NUTRIENT COMPOSITION OF SOME PROCESSED AND UNPROCESSED LESSER KNOWN VEGETABLES CONSUMED IN KADUNA STATE, NIGERIA

BY

AISHATU MUHAMMAD
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DECLARATION

I hereby declare that the work in this dissertation entitled "Nutrient Composition of some Processed and Unprocessed Lesser Known Vegetables consumed in Kaduna State, Nigeria" was carried by me in the Department of Biochemistry under the supervision of Dr. A.B. Sallau and Prof I.A Umar. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at any University/Institution.

_____ _____

Aishatu Muhammad Date

M.Sc./Sci/43784

CERTIFICATION

This dissertation entitled "NUTRIENT COMPOSITION OF SOME PROCESSED AND UNPROCESSED LESSER KNOWN VEGETABLES CONSUMED IN KADUNA STATE, NIGERIA" by Aishatu Muhammad meets the regulations governing the award of the degree of Master of Science in Nutrition of Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

_____ Date _____

Dr. A.B. Sallau

Chairman Supervisory Committee Signature----------
Department of Biochemistry,
Ahmadu Bello University, Zaria.

_____ Date _____

Prof. I.A. Umar

Member, Supervisory Committee Signature----------
Department of Biochemistry,
Ahmadu Bello University, Zaria.

_____ Date _____

Prof. M. N. Shuaibu

Head of Department Signature----------
Department of Biochemistry,
Ahmadu Bello University, Zaria.

_____ Date _____

Prof. Kabir Bala

Dean, Postgraduate School Signature----------
Ahmadu Bello University, Zaria.

DEDICATION

This research work is dedicated to my husband, Alh. Muhammad Ahmad.

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ABSTRACT

This study was designed to determine nutrient composition of some processed and unprocessed lesser known vegetables (LKCVs) consumed in Kaduna State. Multistage sampling and simple random sampling techniques were adopted to arrive at community of choice for data collection. Six communities were randomly selected from the three (3) senatorial zones of Kaduna state. In each selected community, in-depth interview and Focus Group Discussion (FGD) were conducted with community women to identify types, processing methods and consumption pattern of LKCVs. A total of eight each of the processed and unprocessed LKCVs identified were aseptically collected for laboratory analysis. LKCVs commonly found in Kaduna state were therefore, subjected to analysis to determine their proximate and micronutrient (some minerals: Ca, K, Mg, Fe, Na, Zn and vitamins: vitamin C, vitamim A and folate) content. A total of 21 LKCVs were identified out of which 8 were selected based on availability for the study. All the vegetables were seasonal except *Vigna unguiculata* (Bean leaves), more so boiling and blanching were the common traditional processing methods. *Senna obtusifolia* (Coffee *senna*) (73.81%), *Senna occidentalis* (Coffee senna) (74.60%) and *Clocusia esculentum* (Cocoyam leaves) (61.11%) were consumed sufficiently by the respondents (5-6 times per week). Medicinal value (34.94%) was the dominant reason for consumption of the LKCVs. The proximate nutrient values for unprocessed LKCVs ranged from 50.33% to 13 9% (carbohydrate), 12.49% to 4.09% (crude protein), 5.00% to 0.37% (fat), 7.06% to 6.63% (ash), 61.11% to 28.10% (moisture) and 9.88% to 1.72% (fibres). While in processed LKCVs, proximate compositions ranged from 41.38% to 11.80% (carbohydrate), 6.44% to 2.67% (crude protein) 3.16% to 0.17% (fat), 5.72 % to 2.72% (ash), 72.30% to 50.05% (moisture), and 6.43% to 0.93% (fibres). Minerals nutrient value of unprocessed LKCVs showed that potassium has the highest value range of 3,277.6omg to 220.10mg/100g; magnesium, 128mg to 99.96mg/100g; calcium, 200.22mg to 5.33mg/100g; sodium, 7.14mg to 0.07mg/100g; iron, 19.53mg to 0.39mg/100g; zinc, 9.61mg to 0.23mg/100g; vitamin A, 11.78mg to 0.19mg/100g; vitamin C, 4,22mg to 0.07mg/100g; vitamin B9, 12.49mg to 5.24mg/100g. The minerals and vitamins nutrient of processed LKCVs analyzed also gave ranges for potassium, 996.50mg to72.30mg/100g; magnesium, 85.7mg to 125.08mg/100g; calcium, 2.7mg to 103.48mg/100g; sodium, 0.36mg to 9. 39mg/100g; iron, 0.19mg to 11.78mg/100g; zinc, 0.29mg to 5.38mg/100g; vitamin A, 6.99mg to 14.59mg/100g; vitamin C, 0.35mg to 3.35mg/100g; Vitamin B9, 2.77mg to 8.11 mg/100g. There was significant ($p<0.05$)

difference between the processed and unprocessed nutrient content of LK C Vs in favour of unprocessed that had the higher nutrient in all the vegetables except for moisture content. All the vegetable are of low fat content and the nutrient level vary widely. Vegetables when combined would complement each other and provides more nutrient- rich local diet, thus contributes to food security.

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LIST OF ABBREVIATION

Abbreviation	Meaning
ANOVA	Analysis of Variance
AAS	Atomic Absorption Spectrophotometry
AOAC	Association of Official Analytical Chemist
FAO	Food and Agricultural Organization
FGD	Focus Group Discussion
HDL	High Density Lipoprotein
LDL	Low Density Lipoprotein
LKCV	Lesser Known Consumed Vegetables
NARICT	National Research Institute for Chemical
NTD	Neutral Tub Detect
RDA	Recommended Daily Allowance
WHO	World Health Organization

CHAPTER ONE

1.0 INTRODUCTION

Vegetables are edible parts of plant that are consumed wholly or in parts, raw or cooked as part of main dish or salad. They include leaves, stems, roots, flowers, seeds, fruits, bulbs, tubers and fungi (Asaolu and Asaolu, 2010). Vegetables are made up of chiefly cellulose, hemi cellulose and pectin substances that give them their structures and firmness (Mohammed and Sharif, 2011). They are good sources of oil, carbohydrate, minerals and vitamins depending on the vegetables consumed (Mepba *et al.,* 2007).

Leafy vegetables are important items of diet in many Nigerian homes because of the presence of vitamin and mineral elements (Mohammed and Sharif, 2011) They are valuable sources of nutrients especially in rural areas where they contribute substantially to protein, minerals, vitamins, fibres and other nutrients which are usually in short supply in daily diet (Anjorin *et al*., 2010). It is worthwhile to note that consumption of numerous types of edible vegetable are sources of food, that could be beneficial to nutritionally marginalized population especially in developing countries, where poverty and climate is causing havoc to common rural people. Asaolu *et al.,* (2012) reported that in many developing countries, the mineral intake is inadequate to meet the nutrient requirements of the rapidly growing population, and that minerals cannot be synthesized by the human body and must be provided by plants (through dietary means). Sobukola *et al., (*2007) described leafy vegetables as very important

protective foods and useful for health maintenance, prevention and treatment of various diseases. Ononugbo, (2002) also reported that vegetable fats and oil lower blood lipid thereby reducing the occurrence of coronary artery diseases which can damage the heart.

Vitamins and minerals are essential and their deficiency result in impairment of biological functions. Micronutrient deficiency also increase risk of overall mortality that are associated with a variety of adverse health effects, including poor intellectual development and cognition, decreased immunity, and impaired work capacity (Mohammed and Sharif, 2011). In Nigeria leafy vegetables are relatively available and affordable particularly during raining season but are found to be among the least consumed foods due to the ignorance of their nutrients composition (Orech *et al*., 2005). A study reported, adult per capital consumption of vegetable to be 59g/day during the months of July-October in Nigeria (Hart *et al.*, 2005). WHO, (2003) recommended individuals to consume 400g or more of fruits and vegetables per day to protect against none communicable diseases such as, obesity and cardiovascular diseases.

1.1 Statement of Research Problem

In Nigeria, leafy vegetables are relatively available and affordable particularly during the raining season but are found among the least consumed food due to ignorance of their nutrient composition and uses, (Orech *et al*., 2005).

In many developing countries the supply of mineral intake is inadequate to meet the actual nutrient requirements of rapidly growing population and that, these minerals cannot be synthesized by human body and must be provided by plant vegetables (Mepba *et al*., (2007).

Most available food composition tables and databases do not hold information on all of the lesser consumed vegetables, thus giving unrepresentative actual nutrient intake estimation in Nigeria. Although a number of studies have documented the diversity of plant vegetable usage including their seasonal importance in the southern part of Nigeria, (Okafor, 1991; Oguntona *et al*.,1998; Hart *et al.*, 2005), none have, however, been able to undertake an in depth study of the actual nutritional composition of lesser consumed vegetables in the northern part of Nigeria

1.2 Justification

Data collection on the nutrient composition of lesser consumed leafy vegetables becomes important, because it will serve as a source of enriching existing food composition tables and databases.

Information obtained at the end of this study would enrich the scanty information available about the nutrient composition of lesser consumed vegetables in Kaduna State.

This research will also provide more data on choice of vegetable with regards to the management of some nutrition related diseases. Increased information on the nutrient composition of lesser consumed vegetables will encourage their use in food other than

accompanying sauce. It will also ensure the usage of vegetable at least twice daily, thus increasing the opportunities for their consumption and preventions of micronutrients deficiency at all stages of life (Orech *et al.,* 20005).

1.3 Aim and Objectives of the Study

The aim of the study is to determine the nutrient composition of processed and unprocessed lesser known consumed vegetables in Kaduna state.

Specific Objectives

- To identify lesser known consumed vegetables in Kaduna State.
- To determine methods of processing and consumption pattern of the lesser known consumed vegetables in Kaduna state
- To evaluate and compare the proximate and some micronutrient (minerals and vitamins) composition of processed and unprocessed lesser known consumed vegetables.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 **Vegetables**

Vegetables are the fresh edible portions of herbaceous plants, which can be eaten raw, or cooked (Francisca and Enazaquire, 2007). The word 'vegetable' comes from the Latin *Vegetabilis* (animated) and from *Vegetare* (enliven). Vegetables are eaten in variety of ways, as part of main meals and as snacks. The nutritional content of vegetables varies considerably, though generally they contain little protein, fat, and varying proportions of vitamins such as vitamin A, vitamin K, vitamin B6, provitamins, dietary minerals, fibre and carbohydrate (Ajayi and Onayemi, 2009). Vegetables contain variety of other phytochemicals, some of which have been reported to have: antioxidants which defend against free radicals capable of protecting the body against diseases, antiviral by forming a complex, blocking the interaction of the virus and cell membranes, as anti carcinogenic properties by inhibition of tumor formation thus, reduction in cancerous growth and as antibacterial by absorbing and eliminating radioactive elements and heavy metals contamination from the body (Mosha and Gaga, 2008). However, vegetables often contain toxins and anti-nutrients such as: solanine, enzyme inhibitors, cyanide, oxalic acid, phytate etc (Getachew *et al*., 2013). Depending on the concentration, such compounds may reduce the edibility, nutritional value, and health benefits of dietary vegetables (Mepba *et al*., 2007). Cooking and/or other processing may be necessary to eliminate or reduce them (Aju and Poopola, 2010).

2.1.1 **Classification of Vegetables**

- *Leafy vegetables*: Leafy vegetables are any of the various leafy plants or their leaves and stems eaten as vegetables. They are also called potherbs, green vegetables, greens, leafy greens or salad greens. Although they come from a very wide variety of plants, most share a great deal with other leafy vegetables in nutrition and cooking methods (Imaobong and Promise, 2013). The plant's whole edible parts are the leaves e.g. Amaranth, bitter leaf, sorrel, baobab, lettuce, cabbage etc.

- *Fruit and flower vegetables*: The plants whole edible parts are the fruits and the flowers. They are fruit or buds of flowers in reality, but are used as vegetables e.g. avocado, melon, cucumber, egg plant, tomato, okra, etc. (Ayodele, 2005).

- *Podded vegetables:* They include all the varieties of beans, peas, and lentils, etc.

- *Root, tuber and bulb vegetables*: The varieties included in this class are closely related e.g. yam, cassava, taro, onion, garlic, carrot, etc (Asaolu *et al.,* 2012)

- *Seaweed vegetables*: The seaweed contains, in solution, every element necessary to maintain healthy life. Therefore, sea weed offers essential nutrients found in human blood serum e.g. iron and iodine (Asaolu *et al.,* 2012)

- *Mushrooms:* Mushrooms are fungi that are consumed as vegetables (Murano, 2003).

2.1.2 African Indigenous Vegetables

Indigenous vegetables are those vegetables whose natural home is in a specified region, while lesser consumed vegetables are underutilized indigenous vegetables. There are more than 45,000 species of plants in sub- Saharan Africa of which about 1000 can be eaten as green leafy vegetables and happen to be the mainstay of traditional African diet (Lyimo *et al.,*

2011). Indigenous or traditional vegetables are used to describe leafy vegetables that have been part of the food systems in Sub-Saharan Africa for generations (Habwet and Wallingo, 2008). Indigenous leafy vegetables are those that have their natural habitat in Sub-Saharan African while the traditional leafy vegetables were introduced over a century and constitute part of the food culture in the sub-continent due to long time uses (Habwet, 2008).

2.2 Consumption of Indigenous Vegetables

Most of indigenous leafy vegetables are commonly consumed in some areas, because they are free source of nutritious foods that can be easily accessed and regularly harvested during the growing season (Faber *et al.*, 2010). However, information on the per capita consumption of indigenous leafy vegetable is just as scarce as data on their production level. It is generally believed that the introduction of exotic varieties contribute to the decline in the production and consumption of indigenous vegetables (Mepba *et al.,* 2007). A study reported that, adult per capita consumption of vegetables to be 59% per day during the months of July – October in Nigeria (Hart *et al.*, 2005)

Low consumption of vegetables and fruit is among the top risk factors contributing to mortality worldwide (Ezzati *et al.*, 2010). Therefore, WHO have recommended a daily intake of more than 400g of vegetables and fruits per person to protect against diet related chronic diseases (WHO, 2003). An increased intake of vegetables and fruit is therefore needed. However, in developing countries, the diets of the poor are predominantly cereal based and nutrient poor, with very little foods of animal origin, vegetables and fruits (Okeno *et al*., 2003). Research has shown that indigenous communities in Africa have dietary additives of domesticated and non-domesticated green leafy vegetables that contain antioxidants to degrade cholesterol from their traditional foods of meat, milk and blood (Getachew *et al.,* 2013).

Micronutrient supplementation and food fortification are short- and medium-term strategies to address the hidden hunger (micronutrient malnutrition), but in the long term dietary diversification through a food-based approach involving agriculture, has been proposed as one of the more sustainable options (Faber *et al.*, 2010). Therefore dietary diversification has to widen its scope to include underutilized vegetables (LCV) crops, such as pumpkin leaves, cocoyam leaves and wild-growing green leafy vegetables (Oladele, 2004).

A study showed that, the potential value for food security and rural development of gathering wild vegetables, growing locally adapted varieties of vegetables and eating from the local ecosystem, is recognized by an international initiative (under the umbrella of the Convention of Biological Diversity) lead by the FAO, together with Biodiversity International, with the overall aim of promoting the sustainable use of biodiversity in programmes contributing to food security and human nutrition (WHO, 2003).

The potential effect of African leafy vegetables on the nutritional status of a particular population will depend among other things; on the species that are geographically and seasonally available, the species that are known and socio-culturally acceptable or popular as food and the frequency of consumption and amount consumed (Akanbi, 2013).

2.2.1 The Affordability of Indigenous Vegetables

Oreach *et al*., (2005) reported that, in Nigeria leafy vegetables are relatively available and affordable particularly during rainy season, but are found to be among the least consumed foods. This may be due to ignorance of their nutrient composition. In addition, Faber *et al.*, (2010) stated some negative perceptions that, some people generally regard indigenous

vegetables as a poor person's food, and people who eat them are generally judged as being poor and have no food. Therefore, the aspect of affordability should be used carefully during promotion, as to avoid the perception that African leafy vegetables are food for the poor. The emphasis should rather be on potential nutritional and hence health benefits the consumption of these vegetables could offer (Getachew *et al.,* 2013). Also published by Johns and Sthapit, (2004) was the study on promotion and consumption African leafy vegetables which indicated that vegetables should be approached within a framework of holism and interrelatedness which includes models such as; nutrition and health status, socio-cultural traditions, income generation, and biodiversity conservation for developing country food systems.

2.2.2 Method of Consumption of Indigenous Vegetables

The indigenous vegetables are of valuable source of nutrition in rural areas and they contribute substantially to protein, minerals and vitamins together with fibres to the diet of people. These leafy vegetables are served and consumed in different ways. Faber *et al.*, (2012) reported that, the leaves are compatible to be used with starchy staples (maize meal porridge, sorghum porridge, and yam and potato porridge) because they contain ascorbic acid, which enhance iron absorption.

Indigenous leafy vegetables are widely consumed in processed or semi processed as part of main dish or salad because of the taste and flavor added to the foods (Asaolu *et al.*, 2010). A study also confirmed that, the indigenous vegetables consumed singly or in combination as in local salad, as in soups served with starchy staples (*molded paste rice)* (Mohammed and Sharif, 2011).

2.2.3 The Roles of Indigenous Vegetable

Quite a large number of indigenous leafy vegetables have health protecting properties and uses (Okeno *et al.*, 2003). It was observed by Ayodele, (2005) that the roots, leaves and twigs as well as the bark of the tree are used in traditional medicine. Several of these indigenous leafy vegetables continue to be used for prophylactic and therapeutic purpose by rural communities. This indigenous knowledge of the health promoting and protecting attributes of leafy vegetables is clearly linked to their nutritional and non-nutrient bioactive properties (Ayodele, 2005).

There are inexpensive, easily accessible and provide millions of African consumers with health promoting compounds such as vitamin, mineral, ant-oxidants and even anti-cancer factors needed to maintain health and fight of infection (Abukutsa-onyango, 2003). Studies have also shown that countries that retain indigenous vegetables diet and have high consumption of these vegetable are much less likely to be affected by cardio vascular diseases, diabetes and other adverse consequences of nutrition in transition (Johns and Shapit, 2004)

2.3 Processing of Indigenous African Vegetables

Large quantities of indigenous vegetable spoil due to insufficient processing capacity and growing market difficulties caused by intensifying competition from exotic vegetables (Adebooye and Opadode, 2004). Drying has been an African way of processing leafy vegetables to make them available during periods of short supply. Although Francisca and Enazaquire, (2007) reported that, drying is one solution to the problem of perishability, it does

not satisfy the need of a large population of consumers, particularly urban dwellers. Traditional sun drying methods often yield poor quality, since vegetables are not protected against dust, rain and wind or even against insects, birds, rodents and domestic animals while being dried (Habwet and Walingo, 2008). In addition soil contamination with microorganisms, formation of mycotoxins and infection with disease-causing microorganisms are some of the problems associated with sun drying (Habwet and Walingo, 2008). The drying equipment used in industrialized countries overcomes all of these problems, but unfortunately it is not very well-suited for use in developing countries like Nigeria because it requires substantial capital investment and well-developed infrastructure (Hart *et al*., 2005).

