable in Nigeria. PI Fds *Hum*. *Nutr*. 47:21-28.

Barminas, J.T, Charles, M. and Emmanuel, D. (1998). Mineral composition of non-conventional leafy vegetables.*Plant Foods Human Nutr* 55;29-30.

Baumer, M. (1993). Notes on trees and shrubs in Arid and Semi-arid regions FAO/UNEP programme. p 2

Berg, H. V. (1997). Bioavailability of Vitamin D . *European J. Clinical Nutrition 51 Suppl 1:576-9.*

Bokhari, M. H. and Ahmed M. J. (1979). Food plants in Borno State Nigeria University press, Maiduguri, Nigeria. pp. 20 – 21

Bown, D. (1995). Encyclopaedia of Herbs and Their use; Down Kidersley, London. p.31

Brown, W. H. and Rogers, E. P. (1987). General, Organic and Biochemistry (3rd Edition) Brooks / Coles Publishing Company Montene, California pp 69B, 582.

Combs G, (1992). The Vitamins: Fundamental Aspects in Nutrition and Health. Academic Press, Inc. San Diego California pp 311

Donatelle, R. J. (2005). *Health*: *The Basics* 6th Edition, Pearson Education Publishers San Fransisco. p 20.

Durupts, D. I, and Nove, J. R (2000) (Hereditary hemochromatosis) *Rev*. *Med*. *Interne 21(11):961-71 [Medlive]*.

Ensansa, K.C.L and Clegg, J. L M. (2002). Manganese Metabolism in animal and humans including toxicity of Manganese p. 27

Eromosele, I.C, Eromosele, C.O, Alantoye, A.O. and Komolafe, T.O (1994).Characterization of Oil and Chemical Analysis of the Seeds of Wild Plants. *J of plant food for human nutrition*. 45:361-365

Faboya, O.O.P (1983). The Mineral contents of some green leafy vegetables commonly found in the western part of Nigeria. *Food chem*. 12: 213-216

Fafunso, M. and Bassir, O. (1977). Variations in the loss of vitamins in leafy vegetables with various methods of food preparation. *Food chemistry*, 2: 51-55

Falusi, O. A. (1999). Genetic Studies in the genus *sesamen pedliacea*. PhD Thesis. Federal University of Technology, Minna, Nigeria, p. 92.

Farell, P. and Roberts, A. (1994). Vitamin E; Modern Nutrition and Health and Disease, (8th edition) Philadelphia P.A and Febiger.pp 26 – 27.

Folate, B. I (1996). Vitamin B_{12} and Neuro-psychiatric Disorders. *Nutr. Rev*. 54: 382-90

Friedrike B and Claus L. (1996). The importance of micronutrient for human development – a plea for vegetables. *Agric + Rural Dev*. 3:45-47.

Green, C. and Wothers, W. (2001). Organic Chemistry. Oxford University Press p 25.

Herbige, L. S. (1996). Nutrition And Immunity With Emphasis On Infection And Auto Immune Disease. *Nut Health*, 10:285-290.

Ifon, E. T. and Bassir, O. (1979). The nutritive value of some Nigerian leafy green vegetables Part I: Vitamin and Mineral content. *Food chemistry* 5: 253-267

Ihekoronye, A. I. And Ngoddy, P.O. (1988). Integrated Food Science and Technology for the Tropics. Macmilliam Education Limited, London pp 22-25.

Jacobs, M. B. (1999). The Chemical Analysis of Foods and Food Products (3rd edition) CBS Publishers New Delhi, India.

Keay, R.W.J. (1989) A revised version of Nigerian trees oxford university press New York pp. 284-284.

Kubmarawa, D. Andeyang, I.F.H and Magomya, A.M (2008) Amino acid profile of two non-conventional leafy vegetables (*Sesamum indicum* and *Balanites aegyptiaca*) *African j. of Biotechnolog. 7:19 3502-3504.*

Mabberley, D. J. (1987) The Plant Book. A Portable Dictionary of the Higher Plants. Cambridge University Press, Cambridge p 706.

