ASSESSMENT OF SOME TRADITIONAL LEAFY VEGETABLES OF UPPER EAST REGION AND INFLUENCE OF STAGE OF HARVEST AND DRYING METHOD ON NUTRIENTS CONTENT OF SPIDER FLOWER (*Cleome gynandra* L.)

A THESIS SUBMITTED TO THE DEPARTMENT OF HORTICULTURE

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI, GHANA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE

MASTER OF SCIENCE DEGREE

IN

POST HARVEST PHYSIOLOGY

BY

CLEMENT ABUGRE

SEPTEMBER, 2011

DECLARATION

I hereby declare that this thesis document except for references to other peoples work which have been duly acknowledged, this work submitted to the Board of Postgraduate Studies, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana is the result of my own research work and investigation and has not been presented for any other degree anywhere else before.

………………………………… ……………………

CLEMENT ABUGRE DATE

CANDIDATE

-- ---------------------------------

MR FRANCIS APPIAH DATE

SUPERVISOR

………………………………….. ---------------------------------

DR. B. M. KISSINGER DATE

HEAD OF DEPARTMENT

ABSTRACT

Traditional leafy vegetables eaten in the Upper East region of Ghana were assessed. A survey was carried out to determine consumer perception of indigenous vegetables in the Upper East Region of Ghana. The survey was aimed at cataloguing a list of commonly eaten leafy vegetables in the Region and also obtaining information on level of production, harvest and postharvest practices such as: harvesting methods, transportation to market centres, level of losses to diseases and pests, processing and packaging methods used as well as its implication on quality. The research also studied the effect of stage of harvesting and drying method on nutritional composition of *Cleome gynandra* (Spider flower) grown in two (2) ecological zones. The study recorded 11 cultivated and 10 wild leafy vegetables commonly consumed in the region. The results of the survey indicated that majority of the leafy vegetable farmers (50.3 %) in the region had no formal education and were predominantly female (83.3%).The results also showed that traditional leafy vegetables are produced by 72.3 % and consumed by 98.3% of respondents in the region as against the exotic leafy vegetables. Harvesting of vegetables is done using varying methods (as indicated by 42 % of the respondents), and was mainly transported to and from the marketing centres using donkey carts (60 %). It was noted that vegetable farmers in the region lose up to 20 % of their vegetables to pests and diseases. Sun-drying (98.6 %) is the main method used in the region to process leafy vegetables to keep for future use. Processed leafy vegetables were mainly stored in polypropylene sacks (60 %). A common practice at the marketing centres was sprinkling of water (70.6 %) on the vegetables to maintain their freshness. In the second phase of the study, Spider flower (*Cleome gynandra* L.) was chosen due to its widespread use in the region at the beginning of the rainy season when grain stocks are depleted and grown in two different locations (Kumasi and Bolgatanga), harvested at two different harvest times (6 weeks and 7 weeks of age), processed with two different processing methods (sun and oven drying) and analyzed for proximate and mineral nutrients The study recorded varying results for proximate nutrient content in samples from the two locations. Harvesting at 6 weeks of age from both locations gave significantly ($P< 0.05$) higher levels of moisture (15.90 % and 16.47 %) on fresh weight basis for both locations

