

**ELEMENTAL AND PHYTOCHEMICAL SCREENING OF SOME EDIBLE PLANT
PARTS IN HONG LOCAL GOVERNMENT AREA OF ADAMAWA STATE**

BY

TADZABIA, KADAM

(M.TECH/CH/09/0312)

A Thesis Submitted to the Department of Chemistry, School of Pure and Applied Sciences,

Modibbo Adama, University of Technology Yola,

In Partial Fulfilment of the Requirements for the Award of Masters of Technology

(M. Tech) Degree in Analytical Chemistry

January, 2014

DECLARATION

I hereby declare that this thesis was written by me and it is a record of my own research work. It has not been presented before in any previous application for a higher degree. All references cited have been duly acknowledged.

.....
Tadzabia Kadam

.....
Date

DEDICATION

This research work is dedicated to my beloved wife Mrs. Rita Kadam and my Children Jahani and Judith.

APPROVAL PAGE

This thesis entitled “Elemental and Phytochemical Screening of Some Edible Plant Parts in Hong Local Government Area of Adamawa State” meets the regulations governing the award of Master of Technology (M. Tech.) Degree in Analytical Chemistry, Modibbo Adama University of Technology, Yola and is approved for its contribution to knowledge and literary presentation.

.....
Professor. H.M. Maina
(Supervisor)

.....
Date

.....
Dr. O.N. Maitera
(Internal Examiner)

.....
Date

.....
(External Examiner)

.....
Date

.....
Dr. S.A. Osemeahon
(Head of Department)

.....
Date

.....

.....

Prof. M.R. Odekunle
(Dean, School of Postgraduate Studies)

Date

ACKNOWLEDGEMENTS

I am grateful to God Almighty for the privilege given to me to carry out this research successfully.

I wish to register my profound gratitude to my esteemed supervisor Dr. H.M. Maina and my internal examiner Dr. O.N. Maitera for their time taken to guide me through this research work.

I appreciate the efforts of my Head of Department Dr. S.A. Osemeahon and my able lecturers for academic empowerment.

I really appreciate the assistance given to me by the laboratory staff, the secretary, Clarks and the cleaners of Chemistry Department.

Finally, I would like to express my gratitude to my colleagues, Raymond, Bala, Mohammed, Earnest, Dan, Modibbo, Gambo, Usman, Julie and Amina for their assistance throughout the study. God bless you all.

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ABSTRACT

Phytochemical and elemental contents of leaves and stem-bark of *Celtis integrifolia*, *Ficus sycomorus*, *Balanites egyptiaca*, *Vitex doniana* and *Haematostaphis barteri* were collected from ten locations in Hong Local Government area of Adamawa State. Qualitative methods were used for the phytochemical screening. The results of the phytochemical screening showed the presence of alkaloid in the leaves and stem bark of *Celtis integrifolia* while flavonoids were present in the leaves. Tannin, alkaloid and flavonoid were recorded in the parts of *Ficus sycomorus*, but saponin was not observed in the entire samples. The leaves of *Balanites egyptiaca* demonstrated the presence of tannin and saponin in all the plants screened from all the locations. *Vitex doniana* leaves and stem bark recorded the presence of tannin and saponin while glycosides and flavonoids were not observed in the same parts by the method employed. Saponins, tannins, alkaloids and flavonoids were also recorded in the parts of *Haematostaphis barteri*. The essential element and heavy metal contents of the samples were determined by Atomic Absorption Spectroscopy (AAS). For essential elements in *Celtis integrifolia*, Na was recorded highest (1.600 µg/g) in the stem bark followed by K (1.230 µg/g). For heavy metals, Zn was observed highest followed by Cd (0.320 µg/g) around Hildi and Fa'a areas. There was no significant difference ($p \leq 0.05$) observed in terms of essential element and heavy metal contents in *Celtis integrifolia* parts among the plants in ten locations. There was significant difference of the mean distribution of essential elements in the leaves of *Ficus sycomorus* among the ten plants observed at $p \leq 0.05$. Considerable amount of Zn (5.710 µg/g) was recorded in the stem bark of *Ficus sycomorus* around Hong area. For *Vitex doniana*, Na was recorded highest (3.48 µg/g) in the stem bark followed by Zn (2.030 µg/g). The value for K was observed highest (0.800 µg/g) in *Balanites egyptiaca* leaves followed by Na (0.520 µg/g). There was no significant difference ($p \leq 0.05$) observed among the plants in terms of Zn, Cu and Pb contents in *Vitex doniana* leaves. *Haematostaphis barteri* parts contained essential elements and heavy metals, but no significant difference was observed with regard to their contents among the plants investigated at $p \leq 0.05$. The trends of total essential element levels in the plant parts investigated followed the sequence: Na > K > Mg > Ca. For total mean levels of heavy metals, Zn was recorded highest in *Ficus sycomorus* stem bark followed by Cu in *Vitex doniana*. Pb was below the detectable limit of the analytical method used for the entire samples. The elemental composition levels in the plants are within the recommended safety limits of WHO, except for Cd which was slightly above recommended level. The essential elements observed are very much required by human bodies for maintenance of good health while the phytochemicals have many pharmacological properties.

Key words: Element, phytochemical, plants, determination, leaves, stem bark

CHAPTER ONE

GENERAL INTRODUCTION

1.1 Background of the Study

Plant leaves are generally eaten as vegetable or salad in many African countries. They are eaten at least once daily in many areas and some of them have been found to have high crude protein content (Nkafamiya *et al.* 2010). Vegetables are good sources of oils, carbohydrates, minerals, and vitamins depending on the vegetable consumed (Ihekoronye and Ngoddy, 1985).

In Nigeria and other developing countries, as a result of food shortage and high cost of cultivated green leafy vegetables, wild and semi-wild food resources are frequently consumed as the dominant source of leafy vegetables especially in the rural communities (Barminas *et al.* 1998). These plant vegetables play an important role in every day cooking especially in the rural areas. In addition, the vegetables supply calories and nutrients during dry season when there is shortage of cultivated green vegetables and other food resources (Kubmarawa *et al.* 2008).

Throughout the years, even in the absence of famine, edible plants play an important role in every day cooking. A study carried out by Humphery *et al.* (1993) showed that a variety of leaves are used as seasonings and in sauces at every meal in Southern Niger. They found that the midday meal often centres on cooked wild leaves from *Corchorus tridens*, *Leptadenia hastate*, *Hibiscus sabdarifa* and *Moringa oleifera* flavoured with groundnuts. The side-dish of soup at the evening meal relies on gathered leaves for its flavour. Leaf-bundle snacks are made as well from variety of leaves.

Until recently, little attention has been given to the role of plant foods (Freiberger *et al.* 1998). By learning more about the protein, fat and mineral content of each plant, one can better assess their importance in nutritional well-being of the communities. The ability to inform nutritionists and public health workers as to which plants can offer the population these nutrients is important.

The nutritional content of vegetables varies considerably though they contain a small proportion of proteins and fats and a relatively high proportion of vitamins, provitamins, dietary minerals, fibres and carbohydrates (Adenipekun and Oyetunji 2010). Many vegetables also contain phytochemicals which may have antioxidant, antibacterial, antifungal, antiviral and anticarcinogenic properties (Steinmetz and Potter, 1996). Phytochemicals have the capacity to modulate one or more metabolic processes that result in the promotion of better health (Starvic, 1994). Phytochemicals give plants natural defence against diseases and they perform similar function for humans. It is most common to find mixtures of phytochemicals within a plant food. Some plant foods have nutritional and medicinal properties because of the interaction between their nutrients and phytochemical constituents (Nnam *et al.* 2012).

Several studies have reported elemental contents in plant extracts which are consumed as herbal health drink or in orthodox medicine (Rajua et al. 2006). The quantitative estimation of various trace elements concentration is important for determining the effectiveness of medicinal plants in treating various diseases and also to understand the pharmacological action. Trace metals are metals in extremely small quantities that reside in plants cells or tissues. They are a necessary part of good nutrition, although they can be toxic if ingested in excess quantities (Shagal et al. 2012). Toxic metals bio-accumulate in the body via food chain. Reports have shown that, vegetables grown in rich heavy metal soils are also contaminated (Sharma et al., 2007). Vegetable take up metals from contaminated soil through the roots and incorporated them into the edible part of the plant tissues or as a deposit on the surface of vegetables (Nwajei, 2009).

Diet-related non communicable diseases like obesity, diabetes, hypertension, cardiovascular diseases are increasingly becoming public health problems in Nigeria. This is

partly due nutrition transition, which essentially has to do with changes in food consumption patterns associated with modernization, urbanization, economic development and market globalization (Nnam *et al.* 2012). There is a shift away from the traditional foods towards overconsumption of processed foods high in saturated fats and sugar but low in fiber, vitamins, phytochemicals and minerals. Some traditional foods like green leafy vegetables contain a lot of promoting bioactive substances. There is contrasting information on some nutritional status of some many vegetables in the tropics (Ladeji *et al.* 2004; Nkafamiya *et al.* 2010). The fight against malnutrition and undernourishment continues to be a basic goal of development and a variety of strategies are being applied. The strategy on nutrient-rich food like vegetable is considered essential (Susane, 1996). This has lead to our motivation in carrying out analysis on some elements (Na, K, Ca, Mg, Cu, Zn, Pb and Cd) and phytochemicals (alkaloids, tannin, saponins, flavonoids and glycosides) in some edible plant parts (*Celtis integrifolia*, *Ficus sycomorus*, *Balanites egyptiaca*, *Vitex doniana* and *Haematostaphis barteri*) in Hong Local Government area of Adamawa State.

1.2 Statement of the Problem

Plant leaves consumed as vegetables in Nigeria have been the subject of many analytical studies in the past (Barminas *et al.* 1998; Kubmarawa *et al.* 2008; Nkafamiya *et al.* 2010; and Adenepekun *et al.* 2010).Considerable information exists on the nutritional, elemental composition and phytochemicals. The content of mineral elements and phytochemicals depends to a high degree on the soil type (Kruczek, 2005). Some of the short comings of the studies carried out are scope limitations. There is a need therefore, to carry out similar study in different locations.

1.3 Aim and objectives of the Study

The main aim of the research is to estimate the elemental components and phytochemicals of five edible plant parts (*Celtis integrifolia*, *Ficus sycomorus*, *Balanites egyptiaca*, *Vitex doniana* and *Haematostaphis barteri*) in Hong L.G.A of Adamawa state. The main objectives of the study are as follows:

- i. To determine some heavy metal components in the plant leaves and stem bark
- ii. To estimate some essential elements in the plant leaves and stem bark
- iii. To determine some phytochemicals in the plant leaves and stem bark
- iv. To compare the elemental and phytochemical compositions within the plant leaves and stem bark

1.4 Significance of the Study

Over 60 species of plant leaves are consumed as vegetables in Nigeria (Okoli *et al.* 1988). These leaves are frequently consumed in the rural communities (Barminas *et al.* 1998).

The significance of this study therefore, is to expose the type of elements and the phytochemicals in the plant leaves consumed by the people of the area under study. The results obtained will also serve as basis for further research on other edible plants in any area.

CHAPTER TWO

LITERATURE REVIEW

2.1 Nutritional Values of Vegetables

Vegetables are annual or perennial plants whose edible parts are characterized by very much moisture content of at least 80% (Adenipekun and Oyetunji, 2010). Vegetables are good sources of oil, carbohydrate, minerals and vitamins depending on the vegetable consumed (Ihekoronye and Ngoddy, 1985). They are eaten at least once in many areas and some of them have been found to have high crude protein content (Nkafamiya *et al.* 2010). Vegetable fats and oils lower blood lipids whereby reducing the occurrence of disease associated with the damage of the coronary artery and are precursors of prostaglandins which are known to perform the role of vasoconstriction and vasodilation of the blood vessels. They also serve as precursors of thromboxane which facilitates blood clotting in human (Ononogbu, 2002).

Wild and semi-wild plant leaves are frequently consumed as dominant leafy vegetables especially in the rural communities (Barminas *et al.* 1998; Kubmarawa *et al.* 2008). They constitute indispensable constituents of human diet in Africa most especially West Africa. Vegetables are important protection foods and highly beneficial for the maintenance of health and prevention of diseases and also reinforce the resisting ability of the cells to counter bacterial infections due to the fact that they contain valuable food ingredient which is utilized to build and repair body (Freiberger *et al.* 1998). Green leafy vegetables are best cooked when freshly harvested because some of their vitamin contents deteriorate on storage. Most leafy vegetables particularly the dark green variety contain pro-vitamin A as do carrots, sweet peppers and some tomatoes. They also supply vitamin C and in many cases, iron and calcium to the diet. The search for nutrient-rich food like vegetable is therefore essential (Susane, 1996).

2.1.1 *Celtis integrifolia*

Celtis integrifolia is a family of Ulmaceae. The Hausa name is Zuwo. It is often found in villages or on farm land in Adamawa and Borno states. The fruit is edible. The leaves are regarded as a

good pat-herb and a sustaining food, used in soup and a sort of salad. The baste fibbers of the bark are plaited into bands, mats etc. The leaves, roots and bark are used medicinally for treatment of pains and in the treatment of epilepsy. It was reported to contain Gamma Amino Butyric Acid (GABA) that its deficiency may lead to convulsions (Muazu and Kaita, 2008).

2.1.2 *Ficus sycomorus*

Ficus sycomorus belongs to the family *moraccae* which consists of about 40 genera and over 1,400 species with milky latex juices (Adeshina *et al.*, 2010). They are usually found near streams in the savannah area.

Ficus species have wide distribution and uses worldwide traditionally as medicines, vegetable food, fodder and fuel (Kiran, 2011). The extracts of these plants are used in Northern Nigeria for the treatment of various ailments such as mental illness, dysentery, cough, diarrhoea, chest condition, tuberculosis, convulsive disorder and pain relief (Sandabe and Kwari, 2000; Wakeel *et al.* 2004).

In Nigeria and other developing country, *Ficus sycomorus* leaves are consumed as a result of food shortage and high cost of cultivated green leafy vegetables (Barminas *et al.* 1998; Kubmarawa *et al.* 2008). It contains minerals, vitamins and amino acid profile (Nkafamiya *et al.* 2010).

2.1.3 *Balanites aegyptiaca*

Balanites aegyptiaca is a member of Balanitacea family. The Hausa name is aduwa. It is mainly distributed in semi-arid and arid zones in tropical Africa. The species are found wild in Adamawa and Borno state (Bokhari and Ahmed, 1999). It is used for various needs such as fodder, medicines, charcoal and pesticides. The almond is rich in saturated fatty acid that is used as cooking oil. It contains steroids (saponins, sapogenins, diosgenins) used as raw materials for

industrial production of contraceptive pills, corticoids, anabolisants and other sexual hormones (Mansor *et al.* 2004). The leaves are eaten by humans. It has considerable amount of vitamins and minerals (Nkafamiya *et al.* 2010). The fruits and the kennels are rich in vitamin A and B respectively (Baumer, 1993). The photochemical analysis of the bark showed the presence of saponin and furanocounarin (Eremosele *et al.* 1994).

2.1.4 *Vitex doniana*

Vitex doniana belongs to the family of Verbenaceae. The Hausa name is dinya. It is widely distributed in the Savannah region of Borno and Adamawa states (Adebayo and Tukur, 1999).

Vitex doniana is a medium-sized deciduous tree, 8 – 18 m high, with as heavy rounded crown and a clear bole up to 5m. Bark is rough, pale brown or greyish-white, rather smooth with narrow vertical fissures. The leaves are opposite, glabrous, 14 – 34 cm long, usually with 5 leaf lets on stalks. It is dark green above and pale greyish-green below. The flower petals are white except on largest lobe, which is purple. The flowers are small, blue or violet, 3 – 12 cm in diameter. The fruits are oblong, about 3 cm long. They are green when young and purplish black when ripen.