Processing can transform vegetable from perishable product into stable foods with long shelf lives and thereby aid in their global transportation and distribution (Anon, 2006). According to Smith and Eyzagine, (2007) there is a need to develop and promote locally appropriate processing techniques to minimize post harvest losses and ensure regular supplies of indigenous leafy vegetables from the production areas to consumers in pre-urban and urban centers.

2.3.1 Harvesting of Leafy Vegetables

Harvesting is usually carried out early in the morning with objective of maintaining the full turgidity of leaves and other fleshy parts of the plant. Since transpiration is normally at minimum during the hours of darkness and early in the day, this is optimum time of harvesting fleshy or succulent crops which ideally will remain fresh until they are either consumed or sent to market (Habwet and Walingo, 2008). All leafy crops should be cut or

removed from the stem with sharp knife (Ayodele, 2005). Pulling and tearing may damage the remaining plant tissues in some cases will produce new shoot or leaves. Vegetables should be harvested at the immaturity to obtain maximum quality for immediate use or for use as a stored product. Vegetables picked at peak of immaturity and used promptly are almost always superior in nutritional content, flavor and appearance (Habwet and Walingo, 2008). The difference in vegetable quality is mainly due to the freshness of the product. To maintain quality, vegetables should not be cut or bruised when harvesting. (Nordeida *et al*., 2011)

2.3.2 The Source of Indigenous Leafy Vegetables

Some of indigenous vegetables do occur wildly and does not have to be bought. The vegetables grow in fertile soil in the wild, in the planting fields and gardens (Faber *et al.*, 2010). A study reported that, they are also found on river banks throughout the year, the leaves which are available in the summer, are picked daily or weekly by older women (Mepba *et al.*, 2007). However, some of the indigenous vegetables are cultivated in the community gardens by older women (Imaobong and Promise, 2013). In addition, the plants need little water, no fertilizer and the cultivated vegetables are used for household consumption, and they are not sold (Oladele, 2004).

2.4 Nutrient Composition of Indigenous Vegetables

Like all other plants, vegetables contain a wide range of different chemical compounds and show variation in composition structure. An individual vegetable, being largely composed of living tissues which are metabolically active and is constantly changing its composition, the

rate and extent of such change depends on the physiological role and stage of the organ concerned (Kader, 2002)

2.4.1 Carbohydrate (CHO): The structure framework of plant tissue is largely composed of complex molecules built up from monosaccharides and other closely related compounds (Aremu *et al*., 2006). Green vegetables have little carbohydrate in them, and those that are there are packed in Layers of fibre, which made them very slow to digest (Imaobong and Promise, 2013). Emebu and Anyika, (2011) also reported that, the proportion of different carbohydrates can change due to the metabolic activity of the plant. The main function of carbohydrate is to provide the body with fuel and energy that is required for daily activities. The human body needs constant supply of energy to function properly (Ukam, 2008). Lack of carbohydrate in the diet may result in tiredness or fatigue, poor mental function, and lack of endurance and stamina (Sharon *et al*., 2006).

A balanced meal that provide abundant complex carbohydrates, including fibres, and a little fat help to slow down the digestion and absorption of carbohydrate so that glucose enters the blood gradually, providing a steady, ongoing supply (Gregory, 2014).

The RDA for carbohydrate is 130g/day, which contribute about 45 to 65% of energy intake, and based on the average minimum amount of glucose used by the brain (Sharon *et al*., 2006).

2.4.2 Protein: Proteins are compounds composed of carbon, hydrogen, oxygen and nitrogen atoms, arranged into amino acids linked in chain (Srilakshmi, 2006). Some amino acid also contains sulfur. Proteins are considered as structural constituent since they are the major component of the cytoplasm of living cells (Ijeomah *et al.*, 2012). Antia *et al*., (2006)

considers plant food providing more than 12% of its calorific value from protein as a good source of protein.

Protein is an important part of diets that is used as building materials for growth and maintenance (Sharon *et al*., 2006). Protein also served as an enzyme because it facilitates chemical reactions. It also helps to maintain the acid-base balance of body fluids by acting as buffers. Protein transport substances such as lipids, vitamins, minerals, and oxygen around the body. It served as an antibody and also provides some fuel for the body's energy needs. When young children and infants are deprived of protein or energy or both, result is protein-energy malnutrition (PEM).

2.4.3 Fat: Like carbohydrates, fatty acids and triglycerides are composed of carbon, hydrogen, and oxygen, but lipids have many more carbon and hydrogen in the proportion to their oxygen. However, it can supply more energy per gram (Sharon *et al*., 2006)The fats of the vegetables are like the proteins largely confined to the cytoplasm layer in which they are especially associated with the surface membranes (Kader, 2002). Leafy vegetables are known to be poor sources of fat. Among the proximate components, fat content represent the lowest in this category of food (Imaobong and Promise, 2013). Ifon and Bassir, (2007) reported that, it is unusual to find leaves with other extract exceeding 1-1.5% in fresh leafy vegetables, although content of dry sample can range from 1 – 30%. Ononugbo, (2002); Imaobong and Promise, (2013), reported that, the little fat and oil found in leafy vegetables lower blood lipids, hence contribute to reduce occurrence of diseases associated with coronary artery damage. Dietary fat is a major determinant of palatability of foods. It also provides body with

energy, insulating against temperature extremes, protecting against shock and maintaining cell membranes (Ijeomah *et al*., 2012).

2.4.4 Fibres: They are structural parts of plants and thus are found in all plant-derived foods, (vegetables, fruits, grains, and legumes). Fibres and starch are also polysaccharides but fibres differ from starch in that the bonds between their monosaccharides cannot be broken down by digestive enzymes in the body (Aremu *et al*., 2006). Consequently, fibres contribute no monosaccharides, and therefore little or no energy to the body.

Some fibres dissolve in water (soluble fibres) form gels (viscous), and are easily digested by bacteria in the colon (fermentable). Commonly found in legumes and fruits, these fibres are most often associated with protecting against heart disease and diabetes by lowering blood cholesterol and glucose levels (Sharon *et al*., 2006). Other fibres do not dissolve in water (insoluble fibres), do not form gels (non viscous), and are less readily fermented. Found most in grains and vegetables, these fibres promote bowel movements and alleviate constipation (Sharon *et al*., 2006). Fibres in leafy vegetables play a number of roles in the body. They are known to clean the digestive tract, remove potential carcinogens from the body, as well as keep blood sugar levels under control (Imaobong and Promise, 2013).

2.4.5 Moisture: Fresh leafy vegetables have high moisture content ranging from 72% in cassava leaves to 92 – 93% medium in spinach and bitter leaves (Mepba *et al.*, 2007). The amount in individual vegetable will be of course, depend on several factors including age, agronomic practices prevailing during cultivation and freshness (Oguntona *et al*,. 1998).The high moisture contents of vegetable help in maintaining the protoplasmic content of the cell

(Mepba *et al.*, 2007). It also support the grater activity of water soluble enzymes and co-enzymes needed for metabolic activities in the leafy vegetables (Faber *et al.*, 2010). However high moisture content makes vegetable susceptible to spoilage. Micro organisms that cause spoilage are known to thrive in foods containing high moisture content (Mohammed and Sharif, 2011).

2.4.6 Ash: It is the portion of the food or any organic material that remains after it is burned at very high temperature.

The ash constituents include potassium, sodium and magnesium, which are present in large amounts as well as smaller quantities of aluminum, iron, copper, manganese, zinc, iodine, fluorine and other elements present in trace (Percio *et al.*, 2012). Ash content represents the total mineral content in foods. Although minerals represent a small proportion of dry matter, often less than 7% of the total (Ndie, 2010). They play an important role from physiochemical, technological and nutritional point of view (Ifon and Bassir, 2007).

Hodder, (2004) stated that determination of ash content may be important for several reasons: It is part of proximate analysis for nutritional evaluation and, ashing is the first step in preparing food sample for determination of specific elemental analysis (Ijeomah *et al*., 2012).

2.5 Minerals

Mineral nutrients are the chemical elements required by living organisms, other than the four elements: carbon, hydrogen, nitrogen and oxygen present in common organic molecules (Ijeomah *et al.*, 2012). Minerals cannot be destroyed by heat, air, or mixing, consequently, little care is needed to preserve minerals during food preparation (Gupta *et al.*, 2005). The ash

that remains when a food is burned contains all the minerals that were in the food originally; therefore the total amount of mineral matter in vegetable is represented by the ash content, (Sharon *et al.,* 2006). Minerals can be lost from vegetables only when they are leached into water that is then poured down the drain (Asaolu *et al*., 2012).

The differences in the mineral content of the vegetable plant might be due to soil compositions and the rate of uptake of minerals by individual plant (Anjorin *et al.*, 2010; Asaolu and Asaolu, 2010). Therefore plants usually contain in varying portions, the full range of mineral element which are present in the soil in which they are grown (Asaolu, 2012).

Minerals can be divided into macro and micro mineral elements. Macro minerals are essential mineral nutrients found in the human body in amount larger than 5g (Getachew *et al*., 2013). They are present and needed in large amount in the body and they include: calcium, phosphorus, sulphur, potassium, sodium, chlorine, and magnesium. Micro minerals are essential mineral nutrients found in the body in amounts smaller than 5g (Getachew *et al*., 2013). They are present, and needed, in relatively small amount in the body and they include: iron, manganese, copper, zinc, selenium, chromium, molybalenum, tin, fluorine cobalt and nickel (Adelekan, 2007). Appropriate intakes of certain chemical nutrients have been demonstrated to be required to maintain optimal health (Sharon *et al*., 2006). Diet can meet all the body's chemical nutrient requirements, although supplements are not adequately met by the diet, or when chronic or accurate deficiencies arise from pathology, injury etc (Deman, 2007).

2.5.1 Calcium: Calcium is the most abundant mineral in the body and about 99% of the body's calcium is in the bones and teeth. The rest is distributed in blood and soft tissues, such as muscles, the liver and hearth (Sharon *et al*., 2006).

Calcium plays two important roles. Firstly, it is an integral part of bone structure, providing a rigid frame that holds the body upright and serves as attachment points for muscles, making motion possible. Secondly, it serves as a calcium bank, offering as a source of the mineral to the body fluids (Sirlakshmi, 2006). Calcium ion participates in the regulation of muscle contractions, clothing of blood, transmission of nerve impulses, secretion of hormones and activation of some enzyme reactions (Mohammed and Shaif, 2011). An adequate dietary calcium intake may help prevent excessive fat accumulation by stimulating hormonal action that targets the breakdown of stored fat (Srilakshmi, 2006). Food rich sources of calcium are all dairies, meat, fish, vegetables, oysters, cracked bones from chicken, turkey and mineral water, etc.

A low calcium intake during growing years limits the bone's ability to reach their optimal mass and density, a condition known as osteoporosis (Wardlaw and Kessel, 2012). All adults lose bone as they grow older, beginning between the ages of 30 and 40 (Srilakshmi, 2006). Obtaining enough calcium during growth helps to ensure skeleton to be stronger and dense. Recommendation has been set high at 1,300 milligrams daily for adolescents up to the age of 18 years. Between the ages of 19 and 50, recommendations are lower to 1,000 milligrams a day; for later life recommendations are raised again to 1,200 milligrams a day to minimize the bone loss that tends to occur later in life (Sharon *et al*., 2006).

2.5.2 Magnesium: Over half of the body's magnesium is in the bones; most of the rest is in the muscles and soft tissues, with only 1% in the extracellular fluid (Sharon *et al*., 2006). Magnesium plays important roles in the body. It acts in all the cells of the soft tissues, where it forms part of the protein-making machinery and necessary for energy metabolism, impulse transmission, and maintenance of health, blood clothing and function of immune system (Ndie, 2013). Magnesium is also critical to heart function and seems to protect against hypertension and heart disease (Sharon *et al.,* 2006).

The significant sources of magnesium include: nuts, legumes, whole grains, dark green vegetables, sea foods, chocolate, cocoa etc (Gregory, 2014).

Deficiency of magnesium can occur in people who abuse alcohol or in those who absorb less magnesium (Ndie, 2010). The deficiency symptoms include: weakness, confusion, anorexia, apathy, fatigue, insomnia and if extreme, convulsion, bizarre muscle movement (especially of eye and face muscles), hallucinations, difficulty in swallowing among children and growth failure (Sharon *et al*., 2006).

2.5.3 Potassium: Like sodium, potassium is a positively charged ion, and in contrast to sodium, potassium is the body's principal cation (98%) inside the body cells (Gupta *et al*., 2005). It plays very important role in the human body. Along with sodium, it regulates the water balance and the acid-base balance in the blood and tissues (Sharon *et al*., 2006). Potassium helps generate muscle constractions and regulates the heart beat (Maikhuri, 2000). Potassium assists in the metabolic processing of various nutrients like fats and carbohydrates. It maintains normal blood pressure and sometimes lowering elevated blood pressure (Mepba

et al., 2007). Some of the enzymes that participate in energy metabolism function more efficiently when they are bound to potassium (Muikhuri, 2008). Potassium is also active in glycogen and glucose metabolism, converting glucose to glycogen that can be stored in the liver for future energy (Ayoola *et al*., 2010).

Potassium is important for normal growth and for building muscle. Potassium deficiency is the most common electrolyte imbalance. It is more often caused by excessive losses than by deficient intakes (Ndie, 2013). Conditions such as diabetes acidosis, dehydration, or prolonged vomiting or diarrhea can create a potassium deficiency (Hodder, 2004). The symptoms of deficiency include: muscular weakness, paralysis, confusion, hypokalemia, castlessness, anorexia, in the extreme even death (Emebu and Ayinka, 2011). Potassium sources of food include: oranges, citrus fruits, banana, apples, avocados, wheat germ, whole grains, seeds, nuts, salmon, sardines, meats, milk, vegetables and legumes (Sharon *et al*., 2006).

2.5.4 Sodium: Sodium is the principal cation of the extracellular fluid. The adult human body contains from 90 to 130g sodium and roughly half of that is in the bone (Borminas *et al.*, 2010). The major functions of sodium in the body include regulating blood pressure and water balance in cells. Sodium also helps maintain acid-base balance and is essential to nerve impulse transmission and muscle contraction (Fagbohun *et al*., 2012).

Sodium deficiency is rarely caused by inadequate dietary intake. So if blood sodium drops, usually it may be due to vomiting, diarrhea, or heavy sweating, and both water and sodium must be replenished (Faber *et al*., 2002).

Deficiency symptoms include: Muscle cramps, loss of appetite weakness, dizziness, headache, shock etc (Gupta *et al*., 2005). The major sources of dietary sodium are; table salt, soy sauce, meat, milk, bread, chesses tomato juice, vegetables and large amount in processed foods (Oladunmoye *et al*., 2005).

2.5.5 Iron is an essential nutrient vital to many cellular activities, but it poses a problem for millions of people. Most of the body's iron is found in two proteins; hemoglobin in the red blood cells and myoglobin in the muscle cells (Srilakshmi, 2006).

Iron plays vital roles in body: it can serve as a co-factor to enzymes involved in oxidation-reduction reactions. Iron is also required by enzymes involved in the making of amino acids, collagen, hormones and neurotransmitter (Emebu and Anyika, 2011). Iron as part of the protein hemoglobin, which carries oxygen in the blood. Also as part of the protein myoglobin in muscles, which makes oxygen available for muscles contraction, it is also necessary for the utilization of energy as part of the cells' metabolic machinery (Ekop, 2007).

Iron deficiency refers to depleted body iron stores without regard to the degree of depletion or to the presence of anemia. While iron-deficiency anemia refers to the severe depletion of iron stores that results in a low hemoglobin concentration (Fagbohum *et al*., 2012). In iron-deficiency anemia, red cells are pale and small (microcytic). They can't carry enough oxygen from the lungs to the tissue, energy metabolism is impaired and the result is fatigue, weakness, headaches, apathy, pallor, poor resistance to cold temperatures, pale skin, and very pale tongue and eye lining (Gregory, 2014). Developing iron-deficiency anemia affects behavior, even at slightly lowered iron levels (Muikhuri, 2008). Energy metabolism is

impaired and neuron-transmitter synthesis is altered, reducing physical work capacity and mental productivity (Sharon et al, 2006). So without the physical energy and mental alertness to; work, plan, think, play, sing, or learn, people simply do these things less (Fleurent, 2000). They have no obvious deficiency symptoms; they just appear unmotivated, apathetic, and less physically fit (Ndie, 2013). Work productivity and voluntary activities decline (Ebueni *et al*., 2007).The sources include: red meats, fish, poultry, shellfish, eggs, vegetables, legumes, dried fruits etc (Gregory, 2014).

2.5.6 Zinc: It is a versatile trace element that is naturally present in added to others and available as a dietary supplement. Zinc is found in cells throughout the body (Ayoola *et al.,* 2010). It is involved in a variety of metabolic processes. In addition, zinc stabilizes cell membranes, helping to strengthen their defense against free-radical attacks (Sharon *et al*., 2006). Zinc also assists in immune function and in growth and development. Zinc participates in the synthesis, storage, and release of the hormone insulin by the pancreas (Maikhuri, 2000). It also interacts with platelets during blood clothing, affects thyroid hormone function, and influences behavior and learning performance (Mosha and Gaga, 2008). In addition it is needed to produce the active form of vitamin A (retinal) in visual pigment and the retinal-binding protein that transports vitamin A (Ashok *et al*., 2011). It is essential to normal taste perception, wound healing, the making of sperm, and fetal development (Gregory, 2014).

Severe zinc deficiencies are not widespread in developed countries, but occur in vulnerable groups: pregnant women, young children, the elderly, and the poor (Ayodele, 2005). Children have especially high zinc needs because they are growing rapidly and synthesizing much zinc-containing proteins (Srilakshmi, 2006). Zinc deficiency lead to severe growth retardation and

arrest sexual maturation characteristic. In addition, zinc deficiency hinders digestion and absorption, causing diarrhea, which worsens malnutrition (Gregory, 2014). It impairs the immune response, making infections likely possible. Chronic zinc deficiency damages the central nervous system and brain and may lead to poor motor development and cognitive performance (Srilakshmi, 2006). Zinc deficiency directly impairs vitamin A metabolism, also disturbs thyroid function and metabolic rate. It alters taste, causes loss of appetite, and slow wound healing (Sharon *et al*., 2006).The sources of zinc include protein contain foods: such as red meat, fish, egg, shellfish, and others like nuts, legumes, vegetables, whole grain and yeast. (Orazulike, 2003).