(Kumasi and Bolgatanga) respectively than the 7th week harvest (14.57 %). Significantly higher levels were also recorded for crude fibre (15.67g/100g) in samples harvested in the 6th week from Kumasi and dried in the oven as well as carbohydrate (33.90 g/100 g) in samples harvested from Kumasi at week 6 and dried in the sun. Crude protein (29.80 g/100 g) in samples harvested from Kumasi at week 7 and dried in the oven, crude fat (3.50 g/100 g) in samples harvested from Kumasi at week 7 and dried in the sun and ash content (10.75 g/100 g) in samples harvested from Kumasi at week 7 all showed significant interaction. Analysis of spider flower harvested from Bolgatanga indicated significantly ($P<0.05$) higher levels of crude protein (32.10 g/100 g) and crude fat (3.50 g/100 g) in harvests at 6th week dried in the oven as well as ash content (13.50 g/100 g) in samples harvested at week 7 and dried in the oven, fibre (19.29 g/100 g) and carbohydrates (28.84 g/100 g) in that harvested at week 7 and dried in the sun as compared to the other treatments. Differences in time of harvest as well as drying method were not significant ($P<0.05$) with respect to mineral composition except for phosphorus content in the samples produced at Bolgatanga. Ranges recorded for the other test minerals in the study were; potassium (2.83 – 3.08 g/100 g), calcium (2.37 – 3.17 g/100 g), magnesium (1.72 - 2.17 g/100 g) and iron (3.3 - 13.8 mg/100 g). Generally oven drying resulted in better preservation of nutritional components (protein and crude fibre). The results of this study suggest that oven-drying should be the method of choice when it comes to protein and fibre preservation. However, as far as mineral content was concerned the drying method did not matter and that sun-drying was as good as oven-drying. Producers of *C. gynandra* could therefore use either drying methods for drying the vegetable without significant variation in mineral composition.

ACKNOWLEDGEMENT

For the abundant gift of good health and travelling mercies, I say thank you Almighty God.

I also sincerely thank my main academic supervisor, Mr. Francis Appiah for his immeasurable assistance and good guidance. Out of his very busy schedules, he still found time to give me the maximum attention I needed in the study. To him I say God richly bless you. I am also grateful to Mrs. Timpo, Dr. B. Banful, Dr. B. M. Kissinger and all other lecturers of the Department of Horticulture, KNUST for their support to me during the study.

I extend my thanks to my wife Vida, my siblings David and Victoria for their moral and financial support to me during the study. To my colleagues Edmond Nyamah Yeboah, Ramatulayye Guisse and Tony Kessie, I say thank you for the moral, psychological and physical support you offered me during the study. I extend the thanks to Mr. Emmanuel Odame, a senior colleague also of the Department of Horticulture, KNUST for his support to me in the study. I am also highly indebted to Mr. Oswald Azegola Bataki of the Bolgatanga Polytechnic who assisted me in the survey data collection in the Kasena-Nankana district where I was deficient in the Kasem dialect. I cannot end my thanks without the mention of Mr. Acquah of the Soil Science Laboratories, Faculty of Agriculture, KNUST and Mr. Bentil of the Animal Science laboratories, Faculty of Agriculture for assisting me in the nutritional analysis of the *Cleome gynandra* L. grown. To them I say Thank you.

DEDICATION

I dedicate this thesis to my little daughter, Rufina Abugre who was born during the study period. It is my hope and prayer that she grows to become academically inclined.

TABLE OF CONTENTS **PAGE**

1.0 INTRODUCTION

1.1 Background

Traditional African Leafy vegetables are eaten by many African families. In a survey in rural Zambia, it was found that traditional vegetables were used by 52-95% of the respondents (Ogle *et al.* 1990). Out of 150 food-plants commonly consumed by man, 115 are indigenous African species (Kumbi and Atta-Krah, 2003). The vegetables are very much depended upon in the lean seasons during which time most grain stocks get depleted from many homes and the available staples become expensive in the markets.

There is evidence that indigenous vegetables offer a significant opportunity for the poorest people to earn a living, as producers and or as traders, without requiring large capital investments (Schippers, 2000). The traditional leafy vegetables are rich in micro nutrients needed by humans for good health, growth and development. A study by Abbey *et al.* (2006) indicated that the nutrient contents of some local Ghanaian and other African vegetables are superior to some exotic types. The indigenous African plant species are also well adapted to the tropical African climate than their exotic counterparts and therefore could contribute significantly to food security, which is a prerequisite for human development (Diouf, 1995). Cultivation of more indigenous leafy vegetables instead of exotic vegetables means a better adaptation to the ecosystem and reduction in the need for pesticides application. Maintenance of the complex of indigenous vegetables means in-situ conservations of rich diversity of genotypes of importance for future generations (Chadha, 2003).