The various parts of the plant are used by traditional medicine practitioners in Nigeria in the treatment and management of ailment like rheumatism, hypertension, cancer and inflammatory diseases (Agbafor and Nwanchukwu, 2011). The fruit is used to improve fertility and to treat anaemia, jaundice, leprosy and dysentery. The root is used for gonorrhoea treatment and backaches. The young tender leaves are pounded and the juice squeezed into the eyes to treat eye troubles (Kilani, 2006). The leaves are often eaten as salad and herb for cooking. The fruit is

sweet and tasted like prunes. It contains vitamin A and B. The fruit can also be made into wine. The bark yields a dyestuff for cloths (Kilani, 2006).

2.1.5 *Haematostaphis barteri*

Haematostaphis barteri popularly known as blood plum is a member of Anacardiaceae family. The Hausa name is Jinin kafiri. It is found wild in Adamawa and Borno states. The fresh tender leaves are edible. The fruit has oily seed which is edible (Bukhari and Ahmed, 1999). *Haematostaphis barteri* is composed of 54.5% oil, 4.11% crude protein, 2.4% crude fibre, 1.0% ash, 9.0% moisture and 29.0% carbohydrate (Eromosele *et al.* 1994). The pictures of the various plants are shown in appendix 1.

2.2 Dietary Elements

Dietary elements are chemical elements required by living organisms, other than the three elements carbon, hydrogen and oxygen present in common organic molecules. Most of the minerals that enter into the dietary physiology of organisms consist of simple chemical elements. They are classified as macro elements (Ca, Mg, Na, K and P) and micro elements (Fe, Zn, Cu and Mn). The significance of these elements for human health is well documented (World Health Organization, 1996).

2.2.1 Calcium

Calcium is one of the most important elements human requires in the greatest amount (Norman and Joseph, 1996). It is needed for muscle development, heart and digestive system. It is also essential for the normal development and maintenance of bones, teeth, supports and synthesis of blood cells. A deficiency results in poor bone and tooth formation, retarded growth, rickets and low blood clotting. Dietary sources of calcium include dairy products, fish with bones, orange, green leafy vegetables, nuts and seeds (Ihekoronye and Ngoddy, 1985).

2.2.2 Magnesium

Magnesium is essential to the function of several enzymes. It is important in maintaining electrical potential in nerves and membranes. It is involved with liberation of energy for muscle contraction and is required for normal metabolism of calcium and phosphorus. The Recommended Daily Allowance (RDA) is 420 mg. Deficiency causes hypomagnesemia while excess of magnesium result in hypermagnesemia. The sources of magnesium are nuts, soya beans, cocoa mass and vegetables (Norman and Joseph, 1996).

2.2.3 Sodium

Sodium is one of the chief extracellular ions of the body. It is a systematic electrolyte and is essential in regulating ATP. It also helps in regulating nerves and irritability. The Recommended Daily Allowance (RDA) is 1500 mg. Deficiency of sodium result to hyponatremia. Dietary sources include table salt, milk, vegetable, fish, eggs and poultry (Donatelle, 2005).

2.2.4 Potassium

Potassium is the principal intracellular cation and with sodium, it helps to regulate osmotic pressure and pH equilibrium. It also involves with cellular enzyme function. The RDA is 4700 mg. Deficiency of potassium causes hypokalemia, muscle weakness, decreased reflex response and respiratory paralysis. Dietary sources include legumes, potato, bananas, tomatoes and green leafy vegetables (Norman and Joseph, 1996).

2.2.5 Lead

Lead is a major metal contaminant, notorious for poisoning a significant risk to humans, especially children. For example, it has been estimated that in the USA alone lead poisoning affects more than 8000 children between the age of one and five (Pirkle *et al.* 1998). The phytoavailable lead in soils is usually very low due to its strong association with organic matter, Fe-Mn oxides, clays and precipitation as carbonates, hydroxides and phosphates (Shen *et al.* 2002). Its average concentration in the soil has been estimated to be between 15 and 25 mg/kg. It is naturally in galena (PbS), and soil derived from the weathering of this mineral is deemed to have high Pb content. But its major anthropogenic source in the environment include the use of Pb printing, Pb paint flakes, sewage sludge and the use of pesticides containing Pb compounds (Radojevic and Bahkin, 1999).

2.2.6 Cadmium

Cadmium is a heavy metal naturally present in soil at concentrations of slightly more than 1 mg/kg (Peterson and Alloway, 1979). It is highly toxic to most organisms, having toxicity 2-20 times higher than any heavy metals (Vassilev *et al.* 1998). Cadmium content in soil has been dramatically increased from anthropogenic sources including smelters and agricultural applications of fertilizer and sewage sludge. Cadmium in soil can be bioavailable for plant uptake and subsequent human uptake. Thus cadmium in the environment poses significant health risk (McLaughlin *et al.* 1999).

2.2.7 Zinc

Zinc is an essential constituent of enzymes involved in carbohydrate and protein metabolism and nucleic-acid synthesis. It is required in micro quantity (11 mg). Its deficiency results in impaired growth and development, skin lesions and loss of appetite. Zinc sources are meat, fish, grains, seeds, nuts and sea foods (Norman and Joseph, 1996).

2.2.8 Copper

Copper is required component of many redox enzymes, including cytochrome C oxidase. It is essential for the formation of haemoglobin of the red blood cells. It is required in a trace quantity by humans. The Recommended Daily Allowance (RDA) is 900 µg. Its deficiency results in anaemia-like symptoms. Sources are liver, kidney, brains, nuts, cocoa, root crops, dried legumes, cereals, vegetable and meat (William, 2003).

2.3 Sources of heavy metals

Heavy metals are those metals with densities greater than 5 gcm³. They are commonly referred to as trace metals. One of the sources of metals the surface water includes domestic waste and garbage. Therefore, the metals find their way leaches into the soil where plants may be bio- concentrated in the food chain (Shagal *et al.* 2012). Before the technological age, environmental pollution was due to naturally occurring phenomena such as burning, volcanic eruption and very little from human activities. Owing to the increase in technological innovations, a lot of chemicals are emitted into the environment both in urban and rural areas as the result of burning of fossil fuel, mining, smelting and application of pesticide and fertilizers. They are often accumulated in significant increasing concentrations in seas, soils and food (Hertog, 1995).

Adeniyi *et al.* (2008) stated that the most important contaminants are metals and that they originate from industrial processes. Oyelola *et al.*, (2009) observed that the municipal waste dumpsite in Isole, Lagos, accumulated more of Pb, Cr, Fe and Zn, while levels of Cu, Cr and As in soils obtained from Bendel wood treatment factory operating for more than 40 years were very high when compared to soils away from the wood treatment factory (Uwumarogie *et al.* 2008).

2.4 Toxic Elements

The toxic elements cadmium (Cd), lead (Pb) and mercury (Hg) are generally regarded as accidental contaminants although they are frequently found in minute amounts in the new born (Doyle, *et al.*, 1978). These elements are translocated through the food chains to man and animals. As these elements have been recognized to be potentially toxic within specific limiting values, a considerable potentially hazard exist for human nutrition. Food safety issues and potential health risks make this as one of the most serious environmental concerns (Cui *et al.* 2004).

Vegetable accumulate heavy elements in their edible and non-edible parts. Although some of the heavy elements such as Zn, Mn, Ni and Cu act as micro-nutrients at lower concentrations, they become toxic at higher concentrations. Health risk due to heavy elements contamination of soil has been widely reported (Eriyamreumu *et al.* 2005. Muchuweti *et al.* 2006 and Satarug *et al.* 2002). Crops and vegetables grown on soils contaminated with heavy elements have greater accumulation of heavy elements than those grown in uncontaminated soil (Marshall *et al.* 2007; Sharma *et al.* 2007). Intake of vegetable is an important path of heavy elements toxicity to human being. Bioavailability of Cd, Cu, Zn and Mn in the human gastrointestinal tract from the edible part of vegetables using vitro gastrointestinal extraction technique was assessed by Intawongse and Dean, (2006). Dietary intake of heavy elements through vegetables may lead to various chronic diseases. Biotoxic effects of heavy elements depend upon the concentrations and oxidation states of heavy elements, kind of sources and modes of deposition. Severe exposure of Cd may result in pulmonary effects such as emphysema, bronchiolitis and alveolitis. Renal effects may also result due to subchronic inhalation (European Union, 2002; Young, 2005). Cd is concentrated particularly in the kidneys, the liver, the blood forming organs and the lungs. It most frequently results in kidney damage and metabolic anomalies causes reduction is

the haemoglobin synthesis, disturbance in the functioning of kidney, joints, reproductive and cardiovascular and peripheral nervous systems (Ogwuegbu and Muhanga, 2005).

Pb can affect every organ and system in the body. Long-term exposure in adults can result in decreased performance in some tests that measure function of nervous system, weakness in fingers, wrists and ankles; increase in blood pressure and anaemia. It can damage the brain and kidney and even cause miscarriage in women. It can also damage the organ responsible for sperm production (Sabin and Wendy, 2009). The nervous system is sensitive to all forms of Hg. Exposure to high levels can damage the brain, kidney and developing foetuses. Effects on brain functioning may result in irritability, shyness, change in vision, hearing and memory problems. Short-term exposure to high levels of Hg vapour may cause lung damage, nausea, diarrhoea, increase in blood pressure, skin rashes and eye irritation (Sabin and Wendy, 2009).

2.5 The Role of Inorganic Elements in Traditional Medicine

Diet has long been considered as the major source of human exposure trace elements and consequently in basic foodstuff, but medicinal uptakes are of greater interest from the toxicological and nutritional point of view (Dim *et al.* 2004). The human body requires a number of minerals in order to maintain good health. A number of mineral essential to human nutrition are accumulated in different parts of plants as it accumulates minerals essential for growth from the environment (Ajasa *et al.* 2004).

Macro and microelements influence biological processes in the human organization (Brouns and Vermeer, 2000). Drugs are derived either from the whole plant or from their different parts, like leaves, stem bark, roots, flower, and seeds. Plants play an important role in traditional medicine and are widely consumed as home remedies. Since time immemorial, plant based drugs

have been in use in the amelioration of various ailments ranging from common cold to cancer (Kiran, 2011).

In the recognition of the important role that major and trace elements play in health and disease of human body, in the building up and restoration phenomenon, it was observed that during the last few years remarkable progress has occurred in this area of health science. Elements research has definitely been part of this explosion of scientific knowledge (Said *et al.* 1996). Medicinal elementology has not only opened avenues for research on human health related aspects, but also aroused the interest of the pharmaceutical industries to reap the benefits of this research by formulations containing elements reported to be essential for human health (Iqbal *et al.* 2011).

2.6 Phytochemicals

Phytochemicals are biologically active chemical compounds that occur naturally in plants (phyto mean “plant” in Greek). They are the molecules responsible for the colour and organoleptic properties (properties affecting the organs and the senses). The term is generally used to refer to those chemicals that may affect health, but are not established as essential nutrient. They are also referred to a large group of plant-derived compounds hypothesized to be responsible for much of the diseases protection conferred from diets high in fruits, vegetables, beans, cereals and plant based beverages such as tea and wine (Arts and Hollman, 2005).

Phytochemicals are rich sources of organic substances which are used for production of many drugs. Investigation into therapeutic efficacy of plants is therefore urgently needed because of widely usage, acceptability and so many claimed activities for treatment of ailments and diseases (Mustapha *et al.* 2011). The phytochemicals that have medicinal importance are the

secondary metabolites. These secondary metabolites include phenolic compounds such as tannins, alkaloids, glycosides, saponins, terpenes, volatile oils, gums and mucilage.

Epidemiological studies suggest that consumption of a diet high in fruits and vegetables is associated with a reduced risk of chronic disease (Hung, 2004). Hundreds of phytochemical compounds, with several different biological functions have been identified in plant-based foods. Unfortunately, there is not yet enough evidence to support the concept that phytochemicals are responsible for these effects. More research is needed to fully explain the actions of phytochemical compounds in the human body (Halliwell, 2007). Therefore, consuming a variety of plant-based foods helps to ensure the individuals receive the optimum benefits from the fruits and vegetables consumed (Monach, 2004).

2.6.1 Alkaloid

Alkaloids are groups of naturally occurring chemical compounds that contain mostly nitrogen atoms. This group also includes some related compounds with neutral and even weakly acidic properties (McNacght and Wilkinson, 1997). The boundary between alkaloids and other nitrogen-containing natural compounds is not clear-cut. Compounds like amino acids, peptides, nucleotides, nucleic acids, amines and antibiotics are usually not alkaloids (McNacght and Wilkinson, 1997). Natural compounds containing nitrogen in the exocyclic position (mescaline, serotonin, dopamine etc) are usually attributed to amines rather than alkaloids (Leland, 2006). William (1999) and Bansal (2004) consider alkaloids as a special case of amines.

Alkaloids are produced by a large variety of organisms, including bacteria, fungi, plants and animals. They are all part of the group of natural products. Many alkaloids are toxic to other organisms. They often have pharmacological effects and are used as medications and recreational drugs. Examples are the local anaesthetic and stimulant cocaine; the stimulant caffeine

antibacterial berberine; the anticancer compound vincristine; the anti-asthma therapeutic ephedrine; the antimalarial drug quinine; the cholinometric galatamine; the sapsmolysis agent atropine and the vasodilator vincamine. Although alkaloids act on a diversity of metabolic systems in humans and other animals, they almost uniformly invoke bitter taste (Rhoades, 1979).

2.6.2 Flavonoid

Flavonoid was derived from the Latin word “Flavus” meaning yellow colour in their nature. They were originally referred to as vitamin P, likely due to the effect they had on the permeability of vascular capillaries, but this term is really used now. Flovoinoids are widely distributed in plants fulfilling many functions. They are the most important plant pigments for flower colouration producing yellow or red/blue pigmentation in petals designed to attract pollinator animals (Spencer, 2008).

Flovonids such as the catechins are the most common group of polyphenolic compounds in the human diet and are found ubiquitously in plants (Spencer, 2008). Flavonols, the original biflavonoids such as quercetin are also found ubiquitously, but in small lesser quantities. The widespread distribution of flavonoids, their verity and their low toxicity compared to other active plant compound mean that many animals, including humans, ingest significant quantities in their diet. Preliminary research indicates that flavonoids may modify allergens, viruses and carcinogens and so may be biological response modifiers. In vitro studies show that flavonoids also have anti-allergic, anti-inflammatory, anti-microbial, anti-cancer and anti diarrheal activities (Cushnie and Lamb, 2011; Schuler, *et al.* 2005). Consumer and food manufacturers have become interested in flavonoids for their possible medicinal properties, especially their putative role in inhibiting cancer or cardiovascular disease.

Research suggests that flavonoids is an important phytochemical group that contributes to the reduced mortality rates observed in people consuming high levels of plant-based foods. In the Zutphen Elderly study, findings revealed a significant inverse association between flavonoid intake and myocardial infarction (Hertog, 1993). Similarly, findings from the seven countries study (comparing the diets of men living in Finland, Italy, Greece, the former Yugoslavia, Japan, Serbia, the Netherlands and the United states) suggested that consumption of flavonoids was responsible for 25 percent of the observed difference in mortality rates in the various countries studied (Hertog, 1995). Indeed, once consumed and absorbed, flavonoids act favourably in the body, through actions such as inhibiting Xanthine oxidase and arachidonic acid metabolism (Nijveldt, 2001).