2.6 Vitamins

Vitamins are organic, essential nutrients required in tiny amounts to perform specific function that promote growth, reproduction, or the maintenance of health and life (Gregory, 2014).Vitamins differ from carbohydrates, fats and proteins in many ways: firstly in structure, vitamins are individual units, they are not linked together as one molecule of glucose or amino acids. Secondly in function, vitamins do not yield usable energy when broken down; they assist the enzymes that release energy from carbohydrates, fats and protein. Thirdly, the amounts of vitamins people ingest daily from foods and the amounts they require are measured in microgram or milligrams, rather than grams (Okaka *et al.*, 2002). Vitamins certainly support sound nutritional health, but they do not cure all ills. Furthermore, vitamin supplement do not offer the many benefits that come from vitamin-rich foods (Oladunmoye *et al*., 2005): Sharon *et al*., 2006)

As with other nutrients many factors are known to influence the amount of vitamins in leafy vegetables; cultivar and maturity in particular are important factors, while light can also be important sometimes. For example, crops that mature during autumn contain higher vitamin A and their precursors, than those that mature in poorer light of winter (Gregory, 2014). It is known that vitamins are retained at high level in the leaves (at their tender age) before being transferred to the seed or root at maturity (Oguntona *et al* 1998; Fagbohun *et al.*, 2012; Imaobong and Promise, 2013).

2.6.1 Classification of Vitamins

Vitamins are classified primary as to solubility. Some are soluble in water (hydrophilic), water-soluble ones are the eight B vitamins and vitamin C, and some are soluble in fat (hydrophobic) fat-soluble ones are Vitamins A, D, E and K (Sharon *et al*., 2006).

2.6.2 Water-Soluble Vitamins

Water –soluble vitamins are found in the watery compartments of foods. On being absorbed, they move directly into the blood and many of water-soluble vitamins travel freely (Dogar *et al.,2010*). This group of vitamins must be supplied in the diet every day because dietary excesses are excreted in urine and not stored in an appreciable extent (Mulokozi and Svanbeng, 2004).

2.6.3 Folate (Vitamin B_9)

Folate is also known as Folacin or folic acid, pteroylglutamic acid (PGA). Its primary coenzyme form,THF (tetrahydrofolate), helps convert B_{12} to one of its coenzyme forms and helps synthesize the DNA required for all rapidly growing cells, such as in infancy and pregnancy (Gockowski *et al.*, 2003).

Several research studies have confirmed the importance of folate in reducing the risks of Neural Tube Defect (NTD). The brain and spinal cord develop from the neural tube, and defects in its orderly formation during the early weeks of pregnancy may result in various central nervous system disorders and death (Sharon *et al.,* 2006). Diet-riched in folate and folate supplements taken one month before conception and continued throughout the first trimester of pregnancy can help prevent NTD (Percio *et al.*, 2012). For this reason, all women of childbearing age who are capable of becoming pregnant should consume 0.4mg (400 micrograms) of folate daily (Ndie, 2010). This recommendation can be met through a diet that includes at least five servings of fruits and vegetables daily.

Fortified grain products with folate play an important role in defending against heart disease (Dogar *et al.,* 2010). One of folate's key roles in the body is to break down homolysteine. So without folate homocysteine accumulates, which seems to enhance blood clot formation and arterial wall deterioration (Dixon-Maziya *et al.*, 2004). Fortified foods and folate supplements raise blood folate and reduce blood homocysteine levels to an extent that may help to prevent heart disease (Aletor *et al.*, 2012). Folate may also play a role in preventing cancer (Srilakshmi, 2006). Notable, folate may be most effective in protecting those cells most likely

to develop cancers: against pancreatic cancer and against breast cancer (Wardlaw and Kessel, 2012).

Folate deficiency impairs cell division and protein synthesis- processes critical to growing tissues, the replacement of red blood cells and G I tract cells falters. Folate deficiency symptoms are anemia (large – cell type) and G I tract deterioration. DNA synthesis slows and the cells loss their ability to divide, red tongue, mental confusion, weakness, fatigue, irritability and headache (Sharon *et al*., 2006). Food sources of Folate include leafy green vegetables, fortified grain, legumes, seeds and liver. The recommended dietary intake of Folate is 400 microgram/day for an adult person (Sharon *et al*., 2006).

2.6.4 Vitamin C (Ascorbic Acid)

Vitamin C or ascorbic acid is a white water-soluble solid of formula C6, H8, O6. It was first isolated and chemical structure elucidated in 1992 by C.G. King (Mudanabe and Rajagopal, 2008). Ascorbic acid has the sharp taste usually associated with acids and from salts (Brown, 2004).

Vitamin C parts company with the B Vitamins in its mode of action. In some settings vitamin C serves as a cofactor helping a specific enzyme perform its job, but in others it act as an antioxidant participating in more general ways (Nordeida *et al.,* 2011).

2.6.5 Vitamin C as an Antioxidant: Vitamin C loses electrons easily, a characteristic that allows it to perform as an antioxidant. In the body, antioxidants defend against free radicals. A free radical is a molecule with one or more unpaired electrons, making it unstable and highly reactive (Sharon *et al.,* 2006).

In the cells and the body fluid, vitamin C protects tissue from oxidative stress and thus may play an important role in preventing diseases. In the intestines, Vitamin C enhances iron absorption by protecting iron from oxidation (Anyoola *et al*., 2010).Vitamin C acts as a cofactor in collagen formation; it helps to form the fibrous structural protein of connective tissues known as collagen. Collagen serves as the matrix on which bones and teeth are formed (Ashok *et al*., 2011). Collagen also glues the separated tissues (wounded person) together, by forming scars. Other functions of Vitamin C include: thyroxin synthesis, amino acid metabolism and strengthening resistance to infection (Asaolu *et al.*, 2012).

The Vitamin C deficiency disease is called Scurvy and the deficiency symptoms of scurvy include: Anemia (small-cell type), atherosclerotic plaques, pinpoint hemorrhage, bone fragility, joint pain, poor wound healing, frequent infections, bleeding gums, loosened teeth, muscle degeneration, pain, depression, rough skin and blotchy bruises (Mepba *et al*., 2007).The food sources of Vitamin C foods include: citrus fruits, cabbage-type vegetables, dark green vegetables (such as bell peppers and broccoli), cantaloupe, strawberries, lettuce tomatoes, potatoes, papayas, mangoes etc (Asaolu and Asaolu, 2010).The recommended dietary intake of Vitamin C for adult men is 90mg/day and for women is 75mg/day.

2.6.6 Fat- Soluble Vitamins

Fat-soluble vitamins usually occur together in the fats and oils of the foods. Like fats, on absorption, the fat-soluble vitamins must first enter the lymph, then the blood (Begum, 2007). Many of the fat-soluble vitamins require protein carriers for transport and they are held in fatty tissues and liver until needed (Sharon *et al*., 2006). Fat-soluble vitamins tend to remain

in fat-storage sites in the body rather than being excreted, and so are more likely to reach toxic levels when consumed in excess (Wardlaw and Kessel, 2012).

2.6.7 Vitamin A

Vitamin A was the first fat-soluble vitamin to be recognized. There are two sources of dietary vitamin A: active forms and precursors, which continue to intrigue researchers with their diverse roles and profound effects on health (Mulokozi and Svanbeng, 2004). Active forms are sources immediately available to the body and are derived from animal products. These are known as retinoids and include retinal and retinol (Agbaire and Emogan, 2012). Precursor forms- also known as pro vitamins are converted to active forms by the body (in intestine and liver). These are derived from fruits and vegetables containing dark green, orange, and yellow pigment, known as carotenoids, well known as beta-carotene (Gregory, 2014).

Vitamin A is a versatile vitamin which plays essential role in promoting vision. Vitamin A plays two indispensable roles in the eye: helps maintain a crystal-clear outer window, the cornea, and it participates in the conversion of light energy into nerve impulses at the retina (Deman, 2007). Vitamin A participates in protein synthesis and cell differentiation (and thereby maintaining the health of epithelial tissue and skin) (Srilakshmi, 2006). Much more of body's vitamin A is in the cells lining the body's surfaces. Vitamin A also supports reproduction and growth. In men, retinol participates in sperm development and in women (Gregory, 2014). Vitamin A supports normal fetal development during pregnancy (Ekop, 2007). Children lacking Vitamin A fail to grow, but when given Vitamin A supplements, these children gain weight and grow taller (Mulokozi and Svanbeng, 2004).

2.6.8 Beta-Carotene as an Antioxidant

In the body, beta-carotene serves primarily as a vitamin A precursor. Not all dietary beta-carotene is converted to active vitamin A. However, some beta-carotene may act as an antioxidant capable of protecting the body against diseases (Sharon *et al.*, 2006).

Vitamin A deficiency is one of the developing world's major nutrition problems (Akubugwo *et al*., 2007). More than million children worldwide have some degree of vitamin A deficiency and so are vulnerable to infectious disease and blindness (Moris *et al.*, 2004). Night blindness is one of the first detectable signs of vitamin A deficiency and permits early diagnosis, which is caused by a lack of vitamin A at the back of the eye, the retina. Total blindness (failure to see at all) which is also called xerophthalmia is caused by a lack of vitamin A at the front of the eye, the cornea. Keratinization, the vitamin A deficiency that, affects other surface of the body starts from diminishing in number and activity of the goblet cells in the GI tract, limiting the secretion of mucus (Getachew *et al*., 2013). The vitamin A deficiency symptoms include: Night blindness, corneal drying (xerosis), triangular gray spots on eye (Biot's spots), softening of the cornea (Keratomalacid), and cornea degeneration and blindness (xerophthalmia). Plugging of hair follicles, Keratin, and forming white lumps (hyperkeratosis).

The sources of vitamin A include Retinol: fortified milk, cheese, cream, butter, fortified margarine, egg, and liver. Beta-carotene: dark leafy greens, broccoli, deep orange fruit squash, carrots, sweet potatoes, pumpkin and spinach (Asaolu *et al*,. 2012).

RDA for vitamin A is 900 μg /day for men and for women is 700 μg /day.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Materials

3.1.1 Equipment Used, the Model, Type and Manufacturer

Equipment	Type and manufacture	Model
Hot Air Oven	Surgifriend Medicals England	SM 9053
Muffle Furnace	Vinay Trading Company, India	TC-334
Tecator Digestor	Foss Analytical, Hoganans, Sweden.	10014134
Kjeldahl Distiallation Unit	Foss Analytical, Hoganas, Sweden.	10014901
Soxlet Apparatus	Ogawa Seik C ompany Ltd, Japan	OSK-1589
Centrifuge	Gallen Kamp England.	CF-590
Analytical Balance	Setra Systems, Inc, USA.	BL-410S
Flame Photometer	B. Bran Sci.And Instr. Co, England.	6420
Specrophotometer (UV/Visible)	Biochrom Ltd, England.	7120VI.7.0
Water Bath	Cole Medical, England.	411003.
Atomic Absorption Spectrophotometer	Hitachi Polarized Zeeman	180-80

These equipment were obtained from Department of Nutrition and Dietetics, Kaduna Polytechnic and National Research Institute for Chemical Technology (NARICT) Zaria.

3.1.2 Reagents

The reagents used were obtained from representatives of Sigma Chemicals in Kaduna and Zaria. All the reagents used were of analytical grade.

3.1.3 List of reagents

Distilled water

Petroleum ether (boiling point 40-60^{0}C)

Conc. H_2S0_4

40% NaOH

Catalyst mixture (copper sulphate and selenium)

2% Boric acid

0.1 M HCl.

Mixed indicator (7ml of methyl red and 10ml of bromocresol purple)

0.25M sulphuric acid

0.31M sodium hydroxide

Acid mixture (650ml of concentrated HNO_3; 80ml; PCA; 20ml concentrated H_2SO_4)

Alcoholic KOH (4% KOH in 95% Ethanol)

Xylene – Kerosene mixture (1:1)

Starch indicator (1% aqueos solution)

Metaphosphoric acid (0.5% oxalic acid). 2.5ml acetone. Indophenol solution (2, 6-dichlorophenolindophenol)

3.2 Methods

3.2.1 Study Area

This study was conducted in two communities each of the three senatorial districts of Kaduna State. Kaduna state is situated in the Northern part of Nigeria. It lies at latitude $10^0$20' north and longitude $7^0$45' east and it covers an area of 45,712 square kilometers. It consists of three senatorial districts: Northern, Central and Southern Kaduna.

Kaduna State currently has a projected population of 7 461 106 from the 2006 population figure of 6,066,562 (NPC, 2006), using the approved 3.0% growth. The population density stands at 163 people per square kilometer. The major ethnic groups in Kaduna State are Hausa and Gwari with about 80% of them engaged in various agricultural activities.

3.2.2 Sampling Procedure

This study targeted different types of lesser consumed vegetables by the respondents.

Multistage sampling technique was adopted to arrive at communities for data collection.

In each of the three senatorial districts in the state, an LGA was randomly selected: from each of selected LGA, 2 wards were selected randomly, while from each selected wards, one community was then selected from each randomly for the study. Household survey was conducted in the same communities using snowballing sampling technique (Faber, *et al.*, 2010) and 126 respondents (women) were interviewed for the study.

3.2.3 Data Collection

In each selected community a Focus Group Discussion (FGD) was conducted with community women to identify types and method of processing lesser consumed vegetables. A semi structured questionnaire was designed and was administered to the respondents (women) to generate the required data.

3.1.4 Sample Collection and Identification

Fresh samples of leafy vegetables; *Ipomoea batatas* (Sweet potato leaves), *Cucumis melo* (pumpkin leaves), *Vigna unguiculata* (Bean leaves), *Hibiscus esculentus* (Okra leaves), *Senna obtusifolia* (Senna coffee), *Senna occidentalis* (Senna coffee), *Clocusia esculentum* (Cocoyam leaves),and *Mangifera indica* (Mango leaves) were collected in the study communities of Kaduna State, Nigeria. The vegetables were identified in the Herbarium unit, Department of Biological Science, Ahmadu Bello University, Zaria with their voucher numbers: 2816, 2338, 1461, 010913, 030913, 1047, 020913 and 1944 respectively. They are the total of eight (8) samples each of processed and unprocessed vegetables that were collected based on availability as at the time of the study.

3.2.5 Sample Processing for Consumption

Following the local / traditional method of processing the vegetable, a standardization of the processing method was carried out in each case for the identified LKCVs as follows:

1) Ipomoea batatas (Sweet potato leaves)

The fresh leaves (foliage) of *Ipomoea batatas* were harvested, washed, and cut into small pieces. 300ml of boiling water (100ºC) was poured into the cut vegetables (50g) and allowed to stay for 2 minutes then drained (blanched). The drained vegetables were added to boiling

sauce (containing: 0.5g 0f fish, 1 small onions, 0.5g of salt, 1tea spoon of palm oil, 1 small chopped pepper, 2 cubes of maggi, and 1g of fermented locust bean) and allowed to boil for 2 minutes (simmer).

2) Cucumis melo (Pumpkin Leaves)

The fresh (foliage) leaves of *Cucumis melo* were harvested; the midribs were removed, washed and cut into small pieces. The prepared 50g of vegetables were added to 500ml of boiling water (100ºC) and allowed to boil for 15 minutes (until tender) and then drained. The drained vegetables were added to boiling sauce (containing: : 0.5g 0f fish, 1 small onions, 0.5g of salt, 1tea spoon of palm oil, 1 small chopped pepper, 2 cubes of maggi, 1 cup of grand nut paste and 1g of fermented locust bean) and heat was reduced to simmering level.

3) Vigna unguiculata (Bean Leaves)

The fresh tender (foliage) leaves of *Vigna unguiculata* were harvested, washed and cut into small pieces. 300ml of boiled water was poured into the prepared vegetables and allowed to stay for 5 minutes (blanched) then drained. The drained vegetables were added to boiling sauce (containing: 0.5g 0f fish, 1 small onions, 0.5g of salt, 1tea spoon of palm oil, 1 small chopped pepper, 2 cubes of maggi, 1 cup of grand nut paste and 1g of fermented locust bean) and allowed to boil and simmer for 3minutes.

4) Hibiscus esculentus (Okra Leaves):

Fresh (foliage) leaves of *Hibiscus esculentus* (Okra leaves) were harvested washed, and chopped into small Pieces. The prepared 40g of vegetables were added to 300ml of boiling

water (100^0C) and allowed to boil until it begin to foam and draw. It was beaten with a wooden spoon until it homogeneous (smooth).

5) Senna obtusifolia (Coffee Senna)

The fresh (foliage) leaves of *Senna obtusifolia* were harvested destalked and washed. The washed 40g of vegetables were added to 400ml of boiling water and allowed to boil until soft (about 40 minutes). The vegetables were drained and allowed to cool. The drained vegetables were then mixed with ingredients (pinch 0f salt, 1g of chopped pepper, 1 large chopped onion, 2 tea spoons of g/ oil, 3 large chopped tomatoes and 1g of groundnut cake *(Kulikuli)*).

6) Senna occidentalis (Coffee Senna)

Fresh (foliage) leaves of *Senna occidentalis* were harvested, washed and cut into small pieces. The pieces were added to boiling water (100ºc) and allowed to boil until soft (40 minutes) and drained. The drained vegetables were than mixed with ingredients (salt, pepper, chopped onions, oil, chopped tomatoes and Groundnut cake (*Kulikuli*) and served.

7) Clocusia esculentum (Cocoyam Leaves)

Fresh and tender (foliage) *Clocusia esculentum* were harvested. The midribs were removed from the leaves, washed and cut into pieces. The prepared 50g of vegetables were added to 500ml of boiling water and allowed to boil for some time (40-50 minute) in order to remove itching sensation. The leaves were then drained and added to a boiling sauce (containing: 0.5g 0f fish, 1 small onions, 0.5g of salt, 1tea spoon of palm oil, 1 small chopped pepper, 2 cubes

of maggi, 1 cup of grand nut paste and 1g of fermented locust bean). It was then allowed to simmer for 3minutes.

8) Mangifera indica (Mango Leaves)

Fresh tender (foliage) *Mangifera indica leaves* were harvested, washed and cut into small pieces. The 5g of prepared vegetables were added to 500ml of boiling water and were allowed to boil for 30 minutes to soften the leaves. The boiled vegetables were drained and then mixed with other ingredients (pinch 0f salt, 1g of chopped pepper, 1 large chopped onion, 2 tea spoons of g/ oil, 3 large chopped tomatoes and 1g of groundnut cake *(Kulikuli)* and then served.

3.3 Analysis

Analyses conducted include proximate analysis and some micronutrient analysis viz. Mineral elements (iron, calcium, zinc, magnesium, sodium, and potassium) and Vitamins (Vitamin A, Vitamin C and Vitamin B9) content of the vegetables

3.3.1 Proximate Analysis

Determination of moisture, fat, ash, and carbohydrate were carried out according to the standard method of AOAC (1984).