Vegetables according to Shei (2008) are a vital constituent of West African diet and traditional vegetable species are highly important. Obel-Lawson (2005) reported that hunger and malnutrition threaten millions of people in Sub-Saharan Africa, and an increased consumption of African leafy vegetables (ALVs) can have a positive effect on nutrition, health and economic wellbeing of both rural and urban populations. Among factors contributing to preference for exotic vegetables as against indigenous ones include non-appreciation of African traditional vegetables (Obel-Lawson, 2005), urbanization and inadequate scientific information on indigenous African vegetable species (Shei, 2000). This has caused gradual neglect of some of the useful vegetables that have been used for food over the years. This neglect of traditional vegetables according to Chweya and Eyzaguirre, (1999) is unfortunate since these crops are usually better adapted to the environment than the introduced exotic vegetables and also provide low-cost quality nutrition for large parts of the population in both rural and urban areas. The indigenous vegetables are in danger of being lost in Africa. Farmers are replacing them with improved varieties, they lack seed and they lack information about their performance and about input requirements. Information on how farmers can fit them into the production and marketing systems are therefore important (Chadha, 2003).

Many African families who depend on traditional leafy vegetables also process some to enable them have vegetables to feed on when they are out of the vegetable production season. Many different processing methods are adopted for the processing of these leafy vegetables with sun-drying as the popular vegetable processing method within many African families. According to Harison and Andress (2000), drying removes the moisture from the food so bacteria, yeast and mold cannot grow and spoil the food. Drying also slows down the action of enzymes, but does not inactivate them. Because drying removes moisture, the food becomes smaller and lighter in weight.

Type and level of processing influence the presence and quantities of micronutrients in varying ways. According to Henry and Massey (2001), micro nutrients show varying degree of stability when food is processed and this depend on the nutrient, processing method and degree of processing. Chweya and Mnzava (1997) noted that nutritional value of spider flower may vary with soil fertility, environment, plant type, plant age and production technique used. They also indicated that in choosing the stage at harvest and drying method, the particular nutrients needed to be retained in the vegetables should be considered.

There is paucity of scientific information on processing and nutritional composition of some of the traditional vegetables. More research on these vegetables should be carried out to bridge this information gap and to increase levels of production, home consumption and encourage commercialization. The consumption of green leafy vegetables, which have the highest nutritional value, will especially add to the nutritional status of poor rural and urban households. This study was therefore aimed at identifying various traditional leafy vegetables commonly grown and eaten in the Upper East Region of Ghana. In addition, the effects of time of harvest at harvest and drying method on nutrient composition was determined using *Cleome gynandra* L., an indigenous vegetable which is usually preserved by drying in the Upper East Region of

Ghana was grown in 2 ecological zones in Ghana.

1.2 Problem Statement

Traditional African leafy vegetables are better adapted to the environment than the introduced exotic vegetables and also provide low-cost quality nutrition for large parts of the population in both rural and urban areas (Chweya and Eyzaguirre, 1999). Inadequate information on these vegetable species is causing gradual neglect of some of the useful ones that have been used for food over the years. Vegetables are a vital constituent of West African diet, and traditional vegetable species are highly important yet, many species are poorly known, being used only locally (Shei, 2008). *Cleome gynandra* is widely used in Africa and despite this widespread use of the vegetable, information is lacking on the effect of preservation method on nutrient contents and the best methods for its preservation (Hassan *et al.* 2007). More research into these African leafy vegetables will help address such problems.

1.3 Justification

Many African families very much depend on indigenous vegetables for their livelihood. Despite the great value of these traditional leafy vegetables, not much research has been carried out on them especially in the area of nutrition. Drying of the vegetables reduces the moisture content to a level, which prolongs shelf life during storage, reduces colonization by microorganisms and as a source of food after rainy season (Hassan *et al.* 2007). PROTA (Plant Resources of Tropical Africa) has classified Spider flower (*Cleome gynandra* L.) in priority group, with a well-defined vegetable use and that it deserves more attention and research (Mbugua *et al.* 2007).