2.6.3 Tannin

The term tannin (German word for oak tree) refers to the use of wood tannins from oak in tanning animal hides into leather. However, the term “tannin” by extension is widely applied to any large polyphenolic compound containing sufficient hydroxyls and other suitable groups (such as carboxyl) to form strong complexes with proteins and other macromolecules. The tannin compounds are widely distributed in many species of plants, where they play a role in protection from predation and also as pesticides and in plant growth regulation (Katie and Thorington, 2006). The astringency from the tannins is what causes the dry and pucker feeling in the mouth following the consumption of unripened fruit or red wine (McGee, 2004).

Tannins are found in leaf, bud seed, root and stem tissues. They help to regulate the growth of these tissues. There may be a loss in the bio-availability of still other tannins in plants due to birds, pest and other pathogens (Kadam *et al.*, 1990). The most abundant polyphenols are

the condensed tannins, found in virtually all families of plants and comprising up to 50% of the dry weight of leaves.

Tannins have traditionally been considered anti-nutritional but it is now known that their beneficial or anti-nutritional properties depend upon their chemical structure and dosage. The new technologies used to analyze molecular and chemical structures have shown that a division into condensed and hydrolysable tannins is far too simplistic (Muller and McAllan, 1992). Recent studies have demonstrated that products containing chestnut tannins included at low dosages (0.15 – 0.2%) in the diet can be beneficial (Schiavone, 2008). Some studies suggested that chestnut tannins have been shown to have positive effects on silage quality in the round bale silage, in particular reducing non protein nitrogen (NPN) in the lowest wilting level (Tobacco *et al.* 2006). Improved fermentability of soya meal nitrogen in the rumen has also been reported (Mathieu and Jouany, 1993).

Pomegranates contain a diverse array of tannins, in particular hydrolysable tannins. The most abundant of pomegranate tannins are called punicalagins. Punicalagins have a molecular weight of 1038 and are the largest molecule found intact in rat plasma after oral ingestion and were found to show no toxic effects in rats who were given a 6% diet of punicalagins for 37 days (Cerdá *et al.* 2003). Punicalagins are also found to be the major component responsible for pomegranate juice's antioxidant and health benefit. Most legumes contain tannins. Red-coloured beans contain the most tannin and white-coloured beans have the least, peanuts without shells have very low tannin content. Chickpea (Garbanzo beans) have a smaller amount of tannin (Reed, 1995).

2.6.4 Saponin

Saponins are a diverse group of compounds widely distributed in the plant kingdom, which are characterized by their structure containing a triterpene or steroid aglycone and one or more sugar chains (Gl-stndag and Mazza, 2007). More especially, they are amphipathic glycosides grouped, in terms of phenomenology, by the soap-like foaming they produce when shaken in aqueous solutions and in terms of their structure, by their composition of one or more hydrophilic triterpene derivative (Hostettmann and Marstan, 1995).

Consumer demand for natural products coupled with their physicochemical properties and mounting evidence on their biological activity such as anticancer and anti-cholesterol has led to the emergence of saponins as commercially significant compounds with expanding applications in food, cosmetics, and pharmaceutical sector (Hostettmann and Marstan, 1995). Saponins in foods have traditionally been considered as anti-nutritional factor. However, food and non-food sources of saponins have come into renewed focus in recent years due to increasing evidence of their health benefits such as cholesterol lowering and anti-cancer properties (Gl-Stndag and Mazza, 2007).

2.6.5 Glycoside

A glycoside is a molecule in which a sugar is bound to a non-carbohydrate moiety, usually a small organic molecule. Glycosides play numerous important roles in living organisms. Many plants store chemicals in the form of inactive glycosides. These can be activated by enzyme hydrolysis, which causes the sugar part to be broken off, making the chemical available for use (Brito-Arias, 2007). Many such plant glycosides are used as medications. In animals and humans, poisons are often bound to sugar molecules as part of their elimination from the body.

2.7 Principles of Atomic Absorption Spectroscopy (AAS)

The principles of AAS involve the production of free atoms from the sample and the absorption of radiation from an external source by these atoms. Free unexcited atoms are produced in the flame and populate the ground state (E_0). These are capable of absorbing resonance radiation produced by an external line source. The line source provides energy exactly equal to the energy required for transition of the analyte element from ground state (E_0) to an excited electronic state (E_1). The resulting unabsorbed radiation is passed through a monochromator for isolation of spectral line and then onto the photodetector. The amount of the energy absorbed is proportional to the amount of the element in the sample (Ogugbuaja, 2000). The relationship between the amount of element in the sample and radiant power is expressed by the equation:

$$\text{Log} I_0/I_t = abc$$

Where;

I_0 = power of incident radiation

I_t = power of transmitted radiation

a = constant

b = pathlength

c = concentration

The calibration curve for each element will be constructed using standard solution. A plot of absorbance against concentration will give a straight line graph. The concentration will be obtained from the graph.

2.8 Principles of flame emission spectrometry (FES)

The sample solution is introduced into the flame as a fine spray. The solvent evaporates, leaving the dehydrated salt. The salt is dissociated into free gaseous atoms in the ground state. A certain fraction of these atoms can absorb energy from the flame and be raised to an excited electronic state. The excited level have a short lifetime and drop back to the ground state, emitting photons which is passed through a monochromator to select and isolate the wavelength of interest and allowed to reach the photodetector (photo-multiplier tube). The ensuing electrical signal is amplified and recorded. The intensity of emission is directly proportional to the concentration of the analyte in the sample (Ogugbuaja, 2000).

A calibration curve of emission intensity as a function of concentration will be prepared.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Materials Required

3.1.1 Instruments/Apparatus

Atomic absorption spectrometer (AAS), laboratory glass ware, analytical balance, pestle and mortar, sieve and Whatman filter paper.

3.1.2 Chemical / Reagents

Tetraoxosulphate (VI) acid (H_2SO_4 , S.G. 1.84, 96% v/v)

Hydrochloric acid (HCl, S.G. 1.18, 36% v/v)

Trioxonitrate (V) acid (HNO_3 , S.G. 1.42, 72% v/v)

Sodium-hydroxide, potassium hydroxide, Fehling's solution Mayer's reagent, ethanol (96% v/v).

3.2 Study Area

The study was carried out in Hong Local Government Area of Adamawa state as shown in Figure 3.1. It is located in the Northern guinea savannah zone on latitude $10^{\circ}00''$ and $10^{\circ}30''$ N and longitude $12^{\circ}40''$ and $13^{\circ}00''$ E. They have mean annual rainfall between 900 and 1100mm. The rainy season last for about 4 – 5 months. The more abundant woody plant species in this zone are: *Tamarindus indica*, *Taminalia*, *Vitex doniana*, *Balanites aegyptiaca*, *Ficus sycomorus*, *Ficus exasperate*, *Celtis integrifolia*, *Haematostaphis berteri*, *Khaya senegalensis*, *Azelia Africana*, *Vitellaria paradoxa*, *Boswellia dalzielii*, *Ziziphus spina-christi* and among others (Adebayo and Tukur, 1999). Some of the plant leaves are eaten in the Local Government Area as vegetables or salad. The ones commonly eaten are *Celtis integrifolia*, *Ficus sycomorus*, *Balanites eagyptiaca*, *Vitex doniana* and *Haematostaphis barteri*.

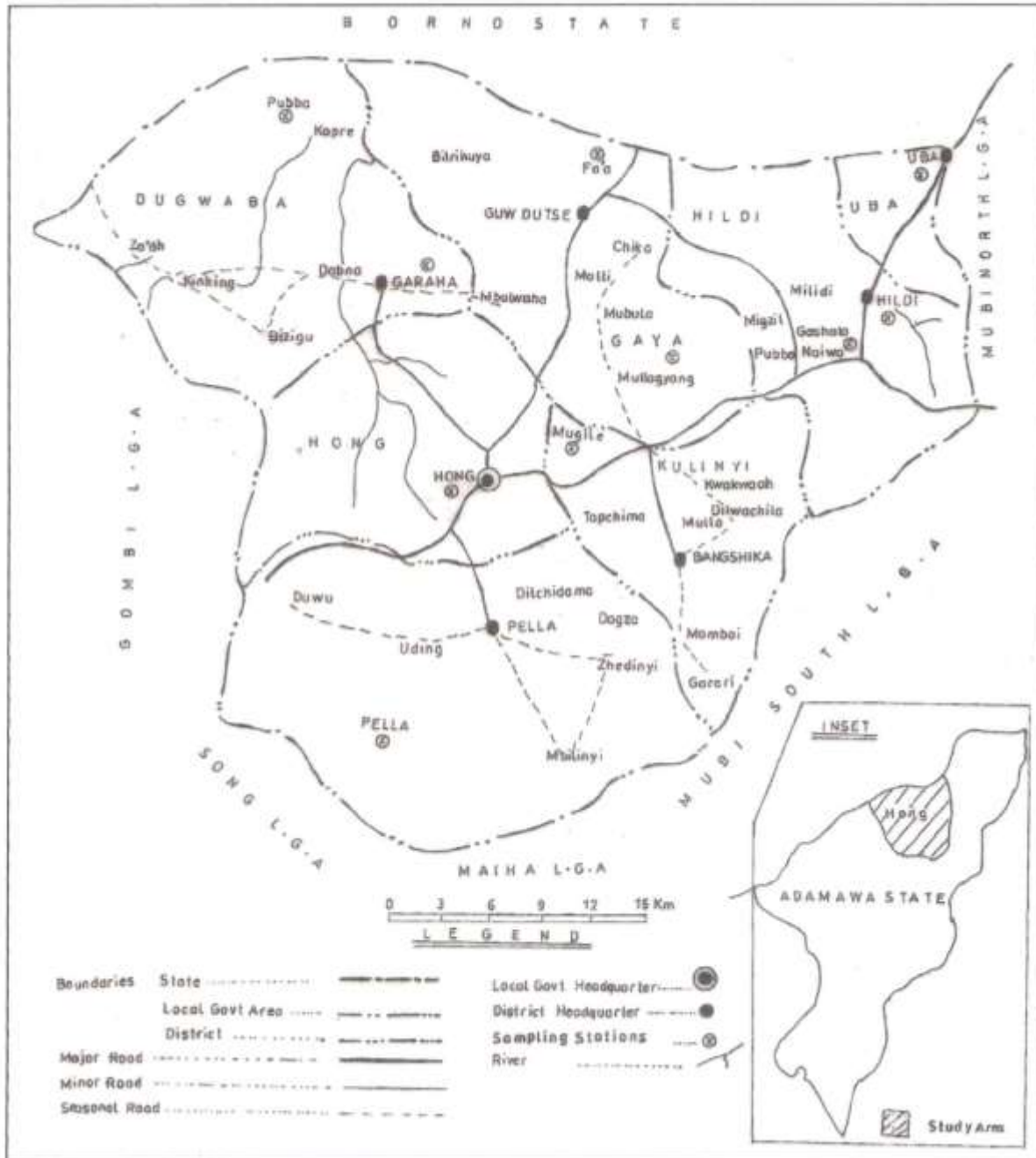


Figure 3.1: Map of Hong Local Government Area showing the Sampling Locations

3.3 Sampling and Sample Preparation

3.3.1 Sampling

Sampling was done according to the method of Ayoola *et al.* (2008). Fresh tender leaves and the stem bark of *Celtis integrifolia*, *Ficus sycomorous*, *Balanites egyptica*, *Haematostaphies barteri* and *Vitex doniana* were collected from 10 locations (Pella, Hong, Hildi, Uba, Gashala, Gaya, Garaha, Mugili, Fa'a and Pubba) in April, 2012 in Hong Local Government area of Adamawa State. Each plant part was dried under shade.

3.3.2 Sample Preparation

Each dried sample was ground to powder and sieved. Representative samples were obtained from each sample by coning and quartering techniques as described by Crosby and Patel (1995). This method involves making a cone shape of the sample, flatten it and divide it into four equal parts; take the opposite two quarters and discard the other two quarters. This was repeated until the sample was reduced to the size required for final analysis and stored in an air tight container.

3.3.3 Sample digestion.

The digestion process was carried out as described by Onwunka (2005) as follows: 3.0g of each of the powdered sample was weighed and pre-treated with 20 mL nitric acid and allowed to stay overnight. 10 mL per-chloric acid was added and heated gently, then vigorously until clear solutions were obtained. The solutions were allowed to cool and then transferred to 100 ml volumetric flask and made up to mark with distilled water. The solutions were filtered and stored in plastic bottles for the analysis of Na, K, Ca, Mg, Cu, Zn, Pb and Cd using Atomic Absorption Spectrophotometer (AAS).

3.4 Elemental Analysis

3.4.1 Preparation of Standard Solutions

The method described by Onwuka (2005) was adopted. Working standard for each element was prepared from their salts by dissolving appropriate amount of metal salts in deionized water to give 1000 ppm. Further dilutions of 1000 ppm stock solutions were made as follows for construction of calibration curves.

3.4.2 Calcium

2.497 g of oven-dried CaCO_3 was dissolved in HCl and diluted to 1000 mL with deionized water. This solution contains 1000 mg of Ca^{2+} ions. Serial dilution of the stock solution was made to obtain 1, 2, 4, 6, and 8 ppm for the construction of the calibration curve.

3.4.3 Sodium

A stock solution containing 1000 mL of sodium ions was prepared by dissolving 2.542 g of oven-dried NaCl in deionized water and diluted to mark. A serial dilution of 2.0, 4.0, 5.0, 6.0 and 7.0 ppm was then prepared from the stock solutions.

3.4.4 Potassium

A stock solution containing 1000 mL K^+ ions was prepared by dissolving 1.907 g of KCl in deionized water. The solution was made to mark with deionized water. A serial dilution of 5.0, 10.0, 15.0 and 20.0 ppm was prepared from the stock solution.

3.4.5 Copper

A stock solution containing 100 mL of Cu^{2+} ions was prepared by dissolving $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$ in de-ionized water and then diluted to 1000 ml. Serial dilution of 0.5, 1.0, 1.5, 2.0 and 2.5 ppm was prepared from the stock solution.

3.4.6 Zinc

1.0 g of zinc ribbon was dissolved in 10 mL of HCl. The solution was evaporated almost to dryness and made to mark in 1000 mL volumetric flask using deionized water. A serial dilution of 1, 2, 3, 4 and 5 ppm was prepared from the stock solution.

3.4.7 Lead

1.6 g $\text{Pb}(\text{NO}_3)_2$ was dissolved in deionized water and finally adjusted to 1000 mL. A serial dilution of 0.5, 1.0, 1.5, 2.0 and 2.5 ppm was prepared from the stock solution.

3.4.8 Cadmium

A stock solution of cadmium was prepared by dissolving 2.11 g of $\text{Cd}(\text{NO}_3)_2$ in deionized water and finally diluted to 1000 mL. A serial solution of 1.0, 2.0, 3.0, 4.0 and 5.0 ppm was prepared from the stock solution.

3.5 Elemental determination

GBC Avanta GF300 model Atomic absorption spectrophotometer equipped with a digital read-out was used for the determination of metals. Acetylene-air was used as the fuel. A hollow cathode lamp for each element was employed.

The following wavelengths were chosen for the metal analysis: Ca (422.7 nm), Cu (324.7 nm), K (766.5 nm), Na (589.7 nm), Mg (285.2 nm), Cd (228 nm), Pb (217 nm) and Zn (213.9 nm). The equipment was calibrated for the investigation of the elements following the sensitivity and detection limits respectively using standard calibration curve method (Samali *et al.* 2012). All results were recorded in micrograms per gram.

3.6 Phytochemical Determination

10 g each of the powdered plant leaves and stem bark were soaked in ethanol for 24 h. The extracts were filtered through a Whatman filter paper. The filtrates were then concentrated using a rotary evaporator with the water bath set at 40°C (Ayoola *et al.* 2008).

The phytochemical analyses of the extracts were carried out according to the methods described by Trease and Evans (1989) as follows:

3.6.1 Test for Alkaloids

1 mL of 1% HCl was added to 3 mL of the extract in a test tube. The mixture was heated for 20 minutes, cooled and filtered. About 2 drop of Mayer's reagent was then added to 1 mL of the filtrate. A creamy precipitate indicated the presence of alkaloids.