3.3.2 Determination of Moisture Content

Principle

The method is based on loss on drying at an oven temperature 105°C. Beside water, the loss will include other matter volatile at 105°C

Method

A clean crucible was dried to a constant weight in an air oven at 105^0C, cooled in a desiccators and weighted (W1). Two grammes (2.0g) of finely ground sample were accurately weighed into the previously labeled crucible and reweighed (W2). The crucible containing the sample was dried in an oven at 105ºC to a constant weight and weighed (W3). The percentage moisture content was calculated thus:

$$\% \quad \text{Moisture content} = \frac{W2 - W3}{W2 - W1} \times 100$$

3.3.3 Determination of Ash Content

Principle

Ashing procedure uses a high temperature muffle furnace capable of maintaining temperature of between 500 and 600°c. Organic substances are burned in the presence of the oxygen in air to CO_2, H_2O and N_2. The food sample is weigh before and after ashing to determine the concentration of ash present.

Method

The porcelain crucible was dried in an oven at 100^0C for 10 minutes, cooled in a desiccator and weighed (W1). Two grammes of the finely ground sample was placed into the previously weighed porcelain crucible and reweighed (W_2). It was first ignited and then transferred into a furnace, which was then set at 550^0C. The sample was left in the furnace for eight hours to ensure proper ashing. The crucible containing the ash was then removed cooled in the desiccator and weighed (W3). The percentage ash content was calculated as:

$$\% \quad \text{Ash content} = \frac{W_3 - W_1}{W_2 - W_1} \times 100$$

3.3.4 **Determination of Crude Lipid Content**

Principle

Grounded particles of food samples are placed in porous cellulose thimble. The thimble is placed in an extracted chamber, which is suspended above a flask containing the solvent and below a condenser. The flask is heated and the solvent evaporates and moves up to the condenser where it is converted into a liquid that trickles into the extraction chamber containing the samples, and continue for few hours. The solvent in the flask is then evaporated and the mass the of remaining lipid is measured. The percentage of lipid in the initial samples can then be calculated.

Method

A clean, dried 500ml round bottom flasks, containing few anti-bumping granules was weighed (W_1) and 300ml of petroleum ether (boiling point 40-60^{0}C) for the extraction was poured into the round bottom flask. The extractor's thimble containing twenty grammes of the sample was fixed into the soxhlet extraction unit. The round bottom flask and a condenser were connected to the soxhlet extractor and cold water circulation was put on. The heating mantle was switched on. The fat was extracted by dropping into the flask for 5 hours. The electric heat source was then switched off and the flask was allowed to cool. The solvent was evaporated off in hot water bath. The flask and its content were dried in an oven at 100^{0}C for 1 hour, cooled, and weighed W2. The % fat content was calculated as:

$$\% \text{ Fat content} = \frac{W2 - W1}{\text{Wt. of sample}} \times 100$$

3.3.5 Determination of Nitrogen and Crude Protein Content

Principle

The organic matter is oxidized by concentrated sulphuric acid in the presence of catalyst and the nitrogen converted to ammonium sulphate. This is then made alkaline and the liberated ammonia is distilled and estimated. As a very large part of the nitrogen present in foods is derived from protein, the crude protein is estimated by multiplying the percentage of nitrogen by an appropriate factor.

Method

The method of Onwuka, (2005) was used. Exactly 1.5g of the ground defatted sample was dropped into 300 ml Kjedahl flask. Twenty – Five milliliter of conc. H_2S0_4 and 3g of catalyst (copper sulphate and selenium) were also dropped into the Kjedahl flask. Flask was then transferred to the Kjeldahl digestion apparatus. The sample was digested until a clear green color was obtained. The digest was cooled and diluted to 100 ml with distilled water and 20 ml of diluted digest was measured into 500 ml Kjedahl flask containing anti-bumping chips and 40 ml of 40% NaOH was slowly added by the side of the flask. A 250 ml conical flask containing a mixture of 50 ml of 2% boric acid and 4 drops of mixed indictor was used to trap the ammonia being liberated. The conical flask and the Kjeldahl flask were then placed on Kjeldahl distillation apparatus, with the tubes inserted into the conical flask and the Kjedahl flask. The flask was heated to distil out the NH_3 evolved. The distillate was collected into the boric acid solution. From the point when boric acid turns green, it was allowed for 10 minutes for complete distillation of the ammonia present in the digest. The distillate was then titrated with 0.1 M HCl.

Calculation:

$$\% \quad N_2 = \frac{14 \times M \times Vt \times TV}{\text{Wt of sample (mg)} \times Va} \times 100$$

$$\% \text{ Crude protein} = \% \text{ nitrogen } (N_2) \text{ X } 6.25$$

Where: M = Actual molarity of acid

Tv = Titre volume of HCI used

Vt = Total volume of diluted digest

Va = Aliquot volume distilled

3.3.6 Determination of Crude Fibre Content

Principle

The starch and the protein are dissolved by boiling the sample with acid and then with sodium hydroxide. The residence of cellulose and lignin is washed, dried and weighed. The residue is ashing and the weight of the ash subtracted from the weight of the fibre.

Method

The method described by AOAC (1984) was adopted. Two grammes of the finely ground sample was weighed into a round bottom flask, 100 ml of 0.25M sulphuric acid solution was added and the mixture boiled under reflux for 30 mins. The hot solution was quickly filtered under suction. The insoluble matter was washed several times with hot water until it was acid free. It was quantitatively transferred into the flask and 100 ml of hot 0.31M sodium hydroxide solution was added and the mixture boiled again under reflux for 30 minutes and quickly filtered under suction. The insoluble residue was washed with boiling water and acetone until it was base free. It was dried to constant weight in the oven at 100^0C, cooled in a

desiccatos and weighed (C1).The weighed sample (CI) was then incinerated in a muffle furnace at 550^0C for 2 hours, cooled in the desiccator and reweighed (C2).The loss in weight on incineration was calculated as: = C1 – C2.

The % crude fibre was calculated thus:

$$\% \text{ Crude fibre} = \frac{C1 - C2}{\text{Weight of original sample}} \times 100$$

3.3.7 Determination of Carbohydrate Content (by Difference)

The total carbohydrate content was determined by difference as described by AOAC, (1984). The sum of the percentage moisture, ash, crude lipid, crude protein and crude fibre was subtracted from 100.

% Total soluble carbohydrate = 100 – (% Moisture + % crude fat + % crude protein + % fibre + ash).

3.4 Determination of Minerals

The mineral content of the samples was determined according to the method of Onwuka, 2005.

3.4.1 Determination of Calcium, Magnesium, Iron and Zinc by Atomic Absorption Spectrophotometer (AAS)

Principle

When samples are aspirated into the flame through the air stream as a fine mist, this passes into the burner through a mixing chamber, the air meet the fuel gas (acetylene) supplied the burner at a given pressure and the mixture is burnt. The radiations from the resulting flame

passes through a lame, and finally through an optical filter which permit only the tradition characteristics of the element under investigation to pass through the photocell. The atoms held are irradiative with the light produced by the cathode lamp. These atoms held absorb some of the incident radiation, and the amount is proportional to the concentration of the sample in the solution then the output from the photocell is measured on a suitable digital rendout system and is finally printed out via a printer\

Method

Sample Digestion: One gramme of each sample was weighed and digested with 20 ml mixture of 650 ml nitric acid, 80 ml parchloric acid and 20 ml sulphuric acid and heated at 100^0C for 5 hours

Measuring Absorbance: - The absorbance of individual mineral was measured in atomic absorption spectrophotometer (AAS) as follows: calcium at 430nm; magnesium at 285 nm, iron at 248 nm and zinc at 215 nm. The level of each mineral was extrapolated from a standard curve.

3.4. 2 Determination of Sodium and Potassium by Flame Photometry

Principle

The sample is digested with 20ml of acid mixture (650ml of concentrated HNO_3; 80ml; PCA; 20ml concentrated H_2SO_4) and aliquots of the diluted clear digest taken for photometry using flame analyzer

Method

Sample digestion: Two grammes (2.0g) of each sample were digested in 20 ml mixture of 650 ml nitric acid, 80 ml perchloric acid 20ml sulphuric acid at 100c for 5 hours.

Measuring absorbance: the digest was measured in a flame photometer sodium was measured at 767 nm while potassium was at 589 nm

3.5 Determination of Vitamins

3.5.1 Determination of Vitamin A Content:

Principle

Vitamin A (retinol) is destroyed when exposed to ultraviolet light. After saponification with alcoholic KOH, retinol (and carotenoids) is extracted by solvent partition using a mixture of xylene-kerosene. The optical absorbance of the sample extract is read at 460nm for determination of total carotenoids and at 328nm for the determination of retinol. The sample extract is then irradiated with ultraviolet light and its absorbance read again at 328nm. The difference in optical absorbance at 328nm before and after irradiation of the samples corresponds to the amount of retinol present. The concentration of carotenoids and retinol are calculated.

Method

The level of beta – carotene in the samples was determined by spectrophotomeric method described by Onwuka, (2005). Ten grammes (10g) of the fresh leaves was macerated in 200

ml distilled water with a blender, the bulk liquid was then filtered and 200 µl of alcoholic KOH was added into the tube and evaporated in a water bath at 55º-60ºC for 20 minute (to saponify). The carotene was extracted by adding 200 µl of xylene – kerosene mixture (1:1). The extract was centrifuged at 1000 rpm for 5 minutes. The absorbance of the aliquot was measured in a spectrophotometer at 460 nm. The extract was then allowed to bleach by placing the test tubes near the window for u v light radiation and the absorbance taken at 460nm. The level of beta – carotene was calculated as follows:

B – Carotene (mg / m l) = A^0 (460) – A' (480)

Where: A^0 = initial absorbance

A' = absorbance after bleaching

3.5.2 Determination of Vitamin C (Ascorbic Acid) Content

Principle

Vitamin C is determined by oxidizing it in acid medium with 2,6-Dichlorophenol indophenol to ascorbic acid. Ascorbic acid reduces the indicator dye to a colorless solution. At the end point of titration excess unreduced dye is a rose-pink color in the acid solution. The titer of the dye can be determined by using a standard ascorbic solution. Then the ascorbic acid in the food sample can be determined by the calculation using the volume of the titration.

Method

Standardization of Indophenol

10ml of standardized ascorbic acid solution was pipette into a small flask and titrated with indophenol solution until a faint pink color persists for 15sec the concentration as mg ascorbic acid equivalent was expressed to 1ml of dye solution. At the end point volume ml dye solution was equivalent to 0.002g (2mg).Therefore the concentration of standard ascorbic acid per ml of dye was 0.002g/v ml.

Assay Procedure

2g of the food sample was weighed and grounded into a paste. 100ml of distilled water was added to the paste in a volumetric flask. Then it was filtered to get a clear solution.50ml of unconcentrated juice was pipetted into 100ml volumetric flask in triplicate. 25ml of 20% metaphosphoric (0.5 oxalic acid) was added as a stabilizing agent and diluted to 100ml volume. 10ml was pipette into small flask in which 2.5ml aceton was added then it was titrated with indophenol solution,(2,6dichlorophenol indophenol) to a faint pink color which pesisted for 15sec. Vitamin C content was calculated as:

Vitamin C=mg/100ml juice=20(v) (c) where

V=ml indophenols solution in titration

C=Mg vitamin C/ml indophenol.

3.5.3 UV-VIS Spectrophotometric Determination of Folic Acid (Vitamin B9)

The vegetable samples were dried at room temperature and ground into powder. Each of the dried sample was extracted in distilled water (3g of the sample in 10mlof distilled water). The mixture was allowed to stand for 6hrs for complete extraction. The sample was filtered using whatmann filter paper. The filtrate was then diluted with distilled water to 100ml. 2ml of this solution was then diluted to 10ml with distilled water and set aside for UV analysis.

Preparation of calibration curve

Pure folic acid (Sigma Pharmaceuticals) was used as external standard for the study. A stock solution of 1mg/ml was prepared and serially diluted to produce concentrations of 10, 20, 30, 40 and 50µg/ml. The absorbance of each solution was measured using a UV/Vis spectrophotometer at a wavelength of 282nm (λmax for folic acid). The absorbance values were then plotted against concentrations to generate a calibration curve (De Leenheer, *et al.,* 1985)

Ultraviolet-Visible spectrophotometric analysis

The absorbance of the dilute solution of each sample in the UV/VIS region was measured at the same wavelength of 282nm as for the standard solutions. The concentration of folic acid in each sample was then calculated using the line equation for the generated calibration curve.

3.6 Data analysis

Statistical analysis was employed to describe findings. This includes mean, percentages and ANOVA and Duncan multiple test for possible significant difference between the sample means.

CHAPTER FOUR

4.0 RESULTS

4.1 Identification of Lesser Consumed Vegetables

Table 4.1 shows 21 different types of lesser consumed vegetables identified with their biological names, family name, English names and local names. *Senna obtusifolia* (Coffee *senna*) and *Senna occidentalis* (Coffee *senna*) belong to the same family of Coesalpiniaceae. *Tamarindu indica* (Tamarin leaves), *Daniela oliverie* (Ilorin balsam) and *Vigna ungucuicutala* (Bean leaves) all belong to family of Fobaceae/Papilionaceae. *Hibiscus esculentus* (okra leaves) and *Hibiscus cannabinus* (Decan hemp) are from the same family of Malvaceae. While *Solanum incanum* (Green garden egg leaves) and *Solanum incanum* (white egg plant leaves) are from the same family of Solanaceae. Other vegetable leaves belong to different families; *Ipomoea batatas* (Sweet potato leaves) from Convoluulaceae family, *Clocusia esculentum* (Cocoyam leaves) from family of Araceae, *Cucumis melo* (pumpkin leaves) from cucurbitaceae family, *Mangifera indica* (Mango leaves) from Anacardiaceae, *Leptadenia hastata* from Aselipiadaceae family and *Manihot esculenta* (Cassava leaves) from Euphorbiaceae family

Table 4.2 shows the traditional processing methods of LCVs found in Kaduna State. The method of processing LCVs found in the studied areas were mainly blanching and boiling. *Ipomoea batatas* (Sweet potato leaves) and *Vigna unguiculata* (Bean leaves) were processed by blanching, while *Cucumis melo* (Pumpkin leaves), *Hibiscus esculentus* (Okra leaves), *Senna obtusifolia* (Coffee senna), *Senna occidentalis* (Coffee senna), *Mangifera indica* (Mango leaves), and *Clocusia esculentum* (Cocoyam leaves) were processed by boiling.

Table 4.3 describes the source and availability of LCV in the areas studied. Sweet potato leaves *(Ipomoea batatas*), Pumpkin leaves (*Cucumis melo*), Bean leaves (*vigna unguiculata)*, Okra leaves (*Hibiscus esculentus*), Cocoyam leaves (*Clocusia esculentum)* and Mango leaves (*Mangifera indica*) were cultivated (domesticated) while Coffee senna (*Senna obtusifolia*) and Coffee senna (*Senna occidentalis*) were wild (none domesticated) vegetables leaves The table also show that all the vegetables were seasonal except *Hibiscus esculentus* (Okra leaves) that were available throughout the year.

Table 4.1: Types of some Lesser Known Consumed Vegetables (LKCVs) found in Kaduna State

S/N	Botanical Name	Family Name	Local Name	English Name
1	*Senna obtusifolia*	*Caesalpiniaceae*	"Ganyen Tafasa"	Coffee senna
2	*Vihex doniana*	*Verbenaceae*	"Ganyen Dinkin"	Nettle tree leaves
3	*Solanum incanum*	*Solanaceae*	"Ganyen Yalo"	Egg Plant leaves
4	*Ocimum gratissimum*	*Labiatae*	"Ganyen Korry"	Thyne or Scent leaves
5	*Senna occidentalis*	*Caesalpiniaceae*	"Ganyen Raidore"	Coffee senna
6	*Hibiscus esculentus*	*Malvaceae*	"Ganyen Kubewa"	Okra Leaves
7	*Daniela oliverie*	*Fabaceae*	"Ganyen Maje"	Ilorin Balsam
8	*Manihot esculenta*	*Euphorbiaceae*	"Ganyen Rogo"	Cassava Leaves
9	*Vigna unguiculata*	*Fobaceae/papilionaceae*	"Ganyen Wake"	Bean Leaves
10	*Hbiscus cannabinus*	*Malvaceae*	"Ganyen Rama"	Deccan hemp
11	*Ipomoea batatas*	*Convolvulaceae*	"Ganyen Dankali"	Sweet potato leaves
12	*Cucumis melo*	*Cucurbitaceae*	"Ganyen Kabewa"	Pumpkin leaves
13	*Clocusia esculentum*	*Araceae*	"Ganyen Kwaza"	Cocoyam leaves
14	*Leptadenia hastate*	*Asclipiadaceae*	"Ganyen Yadiya"	Tears leaves
15	*Mangifera indica*	*Anacardiaceae*	"Ganyen mangoro"	Mango leaves
16	*Ximenia Americana*	*Olacaceae*	"Ganyen Tsada"	Spiny plum leaves
17	*Solanum incanum*	*Solanaceae*	"Ganyen Gauta"	Green egg plant leaves
18	*Discorea sp*	*Discoreaceae*	"Ganyen doya"	Yam leaves
19	*Tamarin dus indica*	*Fabaceae*	"Ganyen Tsamiya"	Tamarin Leaves

Table 4.2 Traditional Processing Method of Lesser Known Consumed Vegetables (LKCVs) found in Kaduna State

Vegetable	Processing Method
Ipomoea batatas (Sweet Potatoes Leaves)	Blanching
Cucumis melo (Pumpkin Leaves)	Boiling
Vigna unguiculata (Bean Leaves)	Blanching
Hibiscus esculentus (Okra Leaves)	Boiling
Senna obtusifolia (Coffee Senna)	Boiling
*Senna occidentalis (*Coffee Senna)	Boiling
*Clocusia esculentum(*Cocoyam leaf)	Boiling
Mangifera indica (Mango Leaves)	Boiling

Table 4.3 Source and Availability of Lesser Known Consumed Vegetables in Kaduna State

S.N	Vegetable	Source of Vegetables	Availability
1	*Ipomoea batatas* (Sweet Potatoes Leaves)	Cultivated	Seasonal
2	*Cucumis melo* (Pumpkin Leaves)	Cultivated	Seasonal
3	*Vigna unguiculata* (Bean Leaves)	Cultivated	Seasonal
4	*Hibiscus esculentus* (Okra Leaves)	Cultivated	Always available
5	Senna obtusifolia (Coffee Senna)	Wild	Seasonal
6	*Senna occidentalis* (Coffee Senna)	Wild	Seasonal
7	*Clocusia esculentum* (Cocoyam leaf)	Cultivated	Seasonal
8	*Mangifera indica* (Mango Leaves)	Cultivated	Seasonal

4.2 Consumption Pattern of LKCVs

Table 4.4 shows consumption frequency of the vegetable (LKCVs) under this study classified as either adequate (when consumed 5 -6 times) or inadequate (when consumed less than five times per week). The vegetables found to be adequately consumed during the study were *Senna obtusifolia* (73.81%), *Senna occidentalis* (74.60%) and *Clocusia esculentum* (61.11%). Other LKCVs were inadequately consumed. Their level of inadequacies ranged from 6.35% (*Mangifeca indica*) to 32.54% (*Ipomoea batatas*)

Table 4.5 indicated reasons for the consumption of LKCVs in the study areas. Above 34% of the respondents consumed these vegetables for their medicinal values, followed by 21.43% who consumed these vegetables because of their better flavour and taste. Above 15% of them consumed these leaves because of their cheapness and only 5(3.97%) of the respondent consumed these vegetables because of their belief in their high nutritional values.