The study which investigates postharvest handling practices carried out by vegetables farmers and also the effects of time of harvest at harvest and processing method on nutrient quality of *Cleome gynandra* L. will make available documented information for reference by consumers and researchers.

1.4 Objectives

1.4.1 Main Objective

The main objective of this study was to assess the consumer perception and nutritional composition of some traditional leafy vegetables of the Upper East Region.

1.4.2 Specific Objectives:

1. assess the consumer perception on indigenous leafy vegetables in the Upper East Region of Ghana.
2. determine the proximate composition of tender shoots of *Cleome gynandra* L.
3. determine the mineral composition of tender shoots of *Cleome gynandra* L.
4. determine the effect of time of harvest at harvest on proximate and mineral composition of tender shoots of *Cleome gynandra* L.
5. determine the effect of sun drying and oven drying methods on proximate and mineral composition of tender shoots of *Cleome gynandra* L. grown under different ecological zones.

2.0: LITERATURE REVIEW

2.1 Introduction

Leafy vegetables are plant species of which the leafy parts, which may include young, succulent stems, flowers and very young fruit, are used as vegetable. Leafy vegetables have been used through history to date (Vorster *et al.*, 2005). According to Mwangi and Mumbi (2006) most widespread and debilitating nutritional disorders, including birth defects, mental and physical retardation, weakened immune systems blindness and even death has resulted from non-consumption of fruits and vegetables habits. Hunger and malnutrition threaten millions of people in sub-Saharan Africa, yet the value of African traditional vegetables is not fully appreciated. An Increased consumption of African leafy vegetables (ALVs) can have a positive effect on nutrition, health and economic wellbeing of both rural and urban populations (Obel-Lawson, 2005).

In developing countries, nearly 16 million people die every year from preventable causes and sixty percent of these deaths are from hunger and malnutrition. Most poor people who battle hunger, battle with malnourishment, especially vitamins and minerals deficiencies which results in stunted growth, weakness and heightened susceptibility to illness (BWI, 2004).

Surveys carried out by the National Resource Institute in Cameroon and in Uganda provided evidence that indigenous vegetables offer a significant opportunity for the poorest people to earn a living, as producers and or traders, without requiring large capital investments (Schippers, 2000).

Mingochi and Luchen (1996) reported that there is generally inadequate knowledge on the importance, especially nutritional of indigenous vegetables leading to neglect. A study by Abbey *et al.* (2006) indicated that nutrient contents of local Ghanaian vegetables are better than some exotic types.

2.2 Traditional African Leafy Vegetables

Traditional vegetables, though not necessarily indigenous to a country, can be associated with traditional production systems, local knowledge of farmers and usually have a long history of local usage and selection. Traditional vegetables are an important component in the household diets of both low-income and high-income groups. These vegetables are used in diverse forms and many of them can be considered multi-purpose crops. For example, most of them are used for their preventive and curative medicinal properties besides serving as daily food (Chweya and Eyzaguirre, 1999).

In Africa, the number of indigenous vegetable species is far greater than exotic ones. The consumption of green leafy vegetables, which have the highest nutritional value add to the nutritional status of poor rural and urban households (Chadha, 2003). In addition, increased consumption of African indigenous vegetables enhances crop diversity, alleviates poverty and promotes food security (Barry *et al.*, 2008). However, the statuses of the crops, as well as their conservation, need to be addressed to ensure sustainable use (Vorster *et al.*, 2007). According to the authors important research needs of traditional leafy vegetables include: the development of appropriate intercropping production techniques for the high yielding traditional crops to help increase food security, as well as evaluating drying methods to establish the most effective ways of preserving the nutritional content. In Ghana one of the important leafy vegetable used for food is *Cleome gynandra* (Spider flower or cat's whiskers).