Muazu, J. (1997) Plants used traditionally in the treatment of epilepsy: A review. B. Pharm Thesis submitted to Department of Pharmaceutical Chemistry, Ahmadu Bello University, Zaria.

Muazu, J. and Kiata, A.H. (2008) A review of traditional plants used in the treatment of epilepsy amongst the Hausa/Fulani tribes of northern

Nigeria. *Africa J. of Traditional Complementary, and Alternative Medicine* Vol. 5 No. 4 pp 387-390.

Oguntona, T and Oguntona C.R.B (1985). Loss of thiamin in some Nigerian vegetables. Paper presentation at the First Int. Conference on Food and Health Salsamaggiore Parma, Italy. (Oct. 1985).

Oguntona, T. and Oguntona, C. R. B. (1986). Proximate composition of three leafy vegetables commonly consumed in Northeastern Nigeria, Paper presented at the 1st National Workshop of food composition at Ibadan, Nigeria, pp 1-3

Oke, O. L. (1969). Composition of some Nigerian leafy vegetables. *J America Diet*. Association. 53(2):130-132

Okoli, E. C, Nmorka, O. O. and Unaegbu, A. (1988). Blanching and storage of some Nigerian vegetables. *Int journal food. Sci Tech*. 23: 639-641

Onwuka, G. I (2005). Food Analysis and Instrumentation Theory and Practice. Naphtali Prints, Nigeria, pp 126-129

Osagie, A. U. and Eka, O. U. (1998). Nutritional Quality of Plant Foods. Post harvest Research Unit Publishers, University of Benin.

Oyebiodun, G.L, Gabriel, O.F and Babatunde, L.F. (1983). Nutritional value of the fluted pumpkin (*Telferia Occidentalis*) *Agric Food Chem.* 31:989-992.

Pacey, A. (1990). Gardening for better Nutrition. Intermediate Technology Publications Ltd, London. p21

Paul, G. and Gyorgy, W. N. (1967). The Vitamins. 2nd Edition. Academic press Inc. London.

Reed, C.F. (1976). Information Summaries on 100 economic plants. Typed scripts submitted to the USDA pp 258-259.

Sceriano, J.K, Walter, E.A Glew, R.H, Hollis, B.W, Henry A, Ocheke I and Ischei, C.O. (1995). Serum levels of pyrodinoline crosslinked carboxyterminal telopeptides of type 1 collagen (ICTP) and Osteocalcin in rachitic children in Nigeria. *Clin. Biochem.* 28:541-545

Sommer, A. (1982). Nutritional Blindness: *Xeropthalmia Keratomdacia*. Oxford University Press, London, New York, p 4.

Suitor, C. W. And Bailey, L. B. (2000). Dietary Folate Equivalents : Interpretation and Application. *Journal of the American Dietetic Association 1 : 88- 94.*

Susane, G. (1996). Vegetable production – a challenge for urban and rural development. *Agric and rural development 3:42-44.*

Tanyel, M. C. and Mancano, L. D. (1997). Neurologic Findings in Vitamin E Deficiency. *Animal Farm Physician*. 55:1-20.

Valko, M. and Morris, H. C. (2005). Metals Toxicity And Oxidative Stress. *Current Medical Chemistry* (12) 1161 - 1208

Victor, J. T. (1998). Lesser Known Plant Foods In Nutritional Quality of Plant Foods. Ambik Press, University of Benin pp 245-246.

West, C.E., Pepping, F. and Temalilwa, C.R. (1988). The composition of foods eaten in East Africa Wageningen Agricultural University. The Netherlands.

Whitaker, (2001). *Reversing Diabetes*, Warner Books Publishers, pp 269-271

WHO/FAO (1973). Report: Energy and Protein requirements Geneva: World Health Organization (WHO) Technical Report Series No, 522, pp 32-33.

William, D. C. (2003). Materials Science and Engineering An Introduction (6^{th} Edition) Wiley International Press, New York pp 137-139.

Zohary, D and Hopf, M. (2002). Domestication Of Plants In The Old World, (3^{rd} Edition). Oxford University Press, p 140.