Table 4.6 presents consumption method and affordability of LK C Vs in the study areas. *Ipomoea batatas, Cucumis melo, Vigna unguiculata*, *Hibiscus esculentus* and *Clocusia esculentum* were consumed cooked, combined with other foods, while *Senna obutusifolia* and *Senna occidentalis* were consumed cooked alone and can also be combined with other foods. It was only *Mangifera indica* that were consumed cooked alone.

Table 4.4 Frequency Distribution of Consumption Pattern of Lesser Known Consumed Vegetables (LKVCs) per Week in Kaduna State

S/N	Vegetables	Level of adequacy		Level of inadequacy		Total	
		Freq.	%	Freq.	%	Freq	%
1	*Ipomoea batatas* (Sweet Potatoes Leaves)	41	32.54	85	67.46	126	100
2	*Cucumis melo* (Pumpkin Leaves)	18	14.29	108	85.71	126	100
3	*Vigna unguiculata* (Bean Leaves)	24	14.05	102	80.95	126	100
4	*Hibiscus esculentus* (Okra Leaves)	13	10.32	113	89.68	126	100
5	Senna obtusifolia (Coffee Senna)	93	73.81	33	26.19	126	100
6	*Senna occidentalis (*Coffee Senna)	94	74.60	32	25.40	126	100
7	*Clocusia esculentum(*Cocoyam leaves)	77	61.11	49	38.89	126	100
8	*Mangifera indica* (Mango Leaves)	8	6.35	118	93.65	126	100

Table 4.5 Percentage Distribution of the Respondents by the Reasons for the Consumption of Lesser Known Consumed Vegetable (LKCVs) in Kaduna State.

Reasons	Frequency	Percentage (%)
Belief in their high nutrient value	5	3.97
Better flavour and taste they give to foods	27	21.43
Family preference	21	16.67
Medicinal values	44	34.94
Due to their availability	10	7.94
Due to their cheapness	19	15.08

Table 4.6 Affordability and Consumption Method of Lesser Known Consumed Vegetables in Kaduna State

S/N	Vegetable	Method of consumption	Affordability
1	*Ipomoea batatas* (Sweet potato leaves)	Cooked combined with other food (molded rice paste)	Affordable
2	*Cucumis melo* (Pumpkin leaves)	Cooked combine with other foods (sweet potato porridge)	Affordable
3	*Vigna unguiculata* (Bean leaves)	Cooked combined with other foods (Garnishing boiled rice)	Affordable
4	*Habiscus esculentus* (Okra leaves)	Cooked combined with other foods (molded paste maize)	Affordable
5	*Senna obtusifolia* (coffee senna)	Cooked alone, and cooked combined with other foods (maize porridge/ yam porridges)	Affordable
6	*Senna occidentalis* (coffee senna)	Cooked alone, and cooked combined with other foods (Local salad)	Affordable
7	*Clocusia esculentum* (Cocoyam leaves)	Cooked combined with other foods (molded rice paste/ pounded yam)	Affordable
8	*Mangifera indica* (Mango leaves)	Cooked alone (Salad)	Affordable

4.3 Proximate Composition of LCVs

Table 4.7a: shows the comparative analysis of proximate composition (%) of processed and unprocessed LKCVs; Carbohydrates (CHO), protein, and fat) (foliage) found in Kaduna State. There was significant ($P<0.05$) difference in the CHO content of processed and unprocessed vegetables. From the result, the unprocessed LK C Vs had higher CHO content in all the 8 different types of LK C Vs. On the other hand, there was significant ($P<0.05$) difference in the CHO content for the 8 different types of unprocessed vegetables. The highest CHO content (50.33%) was recorded from *Senna obtusifolia* (coffee senna), which was significantly ($P<0.05$) higher than those of unprocessed Clocusia *esculentum* (Cocoyam leaves) and *Hibiscus esculentus* (Okra leaves). The least value of CHO was recorded for unprocessed *Ipomoea batatas* (sweet potato leaves), which was lower than values obtained from unprocessed *Vigna unguiculata* (Bean leaves), unprocessed *Cucumis melo* (Pumpkin leaves), and *Senna occidenlis* (Coffee senna). The processed CHO values for the 8 different types of LK C Vs varied and it ranged from 11.80% to 41.38%. The highest CHO content was recorded from processed *Hibiscus esculentus* (Okra leaves) which was significantly ($P<0.05$) higher than values obtained from *Senna obtusifolia* and processed *Mangifera indica* (Mango leaves). The least CHO content was recorded for processed *Ipomoea batatas* (Sweet potato leaves) (11.80%), and then followed by processed *Clocusia esculentum* (Cocoyam leaves) (11.99%) then *Vigna unguiculata* (Bean leaves) (14.55%).

Crude protein level (%); from the result, the unprocessed vegetables have higher protein content in all the eight different types of LK C Vs. On the other hand, there was significant ($P<0.05$) difference in protein content of the processed vegetables, which ranged from 2.67 to

6.44%. The processed *Ipomoea batatas* leaves had the highest value of protein content, which was significantly (P<0.05) higher than that of processed *Cucumis melo* and processed *Vigna unguiculata*. The processed *Hibiscus esculentus* and processed *Mangifera indica* leaves had the least protein content of 2.67% and 2.98% respectively. Comparing the eight unprocessed LK C Vs, the protein content varied and it ranged from 4.09% to 12.49%. The highest protein content still was from unprocessed *Ipomoea batatas* (12.49%), which was significantly (P<0.05) higher than others. Unprocessed *Mangifera indica* (4.09%) had the least value of protein, which was significantly lower than values of protein obtained from unprocessed *Vigna unguiculata* (8.05%) and unprocessed *Cucumis melo* (8.11%).

There was significant (P<0.05) difference in the fat content of processed and unprocessed LK C Vs. From the result (Table 4. 7a) the unprocessed vegetables have higher fat content in all the eight LKCVs compared to the processed LKCVs. On the other hand, there was significant P<0.05) difference in the fat content across the eight unprocessed vegetables and it ranged from 0.37% to 5.00%. The highest fat content was recorded from unprocessed *Cucumis melo* (5.00%) which was significantly (p<0.05) higher than the others, such as unprocessed *Ipomoea batata*s, *Vigna unguiculata*, *Senna occidentalis* and *Hibiscus esculentus* with fat values of 3.04%, 2.04%,1.31% and 1.13% respectively. The fat content of the processed eight different types of LK C Vs also varied and it ranged from 0.17% to 3.16%. Comparing the eight processed different types of LKC Vs, the processed *Clocusia esculentum* and processed *Cucumis melo* had the highest fat content of 3.16% and 3.13% respectively, which were significantly (P<0.05) higher than the others; processed *Ipomoea batatas* (1.65%), and processed *Vigna unguiculata* (1.34). Processed *Mangifera indica* (0.17%) had the least fat

content which was significantly lower than processed *Senna occidentalis* and *Hibiscus esculentus* with the same values of fat content as 0.31% each.

Table 4.7b shows comparative analysis of proximate composition (%) of processed and unprocessed LKCVs (ash, fibre, and moisture) (foliage) found in Kaduna State. There was significant ($P<0.05$) difference in the ash content of processed and unprocessed vegetables. From the result the unprocessed vegetables had higher ash content in all the eight different types of LK C Vs. On the other hand, there was significant ($P<0.05$) difference in ash content across the eight different types of processed vegetables. Their content varied and ranged from 2.72% to 5.72%. The highest ash content was recorded for processed vegetables: *Ipomoea batatas*, followed by *Vigna unguiculata*, then *Clocusia esculentum* and then *Senna obtusifolia*" with similar values of 5.72%, 5.30%, 5.92% and 5.11% respectively. The values are significantly $P<0.05$) different from *Senna occidentalis* (4.93%), and the least ash content was obtained from processed *Mangifera indica* (2.72%). comparing the eight different types of unprocessed vegetables, the ash content varied and ranged from 4.67% to 7.06%. The highest ash content were recorded from: *Cucumis melo*, *Clocusia esculentum*, *Senna occidentalis*, *Senna obtusifolia*, *Vigna unguiculata* and *Ipomoea batatas* with values of 7.06%, 6.90%, 6.79%, 6.75%, 6.74% and 6.74% respectively. These values were significantly ($P<0.05$) higher than the ash content of unprocessed *Mangifera indica* (4.67 %.).The moisture content in processed and unprocessed different types of LK C Vs, there were significant ($P<0.05$) differencse in the moisture content of processed and unprocessed vegetables. From the result (Table 4. 7b) the processed vegetables had higher moisture content in all the eight LK C Vs. On the other hand, there was significant $P<0.05$) difference in the moisture content

across the unprocessed eight different types of LK C Vs which ranged from 28.10% to 61.11%. The highest moisture content was obtained from unprocessed vegetables *Vigna unguiculata* (61.11%), followed by *Ipomoea batatas* (60.44%) and *Clocusia esculentum* (60.64%) which were all significantly P<0.05) higher than unprocessed *Cucumis melo* (51.92%), S*enna occidentalis* (45.22%) and *Mangifera indica* (48.94%). The unprocessed *Senna obtusifolia* had the least moisture content (28.10%) which was significantly lower than that of unprocessed *Hibiscus esculentus* (39.78%). Comparison of the eight different types of processed LK C Vs, showed that the highest moisture content was recorded for *Senna occidentalis* (72.30%) which was significantly (P<0.05) higher than those of *Cucumis melo* (69.07%), *Mangifera indica* (62.78%) and *Ipomoea batatas* (62.78%). The processed *Hibiscus esculentus* and *Vigna unguiculata* had the least moisture content of 50.16% and 50.05% respectively.

The fibre content in the processed and unprocessed eight different types of LK C Vs is presented on the same table (Table 4.7b). There was significant (P<0.05) difference in the fibre content in the processed and unprocessed eight different types of LK C Vs. Based on the result, the unprocessed vegetables had higher fibre contents in all the 8 different types of LK C Vs. On the other hand there was significant (P<0.05) difference in fibre content across the eight unprocessed LK C Vs and values ranged from 1.72% to 9.88%. The highest fibre content was obtained from unprocessed *Cucumis melo* (9.88%) which was significantly (P<0.05) higher than the fibre content values recorded for unprocessed *Senna obtusifolia* (7.10%), *Vigna unguiculata* (6.72%) and *Ipomoea batatas* (6.72%). Unprocessed *Mangifera indica* had the least fibre content (1 .72%), which was significantly lower than values obtained

from *Hibiscus esculentus* (3.36%) and *Senna occidentalis* (4.45%). The result of the eight processed LK C Vs showed that, processed *Cucumis melo* had the highest fibre content (6.43%). This value was significantly ($P<0.05$) different from the fibre values recorded for *Senna obtusifolia* (5.41%), *Ipomoea batatas* (4.12%), *Senna occidentalis* (3.60%) and *Mangifera indica* (0.93%).

Table 4.7a: Proximate Composition (g/100%) of Processed and Unprocessed Lesser Known Consumed Vegetables (LKCVs) (Foliage) Found in Kaduna State

S/No	Types of Vegetable	PROXIMATE COMPOSITION					
		Carbohydrate		Protein		Fat	
		Processed	Unprocessed	Processed	Unprocessed	Processed	Unprocessed
1	*Ipomoea batatas* (Sweet Potato leaves)	11.80 ± 0.07^{g}	13.96 ± 0.05^{g}	6.44 ± 0.02^{a}	12.49 ± 0.01^{a}	1.65 ± 0.04^{b}	3.04 ± 0.02^{c}
2	*Cucumis melo* (Pumpkin leaves)	16.86 ± 0.04^{d}	17.73 ± 0.03^{e}	5.65 ± 0.05^{b}	8.05 ± 0.06^{b}	3.13 ± 0.03^{a}	5.00 ± 0.02^{a}
3	*Vigna unguiculata* (Bean leaves)	14.55 ± 0.05^{e}	15.28 ± 1.27^{f}	5.03 ± 0.02^{b}	8.11 ± 0.20^{b}	1.34 ± 0.04^{c}	2.04 ± 0.26^{d}
4	*Hibiscus esculentus* (Okra leaves)	41.38 ± 0.54^{a}	42.39 ± 0.36^{b}	2.67 ± 0.56^{e}	6.60 ± 0.36^{c}	0.31 ± 0.01^{e}	1.13 ± 0.09^{f}
5	*Senna obtusifolia* (Coffee senna)	31.06 ± 0.04^{b}	50.33 ± 0.17^{a}	3.83 ± 0.16^{d}	5.57 ± 0.49^{d}	0.31 ± 0.01^{e}	1.12 ± 0.03^{f}
6	*Senna occidentalis* (coffee senna)	25.43 ± 0.37^{c}	35.94 ± 0.06^{d}	4.78 ± 0.12^{c}	6.39 ± 0.02^{c}	0.96 ± 0.05^{d}	1.31 ± 0.02^{e}
7.	*Clocusia esculentum* (Cocoyam Leaves)	11.99 ± 0.03^{g}	42.46 ± 5.76^{b}	4.39 ± 0.46^{c}	5.55 ± 0.57^{d}	3.16 ± 0.26^{g}	4.04 ± 0.31^{b}
8	*Mangifera indica* (Mango leaves)	31.29 ± 0.26^{b}	40.13 ± 0.02^{c}	2.98 ± 0.03^{e}	4.09 ± 0.16^{e}	0.17 ± 0.05^{f}	0.37 ± 0.07^{g}

Means in the same columns and rows with different superscripts are significantly different ($P<0.05$) as above.

Table 4.7b Proximate Composition (g/100%) of Processed and Unprocessed Lesser Known Consumed Vegetables (LKCVs) (Foliage) Found in Kaduna State

S/No	Types of Vegetable	PROXIMATE COMPOSITION					
		Ash		Fibre		Moisture	
		Processed	Unprocessed	Processed	Unprocessd	Processed	Unprocessed
1	*Ipomoea batatas* (Sweet Potato leaves)	5.72±0.01^{a}	6.74±0.64^{b}	4.12±0.03^{c}	6.72±0.01^{c}	62.78±0.07^{c}	60.44±0.58^{a}
2	*Cucumis melo* (Pumpkin leaves)	3.87±0.03^{c}	7.06±0.04^{a}	6.43±0.02^{a}	9.88±0.10^{a}	69.07±1.80^{b}	51.92±0.79^{b}
3	*Vigna unguiculata* (Bean leaves)	5.30±0.05^{a}	6.74±0.64^{b}	3.60±0.02^{e}	6.72±0.37^{c}	50.05±0.05^{e}	61.11±0.03^{a}
4	*Hibiscus esculentus* (Okra leaves)	3.28±0.31^{c}	6.63±0.56^{c}	2.60±0.05^{f}	3.36±0.19^{f}	50.16±0.13^{e}	39.78±0.50^{d}
5	*Senna obtusifolia* (Coffee senna)	5.11±0.11^{a}	6.75±0.05^{b}	5.41±0.51^{b}	7.10±0.11^{b}	59.97±0.24^{d}	28.10±0.10^{e}
6	*Senna occidentalis* (coffee senna)	4.93±0.06^{b}	6.79±0.19^{b}	3.99±0.47^{d}	4.45±0.04^{e}	72.30±0.01^{a}	45.22±0.02^{c}
7.	*Clocusia esculentum* (Cocoyam Leaves)	5.29±0.53^{a}	6.90±0.35^{b}	2.85±0.15^{f}	5.88±0.11^{d}	61.55±0.05^{d}	60.64±0.04^{a}
8	*Mangifera indica* (Mango leaves)	2.72±0.03^{d}	4.67±0.58^{d}	0.93±0.01^{g}	1.72±0.24^{g}	62.78±0.07^{c}	48.94±0.06^{c}

Means in the same columns and rows with different superscripts are significantly different (P<0.05) as above.

4.4 Minerals Composition of LKCVs

Table 4.8a shows the comparison of mineral elements (calcium, magnesium, and potassium) (foliage) levels in the processed and unprocessed eight different types of LKCVs. There was significant ($P<0.05$) difference in processed and unprocessed calcium content in all LKCVs. From the result the unprocessed vegetables had higher calcium content in all the eight LKCVs. On the other hand, there was significant ($P<0.05$) difference in the calcium content across the eight different types of unprocessed LKCVs. The highest calcium content was recorded for unprocessed *Cucumis melo* (200.22 mg/100g) which was significantly ($P<0.05$) higher than that of unprocessed *Ipomoea batatas* (116.51 mg/100g), unprocessed *Clocusia esculentus* (100.32 mg/100g) and unprocessed *Senna occidentalis* (99.50mg/100g). Unprocessed *Mangifera indica* (5.33 mg/100g) had the least calcium value, that was significantly ($P<0.05$) lower than values obtained from unprocessed *Hibiscus esculentus* (10.47 mg/100g) and *Vigna unguiculata* (41.29 mg/100g). Considering the processed eight different LKCVs, the values varied and ranged from 2.71mg/100g to 103.48mg/100g. The highest calcium content still comes from processed *Cucumis melo* (103.48 mg/100g) which was significantly ($P<0.05$) higher than the others, such as processed *Ipomoea batatas* (99.64 mg/100g), processed *Senna occidentalis* (71.48 mg./100g) and processed *Clocusia esculentum* (70.34 mg/100g). Unprocessed *Mangifera indica* had the least content of calcium (2.71 mg/100g) which was significantly ($P<0.05$) lower than values obtained from *Hibiscus esculentus* (8.10 mg/100g).

There was significant ($P<0.05$) difference in the magnesium content of processed and unprocessed LKCVs. From the result, the unprocessed vegetables have higher magnesium

content in all the eight LKCVs. On the other hand, there was significant (P<0.05) difference in the magnesium content across the unprocessed eight different types of vegetable. The values ranged from 99.96mg/100g to 128.50mg/100g. The highest magnesium content were recorded in unprocessed *Clocusia esculentum*, unprocessed *Ipomoea batatas*, unprocessed *Hibiscus esculentus* and unprocessed *Senna obtusifolia* with similar values of 128.50 mg/100g, 127.70 mg/100g, 127.50 mg/100g and 127.00 mg/100g respectively. These values were significantly (p<0.05) higher than the magnesium values obtained for unprocessed *Mangifera indica* (117.60 mg/100g) and unprocessed *Senna occidentalis* (100.60 mg/100g). Considering the magnesium content across the processed eight different types of LKCVs, the values varied and ranged from 85.78mg/100g to 125.08mg/100g. The highest magnesium content was recorded for processed *Ipomoea batatas* (125.08 mg/100g) which was significantly (P<0.05) higher than other samples, like processed *Vigna unguiculata* (121.99 mg/100g), processed *Senna obtusifolia* (103.63 mg/100g). Processed *Hibiscus esculentus* (85.78 mg/100g) had the least magnesium content, which was significantly (P<0.05) lower than the values of magnesium recorded for processed *Senna occidentalis*, processed *Cucumis melo* and then processed *Mangifera indica* with values of 95.13 mg/100g, 99.96 mg/100g and 100.29 mg/100g respectively.