2.3 Spider flower (*Cleome gynandra* L.)

Cleome gynandra L. belongs to the Capparaceae family and is a herbaceous, erect and branched plant. The height of the plant varies between 0.5 m and 1.5 m, depending on the environment. Leaves are compound and palmate with three to seven leaflets. Stems and leaves are covered with glandular hair. Pigmentation on the stems varies from green to pink and purple. The terminal inflorescences have very distinct small white flowers, but pink and lilac coloured flowers also occur. The fruit consists of small siliques. Among the different *Cleome* species that occur, *Cleome gynandra* is the most widely used as a leafy vegetable but *Cleome monophylla* and *Cleome hirta*, which are close relatives, are also used occasionally (Chweya and Mnzava, 1997; Schippers, 2000; Jasen *et al.,* 2007).

The older leaves are divided into five leaflets (like a hand), and the plant is easy to identify by its white flowers. The fruit is an 8-10 cm long pod. It splits open when mature, and scatters its seeds. The first leaves are ready to eat when they are 4-6 weeks old. It is best when the flowers have not yet developed. Spider flower is a promising species for cultivation. The plant produces many leaves, and is found in large numbers in most fields and gardens. Fresh leaves and tender shoots are boiled whole, or chopped and mixed with groundnut flour and other ingredients to produce a tasty relish (IPGRI, 1997).

Spider flower (*Cleome gynandra* L.) is one of the vegetables which grows as a weed in most tropical countries, but is a semi-cultivated popular tropical leafy vegetable in many parts of sub-Saharan Africa, especially in most countries in eastern and southern Africa. (Chwewe and Mnzava, 1997)

2.4 Harvesting Spider flower

Harvesting of Spider flower starts 4-6 weeks after seedling emergence and may last 4-5 weeks. Biweekly removal of tender leaves allows regeneration of branches. When plants reach a height of about 15 cm, they can be harvested by uprooting whole plants, or by topping, cutting back to ground level, or picking individual leaves or leafy branches at frequent intervals. Frequent picking and deflowering encourages lateral growth, thus extending the harvesting period (Chweya and Mnzava, 1997). Picking the leaves also stimulates growth. Seed collection is easy for this species; one need only pick the mature pods and air-dry them (IPGRI, 1997). For most species the young growth points and tender leaves are the plant parts that are used in the preparation of vegetable dishes. Petioles and in some cases young tender stems are also included, but old, hard stems are discarded (Vorster *et al.* 2002).

2.5 Uses of spider flower

Spider flower is consumed in most African and several South Asian countries. The plant is nutritious and is known to contain high levels of beta-carotene, vitamin C, and moderate levels of calcium, magnesium, and iron (Silué, 2009). Throughout Africa, the tender leaves or young shoots, and often the flowers as well, are eaten boiled as a pot herb, tasty relish, stew or side dish. The leaves and shoots are gathered from the wild or are cultivated. In East Africa, fresh leaves are used as ingredients in other mashed foods, and the dried leaves are ground and incorporated in weaning foods (Mathenge, 1995). The leaves are rather bitter, and for this reason are cooked with other leafy vegetables such as cowpea (*Vigna* spp.), amaranths (*Amaranthus* spp.) and black nightshade (*Solanum nigrum* L.). To reduce the bitterness, milk may be added to the boiled leaves, and the mixture should preferably be left overnight in a cooking pot. The leaves could also be boiled and the water discarded and then combined with other ingredients in stew. The leaves and tender shoots are boiled whole, or chopped, and may be mixed with other ingredients. In Zambia, pounded groundnuts are often added to dishes to enhance flavour. The high fibre content (1.3-1.4% -fresh weight) of the leaves enables them to be dried and stored. The leaves may be blanched, made into small balls and sun-dried. These balls can be stored for more than 6 months, and are reconstituted by soaking in water before being used in cooking. In several African countries, the vegetable is an important food in rural areas. In some countries, only this leafy vegetable is available during the relish-gap period, and therefore plays a significant role in household food security during drought (Chweya and Mnzava, 1997). Indigenous knowledge possessed by rural women in Kenya indicates that *Cleome gynandra* has several nutritional uses.