3.6.2 Test for Tannins

1 mL of freshly prepared 10% KOH was added to 1 mL of the extract. A dirty white precipitate showed the presence of tannin.

3.6.3 Test for Saponins

- i. Frothing test: 2 mL of the extract was vigorously shaken in a test tube for 2 minutes and observed for frothing.
- ii. Emulsion test: 5 drops of olive oil was added to 3 mL of the extract in the test tube and vigorously shaken. The absence of frothing and stable emulsion indicated the absence of saponin.

3.6.4 Test for Flavonoids

1 mL of 10% NaOH was added to 3 mL of the extract. The absence of flavonoids showed the absence of yellow colouration.

3.6.5 Test for Glycosides

10 mL of 5% H₂SO₄ was added to 1ml of extract in test tubes. The mixture was heated in boiling water for about 15 minutes. 10 mL of Fehling's solution was then added and the mixture boiled. A brick-red precipitate shows the presence of glycosides.

3.7 Statistical Analysis

Data generated was subjected to Analysis Of Variance (ANOVA) to determine the level of significance using statistical software (CROPSTAT 7.2.3 International Rice Research Institute IRRI, Philippine). Significant means were separated using least significant difference (LSD) technique as described by Gomez and Gomez (1984). Differences were considered significant if probability is less than 5% ($p \leq 0.05$) for all the data.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Phytochemical Screening

The results for the phytochemical screening of *Celtis integrifolia* parts are presented in Table 4.1.1. The leaves and the stem bark showed the presence of alkaloid while flavonoid was recorded in the leaves around Pella area. The leaves demonstrated the presence of alkaloid while the stem bark contained alkaloid and flavonoid in the plant around Hong area. The leaves around Hildi demonstrated the presence of tannin, alkaloid, glycoside and flavonoid while only alkaloid was recorded in the stem bark. Tannin was only observed in the leaves around Hildi area. Glycoside was recorded in the leaves around Hildi and Fa'a areas. The leaves around Pella, Hildi, Fa'a, Garaha, Gashala, Mugili and Pubba demonstrated the presence of flavonoids. Alkaloids were recorded in the entire samples screened while saponin was not observed by the method used.

Table 4.1.2 shows the phytochemical constituents of the leaves and stem bark of *Ficus sycomorus*. Tannin was recorded in the entire parts investigated in all the locations except the stem bark around Gaya area. The leaves demonstrated the presence of alkaloid while most of the stem bark did not show the presence of alkaloid in the locations studied. The stem bark around Hildi, Fa'a and Garaha observed the presence of glycoside. Flavonoids were recorded in the entire parts screened except for the stem bark around Uba and Garaha area. Saponin was not recorded in the entire parts determined.

Table 4.1.1: Phytochemical screening of *Celtis integrifolia* extracts

Location	Plant parts	Tannin	Alkaloid	Glycoside	Flavonoid	Saponin
Pella	Leaves	-	+	-	+	-
	Stem bark	-	+	-	-	-
Hong	Leaves	-	+	-	-	-
	Stem bark	-	+	-	+	-
Hildi	Leaves	+	+	+	+	-
	Stem bark	-	+	-	-	-
Uba	Leaves	-	+	-	-	-
	Stem bark	-	+	-	+	-
Gaya	Leaves	-	+	-	-	-
	Stem bark	-	+	-	+	-
Fa'a	Leaves	-	+	+	+	-
	Stem bark	-	+	-	-	-
Garaha	Leaves	-	+	-	+	-
	Stem bark	-	+	-	-	-
Gashala	Leaves	-	+	-	+	-
	Stem bark	-	+	-	-	-
Mugili	Leaves	-	+	-	+	-
	Stem bark	-	+	-	-	-
Pubba	Leaves	-	+	-	+	-
	Stem bark	-	+	-	-	-

+ = present, - = absent

Table 4.1.2: Phytochemical screening of *Ficus sycomorus* extracts

Location	Plant parts	Tannin	Alkaloid	Glycoside	Flavonoid	Saponin
Pella	Leaves	+	+	-	+	-
	Stem bark	+	-	-	+	-
Hong	Leaves	+	+	-	+	-
	Stem bark	+	-	-	+	-
Hildi	Leaves	+	+	+	+	-
	Stem bark	+	-	-	+	-
Uba	Leaves	+	+	-	+	-
	Stem bark	+	+	-	-	-
Gaya	Leaves	+	+	-	+	-
	Stem bark	-	-	-	+	-
Fa'a	Leaves	+	+	-	+	-
	Stem bark	+	-	+	+	-
Garaha	Leaves	+	+	-	+	-
	Stem bark	+	+	+	-	-
Gashala	Leaves	+	-	-	+	-
	Stem bark	+	+	-	+	-
Mugili	Leaves	+	+	-	+	-
	Stem bark	+	-	-	+	-
Pubba	Leaves	+	+	-	+	-
	Stem bark	+	-	-	+	-

+ = present, - = absent

Table 4.1.3 presents the phytochemical composition of *Balanites egyptiaca*. The leaves and the stem bark demonstrated the presence of tannin in all the locations. Alkaloids were present in the leaves around Hildi and Fa'a. Glycosides were not observed in the entire samples from all the locations. The leaves demonstrated the presence of flavonoid. Saponin was recorded in the leaves and the stem bark around Hong, Fa'a and Garaha areas. However, saponin was observed in the leaves from all the locations.

The phytochemical constituents of *vitex doniana* parts are presented in Table 4.1.4. Tannin was observed in the entire samples. The leaves demonstrated the presence of alkaloid in all the locations except Hong area. Flavonoids and glycosides were not observed in the entire samples. Saponin was recorded in all the parts investigated with exception of the stem bark from Gaya and Gashala areas.

Table 4.1.5 presents the results of phytochemicals obtained in the leaves and stem bark of *Haematostaphis barteri* from 10 locations in Hong local Government area. The leaves and the stem bark demonstrated the presence of tannin in all the samples screened. The leaves showed the presence of alkaloid in all the samples from the locations studied. Glycosides were not observed in the entire samples investigated. The parts from Uba area showed the presence of flavonoid. The stem bark contained flavonoid in all the samples screened. Saponin was also recorded in all the parts analyzed.

Table 4.1.3: Phytochemical screening of *Balanites egyptiaca* extracts

Location	Plant parts	Tannin	Alkaloid	Glycoside	Flavonoid	Saponin
Pella	Leaves	+	-	-	+	+
	Stem bark	+	-	-	-	-
Hong	Leaves	+	-	-	+	+
	Stem bark	+	-	-	-	+
Hildi	Leaves	+	+	-	+	+
	Stem bark	+	-	-	-	-
Uba	Leaves	+	-	-	-	+
	Stem bark	+	-	-	-	-
Gaya	Leaves	+	-	-	+	+
	Stem bark	+	-	-	-	-
Fa'a	Leaves	+	+	-	+	+
	Stem bark	+	-	-	-	+
Garaha	Leaves	+	-	-	+	+
	Stem bark	+	-	-	-	+
Gashala	Leaves	+	-	-	+	+
	Stem bark	+	-	-	-	-
Mugili	Leaves	+	-	-	+	+
	Stem bark	+	-	-	-	-
Pubba	Leaves	+	-	-	+	+
	Stem bark	+	-	-	-	-

+ = present, - = absent

Table 4.1.4: Phytochemical screening of *Vitex doniana* extracts

Location	Plant parts	Tannin	Alkaloid	Glycoside	Flavonoid	Saponin
Pella	Leaves	+	+	-	-	+
	Stem bark	+	-	-	-	+
Hong	Leaves	+	-	-	-	+
	Stem bark	+	-	-	-	+
Hildi	Leaves	+	+	-	-	+
	Stem bark	+	-	-	-	+
Uba	Leaves	+	+	-	-	+
	Stem bark	+	-	-	-	+
Gaya	Leaves	+	+	-	-	+
	Stem bark	+	-	-	-	-
Fa'a	Leaves	+	+	-	-	+
	Stem bark	+	-	-	-	+
Garaha	Leaves	+	+	-	-	+
	Stem bark	+	-	-	-	+
Gashala	Leaves	+	+	-	-	+
	Stem bark	+	-	-	-	-
Mugili	Leaves	+	+	-	-	+
	Stem bark	+	-	-	-	+
Pubba	Leaves	+	+	-	-	+
	Stem bark	+	-	-	-	+

+ = present, - = absent

Table 4.1.5: Phytochemical screening of *Haematostaphis barteri* extracts

Location	Plant parts	Tannin	Alkaloid	Glycoside	Flavonoid	Saponin
Pella	Leaves	+	+	-	-	+
	Stem bark	+	-	-	+	+
Hong	Leaves	+	+	-	-	+
	Stem bark	+	-	-	+	+
Hildi	Leaves	+	+	-	-	+
	Stem bark	+	-	-	+	+
Uba	Leaves	+	+	-	+	+
	Stem bark	+	-	-	-	+
Gaya	Leaves	+	+	-	+	+
	Stem bark	+	-	-	-	+
Fa'a	Leaves	+	+	-	-	+
	Stem bark	+	-	-	+	+
Garaha	Leaves	+	+	-	-	+
	Stem bark	+	+	-	+	+
Gashala	Leaves	+	+	-	-	+
	Stem bark	+	-	-	+	+
Mugili	Leaves	+	+	-	-	+
	Stem bark	+	-	-	+	+
Pubba	Leaves	+	+	-	-	+
	Stem bark	+	-	-	+	-

= present, - = absent

4.2 Elemental determination

Mean distribution of essential elements in *Celtis integrifolia* leaves among ten locations in Hong Local Government Area is presented in Table 4.2 1. The results indicate that Na varies between 0.46 and 0.65 $\mu\text{g/g}$ with a mean value of 0.60 $\mu\text{g/g}$. There was no significant difference ($p \leq 0.05$) observed among locations in terms of Na content. But, in terms of potassium, the mean values ranged between 0.87 to 1.02 $\mu\text{g/g}$, with an overall average of 1.02 $\mu\text{g/g}$. Mg was recorded in the entire samples with total mean value of 0.370 $\mu\text{g/g}$. Highest value for Ca was recorded in Hong area (0.310 $\mu\text{g/g}$). No significant difference ($p \leq 0.05$) was observed among the locations in terms of K, Mg and Ca contents.

The mean levels of heavy metals in *Celtis integrifolia* leaves in ten locations in Hong Local Government area is presented in Table 4.2.2. The value for Cu was below the detectable limit ($< 0.025 \mu\text{g/g}$) of the instrument used for the entire samples analyzed. Zn was only recorded around Garaha (0.260 $\mu\text{g/g}$) and Mugili (0.100 $\mu\text{g/g}$) areas. Pb ($< 0.06 \mu\text{g/h}$) was not observed in the entire samples. Highest amount for Cd was recorded in Hildi area (0.320 $\mu\text{g/g}$) with an overall average value of 0.280 $\mu\text{g/g}$. There was no significant difference ($p \leq 0.05$) observed among the locations in terms of Cu, Pb and Zn contents.

Table 4.2.1: Mean levels of Essential elements in *Celtis integrifolia* leaves ($\mu\text{g/g}$ dry weight)

Location	Elements			
	Na	K	Mg	Ca
Pella	0.650	1.020	0.390	0.150
Hong	0.460	1.010	0.380	0.310
Hildi	0.630	0.980	0.400	0.180
Uba	0.640	1.230	0.410	0.220
Gaya	0.650	1.010	0.420	0.210
Fa'a	0.630	0.990	0.410	0.200
Garaha	0.600	1.020	0.420	0.190
Gashala	0.590	1.000	0.400	0.210
Mugili	0.600	1.020	0.390	0.190
Pubba	0.590	0.870	0.370	0.230
Mean	0.600	1.020	0.400	0.210
SE	0.067	0.093	0.020	0.061
LSD (5%)	0.199	0.276	0.061	0.182

Any two mean having difference greater than LSD are significantly different at 5% level of probability.

SE = Standard error

LSD = Least significant difference

Table 4.2.2: Mean levels of heavy metals in *Celtis integrifolia* leaves ($\mu\text{g/g}$ dry weight)

Location	Metals			
	Cu	Zn	Pb	Cd
Pella	<0.025	<0.008	<0.060	0.300
Hong	<0.025	<0.008	<0.060	0.310
Hildi	<0.025	<0.008	<0.060	0.320
Uba	<0.025	<0.008	<0.060	0.300
Gaya	<0.025	<0.008	<0.060	0.300
Fa'a	<0.025	<0.008	<0.060	0.320
Garaha	<0.025	<0.260	<0.060	0.290
Gashala	<0.025	<0.008	<0.060	0.300
Mugili	<0.025	0.100	<0.060	0.200
Pubba	<0.025	0.090	<0.060	0.160
Mean	0.025	0.027	0.060	0.280
SE	0.0018	0.007	0.0068	0.0156
LSD (5%)	0.0054	0.020	0.0202	0.0472

Any two mean having difference greater than LSD are significantly different at 5% level of probability.

SE = Standard error

LSD = Least significant difference

Table 4.2.3 shows the essential element levels of *Celtis integrifolia* stem bark. The value for Na observed was in the range 1.250 to 1.590 µg/g with an overall mean value of 1.520 µg/g. No significant difference ($p \leq 0.05$) was observed among the locations in terms of Na composition. K was recorded highest in the samples around Uba (0.450 µg/g), Fa'a (0.450 µg/g) and Gashala (0.450 µg/g) areas. Mg was present in the entire samples with average value of 0.218 µg/g. Ca was recorded highest in the sample around Gashala (0.700 µg/g). No significant difference was observed with respect to Na, K and Ca compositions in the locations investigated at $p \leq 0.05$, but there was significant difference ($p \leq 0.05$) in terms of Mg content.

Table 4.2.4 presents the mean levels of heavy metals in *Celtis integrifolia* stem bark in ten locations within Hong Local Government Area. Cu was only recorded in Fa'a area with the mean value of 0.175 µg/g. The range for the values of Zn observed in the locations were 0.400 to 0.660 µg/g. the amount for Pb was below the detectable limit (< 0.06 µg/g) of the machine used. Highest amount of Cd was recorded in Mugili area (0.100 µg/g). There was no significant difference ($p \leq 0.05$) in terms of Cu, Pb and Zn among the ten locations observed.

Mean distribution of essential elements in *Ficus sycomorus* leaves among ten locations in Hong Local Government is presented in Table 4.2.5. The values for Na ranged between 2.900 to 4.100 µg/g with highest amount in Uba and Mugili areas (4.100 µg/g). The values for K observed were below the detectable limit (< 0.008 µg/g) of the instrument used with exception of the sample from Pella area (0.070 µg/g). The results indicate that Mg varies from 0.280 to 0.330 µg/g with a total mean value of 0.312 µg/g. Ca was recorded highest around Fa'a area (0.700 µg/g). There was no significance difference ($p \leq 0.05$) among the locations in terms of Na, Mg and Ca content, but significance difference ($p \leq 0.05$) was observed in K compositions.

Table 4.2.3: Mean levels of essential Elements in *Celtis integrifolia* Stem bark ($\mu\text{g/g}$ dry weight)

Location	Elements			
	Na	K	Mg	Ca
Pella	1.500	0.400	0.200	0.060
Hong	1.590	0.420	0.210	0.080
Hildi	1.580	0.430	0.200	0.070
Uba	1.250	0.450	0.230	0.090
Gaya	1.580	0.430	0.210	0.070
Fa'a	1.600	0.450	0.190	0.080
Garaha	1.590	0.430	0.210	0.080
Gashala	1.430	0.450	0.220	0.700
Mugili	1.610	0.430	0.210	0.400
Pubba	1.480	0.360	0.300	0.120
Mean	1.521	0.425	0.218	0.112
SE	0.121	0.056	0.017	0.098
LSD (5%)	0.359	0.166	0.05	0.291

Any two mean having difference greater than LSD are significantly different at 5% level of probability.