There was significant (P<0.05) difference in the potassium content between processed and unprocessed LKCVs. Based on the result, the unprocessed vegetables had higher potassium content in all the eight vegetables. On the other hand, there was significant (P<0.05) difference in the potassium contents across the eight different types of unprocessed vegetables. The potassium content ranged from 220.10mg/100g to 3,277.75 mg/100g for

unprocessed vegetables. The *Hibiscus esculentus* (220.10mg/100g) had the least potassium content, which was significantly (P<0.05) lower than values of potassium obtained from *Vigna unguiculata* (289.35 mg/100g), and then *Clocusia esculentum* (294.08 mg/100g). The highest potassium value was recorded for *Ipomoea batatas* (3,277.75mg/100g), which was significantly (P<0.05) higher than potassium values recorded for *Senna obtusifolia* (2,379.94mg/100g), and *Mangifera indica* (1,378.18 mg/100g). Comparing the eight processed different types of LKCVs, the potassium values ranged from 72.50 mg/100g to 996.45 mg/100g. The highest potassium content was for *Ipomoea batatas* (996.45 mg/100g) which was significantly (P<0.05) higher than potassium values obtained from *Hibiscus esculentus* (299.26 mg/100g), *Vigna unguiculata* (235.62 mg/100g), and then *Mangifera indica* (233.86 mg/100g). The least potassium content was obtained for *Cucumis melo* (72.50 mg/100g) which was lower than values of potassium content obtained from *Senna obtusifolia* (145.02mg/100g) and *Senna occidentalis* (176.51 mg/100g).

Table 4.8b shows the comparison of mineral elements (sodium, iron, and zinc) (foliage) content of some processed and unprocessed LKCVs found in Kaduna State. There was significant (P<0.05) difference in their micronutrient content. Based on the result, unprocessed vegetables had higher sodium content in all the vegetables except, *Vigna unguiculata*. The sodium content across unprocessed different types of LKCVs varied and ranged from 0.47mg/100g to 11.14mg/100g. The highest quantity of sodium content was recorded for unprocessed *Cucumis melo* (11.14mg/100g). This value was significantly (P<0.05) higher than the sodium content in unprocessed *Ipomoea batatas* and *Hibiscus esculentus* with values of 10.37mg/100g and 6.33mg/100g respectively. *Vigna unguiculata*

(0.47mg/100g) had the least sodium content which was lower than the values for *Senna obtusifolia* (0.87mg/100g) and *Mangifera indica* (1.82mg/100g). Considering values across eight processed different types of LKCVs, their sodium content also varied and ranged from 0.36mg/100g to 9.93mg/100g. The highest sodium content was recorded for *Ipomoea batatas* and *Vigna unguiculata* with sodium values of 9.93mg/100g and 8.07mg/100g respectively. These sodium content were significantly ($P<0.05$) different from sodium content obtained from *Cucumis melo* (4.67mg/100g) and *Senna obtusifolia* (0.68mg/100g). *Mangifera indica* had the least sodium content (0.36mg/100g) followed by *Senna occidentalis* (0.58mg/100g).

On the zinc level in the processed and unprocessed eight different types of LKCVs, there was significant ($P<0.05$) difference between processed and unprocessed zinc content in all the eight vegetables. Based on the result, the unprocessed vegetables had higher zinc content in all the eight vegetables. However, there was significant ($P<0.05$) difference in the zinc content across the different types of unprocessed LKCVs. The zinc content of the vegetables ranged from 0.23mg/100g to 9.47mg/100g (unprocessed). The highest values of zinc were obtained for *Senna obtusifolia* (9.61mg/100g) and *Ipomoea batatas* (9.47mg/100g). However, these values were significantly ($p<0.05$) different from zinc content of other unprocessed vegetable samples like *Cucumis melo* (6.64mg/100g), *Hibiscus esculentus* (1.59mg/100g) and *Vigna unguiculata* (1.23mg/100g).*Senna occidentalis* had the least zinc content (0.23mg/100g) followed by *Mangifera indica* (0.72mg/100g) and *Clocusia esculentum* (0.79mg/100g). Comparing the eight different types of processed vegetables, the zinc values ranged from 0.29mg/100g to 5.38mg/100g. The highest zinc value was obtained for *Senna obtusifolia* (5.38mg/100g) which was significantly ($P< 0.05$) different from values obtained for *Senna*

occidentalis and *Vigna unguiculata* with values of 0.55mg/100g and 0.77mg/100g respectively. *Mangifera indica* had the least zinc content (0.29mg/100g) which was lower than 0.47mg/100g each of zinc content for *Clocusia esculentum* and *Hibiscus esculentu*.

The iron content in the processed and unprocessed eight different types of L K C Vs is also presented in Table 4.8b. There was significant ($P<0.05$) differences in the iron level of processed and unprocessed in all the vegetables. Based on the result, the unprocessed vegetables had higher iron content in all the eight vegetables. On the other hand, there was significant ($p<0.05$) differences in iron content across the eight different types of processed vegetables. The processed vegetable iron content also ranged from 0.19mg/100g to 11.78mg/100g. The highest iron content was obtained for processed *Ipomoea batatas* and *Cucumis melo* with values of 11.78mg/100g and 10.44mg/100g respectively. These values were significantly ($P <0.05$) different from the values obtained for *Senna obtusifolia* (3.04mg/100g) and *Mangifera indica* (1.39mg/100g). The least iron value was recorded for processed *Clocusia esculentum* (0.19mg/100g) which was lower than values obtained for *Vigna unguiculata* (0.80mg/100g) and *Senna occidentalis* (0.63mg/100g). The iron content of the eight unprocessed vegetables, ranged from 0.39mg/100g to 19.53mg/100g. The highest iron content was from unprocessed *Ipomoea batatas* (19.53mg/100g) which was significantly ($P<0.05$) higher than the values from unprocessed *Cucumis melo* (12.05mg/100g) and *Senna obtusifolia* (4.66mg/100g). The least iron content was recorded for *Clocusia esculentum* (0.39mg/100g) followed by *Mangifera indica* (1.03mg/100g).

Table 4. 8a Mineral Composition (mg/100g) of Processed and Unprocessed Lesser Known Consumed Vegetables (LKCVs) (Foliage) found in Kaduna State

S/N	Types of Vegetable	MINERAL COMPOSITION					
		Calcium		Magnesium		Potassium	
		Processed	Unprocessed	Processed	Unprocessed	Processed	Unprocessed
1	*Ipomoea batatas* (Sweet Potato leaves)	99.64±0.03^{b}	116.51±0.02^{b}	121.99±0.01^{b}	127.69±0.01^{b}	996.45±0.01^{a}	3277.75±0.57^{a}
2	*Cucumis melo* (Pumpkin leaves)	103.48±0.42^{a}	200.22±0.02^{a}	95.13±0.03^{g}	110.57±0.47^{d}	72.50±0.02^{h}	856.60±0.02^{e}
3	*Vigna unguiculata* (Bean leaves)	23.52±0.02^{f}	41.29±0.01^{e}	98.96±0.02^{f}	99.96±0.02^{f}	235.62±0.33^{c}	289.35±0.01^{g}
4	*Hibiscus esculentus* (Okra leaves)	8.10±0.01^{g}	10.47±0.07^{f}	100.29±0.02^{d}	127.51±0.15^{b}	299.26±0.23^{b}	220.10±0.05^{h}
5	*Senna obtusifolia* (Coffee senna)	25.84±0.14^{e}	59.52±0.42^{d}	103.63±0.02^{e}	127.02±0.01^{b}	145.02±0.45^{g}	2379.94±0.01^{b}
6	*Senna occidentalis* (coffee senna)	71.48±0.01^{d}	99.50±0.01^{c}	85.78±0.47^{h}	100.61±0.15^{e}	176.51±0.02^{f}	1025.49±0.05^{d}
7.	*Clocusia esculentum* (Cocoyam Leaves)	70.34±0.01^{c}	100.32±0.03^{b}	125.08±0.05^{a}	128.53±0.41^{a}	197.66±0.57^{e}	294.08±0.03^{f}
8	*Mangifera indica* (Mango leaves)	2.71±0.01^{g}	5.33±0.03^{h}	102.49±0.03^{d}	117.61±0.03^{c}	233.86±0.12^{d}	1378.18±0.02^{c}

Means in the same columns and rows with different superscripts are significantly different (P<0.05) as above.

Table 4.8b Mineral Composition (mg/100g) of Processed and Unprocessed Lesser Known Consumed Vegetables (LKCVs) (Foliage) found in Kaduna State

S/No	Types of Vegetable	MINERAL COMPOSITION					
		Sodium		Iron		Zinc	
		Processed	Unprocessed	Processed	Unprocessed	Processed	Unprocessed
1	*Ipomoea batatas* (Sweet Potato leaves)	9.93 ± 0.02^{a}	10.37 ± 0.03^{b}	1.39 ± 0.02^{c}	19.53 ± 0.02^{a}	4.57 ± 0.04^{e}	9.47 ± 0.02^{a}
2	*Cucumis melo* (Pumpkin leaves)	4.67 ± 0.03^{d}	11.14 ± 0.04^{a}	0.19 ± 0.01^{g}	12.05 ± 0.02^{b}	4.56 ± 0.20^{c}	6.64 ± 0.04^{b}
3	*Vigna unguiculata* (Bean leaves)	8.07 ± 0.01^{b}	0.47 ± 0.02^{f}	0.42 ± 0.03^{f}	2.34 ± 0.03^{d}	0.77 ± 0.02^{d}	1.23 ± 0.02^{d}
4	*Hibiscus esculentus* (Okra leaves)	5.89 ± 0.16^{c}	6.33 ± 0.02^{b}	0.04 ± 0.04^{b}	2.97 ± 0.02^{d}	0.47 ± 0.04^{e}	1.59 ± 0.01^{c}
5	*Senna obtusifolia* (Coffee senna)	0.68 ± 0.10^{e}	0.87 ± 0.03^{e}	0.63 ± 0.01^{f}	4.66 ± 0.01^{c}	5.38 ± 0.02^{g}	9.61 ± 0.59^{a}
6	*Senna occidentalis* (coffee senna)	0.58 ± 0.08^{f}	3.24 ± 0.04^{c}	10.44 ± 0.02^{a}	1.03 ± 0.01^{f}	0.55 ± 0.02^{d}	0.23 ± 0.02^{f}
7.	*Clocusia esculentum* (Cocoyam Leaves)	0.68 ± 0.27^{e}	3.26 ± 0.55^{c}	11.78 ± 0.02^{a}	0.39 ± 0.02^{g}	0.47 ± 0.03^{e}	0.79 ± 0.02^{e}
8	*Mangifera indica* (Mango leaves)	0.36 ± 0.55^{g}	1.82 ± 0.01^{d}	0.80 ± 0.01^{d}	1.37 ± 0.03^{e}	0.29 ± 0.02^{f}	0.72 ± 0.03^{e}

Means in the same columns and rows with different superscripts are significantly different ($P<0.05$) as above.

4.5 Vitamin Composition of the LKCV

Table 4.9 presents comparative analysis of vitamins composition in processed and unprocessed eight different types of L K C Vs (foliage) found in Kaduna State. Based on the result there was significant ($P < 0.05$) difference in the vitamin A content of processed and unprocessed L K C Vs, however the unprocessed vegetable had higher vitamin A content in all the eight L K C Vs. On the other hand, there was significant ($P<0.05$) difference in the vitamin A content across the processed eight different types of vegetables. The vitamin A content of the different vegetables varied from 6.99mg/100g to 13.99mg/100g. The highest vitamin A content was recorded for *Mangifera indica* (13.99mg/100g) which was significantly ($P<0.05$) higher from vitamin A content for *Senna obtusifolia* (11.93mg/100g) and *Ipomoea batatas* (13.44mg/100g). The least vitamin A was recorded for processed *Senna occidentalis* (6.99mg/100g), which was lower than values of vitamin A obtained for processed *Vigna unguiculata* (8.74mg/100g) and processed *Cucumis melo* (9.50mg/100g). Comparing the unprocessed eight vegetables showed, the vitamin A content ranged from10.22mg/100g to 14.36mg/100g. The unprocessed *Cucumis melo* (14.36mg/100g) had the highest vitamin A content, which was significantly ($p<0.05$) different from vitamin A values recorded for unprocessed *Vigna unguiculata*, unprocessed *Ipomoea batatas*, and unprocessed *Senna occidentalis* with values of 14.04mg/100, 14.03mg/100g, 14.03mg/100g, and 14.03mg/100g respectively. The least vitamin A content was for *Hibscus esculentus* (10.22mg/100g) which was lower than vitamin A values obtained from unprocessed *Senna sobtusifolia (*13.20mg/100g).

The vitamin C composition of processed and unprocessed eight different types of L K C Vs is presented in the same Table 4.9. From the result there was significant (P<0.05) different in vitamin C content of processed and unprocessed vegetables. The unprocessed vegetables had higher vitamin C content in all the eight L K C Vs. On the other hand, there was significant (P<0.05) different in the vitamin C content across the eight different types of unprocessed vegetables. It ranged from 0.35mg/100g to 4.22mg/100g in the unprocessed vegetables. The highest vitamin C content was from unprocessed *Hibiscus esculentus* (4.22mg/100g) which was significantly (P<0.05) higher than values obtained for *Senna occidentalis* and *Mangifera indica (*unprocessed) with the values of 0.86/100g and 0.83mg/100g respectively . The least value of vitamin C was recorded for unprocessed *Clocusia esculentum* (0.35mg/100g) which was slightly lower than vitamin C values obtained for unprocessed *Ipomoea batatas* (0.36mg/100g) and unprocessed *Senna obtusifolia* (0.40mg/100g Comparing the processed eight vegetables, the vitamin C content ranged from 0.30gm/100g to 3.35mg/100. Processed *Hibiscus esculentus* (3.35mg/100g) had the highest vitamin C content, which was significantly (P<0.05) higher than vitamin C content for processed *Cucumis melo, Senna obtusifolia, Ipomoea batatas,* and *Clocusia esculentum* with the same vitamin C values of 0.35mg/100g each. *Mangifera indica* (0.30mg/100g) had the least content of vitamin C, which is slightly lower than vitamin C values from *Senna occidentalis* (0.32mg/100g).

The folate (vitamin B9) composition of processed and unprocessed eight different types of L K C Vs. Based on the result, there was significant (P<0.05) difference in folate (vitamin B9) content in the processed and unprocessed vegetables. However, the unprocessed vegetables had higher vitamin B9 content in all the eight vegetables. In the unprocessed vegetables, there

was significant (P<0.05) difference in vitamin B9 content of the eight different types of L K C Vs. The folate content of the unprocessed vegetables varied from 5.24 mg/100g to 12.49mg/100g. The highest folate (12.49mg/100g) content was recorded for unprocessed *Hibiscus esculentus*, which was significantly (P<0.05) higher than folate recorded for unprocessed *Vigna unguiculata* and unprocessed *Cucumis melo* with values of 7.80mg/100g and 7.62gm/100 respectively. The least folate content was recorded for *Clocusia esculentum* (5.24mg/100g), which was lower than the values obtained from unprocessed *Mangifera indica* (5.76mg/100g). In the processed eight vegetables, the folate content ranged from 2.77mg/100g to 8.11mg/100g. The processed *Senna obtusifolia* had the highest folate content (8.11g/100g) which was significantly (P<0.05) different from values obtained for processed *Hibiscus esculentus* (7.7.4mg/100g), processed *Cucumis melo* (5.21mg/100g), processed *Ipomoea batatas* (11.61mg/100g), and processed *Senna occidentalis* (4.45mg/100g). The least folate values were recorded for processed *Mangifera indica* and processed *Clocusia esculentum* with values of 2.77mg/100g and 2.96mg/100g respectively.

Table 4.9 Vitamin Composition (mg/100g) of Processed and Unprocessed Lesser Known Consumed Vegetables (LKCVs) (Foliage) found in Kaduna State

S/No	Types of Vegetable	VITAMIN COMPOSITION					
		Vitamin A		Vitamin C		Folate (B_9)	
		Processed	Unprocessed	Processed	Unprocessed	Processed	Unprocessed
1	*Ipomoea batatas* (Sweet Potato leaves)	13.44 ± 0.02^{b}	14.04 ± 0.01^{b}	0.35 ± 0.01^{c}	0.36 ± 0.01^{f}	4.61 ± 0.37^{d}	6.26 ± 0.57^{e}
2	*Cucumis melo* (Pumpkin leaves)	9.05 ± 0.02^{f}	14.36 ± 0.03^{a}	0.35 ± 0.01^{c}	0.46 ± 0.01^{d}	5.21 ± 0.40^{c}	7.62 ± 0.53^{c}
3	*Vigna unguiculata* (Bean leaves)	8.74 ± 0.31^{g}	14.04 ± 0.02^{b}	1.49 ± 0.01^{b}	3.23 ± 0.03^{b}	3.84 ± 0.23^{e}	7.80 ± 0.18^{c}
4	*Hibiscus esculentus* (Okra leaves)	9.82 ± 0.03^{e}	10.22 ± 0.02^{f}	3.35 ± 0.01^{a}	4.22 ± 0.01^{a}	7.74 ± 0.29^{b}	9.84 ± 0.20^{b}
5	*Senna obtusifolia* (Coffee senna)	11.93 ± 0.01^{c}	13.20 ± 0.01^{e}	0.35 ± 0.02^{c}	0.40 ± 0.02^{e}	8.11 ± 0.27^{a}	12.49 ± 0.13^{a}
6	*Senna occidentalis* (coffee senna)	6.99 ± 0.03^{h}	14.03 ± 0.01^{c}	0.32 ± 0.01^{d}	0.86 ± 0.01^{c}	4.45 ± 0.22^{d}	6.77 ± 0.04^{d}
7.	*Clocusia esculentum* (Cocoyam Leaves)	10.98 ± 0.01^{d}	13.68 ± 0.02^{d}	0.34 ± 0.01^{c}	0.35 ± 0.03^{g}	2.96 ± 0.08^{f}	5.24 ± 0.29^{f}
8	*Mangifera indica* (Mango leaves)	13.99 ± 0.02^{a}	14.03 ± 0.01^{c}	0.30 ± 0.02^{e}	0.83 ± 0.02^{c}	2.77 ± 0.31^{f}	5.76 ± 0.31^{f}

Means in the same columns and rows with different superscripts are significantly different ($P<0.05$) as above

CHAPTER FIVE

5.0 DISCUSSION

5.1: Discussion

In this study twenty one different types of lesser known consumed vegetables (LKCVs) were identified. The vegetables include *Senna obtusifolia (*Coffee senna*)* dawn to *Tamarindus indica* (tamarin leaves) with their botanical names, family names, local names, and English names. A similar study carried out by Fransica and Enzaquire, (2007) reported that, it is important that the leafy vegetables are correctly identified by both their botanical names and local names, as this provides the basis for identifying the variation on nutrients and health protecting traits among cultivars within a given vegetable species

Among the eight vegetable samples selected from identified vegetables in this study, six were cultivated vegetables while the remaining two vegetable samples were wild vegetables. A similar survey in south western Nigeria identified twenty (20) leafy vegetable species but only about eight (8) were relatively cultivated for consumption, while the rest exist in the forest (Aju and Poopola 2010).