Leaves may be crushed to make a concoction that is drunk to cure diseases such as scurvy. In many cultures, boiled leaves are regarded as a medicinal meal. In other communities, leaves are boiled and soaked in sour milk for 2-3 days and eaten as a nutritious meal, which is believed to improve eyesight, provide energy and a cure for marasmus. It is a highly recommended meal for pregnant and lactating women. Eating the vegetable is believed to reduce dizzy spells in pregnant women. It is believed that regular consumption of the leaves by pregnant women will ease childbirth by reducing the length of their labour, and helps them regain normal health more quickly afterwards. The vegetable does not appear to be a popular infant meal (for babies of up to 10 months), but is given to children from toddler age upwards.

The seeds are oleiferous, containing polyunsaturated oil, which is extracted by pressure and does not need refining. They are used as bird food. The seed cake has an excellent acid spectrum and can therefore be utilized in animal feeds. In some African countries (e.g. Zambia, Zimbabwe, Botswana, Malawi, Uganda, Tanzania and Kenya), during periods of abundance, the leaves and young tender shoots are sold in rural and urban markets by gatherers and growers, who are mostly rural women. The vegetable can therefore provide a source of income for rural areas, especially for the poor and the unemployed (Chweya and Mnzava, 1997). Seed of spider flower has high levels of polyunsaturated oils that can reach up to 29.6 %. The oil can be extracted by simple pressing and does not require refining. The seed cake can be used for animal feed, and the seed itself for feeding birds.

In Uganda, the plant is used to induce labour during childbirth. After giving birth, some women consume spider flower to increase lactation and blood formation. Spider flower remedies are used to alleviate migraine, vomiting, diphtheria, vertigo, headache, pneumonia, septic ears, and stomach ailments; the plant is also used as eyewash and fed to boys after circumcision. Spider flower has insecticidal and insect repellent properties. Spraying an aqueous extract of spider flower can considerably reduce aphid and thrip populations. Intercropping spider flower with cabbage also reduces diamondback moth as well as thrip attacks. Intercropping spider flower in rose-producing greenhouses at 8.3 plants/m^2 was reported to reduce red spider mite populations in Kenya. The plant also was shown to have anti-tick properties (Silué, 2009). *Cleome gynandra* L. (cat whiskers) has traditionally been used for the treatment of rheumatic and other inflammatory conditions (Narendhirakannan *et al.* 2005).

2.6 Processing of Spider flower

The fundamental purpose of food preservation is to extend shelf life by destroying or inhibiting micro-organisms and slowing down enzyme activity. Traditional methods of preservation still in use include drying and salting. The knowledge of the various food processes and the nutrient losses that occur during each process will allow improvements to be made and losses to be minimized. Food processing has inevitable consequences on the nutritional value of foods. The macro- and micro-nutrients contained within foods all show varying degrees of stability when foods are stored or processed. The degree of stability depends largely on the type and structure of the food or nutrient, food chemistry and the severity and duration of processing (Henry and

Massey, 2001).

Many of the leafy vegetable species, especially those that grow as weeds or in the wild, are seasonal and highly perishable. To extend the period during which they are available, different ways of preserving these vegetables have been developed. The two main methods are the sun-drying of fresh leaves and the sun-drying of blanched or cooked leaves. Both methods transform the leafy vegetables into dry products that have long shelf life (Vorster *et al.*, 2005). During drying, usually two processes namely; the addition of heat and the removal of moisture from the food occur. Nutritional losses during drying are more due to the application of heat than to the removal of moisture (Morris *et al.*, 2004).

The leaves of spider flower can be preserved by blanching and then sun-drying. The leaves and flower buds are washed and boiled in water with a little salt. A relatively long cooking time (2 hours) is normally used to remove the bitter flavour. For drying, the boiled leaves are made into small balls and placed out in the sun. To reconstitute the dried leaves, it is soaked in water and then prepared in the usual manner (IPGRI, 1997).

2.6.1 Processing by drying

Drying is the oldest method of preserving food. Throughout history, the sun, the wind, and a smoky fire have been used to remove water from fruits, meats, grains, and herbs. By definition, food dehydration is the process of removing water from food by circulating hot air through it, which prohibits the growth of enzymes and bacteria

(Medeiros and Ramlay, 2009).