SE = Standard error

LSD = Least significant difference

Table 4.2. 4: Mean levels of heavy metals in stem bark of *Celtis integrifolia* ($\mu\text{g/g}$ dry weight)

Location	Elements			
	Cu	Zn	Pb	Cd
Pella	<0.025	0.630	<0.060	0.060
Hong	<0.025	0.650	<0.060	0.040
Hildi	<0.025	0.640	<0.060	0.050
Uba	<0.025	0.660	<0.060	0.040
Gaya	<0.025	0.660	<0.060	0.050
Fa'a	0.175	0.650	<0.060	0.030
Garaha	<0.025	0.450	<0.060	0.050
Gashala	<0.025	0.640	<0.060	0.050
Mugili	<0.025	0.500	<0.060	0.100
Pubba	<0.025	0.400	<0.060	0.020
Mean	0.040	0.588	0.060	0.044
SE	0.024	0.135	0.0068	0.009
LSD (5%)	0.018	0.400	0.0202	0.028

Any two mean having difference greater than LSD are significantly different at 5% level of probability.

SE = Standard error

LSD = Least significant difference

Table 4.2. 5: Mean levels of essential elements in *Ficus sycomorus* leaves ($\mu\text{g/g}$ dry weight)

Location	Elements			
	Na	K	Mg	Ca
Pella	4.033	<0.008	0.313	0.100
Hong	3.903	<0.008	0.330	0.110
Hildi	4.000	<0.008	0.320	0.120
Uba	4.100	<0.008	0.310	0.120
Gaya	4.000	<0.008	0.310	0.380
Fa'a	3.800	<0.008	0.320	0.700
Garaha	3.800	<0.008	0.310	0.110
Gashala	3.980	<0.008	0.300	0.120
Mugili	4.100	<0.008	0.330	0.390
Pubba	2.900	0.070	0.280	0.100
Mean	3.862	0.014	0.312	0.225
SE	0.246	0.011	0.021	0.156
LSD (5%)	0.731	0.033	0.061	0.464

Any two mean having difference greater than LSD are significantly different at 5% level of probability.

SE = Standard error

LSD = Least significant difference

The results of heavy metal levels in *Ficus sycomorus* leaves are shown in Table 4.2.6. Cu and Pb contents were below the sensitivity range of the instrument used ($<0.025 \mu\text{g/g}$ and $<0.06 \mu\text{g/g}$ respectively). The result for Zn varies between $1.323 \mu\text{g/g}$ to $4.800 \mu\text{g/g}$ with a total mean value of $1.742 \mu\text{g/g}$. there was no significance difference ($p \leq 0.05$) observed among locations in terms of Zn and Cd contents.

Table 4.2.7 indicates the mean distribution of essential elements in *Ficus sycomorus* stem bark in ten locations in Hong Local Government Area. The value for Na was recorded highest in Pubba area ($1.000 \mu\text{g/g}$). The amount for K ranged between $0.900 \mu\text{g/g}$ to $1.020 \mu\text{g/g}$ with an overall average of $0.982 \mu\text{g/g}$. Mg and Ca were recorded in the entire samples with total mean values of $0.312 \mu\text{g/g}$ and $0.157 \mu\text{g/g}$ respectively. Significant difference ($p \leq 0.05$) was observed with regard to Na, K and Ca compositions among the locations.

Table 4.2.8 presents heavy levels in *Ficus sycomorus* stem bark among ten locations in Hong Local Government. Cu was only observed in the samples around Pubba ($0.130 \mu\text{g/g}$). Considerable amount of Zn was recorded in all the locations with highest value in Hong ($5.710 \mu\text{g/g}$). Pb was below minimum detectable limit ($<0.06 \mu\text{g/g}$) of the analytical instrument used. For Cd, the values ranged between 0.280 to $0.320 \mu\text{g/g}$. significant difference ($p \leq 0.05$) occurred among the locations in terms of Cu, Zn and Cd contents.

Table 4.2.6: Mean levels of heavy metals in *Ficus sycomorus* leaves ($\mu\text{g/g}$ dry weight)S

Location	Metals			
	Cu	Zn	Pb	Cd
Pella	<0.025	1.430	<0.060	0.260
Hong	<0.025	1.410	<0.210	0.320
Hildi	<0.025	1.400	<0.060	0.240
Uba	<0.025	1.430	<0.060	0.025
Gaya	<0.025	1.410	<0.060	0.025
Fa'a	0.025	1.420	<0.060	0.024
Garaha	<0.025	1.400	<0.060	0.023
Gashala	<0.025	1.400	<0.060	0.023
Mugili	<0.025	4.800	<0.060	0.017
Pubba	<0.025	1.323	<0.060	0.019
Mean	0.025	1.742	0.060	0.238
SE	0.000	0.040	0.004	0.010
LSD (5%)	0.002	0.118	0.038	0.031

Any two mean having difference greater than LSD are significantly different at 5% level of probability.

SE = Standard error

LSD = Least significant difference

Table 4.2.7: Mean levels of Essential Elements in *Ficus sycomorus* stem bark ($\mu\text{g/g}$ dry weight)

Location	Elements			
	Na	K	Mg	Ca
Pella	0.710	1.000	0.310	0.150
Hong	0.720	1.010	0.280	0.160
Hildi	0.820	1.000	0.300	0.150
Uba	0.950	1.020	0.280	0.170
Gaya	0.720	0.993	0.300	0.160
Fa'a	0.720	1.010	0.300	0.160
Garaha	0.820	0.990	0.523	0.150
Gashala	0.900	0.900	0.310	0.150
Mugili	0.690	1.000	0.290	0.180
Pubba	1.000	0.900	0.280	0.140
Mean	0.805	0.982	0.317	0.157
SE	0.028	0.028	0.075	0.006
LSD (5%)	0.084	0.083	0.222	0.017

Any two mean having difference greater than LSD are significantly different at 5% level of probability.

SE = Standard error

LSD = Least significant difference

Table 4.2.8: Mean levels of Heavy Metals in *Ficus sycomorus* stem bark ($\mu\text{g/g}$ dry weight)

Location	Metals			
	Cu	Zn	Pb	Cd
Pella	<0.025	5.700	<0.060	0.280
Hong	<0.025	5.710	<0.060	0.300
Hildi	<0.025	5.690	<0.060	0.310
Uba	<0.025	5.700	0.060	0.300
Gaya	0.025	5.500	<0.060	0.300
Fa'a	<0.025	5.710	<0.060	0.290
Garaha	<0.025	5.650	<0.060	0.300
Gashala	<0.025	5.690	<0.060	0.300
Mugili	<0.025	5.200	<0.060	0.300
Pubba	0.130	4.900	<0.060	0.320
Mean	0.035	5.545	0.060	0.300
SE	0.002	0.019	0.006	0.006
LSD (5%)	0.006	0.058	0.019	0.017

Any two mean having difference greater than LSD are significantly different at 5% level of probability.

SE = Standard error

LSD = Least significant difference

Mean levels of essential elements in *Vitex doniana* leaves in ten locations in Hong Local Government Area is presented in Table 4.2.9. The results revealed that Na varies from 0.326 and 1.01 $\mu\text{g/g}$ with an overall mean value of 0.810 $\mu\text{g/g}$. for K, the value between from 0.110 to 0.640 $\mu\text{g/g}$ with a total mean of 0.566 $\mu\text{g/g}$. Mg was recorded in all the locations with an overall average of 0.111 $\mu\text{g/g}$. highest amount for Ca was recorded in Hong (0.170 $\mu\text{g/g}$ and Uba (0.170 $\mu\text{g/g}$) areas. No significant difference ($p \leq 0.05$) was observed in Na and Ca contents among the locations, but there was significant difference ($p \leq 0.05$) in terms of K and Mg contents.

Heavy metal compositions in *Vitex doniana* leaves within ten locations in Hong Local Government Area is presented in Table 4.2.10. The result showed the presence of Cu in the locations with a total mean value of 1.508 $\mu\text{g/g}$. Highest amount for Zn was recorded in Gashala area (0.570 $\mu\text{g/g}$). The value for Pb was below the detectable limit ($< 0.06 \mu\text{g/g}$) of the instrument used, but in terms of Cd, the mean values ranged between 0.220 to 0.300 $\mu\text{g/g}$. There was no significant difference ($p \leq 0.05$) observed in terms of Cu, Zn and Pb contents among the locations.

Table 4.2.11 shows the mean levels of essential elements in *Vitex doniana* stem bark in Hong Local Government among ten locations. Na content was recorded highest in the samples around Uba (3.400 $\mu\text{g/g}$ with an overall mean of 3.116 $\mu\text{g/g}$. K was only recorded in the samples around Pubba (0.777 $\mu\text{g/g}$). Significant difference ($p \leq 0.05$) was observed among the locations in terms of K content. Mg and Ca were recorded in the entire samples with total average values of 0.204 $\mu\text{g/g}$ and 0.209 $\mu\text{g/g}$ respectively. There was no significant difference ($p \leq 0.05$) with regard to Mg and Ca compositions among the locations.

Table 4.2.9: Mean levels of essential elements in *Vitex doniana* leaves ($\mu\text{g/g}$ dry weight)

Location	Elements			
	Na	K	Mg	Ca
Pella	0.326	0.600	0.120	0.160
Hong	0.980	0.610	0.120	0.170
Hildi	0.970	0.620	0.110	0.160
Uba	0.960	0.630	0.100	0.170
Gaya	0.970	0.610	0.100	0.160
Fa'a	0.940	0.620	0.120	0.140
Garaha	0.980	0.610	0.100	0.160
Gashala	1.010	0.640	0.100	0.150
Mugili	0.900	0.610	0.110	0.160
Pubba	0.830	0.110	0.130	0.140
Mean	0.810	0.566	0.111	0.202
SE	1.000	0.005	0.006	0.140
LSD (5%)	0.290	0.014	0.017	0.416

Any two mean having difference greater than LSD are significantly different at 5% level of probability.

SE = Standard error

LSD = Least significant difference

Table 4.2.10: Mean levels of Heavy Metals in *Vitex doniana* leaves ($\mu\text{g/g}$ dry weight)

Location	Metals			
	Cu	Zn	Pb	Cd
Pella	1.500	0.150	<0.060	0.240
Hong	1.520	0.160	<0.060	0.270
Hildi	1.510	0.150	<0.060	0.260
Uba	1.530	0.140	<0.060	0.250
Gaya	1.520	0.160	<0.060	0.260
Fa'a	1.500	0.160	<0.060	0.240
Garaha	1.520	0.150	<0.060	0.250
Gashala	1.510	0.570	<0.060	0.270
Mugili	1.490	0.210	<0.060	0.220
Pubba	1.480	0.330	<0.060	0.300
Mean	1.508	0.218	0.060	0.256
SE	0.019	0.132	0.006	0.007
LSD (5%)	0.055	0.391	0.018	0.021

Any two mean having difference greater than LSD are significantly different at 5% level of probability.

SE = Standard error

LSD = Least significant difference

Table 4.2.11: Mean levels of Essential Elements in *Vitex doniana* stem bark ($\mu\text{g/g}$ dry weight)

Location	Essential elements			
	Na	K	Mg	Ca
Pella	3.200	<0.008	0.200	0.160
Hong	3.300	<0.008	0.200	0.140
Hildi	3.200	<0.008	0.220	0.160
Uba	3.400	<0.008	0.210	0.160
Gaya	2.310	<0.008	0.180	0.150
Fa'a	3.350	<0.008	0.200	0.160
Garaha	3.100	<0.008	0.210	0.140
Gashala	2.970	<0.008	0.220	0.180
Mugili	3.350	<0.008	0.170	0.670
Pubba	2.980	0.777	0.220	0.170
Mean	3.116	0.085	0.204	0.209
SE	0.314	0.003	0.015	0.164
LSD (5%)	0.930	0.008	0.044	0.488

Any two mean having difference greater than LSD are significantly different at 5% level of probability.

SE = Standard error

LSD = Least significant difference

Table 4.2.12 presents heavy metal levels in *Vitex doniana* stem bark. Cu was recorded in all the locations with highest amount in sample around Mugili (0.180 µg/g). The value for Zn was also recorded highest in sample around Mugili area (2.030 µg/g). Pb was below the detectable limit (0.06 µg/g) of the instrument used. The value for Cd ranged between 0.200 to 0.300 µg/g. there was no significant difference ($p \leq 0.05$) in terms of Zn and Cd contents among the plants investigated.

The mean distribution for essential elements in *Balanites egyptiaca* leaves among ten locations in Hong Local Government is presented in Table 4.2.13. Na was present in the entire samples analyzed with a total mean value of 0.504 µg/g. K had a total mean value of 0.703µg/g. for Mg and Ca, highest mean value was obtained in samples around Gashala (0.420 µg/g) and Uba (0.410 µg/g) respectively. There was no significant difference observed among the locations in terms of Na, Mg and Ca contents at $p \leq 0.05$.

Table 4.2.14 shows the heavy metals in *Balanites egyptiaca* leaves in Hong Local Government Area. Cu was recorded in Gaya (0.115 µg/g), Mugili (0.120 µg/g) and Pubba (0.160 µg/g) areas. Significant difference ($p \leq 0.05$) was observed among the locations with respect to Cu content. Zn was observed in the samples around Pubba (0.210 µg/g) only. Pb was below the detectable limit (<0.06 µg/g) of the machine used. Cd was recorded in all the samples with an overall mean of 0.266 µg/g. there was no significant difference ($p \leq 0.05$) revealed in terms of Cd levels among the plants.

Table 4.2.12: Mean levels of Heavy Metals in *Vitex doniana* Stem bark ($\mu\text{g/g}$ dry weight)

Location	Metals			
	Cu	Zn	Pb	Cd
Pella	0.150	1.650	<0.060	0.300
Hong	0.160	1.680	<0.060	0.210
Hildi	0.140	1.690	<0.060	0.220
Uba	0.170	1.700	<0.060	0.230
Gaya	0.140	1.680	<0.060	0.210
Fa'a	0.160	1.690	<0.060	0.210
Garaha	0.150	1.670	<0.060	0.210
Gashala	0.170	1.680	<0.060	0.200
Mugili	0.180	2.030	<0.060	0.200
Pubba	0.170	0.093	<0.060	0.210
Mean	0.159	1.556	0.060	0.220
SE	0.010	0.023	0.004	0.007
LSD (5%)	0.030	0.070	0.011	0.021

Any two mean having difference greater than LSD are significantly different at 5% level of probability.

SE = Standard error

LSD = Least significant difference

Table 4.2.13: Mean levels of Essential Elements in *Balanites egyptiaca* leaves ($\mu\text{g/g}$ dry weight)

Location	Elements			
	Na	K	Mg	Ca
Pella	0.510	0.770	0.380	0.400
Hong	0.500	0.780	0.410	0.380
Hildi	0.520	0.760	0.400	0.400
Uba	0.480	0.800	0.390	0.410
Gaya	0.520	0.780	0.400	0.380
Fa'a	0.510	0.770	0.390	0.390
Garaha	0.510	0.780	0.400	0.410
Gashala	0.480	0.800	0.420	0.380
Mugili	0.490	0.780	0.370	0.400
Pubba	0.520	0.008	0.370	0.350
Mean	0.504	0.703	0.393	0.390
SE	0.026	0.046	0.026	0.030
LSD (5%)	0.079	0.137	0.078	0.088

Any two mean having difference greater than LSD are significantly different at 5% level of probability.