The present study found out that, all the vegetables studied, except *Hibiscus esculentus* (Okra leaves) were not available throughout the year. A similar study by Getachew *et al* (2013), reported that one of the constraints to vegetable consumption is the fact that many are not available at all during certain parts of the year. Other studies also suggested that, the technologies to extend the harvest period or to facilitate storage are particularly important for

vegetables as well as preservation method such as solar drying, to extend their period of availability throughout the year (Hart *et al*., 2005).

During the in– season a lot of vegetables go to waste because there are too many in the household; however, there is limited supply of these vegetables during off– season thus leading to increased prices and reduced consumption (Hebwet *and* Wallingo,2008). Therefore, the traditional method of processing these vegetables observed in this study could go a long way in minimizing wastage during the in season and ensuring availability of vegetables during the off – season, hence resulting in year – round supply of these nutrients dense commodities.

A study reported that adequate intake of vegetable is clearly a positive solution for problems of poor diet quality in the developing countries (Aju and Poopola, 2010). This study observed sufficient intake of some of the LKCVs. Those with high level of consumption (ie intake between 5 times and above per week) includes *Senna obtusifolia* (73.81%), *Senna occidentalis* (74.60%) and *Clocusia esculentum* (61.11%). However, 62.5% of the studied LKCVs were found to be inadequately consumed (as their frequency of intake was observed to be less than 5 times per week) their level of consumption ranged from 6.35% (*Mangifeca indica*) to 32.54% (*Ipomoea batatas*). The LKCVs with high level of consumption would therefore contribute to solving problems of low quality diets (that leads to malnutrition) in most of our communities especially when deliberate attempt is made to promote their intake. Promoting the consumption of vegetables along with fruits can be a factor in reducing 2.7 million deaths worldwide (Abukutsa-Onyungo, *et al*., 2006).

This study also noted that these vegetables were all affordable which is in agreement with report by Oreach *et al.,* (2005) that in Nigeria leafy vegetables were relatively affordable particularly during the raining season but are found to be among the least consumed food. The findings that these vegetables were consumed cooked alone or in combination with other foods is similar to the report by Asaolu *et al*., (2012) that the vegetables are consumed wholly or in parts, raw or cooked as part of main dishes or salad.

The observation that above 34% of the respondents consumed these vegetables for their medicinal value, did not agree with findings of Fleuret, (2000) who noted that these leaves (L K C Vs) were consumed mainly because of their relative cheapness and easy accessibility. However Muikhuri *et al.,* (2008) reported that they are consumed because of their medicinal role.

Protein is an important nutrient in diets use for body building and repair of tissues. Any plant food providing more than 12% of its calorific value from protein is considered a good source of protein (Antia *et al*., 2006; Imaobong and Promise, 2013). As a result, all investigated vegetables in this study indicate that only *Ipomoea batatas* could be recommended as source of protein. Crude protein content of all the LKCVs were higher than values of protein reported by Mepba *et al.*,(2007) for *Clocusia esculentum* (Cocoyam leaves) (3.9%), *Cucumis melo* (Pumpkin leaves) (1.8%), *Hibiscus esculentus* (Okra leaves) (2.0%) and *Vigna unguiculata* (Bean leaves) (3.11%) in both fresh and also in their processed form. Asaolu *et al.,* (2012) reported higher value of protein content (61.7%) for *Cucumis melo* (unprocessed) while Akubugwo *et al.,* (2007) reported a similar value for protein content (12.9%) for *Amaranthus hybridus* (unprocessed) and 11. 2% for the processed. These vast disparities may

be attributed to differences in application of manure to enrich the nitrogen content of the soils where the different vegetable samples were obtained (Saidu and Jideobi, 2009).

Antia *et al.,* (2006) reported that dietary fat is a major determinant of palatability of food. Maikhuri *et al*., (2000) has also reported that vegetable fats and oil lower blood lipids due to their high level of high density lipoprotein (HDL). HDL is a type of lipid that removes excess bad cholesterol or low density lipoprotein (LDL) from the blood vessel. In doing so it lower the chances of getting a heart attack since it prevents blockage and hardening of blood vessel (Sharon, *et al*., 2006), hence contribute to reduction in the occurrence of diseases associated with coronary artery damage (Ononugbo, 2002; Imaobong and Promise 2013). The present study reported higher fat content among some vegetable samples studied and these values were higher than values reported by Imaobong and Promise (2013) for *Brassica oceracea* (2.42%). As a result, these vegetables could serve as a good source of fats and oil and could be recommended for consumption by people with coronary heart diseases. Some vegetables were observed to have extremely low fat content when compared to the other vegetables fat content reported by Asaolu *et al*., (2012), for *Lactuca sativa* (11.35%) and 5.25% for India spinach.

Ash content in leafy vegetables is a reflection of the amount of mineral elements present in the vegetables (Fagbohun *et al.,* 2012). High ash content in a leafy vegetable would imply high mineral content, hence very nutritious. Although, Ukam (2008) reported that it would be the reverse if it contained toxic metals which also contribute to the ash percentage in leafy vegetables. Therefore, high ash content is not necessarily a conclusive factor regarding the health benefits of vegetables. However, Ifon and Bassir, (2007), reported that leafy vegetables

with ash content greater than 6.5% are healthy for human body. Among the investigated vegetables, *Ipomoea batatas, Vigna unguiculata, Senna occedentalis* and *Clocusia esculentum* could be regarded as healthy vegetables for human body because of their high ash content.

High moisture content helps in maintaining the protoplasmic content and also helps in maintaining the cells (Fagbohun *et al., (*2012). Asaolu and Asaolu, (2010) also reported that high moisture content also supports a greater activity of water soluble enzymes and co-enzymes needed for metabolic activities of leafy vegetables. However, high moisture content makes vegetable susceptible to spoilage and microorganisms that cause spoilage are known to thrive in foods containing high moisture content (Imaobong and Promise, 2013). It was observed that *Cucumis melo* had moderate moisture content in both processed and unprocessed form as 62.78% and 51.92% respectively. *Senna obtusifolia* had the lowest moisture content (28.10%0 in its fresh form among the vegetables studied. Therefore, they are expected to have shelf stability on long storage, as the relatively low moisture content would inhibit growth of microorganisms

Fibre in leafy vegetables plays important role in the body. Fibre is known to cleanse the digestive tract, remove potential carcinogens from the body, as well as keep blood sugar levels under control (Emebu and Anyika, 2011). *Cusumis melo* (9.88%), *Senna obtusifolia* (7.09%) *Ipomea batates* (6.784%) and *Vigna unguiculata* (6.72%) had high of fibre content in their fresh form. The processed vegetables under the study also had moderate fibre content in *Cucumis melo* (6.43%), *Senna obtusifalia* (5.41%) and *Ipomoea batatas* (4.12%) hence are good sources of fibre and therefore make them suitable for people with high blood cholesterol levels. *Senna obtusifolia* (3.99%), *Clocusia esculentum* (2.85%) and *Mangifera indica*

(0.93%) had the lowest fibre content but similar to fibre value obtained by Agbaire and Emogan (2012) 2.4%. The least values of crude fibre content was recorded in *Mangifera indica* as 0.93% and is consistent with that reported by Imaobong and Promise, (2013) in *Gneturm Africanum* (0.85%).

Higher values of carbohydrate were recorded for both processed and unprocessed vegetables that could serve as a good sources of carbohydrate to provide the body with fuel *Hibiscus esculentus* (42.39%), *Senna obtusifolis*(50.26%), *Senna occidental* (35.94%) and *Mangifera indicate* (40.13%) in their fresh forms were lower than values of carbohydrate content reported by Imaobong and Promise, (2013) for *Brassia coleracea* (79.46%), *Heinsia crinite* (73.17%) and *Gnetum africanum* (70.11%). *Ipomoea batatas,Cucumis melo* (17.03%).

Calcium content obtained from the investigated vegetables is lower than RDA of 1000mg/ day for adulst. As such, when these LCVs are regularly consumed in a large volume they could provide the body with enough calcium for much physiological functioning integrity of the skeletal system, cell membranes integrity and permeability, blood clothing, transmission of nerve impulse, regulation of enzymes, and hormones (Sharon *et al*., 2006). Calcium content obtained from the investigated vegetables were also higher when compare with the reports of Asaolu and Asaolu, (2010) for fluted pumpkin (63.36mg/100g). Some of the investigated vegetables had calcium values which were also in agreement with previous report by Habwet, (2008), for *Ipomoea batatas* (117.80mg/100g). These variations in vegetables content of calcium could be as result of the differences in soil mineral compositions

Magnesium (Mg) is reported to be very important in normal functioning as co-factor of many enzymes involved in energy metabolism, protein synthesis, and maintenance of the electrical potential of nervous tissue and cell membranes, (Ebueni, *et al*.,2007) . Magnesium also plays an important role in the metabolism of calcium (FAO/WHO, 2002). The values of Mg obtained from the investigated LKCVs were lower than RDA of 400mg/day for men and 320mg/day for women. Although these values were similar to Mg values in a previous report by Asaolu *et al.,* (2012) for *Telfaria occidentalis* (288.65mg/100g), *Hibiscus sabdrariffa* (120.09mg/100g), and *Amaranthus hybridus* (249.92mg/100g).

The values obtained from the investigated LKCVs were lower than recommended daily allowance of 4,700mg/day for adults (Sharon *et al*., 2006). However, when these LKCVs are consumed in large amount or in combination with other vegetables could provide more than the recommended daily allowance. The potassium content recorded from the LKCVs were still higher than the previous reports carried out by Asaolu *et al.,* (2012) as indicated in *Telfaria occidentalia* (130.24mg/100g), *Amaranthus hybridus* (168.96mg/100g), and Bush buck (99.01mg/100g). As such, these LKCVs could be recommended for consumption by people with problem of high blood pressure, as pointed out by Mepba *et al*., (2007) that increased intake of potassium can lower blood pressure and may help to prevent stroke.

The highest content of sodium (Na) in the LKCVs studied is in *Ipomoea batatas* which is higher than value obtained by Ijeomah *et al.,* (2012) as indicated in *A.digitata* 8.00mg/100g. Some LKCVs Na content was also higher than RDA of 1.5g/day for an adult person. Sodium and potassium are important intracellular and extracellular cations respectively. Low Na content recorded for some processed LKCVs under this investigation could make them

suitable for use in Na restricted diets e.g. hypertensive diet. A study pointed out that high intake of Na can contribute to hypertension in some people (Getachew *et al*., 2013). Sodium is involved in regulation of plasma volume, and acid-base balance nerve and muscle contraction (Akpanyung 2005).

Zinc (Zn) content in all the LKCVs samples investigated was moderately lower when considered against an average requirement of 11mg/day for men and 8mg/day for women (Sharon *et al*., 2006). Meanwhile these vegetables could be consumed in mix of other could reduce morbidity, because it has been reported that zinc deficiency is related not only to decreased growth but also increased morbidity (Wardlaw and Kessel, 2012).

Antia *et al.,* (2006) reported zinc content in *Ipomoea batates* to be 0.08mg/100g. Similarly the values obtained from this study are much higher than values obtained from commonly consumed vegetable like India spinach (3.73mg/100g) (Asuolu *et al*., 2012). An estimated 20% of the world population is reported to be at risk of inadequate zinc intake (Aseola and Asaolu, 2010). Studies in Nigeria shows that zinc deficiency affects 20% of children less than five years, 28.1% of mothers and 43.9% of pregnant women (Dioxin-Maziya *et al.*, 2004).Therefore, these LKCVs could be recommended for children, pregnant women, and a normal adult person for consumption to provide essential micronutrient for human growth and immune function.

The highest value of iron content was recorded in *Ipomoea batatas* as 19.53mg/100g in it fresh form, this value is higher than RDA of 8mg/day for men and 18mg/day for women of children bearing age (Sharon *et al* 2006). The least iron content was recorded for *Clocusia*

esculentum (0.39mg/100g fresh) which is similar to value recorded for *Clocusia esculentum* (0.3mg/100g) (Mepba *et al*., 2007). Iron is an important trace element in the human body, it plays crucial role in control of infection and cell mediated immunity (Mohammed and Sharif, 2011). The deficiency of iron has been described as most prevalent nutritional deficiency and iron deficiency anaemia is estimated to affect more than one billion people worldwide (Mohammed and sheriff 2011). The consequences of iron deficiency include reduced work capacity, impairments in behavior and intellectual performance and decrease resistance to infection (Dioxin-Maziya *et al*, 2004). The low values obtained for iron in some of these vegetables is desirable because it was reported by Gregory, (2014) that large quantity of iron in the food have been reported to have destructive effect on ascorbic acid. The differences in the minerals content of the vegetables plant might be due to compositions and the rate of uptake of minerals by individual plant (Anjorin *et al,* 2010; Asaolu, 2010).

The values of vitamin A recorded for some unprocessed LKCVs were of higher values of than reported by Ukam, (2008), for unprocessed spinach (3.10mg/100g) and *Telferia occidentalis* (6.10mg/100)g. While in their processed form, vitamin A content recorded for these LKCVs were still higher when compare with vitamin A values obtained by Ukam, (2008) for the processed spinach 3.88mg/100g and *Telferia occidentialis* 5.98mg/100g which are higher than 0.09mg/day as RDA. These differences in vitamin A content could be as a result of effect of different methods of processing used. Habwet and Walingo, (2008) also reported thatvitamin A act as an antioxidant capable of protecting the body against diseases. Vitamins A deficiency is one of the developing world's major nutrition problems. More than 100 million children worldwide have some degree of vitamin A deficiency, and so are

vulnerable to infectious diseases and blindness (Sharo *et al*, 2006).Therefore, these LKCVs could serve as a good source of vitamin A to be consumed to prevent vitamin A deficiency that is the major nutrition problem worldwide.

The values obtained from these LKCVs of vitamins C content for processed vegetables were of low when compare with previous work carried out by Ukam, (2008) for unprocessed *Hisbiscus esculentus* (54.56mg/100g), spinach (55.60mg/100g) and *Telferia occidentalis* (35.97mg/100g). It was equally found to be much lower than RDA of 90mg/day for men and 75mg/day for women (Sharo *et al*, 2006). The vitamin C value obtained for processed LKCVs were also lower when compare with vitamin C values reported by Mepba *et al.*, (2007) in fluted pumpkin (20.4mg/100g), Cocoyam leaves (43.9mg/100g) and Vine spinach (52.2mg/100g) of blanched vegetables. The high solubility of ascorbic acid in water and relatives ease with which it is oxidized makes this vitamin particularly susceptible to processing conditions. Vitamin C was reported to act as an antioxidant in the body that defend against free radicals, act as a co -factor in collagen formation, and act as a co-factor in other reactions and as a cure for common cold and in diseases prevention (Sharon *et al.*, 2006). When these LKCVs are consumed regularly they could prevent vitamin C deficiency that lead to so many problems such as; easy gum bleeding around the teeth and spontaneous breaking of capillaries under the skin producing pinpoint haemorrhage (Asaolu, 2010).

Folate (vitamin B9) content in the unprocessed LKCVs ranged from 5.24mg/100g in *Clocusia esculentum* to 12.49mg/100g in *Senna obtusifolia* . These values are higher than RDA as 0.4mg/day or 400µg/day for women of child bearing age. So the folate content of unprocessed LKCVs studied clearly indicates that, they are good sources of folate, and also when

compared with the values obtained for cereals (Ononugbo, 2002). The values of folate that were recorded for processed LKCVs also ranged from 2.77mg/100g for *Mangifera indica* to 8.11mg/100g for *Senna obtusifolia*. These ranges of values compare favourably with values reported by Mepba *et al*., (2006) for *Senna obtusifolia* (7.98mg/100g), Habwet, (2008) for *Telferia occidentalis* (8.59mg/100g) in their processed form. Several research studies have confirmed the importance of folate in reducing the risks of neural tube defects (Sharon *et al*, 2006). The brain and spinal cord develop from the neural tube, and defects in its orderly formation during the early weeks of pregnancy may result in various central nervous system disorders and death (Aju and Poopola, 2010).

CHAPTER SIX

6.0 SUMMARY CONCLUSION AND RECOMMENDATION

6.1 Summary

It has been established that consumption of indigenous vegetables supply significant quantity of essential nutrients that the body need and assist in the maintenance of health and prevention of diseases. Some of these vegetables that are either cultivated or found to exist as wild are given less attention by the communities and can be a potential source of nourishments.

This study was designed to identify and evaluate the consumption pattern and nutrient potential of the lesser consumed vegetables. Findings from this study has identified 21 LKCVs consumed in the three senatorial zones of Kaduna State out of which 8 were selected based on availability for further study.

Boiling and blanching were the major processing methods in the indigenous communities. It was discovered that 37.5% of the LKCVs were regularly and adequately consumed by the communities and these includes *Senna obtusifolia*, *Senna occidentali*s and *Clocusia esculentum* .

Analysis of the LKCVs showed high level of protein, carbohydrate and fibre while fat was generally low. Furthermore it was discovered that most of the LKCVs are high in calcium, potassium and magnesium but low in iron and zinc. The LKCVs studied were also high in vitamin A and folate and low in vitamin C. The comparative analysis between the processed and unprocessed LKCVs revealed significant ($P<0.05$) differences in most of the nutrients in favour of the unprocessed LKCVs which may likely be due to losses during processing.

6.2 Conclusion

The study has shown that most of the vegetable studied (*Clocusia esculentus, Senna obtiusifolia* and *Senna occidentali*) are generally consumed in the study communities, though at low level. The proximate analysis has shown that the vegetables contain high level of protein, carbohydrate and fibre, but were generally low in fat, the vegetables also contain high amount of minerals and vitamins that are within the range of what were reported in most conventional Nigerian vegetables. The comparative analysis between the processed and unprocessed LKCVs revealed significant differences ($P<0.05$) in most of the nutrients in favour of the unprocessed LKCVs which may likely be due to losses during processing. The result offers important information on LKCVs that could be useful in the preparation or enrichment of food composition tables and data-bases.

6.3 Recommendations

These vegetables (LKCVs) are as good as the most vegetables promoted and commonly consumed Nigerian vegetables. Therefore they should be promoted for regular consumption by community members and stake holders.

Further study should be carried out on the amino acids profile of these vegetables, to know more on their nutritional importance. It is also necessary to consider the effect of processing method on the nutrient availability and anti-nutrient level in order to determine level of bioavailability.