According to Harison and Andress (2000), drying removes moisture, the food becomes smaller and lighter in weight. When the food is ready for use, the water is added back. Foods can be dried in the sun, in an oven or in a food dehydrator by using the right combination of warm temperatures, low humidity and air current.

In drying, warm temperatures cause the moisture to evaporate. Low humidity allows moisture to move quickly from the food to the air. Air current speeds up drying by moving the surrounding moist air away from the food. Drying foods is simple, safe and easy to learn. With modern food dehydrators, fruit leathers, banana chips and beef jerky can all be dried year round at home. Vegetables should be dried until they are brittle or "crisp." Some vegetables would actually shatter if hit with a hammer. At this stage, they should contain about 10 percent moisture. Because they are so dry, they do not need conditioning like fruits (Harison and Andress, 2000).

2.6.2 Effects of drying on Quality of vegetables

Drying removes the moisture from the food so bacteria, yeast and mold cannot grow on and spoil the food. Drying also slows down the action of enzymes but does not inactivate them (Harison and Andress, 2000). Dried foods are tasty, nutritious, lightweight, easy-to prepare, and easy-to-store and use. The energy input is less than what is needed to freeze or can, and the storage space is minimal compared with that needed for canning jars and freezer containers (Medeiros and Ramlay, 2009). The nutritional value of food is only minimally affected by drying. Vitamin A is retained during drying; however, because vitamin A is light sensitive, food containing it should be stored in dark places. Vitamin C is destroyed by exposure to heat, although pre-treating foods with lemon, orange, or pineapple juice increases vitamin C content (Medeiros and Ramlay, 2009). Dried fruits and vegetables are high in fibre and carbohydrates and low in fat, making them healthy food choices (Medeiros and Ramlay, 2009). Drying fruits and vegetables is a very imprecise process and exact drying times cannot be predicted. Complete drying is important since foods that are not completely dried are susceptible to mold and may still harbour harmful pathogens that could cause food borne illness (Medeiros and Ramlay, 2009). The best temperature for drying vegetables to preserve carotenoids and vitamin C is at 45°C. Higher temperatures result in higher loses in sun drying and oven drying (Ejoh *et al.*, 2005).

2.6.3 Drying methods

2.6.3.1 Sun drying

Sun drying leaves is an inexpensive and effective method of preserving surplus micronutrient-rich foods. Open drying methods are however, prone to dust and dirt contamination, attacks by birds, rodents and insects, and re-wetting of the drying material by rain. At the same time nutrient loss especially of vitamins is high through sun-drying (Keding *et al.*, 2007). Sun drying is the most widely used method of drying agricultural produce in most of the developing countries of the tropical region (Hassan *et al.*, 2007).

2.6.3.2 Oven-drying

Combining the factors of heat, low humidity and air flow, an oven can be used as a dehydrator. Oven drying is slower than dehydrators because it does not have a built-in fan for the air movement. However, some convection ovens do have a fan. It takes about two times longer to dry food in an oven than it does in a dehydrator. Thus, the oven is not as efficient as a dehydrator and uses more energy (Harrison and Andress, 2000). Oven dried food is more brittle and usually darker and less flavourful than food dried in a dehydrator. Another disadvantage of oven drying is its energy cost. Oven drying takes two or three times longer than drying in a dehydrator. Before drying in an oven, test the oven temperature with an oven thermometer for about 1 hour. The oven should maintain a temperature of 55º C to 65º C. If the oven cannot maintain a temperature in this range, you will not have high-quality dried food (McCurdy, 2003).

2.7 Effects of time of harvest on Quality of Vegetables

A study by Khader and Rama (2003) on effects of time of harvest at harvest on nutrient content of Leafy Vegetables showed that as the plant matured from stage I (15 days) to stage II (30 days), iron and manganese contents increase whereas zinc and copper contents decrease. Varietal differences were also observed at different stages of maturity. Adouko *et al.* (2008) reported that a study on okra fruits showed that lipids concentration increased with age. In their study it was observed that sugar and protein concentrations were highest in fruits that were 5 to 9 days-old on the plant before harvest.