SE = Standard error

LSD = Least significant difference

Table 4.2.14: Mean levels of Heavy Metals in *Balanites egyptiaca* leaves ($\mu\text{g/g}$ dry weight)

Location	Metals			
	Cu	Zn	Pb	Cd
Pella	<0.025	<0.008	<0.060	0.260
Hong	<0.025	<0.008	<0.060	0.280
Hildi	<0.025	<0.008	<0.060	0.270
Uba	<0.025	<0.008	<0.060	0.260
Gaya	0.115	<0.008	<0.060	0.266
Fa'a	<0.025	<0.008	<0.060	0.270
Garaha	<0.025	<0.008	<0.060	0.280
Gashala	<0.025	<0.008	<0.060	0.280
Mugili	0.120	<0.008	<0.060	0.230
Pubba	0.160	0.210	<0.060	0.260
Mean	0.057	0.028	0.060	0.266
SE	0.032	0.002	0.011	0.023
LSD (5%)	0.097	0.006	0.034	0.068

Any two mean having difference greater than LSD are significantly different at 5% level of probability.

SE = Standard error

LSD = Least significant difference

Table 4.2.15 presents mean levels of essential elements in *Balanites egyptiaca* stem bark in ten locations around Hong Local Government Area. The results indicate that Na ranged between 0.540µg/g to 0.600µg/g with a mean value of 0.566µg/g. for K, the value was below the detectable limit (<0.008µg/g) of the instrument used in all the samples investigated. In terms of Mg, The mean value ranged between 0.240µg/g to 0.280µg/g with an overall mean of 0.259µg/g. Ca was recorded highest in the sample around Pella (0.380µg/g). There was no significant difference ($p \leq 0.05$) observed in terms of Na, K, Mg and Ca contents among the locations.

Mean levels of heavy metals in *Balanites egyptiaca* stem bark is presented in Table 4.2.16. the results showed the presence of Cu in samples around Uba (0.145µg/g), Mugili (0.1000µg/g) and Pubba (0.098µg/g) areas while Zn was recorded in Uba (0.056µg/g) and Mugili (0.110µg/g) with a total mean value of 0.023µg/g. Pb was below the detectable limit (<0.06µg/g) of the instrument used in all the samples. Cd was recorded in all the samples with highest amount around Hildi (0.233µg/g). There was no significant difference ($p \leq 0.05$) among the locations in terms of heavy metal compositions.

Table 4.2.17 shows the mean distribution of essential elements in *Haematostaphis barteri* leaves among ten locations in Hong Local Government Area. Na was recorded highest (4.100µg/g) around Hong area. The amount for K varies from 0.070µg/g to 0.900µg/g with an overall average of 0.083µg/g. The values for Mg however, ranged between 0.230 to 0.300µg/g. Ca was also recorded in the entire samples with highest value around Gashala (0.253µg/g). No significant difference was observed with regards to Na, K, Mg and Ca contents among the locations studied at $p \leq 0.05$.

Table 4.2.15: Mean levels of Essential Elements in *Balanites egyptiaca* Stem bark ($\mu\text{g/g}$ dry weight)

Location	Elements			
	Na	K	Mg	Ca
Pella	0.580	<0.008	0.250	0.380
Hong	0.550	<0.008	0.260	0.120
Hildi	0.540	<0.008	0.260	0.100
Uba	0.546	<0.008	0.250	0.100
Gaya	0.540	<0.008	0.250	0.340
Fa'a	0.550	<0.008	0.270	0.100
Garaha	0.560	<0.008	0.260	0.100
Gashala	0.580	<0.008	0.240	0.110
Mugili	0.580	<0.008	0.280	0.080
Pubba	0.600	<0.008	0.276	0.320
Mean	0.566	0.562	0.259	0.175
SE	0.024	0.003	0.030	0.115
LSD (5%)	0.072	0.010	0.091	0.343

Any two mean having difference greater than LSD are significantly different at 5% level of probability.

SE = Standard error

LSD = Least significant difference

Table 4.2.16: Mean levels of Heavy Metals in *Balanites egyptiaca* Stem bark ($\mu\text{g/g}$ dry weight)

Location	Metals			
	Cu	Zn	Pb	Cd
Pella	<0.025	<0.008	<0.060	0.220
Hong	<0.025	<0.008	<0.060	0.227
Hildi	<0.025	<0.008	<0.060	0.233
Uba	0.145	0.056	<0.060	0.210
Gaya	<0.025	<0.008	<0.060	0.210
Fa'a	<0.025	<0.008	<0.060	0.200
Garaha	<0.025	<0.008	<0.060	0.200
Gashala	<0.025	<0.008	<0.060	0.210
Mugili	0.100	0.110	<0.060	0.190
Pubba	0.090	<0.008	<0.060	0.100
Mean	0.051	0.023	0.057	0.200
SE	0.041	0.015	0.013	0.025
LSD (5%)	0.012	0.044	0.039	0.074

Any two mean having difference greater than LSD are significantly different at 5% level of probability.

SE = Standard error

LSD = Least significant difference

Table 4.2.17: Mean levels of Essential Elements in *Haematostaphis barteri* leaves ($\mu\text{g/g}$ dry weight)

Location	Elements			
	Na	K	Mg	Ca
Pella	4.000	0.070	0.260	0.100
Hong	4.100	0.090	0.250	0.100
Hildi	3.900	0.080	0.240	0.100
Uba	4.000	0.080	0.260	0.110
Gaya	3.980	0.090	0.230	0.110
Fa'a	4.000	0.900	0.240	0.090
Garaha	4.000	0.800	0.250	0.080
Gashala	3.800	0.800	0.230	0.253
Mugili	3.990	0.700	0.250	0.100
Pubba	3.800	0.100	0.300	0.090
Mean	3.900	0.083	0.251	0.113
SE	0.534	0.011	0.019	0.042
LSD (5%)	1.586	0.033	0.057	0.125

Any two mean having difference greater than LSD are significantly different at 5% level of probability.

SE = Standard error

LSD = Least significant difference

Table 4.2.18 shows the Mean levels of heavy metals in *Haematostaphis barteri* leaves. The results indicate the presence of Cu in all the locations with highest value around Uba (0.430 µg/g) area. For Zn content, the values ranged from 0.400 to 0.520 µg/g among the locations investigated. The amount for Zn was below the detectable limit (<0.06 µg/g) of the instrument used. Cd was recorded in all the samples with an overall mean of 0.280 µg/g. there was no significant difference ($p \leq 0.05$) among the locations in terms of Cu and Zn contents, but significant difference was observed in Cd.

Mean distribution of essential elements in *Haematostaphis barteri* stem bark among ten locations in Hong Local Government Area is presented in Table 4.2.19. The results showed that Na content varies from 0.760 µg/g and 0.810 µg/g. the value for K was highest in the sample from Gashala area (0.440 µg/g). The amount for Ca ranged between 0.490 to 0.600 µg/g with a total average value of 0.517 µg/g. no significant difference was observed with regard to Na, K, Mg and Ca among the locations at $p \leq 0.05$.

Table 4.2.20 presents the Mean levels of heavy metals in *Haematostaphis barteri* stem bark. The results indicate that Cu was present in all the samples from the locations studied with a total mean value of 0.390 µg/g. the value for Zn was only recorded in sample from Pella (0.038 µg/g). Pb content was below the detectable limit (0.06 µg/g) of the instrument used. Cd compositions among the locations ranged between 0.150 µg/g to 0.370 µg/g, but there was no significant difference ($p \leq 0.05$) observed among the locations in terms of Cu, Zn and Cd contents.

Table 4.2.18: Mean levels of Heavy Metals in *Haematostaphis barteri* leaves ($\mu\text{g/g}$ dry weight)

Location	Metals			
	Cu	Zn	Pb	Cd
Pella	0.410	0.406	<0.060	0.310
Hong	0.400	0.413	<0.060	0.300
Hildi	0.420	0.410	<0.060	0.300
Uba	0.430	0.400	<0.060	0.310
Gaya	0.400	0.400	<0.060	0.280
Fa'a	0.410	0.430	<0.060	0.300
Garaha	0.400	0.420	<0.060	0.290
Gashala	0.400	0.410	<0.060	0.290
Mugili	0.340	0.310	<0.060	0.180
Pubba	0.310	0.520	<0.060	0.240
Mean	0.390	0.412	0.258	0.280
SE	0.031	0.017	0.626	0.021
LSD (5%)	0.092	0.049	0.001	0.063

Any two mean having difference greater than LSD are significantly different at 5% level of probability.

SE = Standard error

LSD = Least significant difference

Table 4.2.19: Mean levels of Essential Elements in *Haematostaphis barteri* Stem bark ($\mu\text{g/g}$ dry weight)

Location	Elements			
	Na	K	Mg	Ca
Pella	0.780	0.400	0.840	0.500
Hong	0.800	0.420	0.820	0.530
Hildi	0.793	0.430	0.840	0.520
Uba	0.790	0.420	0.820	0.490
Gaya	0.780	0.410	0.830	0.500
Fa'a	0.770	0.430	0.840	0.510
Garaha	0.790	0.420	0.830	0.500
Gashala	0.760	0.440	0.830	0.520
Mugili	0.790	0.420	0.800	0.500
Pubba	0.810	0.330	0.940	0.600
Mean	3.158	0.410	0.839	0.517
SE	0.341	0.032	0.026	0.041
LSD (5%)	0.223	0.097	0.079	0.012

Any two mean having difference greater than LSD are significantly different at 5% level of probability.

SE = Standard error

LSD = Least significant difference

Table 4.2.20: Mean levels of Heavy Metals in *Haematostaphis barteri* Stem bark ($\mu\text{g/g}$ dry weight)

Location	Metals			
	Cu	Zn	Pb	Cd
Pella	<0.025	0.038	<0.060	0.370
Hong	<0.025	<0.008	<0.060	0.160
Hildi	0.145	<0.008	<0.060	0.180
Uba	0.115	<0.008	<0.060	0.170
Gaya	<0.025	<0.008	<0.060	0.180
Fa'a	<0.025	<0.008	<0.060	0.160
Garaha	0.025	<0.008	<0.060	0.150
Gashala	<0.025	<0.008	<0.060	0.190
Mugili	0.220	<0.008	<0.060	0.160
Pubba	0.100	<0.008	<0.060	0.200
Mean	0.072	0.019	0.056	0.192
SE	0.047	0.010	0.000	0.060
LSD (5%)	0.014	0.030	0.002	0.180

Any two mean having difference greater than LSD are significantly different at 5% level of probability.

SE = Standard error

LSD = Least significant difference

4.3 Phytochemical compositions of plant parts

Tannin: The results of the phytochemicals showed the presence of tannin in the leaves and stem bark of *Ficus sycomorus*, *Balanites egyptiaca*, *Vitex doniana* and *Haematostaphis barteri* in the locations investigated. *Celtis integrifolia* contained tannin in the leaves around Hildi area. Kubmarawa *et al.* (2007) reported the presence of tannin in *Balanites egyptiaca* roots, *Ficus sycomorus* stem bark, *Vitex doniana* stem bark and *Haematostaphis barteri* aerial parts. Tannins are widely distributed in many plants species. They have astringent properties which are important anti-oxidant and in wound healing (Stndag and Mazza, 2007).

Alkaloid: The leaves and stem bark of *Celtis integrifolia* demonstrated the presence of alkaloid in all the samples. The leaves of *Ficus sycomorus*, *Vitex doniana* and *Haematostaphis barteri* also contained alkaloids. The results obtained by Mutapha *et al.* (2011) showed the presence of alkaloids in *Vitex doniana* stem bark. Alkaloids are produced by large variety of organisms, plants and animals. They almost uniformly invoke bitter taste (Rhoades, 1979). They have pharmacological effects and often used as medications and recreational drugs.

Glycoside: Glycosides were recorded in the stem bark of *Ficus sycomorus* around Fa'a and Garaha areas. These results agree with the findings of Kubmarawa *et al.* (2007) and Zaku *et al.* (2009). The leaves of *Celtis integrifolia* in Hildi area also demonstrated the presence of glycoside. Glycosides play important roles in living organisms. They are used as medications for treatment of congestive heart failure and cardiac arrhythmia (Brian *et al.* 1985).

Flavonoid: The leaves and stem bark of *Ficus sycomorus* demonstrated the presence of flavonoid as revealed by Adeshina *et al.* (2010). *Haematostaphis barteri* stem bark contained flavonoid as reported by Kubmarawa *et al.* (2007) in the aerial parts, while *Celtis integrifolia* and *Balanites egyptiaca* leaves showed the presence of flavonoids. Flavonoids are the most

common group of polyphenolic compounds in the human diet and are found in plants (Spencer, 2008). The widespread distribution of flavonoids and their low toxicity compared to other active plant compounds means that many animals, including humans, ingest significant quantities in their diet. Flavonoids have anti-allergic, anti-inflammatory, anti-bacterial, anti-cancer, anti-diarrheal and anti-oxidant properties (Schuler *et al.* 2005; Cushnie and Lamb, 2011).

Saponin: *Haematostaphis barteri* and *Vitex doniana* parts recorded the presence of saponin. The results are in agreement with findings of Mustapha *et al.* (2011). The leaves and stem bark of *Balanites egyptiaca* demonstrated the presence of saponin, while Kubmarawa *et al.* (2007) reported saponin in the roots. The difference in the composition could be due to geographical location. Saponins have the potential to lower cholesterol levels in humans due to their hypocholesterlemetric effect. They form complexes with cholesterol to reduce plasma cholesterol (Nnam *et al.* 2012).

4.4 Essential Elements Composition in the Plants

Sodium: *Ficus sycomorus* and *Haematostaphis barteri* leaves found in Uba and Hong areas contained the highest amount of sodium (4.100 µg/g) and (4.100 µg/g) respectively, which were lower than the amount obtained by Kiran *et al.*(2011) in *Ficus auriculata* leaves (31.16 µg/g). The stem-bark of *Vitex doniana* also contained the highest amount of sodium (3.400 µg/g) but lower than the amount (163 µg/g) reported by Mustapha *et al.* (2011). The values observed for sodium in the samples were lower than the World Health Organization (WHO) permissible limits range of 400 to 500 µg/g in plants as reported by Mustapha *et al.* (2011). Sodium is one of the chief extracellular ions in the body. It involves in the production of energy, transport of amino acids and glucose into the body cells and its deficiency results in hyponatremia (Donatelle, 2005).

Potassium: The values observed for potassium in the plant parts studied were highest in *Celtis integrifolia* leaves (1.02 µg/g) which was lower than the amount (121 µg/g) reported in the stem-bark of *Vitex doniana* by Mustapha *et al.* (2011). Potassium was below the detectable limit (<0.008 µg/g) of the instrument used in the leaves of *Ficus sycomorus*. The amounts of potassium in the samples investigated are within the safety limits of 10 to 100 µg/g recommended by WHO (1996). Potassium is the principal intracellular cation. It helps to regulate osmotic pressure and pH equilibrium. The recommended daily intake is 4700 mg (Norman and Joseph, 1996). Its deficiency causes muscle weakness, decrease reflex responses and respiratory paralysis.

Magnesium: The stem-bark of *Haematostaphis barteri*, *Ficus sycomorus*, *Balanites egyptiaca*, *Celtis integrifolia* and *Vitex doniana* contained a total mean value of 0.893 µg/g, 0.317 µg/g, 0.259 µg/g, 0.218 µg/g and 0.204 µg/g magnesium respectively, which was lower than the amount (103 µg/g) reported in the stem-bark of *Vitex doniana* by Mustapha *et al.* (2011). The leaves of *Balanites egyptiaca* and *Haematostaphis barteri* had overall mean values of 0.393 µg/g and 0.251 µg/g respectively which was lower than the amounts obtained by Kubmarawa *et al.* (2008). The leaves of *Celtis integrifolia* also contained 0.400 µg/g, *Vitex doniana* 0.111 µg/g and *Ficus sycomorus* 0.312 µg/g magnesium. The amounts of magnesium obtained in the plants parts investigated are lower than the safety limits of 100 to 200 µg/g in plants as reported by WHO (1996). Magnesium plays important role in maintaining electrical potential in nerves and membranes. It improves insulin sensitivity, protect against diabetes and its complications and also reduce blood pressure (Kiran *et al.* 2011).