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APPENDIX I

Nutrient Composition of Some Processed and Unprocessed lesser Known Vegetables Consumed in Kaduna State, Nigeria

SURVEY QUESTIONNAIRE

This questionnaire is designed to generate information on lesser consumed vegetables in Kaduna State

Questionnaire number……

Name of interviewer…….

Background Information

Community …….. LGA …… Senatorial Zone ……

SECTION A: Identification of lesser consumed vegetable

1) What are the types of indigenous vegetables consumed in your community?

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SECTION B: Processing method

2) describe the processing method for each of the vegetables;

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……..

NB: Use attached sheets for the description of other vegetables

3) What are the sources of these vegetables?
   a) Wild ☐ b) cultivated ☐ c) purchase from the market ☐

4) How available are these vegetables?
   Always availabl☐ Seasonal ☐

SECTION C: Consumption pattern

5) How affordable are these lesser consumed leafy vegetables
   Cheap ☐ Expensive☐ Very expensive☐

6) How do you consume these vegetables?
   A) Uncooked alone b) cooked alone c) uncooked with other foods
   d) cooked combined with other foods

7) Give reason for the consumption of the indigeous vegetables
   a) Believe in high nutritional value
   b) Because of their medicinal value
   c) Because of their flavor and taste
   d) Because they are cheap and available

8) Frequency of vegetable consumption per week

Type of vegetable	Frequency of consumption per week							Once in 2 weeks	Occasionally
	1x	2x	3x	4x	5x	6x	7x		

APPENDIX II(a)

Cocoyam Leaves (*Clocusia escolentum)*

Okra Leaves (*Habiscus esculentus*)

Bean Leaves (*Vigna unguiculata)*

Coffee Senna (*Senna occidentalis)*

APPENDIX II(b)

Sweet Potato Leaves *(Ipomoea batatas)*

Pumpkin Leaves (*Cucumis melo)*

Coffee Senna *(Senna obtusifolia)*

Mango Leaves *(Mangifera indica)*

APPENDIX III

Table 2: Two-Way ANOVA for Calcium

Sources of variation	Sum of Squares	Df	Mean Square	F	Sig.
Status	9752.13	1	9752.13	417761.96	0.000
Veg	111690.73	7	15955.82	683515.66	0.000
Status * Veg	9433.93	7	1347.70	57732.98	0.000
Error	0.75	32	0.02		
Corrected Total	130877.54	47			

Table 14: Two-Way ANOVA for Zinc

Sources of variation	Sum of Squares	Df	Mean Square	F	Sig.
Status	32.819	1	32.819	1336.016	0.000
Veg	417.826	7	59.689	2429.896	0.000
Status * Veg	39.334	7	5.619	228.751	0.000
Error	0.786	32	0.025		
Corrected Total	490.765	47			

Table 20: Two-Way ANOVA for Vitamin A

Sources of variation	Sum of Squares	Df	Mean Square	F	Sig.
Status	87.21	1	87.21	14094.58	0.000
Veg	97.26	7	13.89	2245.60	0.000
Status * Veg	85.81	7	12.26	1981.25	0.000
Error	0.20	32	0.01		
Corrected Total	270.48	47			

Table 26: Two-Way ANOVA for Vitamin B9

Sources of variation	Sum of Squares	Df	Mean Square	F	Sig.
Status	91.41	1	91.41	958.90	0.000
Veg	195.75	7	27.96	293.35	0.000
Status * Veg	9.52	7	1.36	14.27	0.000
Error	3.05	32	0.10		
Corrected Total	299.73	47			

Table 29: Two-Way ANOVA for Protein

Sources of variation	Sum of Squares	Df	Mean Square	F	Sig.
Status	83.24	1	83.24	593.03	0.000
Veg	141.47	7	20.21	143.99	0.000
Status * Veg	29.89	7	4.27	30.42	0.000
Error	4.49	32	0.14		
Corrected Total	259.09	47			

Table 32: Two-Way ANOVA for Fat

Sources of variation	Sum of Squares	Df	Mean Square	F	Sig.
Status	9.21	1	9.21	575.49	0.000
Veg	82.69	7	11.81	737.85	0.000
Status * Veg	3.03	7	0.43	27.07	0.000
Error	0.51	32	0.016		
Corrected Total	95.45	47			

Table 41: Two-Way ANOVA for Fiber

Sources of variation	Sum of Squares	Df	Mean Square	F	Sig.
Status	47.34	1	47.34	986.25	0.000
Veg	178.71	7	25.53	531.86	0.000
Status * Veg	15.30	7	2.19	45.54	0.000
Error	1.54	32	0.048		
Corrected Total	242.89	47			

APPENDIX IV (a)

Table 1a: Duncan Test for Calcium Content in different Vegetables (Unprocessed)

Types of Vegetables	N	Subsets						
		1	2	3	4	5	6	7
Mango leaves	3	5.33[a]						
Okra leaves	3		10.47[b]					
Bean leaves	3			41.29[c]				
Ganyentafasa	3				59.52[d]			
Raidore	3					99.50[e]		
Cocoyam leaves	3					100.32[e]		
Sweet potato leaves	3						116.51[f]	
Pumpkin leaves	3							200.22[g]

Means for groups in homogeneous subsets are displayed

Table 1b: Duncan Test for Calcium Content in different Vegetables (Processed)

Types of Vegetables	N	Subsets						
		1	2	3	4	5	6	7
Mango leaves	3	2.71[a]						
Okra leaves	3		8.10[d]					
Bean leaves	3			23.52[c]				
Ganyentafasa	3				25.84[d]			
Cocoyam leaves	3					70.34[e]		
Raidore	3					71.48[e]		
Sweet potato leaves	3						99.64[f]	
Pumpkin leaves	3							103.48[g]

Means for groups in homogeneous subsets are displayed

APPENDIX IV (b)

Table 2a: Duncan Test for Magnesium Content in different Vegetables (Unprocessed)

Types of Vegetables	N	Subsets 1	2	3	4	5	6
Bean leaves	3	99.96[a]					
Raidore	3		100.6[b]				
Pumpkin leaves	3			110.6[c]			
Mango leaves	3				117.6 [d]		
Ganyentafasa	3					127.0[e]	
Okra leaves	3					127.5[e]	
Sweet potato leaves	3					127.7[e]	
Cocoyam leaves	3						128.5[f]
Means for groups in homogeneous subsets are displayed							

Table 2b: Duncan Test for Magnesium Content in different Vegetables (Processed)

Types of Vegetables	N	Subsets 1	2	3	4	5	6	7	8
Raidore	3	85.78 [a]							
Pumpkin Leaves	3		95.13[b]						
Bean Leaves	3			98.96[c]					
Okra Leaves	3				100.3 [d]				
Mango leaves	3					102.49[e]			
Ganyentafasa	3						103.6[f]		
Sweetpotato leaves	3							121.99[g]	
Cocoyam leaves	3								125.1[h]
Means for groups in homogeneous subsets are displayed									

APPENDIX IV (c)

Table 3a: Duncan Test for Zinc Content in different Vegetables (Unprocessed)

Types of Vegetables	N	Subsets 1	2	3	4	5	6
Raidore	3	0.23 [a]					
Mango leaves	3		0.72[b]				
Cocoyam leaves	3		0.79[b]				
Bean leaves	3			1.23[c]			
Okra leaves	3				1.59[d]		
Pumpkin leaves	3					6.64[e]	
Sweet potato leaves	3						9.47[f]
Ganyentafasa	3						9.61[f]

Means for groups in homogeneous subsets are displayed

Table 3b: Duncan Test for Zinc Content in different Vegetables (Processed)

Types of Vegetables	N	Subsets 1	2	3	4	5	6
Mango leaves	3	0.29 [a]					
Cocoyam leaves	3		0.47[b]				
Okra leaves	3		0.47[b]				
Raidore	3			0.55[c]			
Bean leaves	3			0.77[c]			
Pumpkin leaves	3				4.56[d]		
Sweet potato leaves	3					4.57[e]	
Ganyentafasa	3						5.38[f]

Means for groups in homogeneous subsets are displayed

APPENDIX IV (d)

Table 4a: Duncan Test for Vitamin A Content in different Vegetables (Unprocessed)

Types of Vegetables	N	Subsets 1	2	3	4	5	6
Okra leaves	3	10.22 [a]					
Ganyentafasa	3		13.20[b]				
Cocoyam leaves	3			13.68[c]			
Raidore	3				14.03[d]		
Mango leaves	3				14.03[d]		
Sweet potato leaves	3					14.04[e]	
Bean leaves	3					14.04[e]	
Pumpkin leaves	3						14.36[f]
Means for groups in homogeneous subsets are displayed							

Table 4b: Duncan Test for Vitamin A Content in different Vegetables (Processed)

Types of Vegetables	N	Subsets 1	2	3	4	5	6	7	8
Raidore	3	6.99 [a]							
Bean leaves	3		8.74[b]						
Pumpkin leaves	3			9.05[c]					
Okra leaves	3				9.82[d]				
Cocoyam leaves	3					10.98[e]			
Ganyentafasa	3						11.93[f]		
Sweet potato leaves	3							13.44[g]	
Mango leaves	3								13.99[h]
Means for groups in homogeneous subsets are displayed									

APPENDIX IV (e)

Table 5a: Duncan Test for Vitamin C Content in different Vegetables (Unprocessed)

Types of Vegetables	N	Subsets 1	2	3	4	5	6	7
Cocoyam leaves	3	0.35 [a]						
Sweet potato leaves	3		0.36[b]					
Ganyentafasa	3			0.40[c]				
Pumpkin leaves	3				0.46[d]			
Mango leaves	3					0.83[e]		
Raidore	3					0.86[e]		
Bean leaves	3						3.23[f]	
Okra leaves	3							4.22[g]

Means for groups in homogeneous subsets are displayed

Table 5b: Duncan Test for Vitamin C Content in different Vegetables (Processed)

Types of Vegetables	N	Subsets 1	2	3	4	5
Mango leaves	3	0.35 [a]				
Raidore	3		0.32[b]			
Cocoyam leaves	3			0.35[c]		
Sweet potato leaves	3			0.35[c]		
Ganyentafasa	3			0.35[c]		
Pumpkin leaves	3			0.35[c]		
Bean leaves	3				1.49[d]	
Okra leaves	3					3.35[e]

Means for groups in homogeneous subsets are displayed

APPENDIX IV (f)

Table 6a: Duncan Test for Vitamin B9 Content in different Vegetables (Unprocessed)

Types of Vegetables	N	Subsets 1	2	3	4	5	6
Cocoyam leaves	3	5.24[a]					
Mango leaves	3	5.76[a]					
Sweet potato leaves	3		6.26[b]				
Raidore	3			6.77[c]			
Pumpkin leaves	3				7.62[d]		
Bean leaves	3				7.80[d]		
Okra leaves	3					9.84[e]	
Ganyentafasa	3						12.49[f]

Means for groups in homogeneous subsets are displayed

Table 6b: Duncan Test for Vitamin B9 Content in different Vegetables (Processed)

Types of Vegetables	N	Subsets 1	2	3	4	5	6
Mango leaves	3	2.77[a]					
Cocoyam leaves	3	2.96[a]					
Bean leaves	3		3.84[b]				
Raidore	3			4.45[c]			
Sweet potato leaves	3			4.61[c]			
Pumpkin leaves	3				5.21[d]		
Okra leaves	3					7.74[e]	
Ganyentafasa	3						8.11[f]

Means for groups in homogeneous subsets are displayed

APPENDIX IV (g)

Table 7a: Duncan Test for Protein Content in different Vegetables (Unprocessed)

Types of Vegetables	N	Subsets 1	2	3	4	5
Mango leaves	3	4.09[a]				
Cocoyam leaves	3		5.55[b]			
Ganyentafasa	3		5.57[b]			
Raidore	3			6.39[c]		
Okra leaves	3			6.60[c]		
Pumpkin leaves	3				8.05[d]	
Bean leaves	3				8.11[d]	
Sweet potato leaves	3					12.49[e]
Means for groups in homogeneous subsets are displayed						

Table 7b: Duncan Test for Protein Content in different Vegetables (Processed)

Types of Vegetables	N	Subsets 1	2	3	4	5
Okra leaves	3	2.67[a]				
Mango leaves	3	2.98[a]				
Ganyentafasa	3		3.83[b]			
Cocoyam leaves	3			4.39[c]		
Raidore	3			4.78[c]		
Bean leaves	3				5.03[d]	
Pumpkin leaves	3				5.65[d]	
Sweet potato leaves	3					6.44[e]
Means for groups in homogeneous subsets are displayed						

APPENDIX IV (h)

Table 8a: Duncan Test for Fat Content in different Vegetables (Unprocessed)

Types of Vegetables	N	Subsets 1	2	3	4	5	6	7
Mango leaves	3	0.37 [a]						
Ganyentafasa	3		1.12[b]					
Okra leaves	3		1.13[b]					
Raidore	3			1.31[c]				
Bean leaves	3				2.04[d]			
Sweet potato leaves	3					3.04[e]		
Cocoyam leaves	3						4.04[f]	
Pumpkin leaves	3							5.00[g]

Means for groups in homogeneous subsets are displayed

Table 8b: Duncan Test for Fat Content in different Vegetables (Processed)

Types of Vegetables	N	Subsets 1	2	3	4	5	6
Mango leaves	3	0.17 [a]					
Ganyentafasa	3		0.31[b]				
Okra leaves	3		0.31[b]				
Raidore	3			0.96[c]			
Bean leaves	3				1.34[d]		
Sweet potato leaves	3					1.65[e]	
Pumpkin leaves	3						3.13[f]
Cocoyam leaves	3						3.16[f]

Means for groups in homogeneous subsets are displayed

APPENDIX IV (i)

Table 9a: Duncan Test for Ash Content in different Vegetables (Unprocessed)

Types of Vegetables	N	Subsets			
		1	2	3	4
Mango leaves	3	4.67 [a]			
Okra leaves	3		6.63[b]		
Sweet potato leaves	3			6.74[c]	
Bean leaves	3			6.74[c]	
Ganyentafasa	3			6.75[c]	
Raidore	3			6.79[c]	
Cocoyam leaves	3			6.90[c]	
Pumpkin leaves	3				7.06[d]

Means for groups in homogeneous subsets are displayed

Table 9b: Duncan Test for Ash Content in different Vegetables (Processed)

Types of Vegetables	N	Subsets			
		1	2	3	4
Mango leaves	3	2.72 [a]			
Okra leaves	3		3.28[b]		
Pumpkin leaves	3		3.87[b]		
Raidore	3			4.93[c]	
Ganyentafasa	3				5.11[d]
Cocoyam leaves	3				5.29[d]
Bean leaves	3				5.30[d]
Sweet potato leaves	3				5.72[d]

Means for groups in homogeneous subsets are displayed

APPENDIX IV (j)

Table 10a: Duncan Test for Fiber Content in different Vegetables (Unprocessed)

Types of Vegetables	N	Subsets						
		1	2	3	4	5	6	7
Mango leaves	3	1.72[a]						
Okra leaves	3		3.36[b]					
Raidore	3			4.45[c]				
Cocoyam leaves	3				5.88[d]			
Sweet potato leaves	3					6.72[e]		
Bean leaves	3					6.72[e]		
Ganyentafasa	3						7.10[f]	
Pumpkin leaves	3							9.88[g]

Means for groups in homogeneous subsets are displayed

Table 10b: Duncan Test for Fiber Content in different Vegetables (Processed)

Types of Vegetables	N	Subsets						
		1	2	3	4	5	6	7
Mango leaves	3	0.93[a]						
Okra leaves	3		2.60[b]					
Cocoyam leaves	3		2.85[b]					
Bean leaves	3			3.60[c]				
Raidore	3				3.99[d]			
Sweet potato leaves	3					4.12[e]		
Ganyentafasa	3						5.41[f]	
Pumpkin leaves	3							6.43[g]

Means for groups in homogeneous subsets are displayed

APPENDIX V

REAGENT PREPARATION

Protien Determination

40% NaOH solution-400g of NaOH was weighed using an analytical balance on a piece of aluminum and was transferred into a 1litre conical flask. 1litre of distilled water was added in a small quantity with constant stirring and cooling under stirring cold water until fully dissolved.

Receiver Solution 4% Basic acid receiver solution was prepared by weighing 40g of basic acid using an analytical balance and dissolved in a 1litre conical flask using 1litre of boiling distilled water. The solution was allowed to cool to room temperature and 10ml of bromocresol purple, and 7ml of methyl red solution were added and mixed well.

Bromocrecol Purple Indication Solution-100mg of bromocrecol purple powder was accurately weighed using an analytical balance and dissolved in 100ml of 95% ethanol

Methyl red Indicator Solution 100mg of methyl red powder was accurately weighed using an analytical balance and was dissolved in 100ml of 95% ethanol.

95% Ethanol -95mls of absolute ethanol was added into a 100ml volumetric flask and made up to the mark with distilled water.

0.1M HCL-8.9mls of concentrated HCL (having a percent purity of 35%, specific gravity of 1.18 and molarity of 11.3) was added into 1litre volumetric flask and made up to the mark with distilled water.

Catalyst Mixture - A mixture of 7g K_2SO_4 and 0.8g $CuSO_4.5H_2O$.

Crude Fibre Determination

1.25% NaOH Solution -12.5g of NaOH was accurately weighed into a clean 1litre conical flask and was dissolved with 1litre of distilled water.

1.25% H_2SO_4-12.5mls of concentrated H_2SO_4 (having a percentage purity of 94%, specific gravity of 1.84 and molarity of 18.0) was added into a litre volumetric flask and made up to the mark with distilled water.

Mineral Analysis

Acid Mixture-650ml of concentrated HNO_3 was added into a clean conical flask, then 80ml of PCA was added into the same 1litre flask, and finally 20ml to concentrated H_2SO_4 was added to the flask and mixed gently.

Vitamin A Determination

4% Alcoholic KOH – 4g of analytical grade KOH was weighed using an analytical balance and added to conical flask. 100mls of 95% ethanol was added and mixed until well dissolved.

Xylene-Kerosene Mixture (1:1)-100mls of xylene was mixed 100ml of kerosene in 250ml conical flask and mixed well.

1% Starch Solution – 1g of pure starch powder was weighed using an analytical and was into a 150ml conical flask. 100ml of distilled water was added to the starch and mixed with a glass rod until well dissolved.

Vitamin C Determination

2% Metaphosphoric Acid- 20g of metaphosphoric acid crystals was weighed using an analytical balance and added into a clean 100ml volumetric flask and made up to the mark with distilled water.

25mg% Ascorbic Acid Solution- 25mg of analytical grade ascorbic acid was weighed using an analytical balance an transferred into a 100ml volumetric flask and made up to the mark with distilled water, shaked to dissolve well.

60mg% Indophenol Solution-60mg of 2, 6, dichlorophenol-indophenol powder was weighed using an analytical balance and added into a 100ml volumetric flask, then made up to the mark with distilled water and dissolved well.