Calcium: The concentration of calcium in *Haematostaphis barteri* (0.113 µg/g) and *Balanites egyptiaca* (0.390 µg/g) leaves were comparatively lower than the results reported by

Kubmarawa *et al.* (2008) in *Haematostaphis barteri* (1.73 µg/g) and *Balanites egyptiaca* (3.78 µg/g). The values of calcium in the leaves of *Ficus sycomorus*, *Vitex doniana* and *Celtis integrifolia* were 0.225 µg/g, 0.202 µg/g and 0.210 µg/g respectively. The range of the mean values of calcium in the stem-bark of the Samples analyzed were 0.112 to 0.517 µg/g which was lower than the safety limits of 3600 µg/g as reported by WHO (1996). Calcium is needed for muscles development, heart and digestive System. It is also essential for the normal development and maintenance of bones (Norman and Joseph, 1996).

4.5 Heavy Metal Compositions in the Plant parts

Copper: The highest value for copper was recorded in *Vitex doniana* leaves (1.508 µg/g) followed by *Haematostaphis barteri* (0.390 µg/g). It was below the detectable limit (<0.025µg/g) of the instrument used in the parts of *Ficus sycomorus* . However, the values obtained in the samples were lower than the range of 100 to 300 µg/g recommended as normal copper concentration in plants by WHO (1996). Copper plays important role in treatment of chest wound and prevent inflammation arthritis and similar diseases. It is also essential for the formation haemoglobin of the red blood cells. It is required by trace quantity by humans (Kiran, *et al.* 2011).

Zinc: The mean values for zinc obtained in the leaves of *Haematostaphis barteri* (0.412 µg/g) was lower than 6.00 µg/g observed by Kubmarawa *et al.* (2008). The highest value for zinc was recorded in the stem-bark (5.545 µg/g) and the leaves (1.742 µg/g) of *Ficus sycomorus*. 1.556 µg/g was observed in the stem-bark of *Vitex doniana* which was lower than the values (6.00 µg/g) reported by Mustapha *et al.* (2011). The concentration of zinc in the plant parts investigated is lower than the permissible limits range of 150 to 2000 µg/g in plants as reported by WHO (1996). Zinc is essential constituents of enzymes that involve in carbohydrate and

protein metabolism and nucleic acid synthesis. Its deficiency results in impaired growth and development, skin lesion and loss of appetite (Norman and Joseph, 1996).

Cadmium: Cadmium was found in the entire samples investigated. It was present in the leaves of *Celtis integrifolia* (0.280 µg/g), *Ficus sycomorus* (0.238 µg/g), *Balanites egyptiaca* (0.28 µg/g), *Vitex doniana* (0.266 µg/g) and *Haematostaphis barteri* (0.280 µg/g), which are lower than the values obtained in amaranthus (15.83 µg/g) by Shagal *et al.* (2012) and in kenaf (2.04 µg/g) and roselle (2.07 µg/g) by Yahaya *et al.* (2012). The overall mean values for cadmium in the stem-bark of the plants studied were in the range of 0.044 to 0.300 µg/g. However, the concentrations of cadmium in the samples investigated were slightly higher than 0.20 µg/g fresh weight recommended as the maximum permissible level of cadmium in vegetables as reported by FAO/WHO (Afshin and Masoud, 2008). The high level of cadmium obtained in the plants may be due to agricultural activities.

Lead: The value for lead was below the detectable limit (<0.06 µg/g) of the instrument used in the entire samples. Pb has low geochemical mobility and bioavailability. Its transportation to above ground tissues in plants is minimal due to its retention in roots and precipitation (Brennan and Shelly, 1999). An ultra structural study using transmission electron spectroscopy revealed the retention of Pb in the cell wall of roots, particularly around intercellular spaces (Wenger *et al.* 2003). This explains why Pb was not observed in the leaves and stem bark of the plants investigated by the analytical instrument used. Lead is toxic metal and non-essential element for human body as it causes a rise in blood pressure, kidney damage and miscarriage (Kiran *et al.* 2011).

4.6 Comparison of Total Means of Essential Element Levels in Plant leaves

Figure 4.1 shows the total mean concentrations of essential elements in the leaves of plants studied. The value for K was highest in *Celtis integrifolia* followed by Na, Mg and Ca. It

also followed the same pattern in *Balanites egyptiaca*. In *Ficus sycomorus*, the total composition of essential elements observed was in the order: Na > Mg > Ca > K. The amount for Na was highest in *Vitex doniana* followed by K, Ca and Mg. For *Haematostaphis barteri*, the order of element levels are: Na > Mg > Ca > K. The amount of essential elements obtained in the leaves of the plants studied were lower than the amount reported in *Moringa oleifera* by Freiburger *et al.* (1998) and in *Ficus auriculata* leaves by Kiran *et al.* (2011). Plants can store K in larger quantities than what is needed for optimum growth without causing toxicity which is termed as luxury consumption (ICAR, 2009).

K is involved in regulating opening and closing of the stomata (which are essential for photosynthesis), water and nutrient transport and cooling of plants. It the emulsions of colloidal particles that keep the protoplasm hydrated and cellular membrane permeable, and thus maintains cellular organization. It also plays an essential role in the formation of starch in translocation of sugars (ICAR, 2009). The values for total means of essential element levels in plant leaves are shown in appendix 2.

4.7 Comparison of Total means of Heavy Metal Levels in Plant leaves

Figure 4.2 presents the total mean levels of heavy metals in plants investigated. Zn was observed highest in *Ficus sycomorus* followed by Cu in *Vitex doniana*. The concentrations of heavy metals in *Haematostaphis barteri* were in the order: Zn > Cu > Cd. For *Balanites egyptiaca*, the value for Cd was observed highest followed by Cu and Zn. In plants, Cu plays an important role as constituent of superoxide dismutase, which is the main component of the electron transport of photosystem. Zn is a constituent of carbonic anhydrase localized in the cytoplasm and chloroplast used in photosynthesis (Yahaya *et al.*, 2012). Pb was below the detectable limit of analytical method used. Pb is not readily translocated from root to shoot of

plants (Anthony and Balwant, 2009). The values for total means of heavy metal levels in plant leaves are shown in appendix 3.

4.8 Comparison of Total Means of Essential Element Levels in Plants Stem bark

Figure 4.3 shows the comparison of total mean levels of essential elements in plants stem bark. The concentrations of Na in stem bark of the plants follow the sequence: *Haematostaphis barteri* > *Vitex doniana* > *Celtis integrifolia* > *Ficus sycomorus* > *Balanites egyptiaca*. *Ficus sycomorus* contained highest values for K followed by *Celtis integrifolia* and then *Haematostaphis barteri*. K content was below the detectable limit of the instrument used in *Balanites egyptiaca*. The trend of Mg in the stem bark of plants studied follows the sequence: *Haematostaphis barteri* > *Ficus sycomorus* > *Balanites egyptiaca* > *Celtis integrifolia* > *Vitex doniana*. But in terms of Ca content, the orders of occurrence were: *Haematostaphis barteri* > *Vitex doniana* > *Balanites egyptiaca* > *Ficus sycomorus* > *Celtis integrifolia*.

Mg is an essential component of the chlorophyll. It regulates the activities of several enzymes involved in the synthesis of nucleic acids and metabolism of carbohydrates (ICAR, 2006). Ca forms Ca-pectate which is essential constituent of cell wall that maintains the integrity of membranes; in seeds, it is present as a Ca-phytate. Ca is involved in cell division as well as in maintaining chromosome structure. It regulates the growth and functioning of the root tips and also protects the root cells against the ion imbalance, low pH and toxic effects of Al, Fe, etc. (ICAR, 2009). The values for total means of essential element levels in plants stem bark are shown in appendix 4.

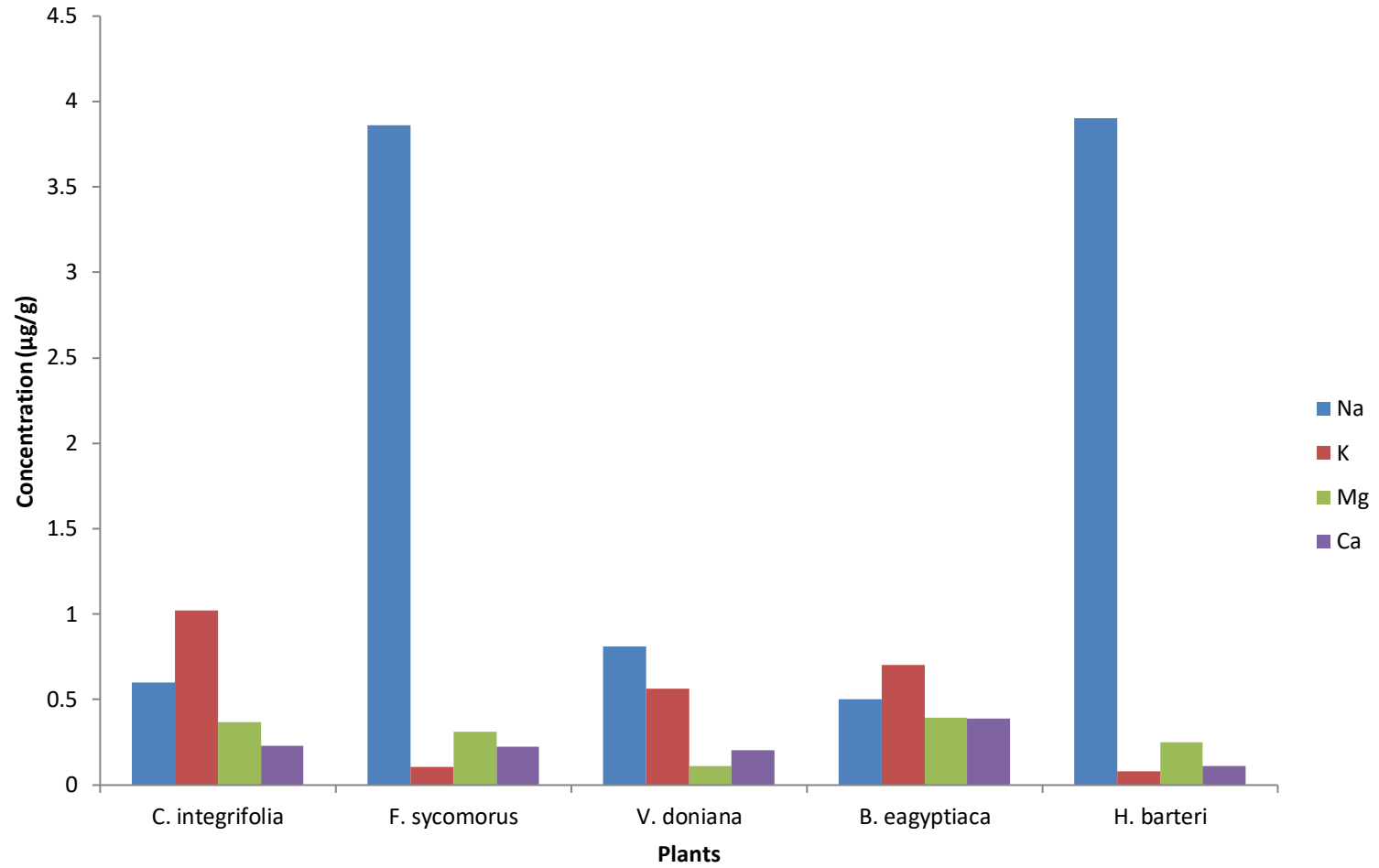


Figure 4.1: Bar chart of total means of essential element levels in plant leaves

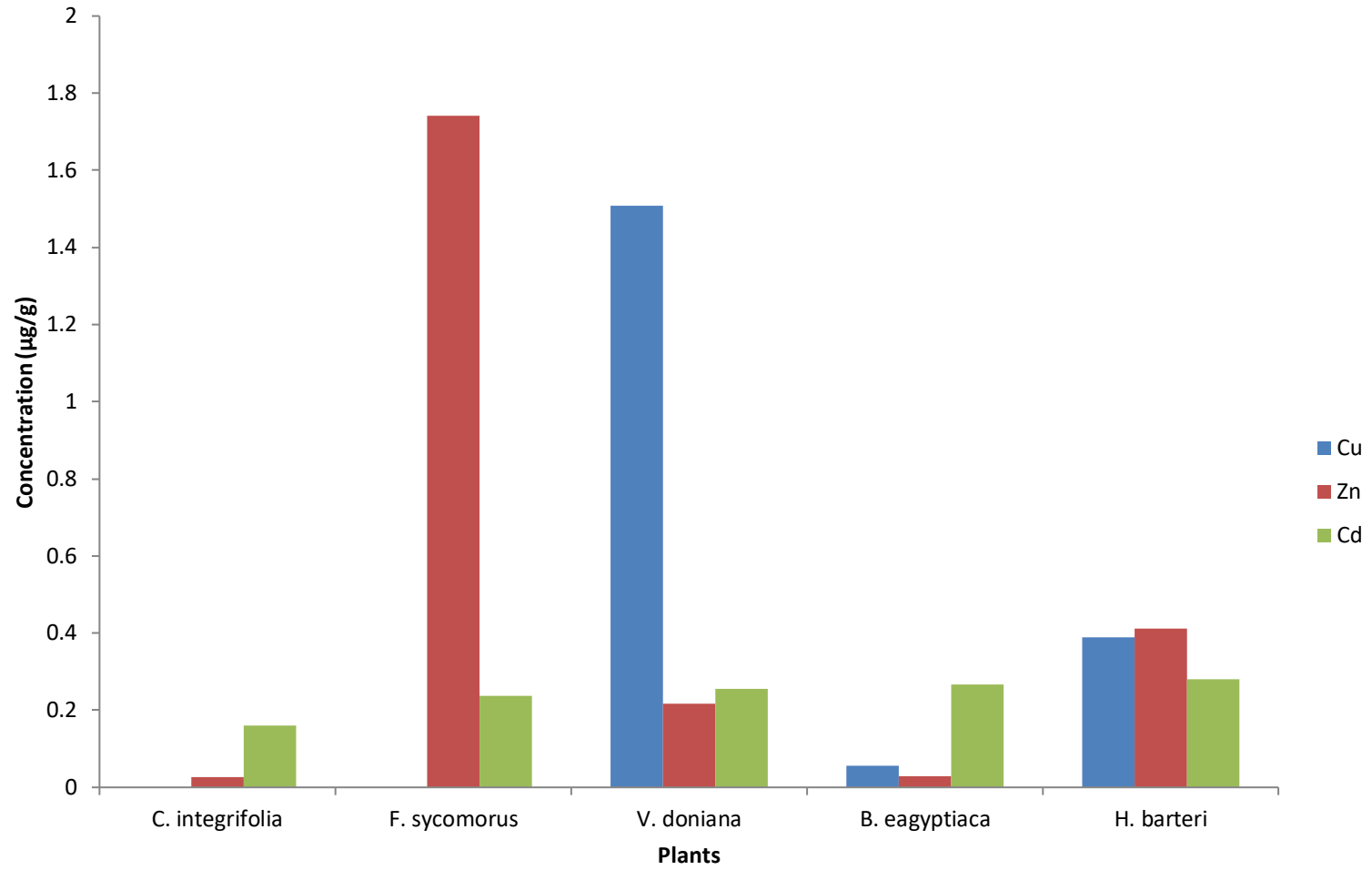


Figure 4.2: Bar chart of total mean levels of heavy Metals in plant leaves

4.9 Comparison of Total Means of Heavy Metal Levels in Plants Stem bark

The total mean levels of heavy metals in the stem bark of plants studied are presented in Figure 4.4. *Celtis integrifolia* contained heavy metals in the stem bark in the following order: Zn > Cd > Cu. It followed the same pattern as in *Ficus sycomorus*. For *Vitex doniana*, Cd had highest value followed by Cu and then Zn. The occurrence of heavy metals in *Balanites egyptiaca* and *Haematostaphis barteri* stem bark have similar pattern (Cd > Cu > Zn). The value for Pb was below the detectable limit of the analytical method used in the entire samples. This is because Pb is not readily translocated from root to shoot of plants (Anthony and Balwant, 2009). Researchers have shown that Cd, Cu, Zn and Pb are more mobile in terms of movement from soil to the root of most plants (Anthony and Balwant, 2009, Kushif et al. 2009). Mobility rate differs from one part of plant to another and from one plant to another (Nirmal et al. 2009). The values for total means of heavy metal levels in plant stem bark are shown in appendix 5.

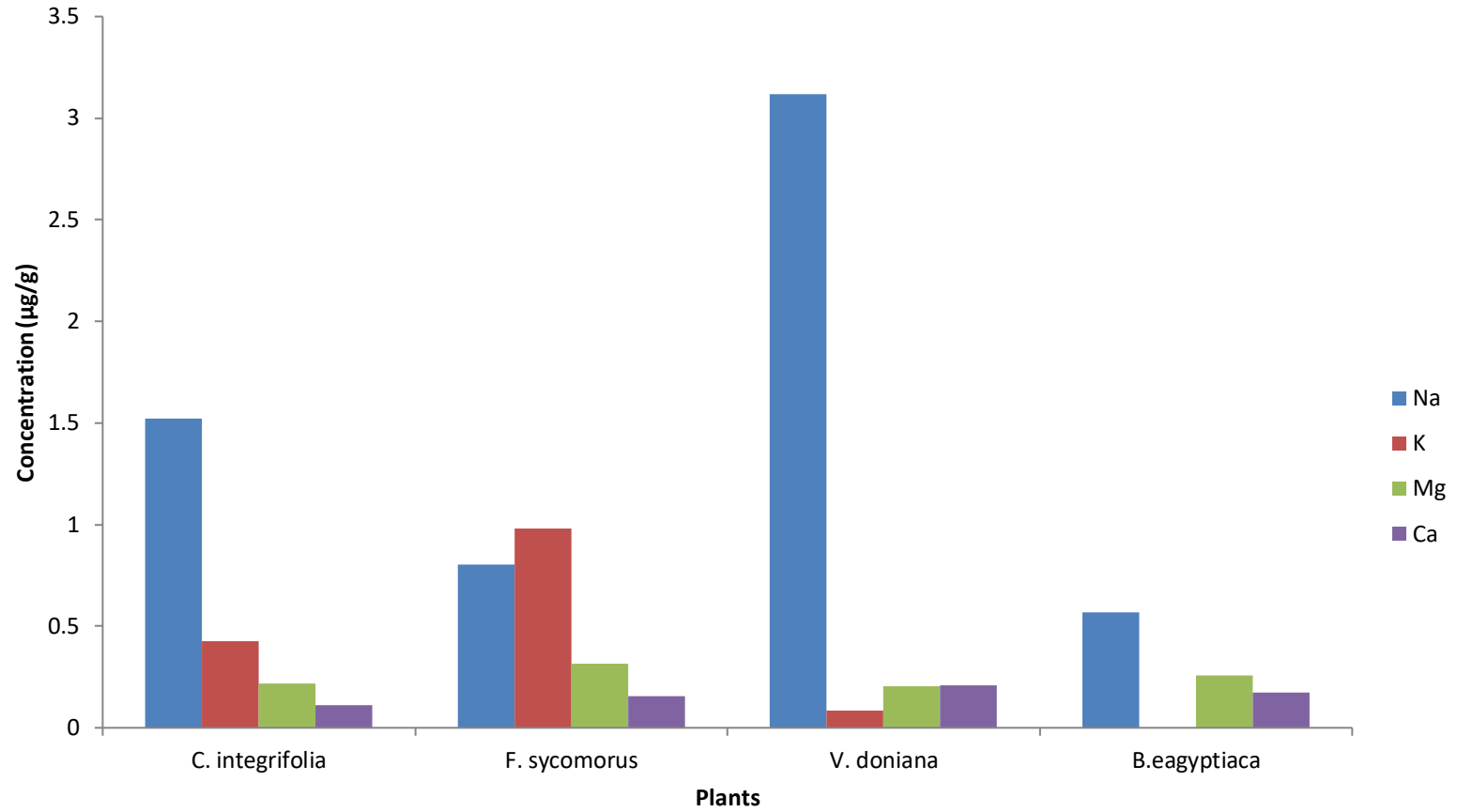


Figure 4.3: Bar chart of total mean levels of essential elements in plant stem bark

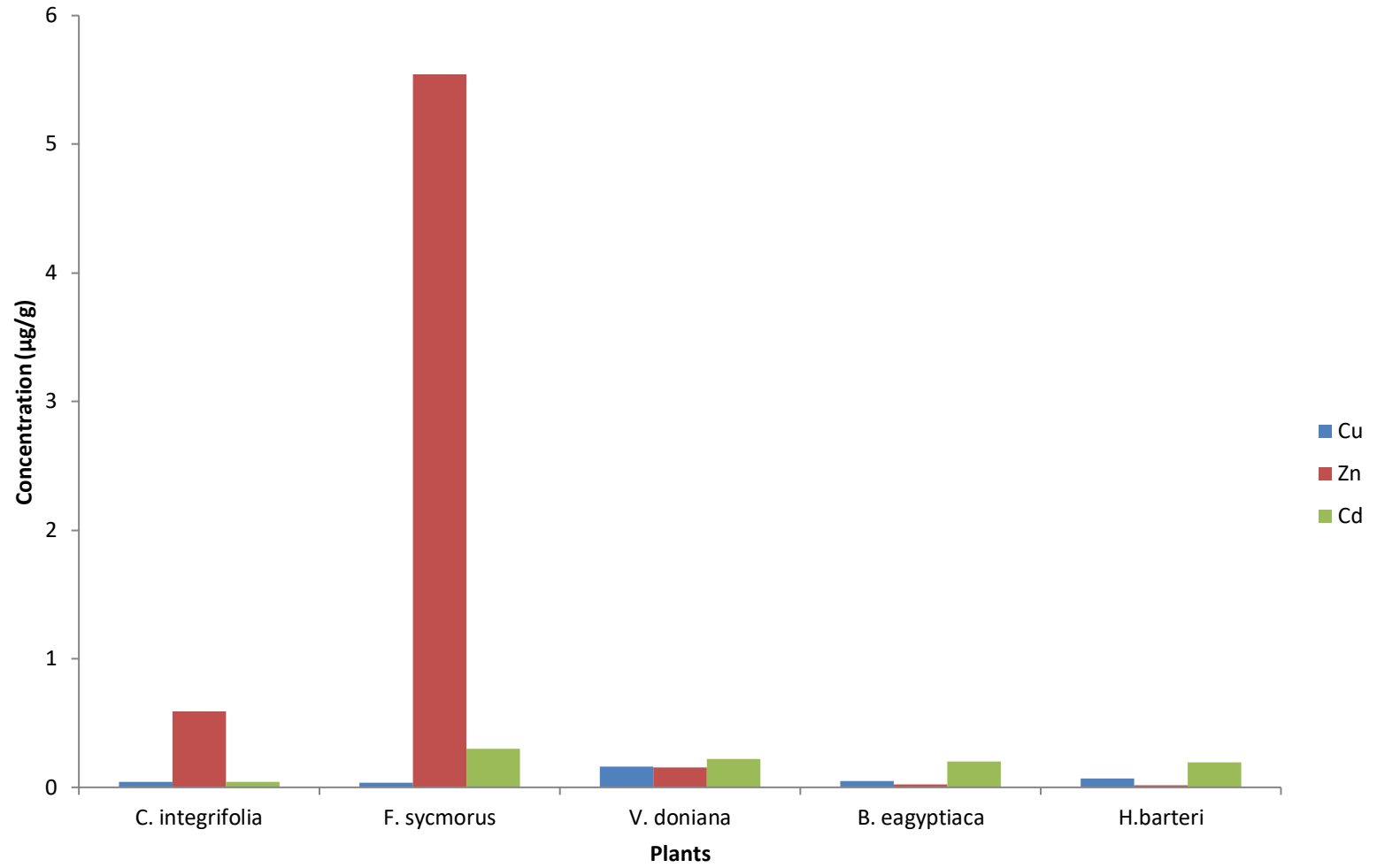


Figure 4.4: Bar chart of total mean levels of heavy Metals in plant stem bark

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Vegetables constitute an important part of the human diet since they contain carbohydrates, proteins, as well as vitamins and minerals. In recent years, their consumption is increasing gradually due to increased awareness of its food values, as a result of exposure to other cultures and acquiring proper education (Mohsen and Mohsen, 2008). However, they contain both essential and toxic elements over a wide range of concentrations. Vegetables also contain phytochemicals which have anti-oxidant, anti-bacterial, anti-fungal, anti-viral and anti-carcinogenic properties (Steinmetz and Potter, 1996).

The results obtained from this study revealed the presence of some essential elements (Na, K, Mg, and Ca) and heavy metals (Cu, Zn and Cd) in the five edible plants parts investigated. The concentrations of elements in the plants are within the range of safety limits as reported by WHO (1996), except for Cd which was slightly above the recommended safety limit (0.2 µg/g), but lower than the results reported in cabbage (41-55 µg/g) and amaranths (6.0 µg/g) by Mohammed and Khamis (2012). Pb was not detected in the entire samples analyzed by the method used. The phytochemical screening of the studied plants showed the presence of tannins, saponins, flavonoids, alkaloids and glycosides in their parts.

The elements revealed by these leafy plants could be rich sources of minerals. Significant contribution regarding recommended daily allowance (RDA) for nutrients may be met by these plants. They contained lower toxic elements relative to the conventional vegetables. These leafy vegetable plants will also play an important role in the diet with regards to the prevention of bone and teeth problems, blood clotting, malaria, cancer and fungal infections.

5.2 Recommendations

Minerals are important in the diet because they serve as cofactors for physiologic and metabolic functions. All the plants analyzed contained adequate levels of important minerals which when consumed in moderate amounts could satisfy about half of the daily requirement of these minerals. The elements and phytochemicals revealed can serve as basis for medicinal plant researchers. More sensitive instruments like Inductively Coupled Plasma (ICP) and X-ray Fluorescence (XRF) should be used to ascertain the levels of essential elements and heavy metals in the plant parts. Sensitization programme should be organized in order to inform the community of the danger of over consumption of the plants since cadmium was found to be slightly above the WHO safety limit. Quantitative screening of the phytochemicals should be conducted so as to know their permissible limits. There is a need to carryout similar study in different locations.

5.3 Contribution to knowledge

- The research has exposed elemental and phytochemical contents of the most five edible plant parts in Hong Local Government Area.
- The heavy metal contents of the plants are lower than some conventional vegetables grown in some areas.
- The essential elements revealed by the plants could be rich sources of mineral diets.
- The phytochemical revealed can also serve as basis for medicinal plant researchers.

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APPENDICES

Appendix 1: Pictures of studied plants



Balanites egyptiaca



Ficus sycomorus



Celtis integrifolia

Pictures of studied plants continuous



Vitex doniana



Haematostaphis barteri

Appendix 2: Comparison of total mean levels of essential elements in plant leaves

Elements	<i>C. integrifolia</i>	<i>F. sycomorus</i>	<i>V. doniana</i>	<i>B. egyptiaca</i>	<i>H. barteri</i>
Na	0.600	3.862	0.810	0.504	3.900
K	1.020	0.014	0.566	0.703	0.083
Mg	0.370	0.312	0.111	0.393	0.251
Ca	0.230	0.225	0.202	0.390	0.113

Appendix 3: Comparison of total mean levels of heavy metals in plant leaves

Metals	<i>C. integrifolia</i>	<i>F. sycomorus</i>	<i>V. doniana</i>	<i>B. egyptiaca</i>	<i>H. barteri</i>
Cu	<0.025	<0.025	1.508	0.057	0.390
Zn	0.027	1.742	0.218	0.028	0.412
Pb	<0.060	<0.060	<0.060	<0.060	<0.060
Cd	0.160	0.238	0.256	0.266	0.280

<0.025 and <0.060= below detectable limit of AAS

Appendix 4: Comparison of total mean levels of essential elements in plants stem bark

Elements	<i>C. integrifolia</i>	<i>F. sycomorus</i>	<i>V. doniana</i>	<i>B. egyptiaca</i>	<i>H. barteri</i>
Na	1.521	0.805	3.116	0.566	3.158
K	0.425	0.982	0.085	<0.008	0.410
Mg	0.218	0.317	0.204	0.259	0.839
Ca	0.112	0.157	0.209	0.175	0.517

<0.008= below detectable limit of AAS

Appendix 5: Comparison of total mean levels of heavy metals in plants stem bark

Metals	<i>C. integrifolia</i>	<i>F. sycomorus</i>	<i>V. doniana</i>	<i>B. egyptiaca</i>	<i>H. barteri</i>
Cu	0.040	0.035	0.159	0.051	0.072
Zn	0.588	5.545	0.156	0.023	0.019
Pb	<0.060	<0.060	<0.060	<0.060	<0.060
Cd	0.044	0.300	0.220	0.200	0.192

<0.060= below detectable limit of AAS

Evaluation of phytochemical and elemental contents of *Haematostaphis barteri* leaves and stem bark in Hong local Government area of Adamawa state, Nigeria

Available on line at www.jocpr.com

ABSTRACT

Phytochemical and elemental constituents of leaves and stem bark of Haematostaphis barteri was determined in ten locations in Hong Local Government Area of Adamawa state. Quantitative methods were used for the phytochemical determination. Tannins and Saponins were observed in the entire samples investigated. Alkaloids were present in the leaves while flavonoids were recorded in the stem bark. Glycoside was not observed in the samples by the method used. The elemental compositions were determined by Atomic Absorption Spectroscopy (AAS). Essential elements (Na, K, Mg and Ca) and heavy metals (Cu, Zn, and Cd) were recorded in the samples observed. There was no significance difference ($p \leq 0.05$) in terms of essential elements and heavy metal contents among the 10 locations investigated. The phytochemicals observed have many pharmacological properties while the essential elements are much required by human bodies for maintenance of good health.

Key words: Determination, element, leaves, phytochemical, stem bark

Elemental and Phytochemical Screening of *Vitex doniana* Leaves and Stem bark in Hong Local Government Area of Adamawa State, Nigeria

Available on line at www.chemijournal.com

ABSTRACT

Plant parts are consumed as vegetables or herbs in most of African countries. The study was carried out to determine some elemental and phytochemical contents in Vitex doniana leaves and the stem bark in Hong local Government Area of Adamawa. The samples were collected from 10 locations in the month of April, 2012 and dried under shade. Atomic Absorption Spectroscopy (AAS) was used for elemental determination. The results revealed some essential elements (Na, K, Mg and Ca) and heavy metals (Cu, Zn and Cd). Pb was below the detectable limit ($0.06 \mu\text{g/g}$) of the instrument used. Qualitative method was used for the phytochemical screening. The results obtained showed the presence tannins, alkaloids and saponins. The phytochemicals recorded have medicinal properties while the essential elements are dietary minerals.

Key words: Element, phytochemical, leaves, stem bark, *vitex doniana*