A study on different stages of maturity of an *Amaranthus* species (*Koyyathotakura*) in India indicated that phosphorus content was more at 15 days of age (63 mg/100 g) and decreased to (60 mg/100 g) at 30 days of age. At 45 days from planting, the phosphorus level further decreased to (56 mg/100 g). Calcium content of the vegetable at 15 days of age was (105 mg/100 g) and increased to (136 mg/100 g) at 30 days of age. It however decreased to (121 mg/100 g) at 45 days old. Magnesium content of the vegetable studied was (42 mg/100 g) at 15 days old, increased to (77 mg/100 g) at 30 days old and then decreased to (72.33 mg/100 g) at 45 days from planting (Khader and Rama, 2003).

2.8 Influence of location (weather and soil) on Nutrients of Leafy Vegetables.

A difference in agro-ecological zones, which includes differences in climate and soil fertility levels, has an influence on the level of various nutrients in leafy vegetables grown in these zones. According to Chweya and Mnzava (1997), plant's nutritional value may vary with soil fertility, environment, plant type, plant age and the production techniques used. Soetan *et al*. (2010) stated that location has been reported to influence the mineral and trace element compositions of rice, wheat, oats and barley and these are mainly attributed to the altered soil conditions and that the nature and chemical composition of the soil are also involved in location differences in mineral elements. Mnamani *et al*. (2009) stated that variations in the chemical compositions of leafy vegetables, including quantity of compounds that are useful and detrimental to humans are influenced by environmental conditions and the age of plants at harvest.

2.9 Proximate compositions of Leafy vegetables.

2.9.1 Moisture Content

Moisture generally refers to the presence of water, often in trace amounts (Moisture-www.wikipedia.com). Water is an important part of all cells and fluids in the body. It carries nutrients to and waste products from cells in the body, aids in digestion and absorption of food and helps to regulate body temperature (Johnson, 1996). The maximum water content varies between individual vegetables because of structural differences and cultivation condition that influence structural differentiation and may also have a marked effect on water levels vegetables (Florkowski *et al.,* 2009). High moisture content in vegetables is indicative of its freshness as well as easy perishability (Adepoju and Oyediran, 2008). Higher moisture content in vegetables also suggests that the vegetable will not store for long without spoilage since a higher water activity could enhance microbial activity, bringing about food spoilage (Ejoh *et al.,* 2007). For vegetables to be kept for a long time before use, the moisture content has to be reduced to inhibit the autocatalytic enzymes (Ladan *et al.,* 1997). Removal of moisture results in increased concentration of nutrients (Morris *et al.,* 2004). *Cleome gynandra* L. has been reported to have varied moisture content of 81.8-89.6 % (Chweya and Mnzava, 1997) and 86.6 % (Silue, 2009). Hassan *et al.* (2007) reported moisture content of *C. gyanandra* as 90 %, 55.80 %, 63.75 %, and 60.75 % in fresh, oven-dried, sun-dried and solar-dried respectively.

2.9.2 Crude Protein

Proteins are essential organic compounds of high molecular weight found in all living tissues which synthesize them at one time or another. They are formed from much similar building units called amino acids. Proteins may be categorized based on factors such as solubility and shape. They are broadly divided in two groups namely: simply and conjugated. Simple proteins consist of only amino acids as building blocks whiles Conjugated proteins contain amino acids but in addition, a non-protein or prosthetic group which may be glycoprotein, lipoprotein, chromoprotein (Osei, 2003).

Results of a study by Nnamani *et al*. (2009) on nutrient values of three underutilized indigenous leafy vegetables *Vitex doniana* Sweet, *Adenia cissamploides* Zepernick and *Zanthoxylum zanthoyloides* Herms, indicated their protein contents as 8.74, 8.5 and 6.12 %, respectively. Crude Protein content of 3.1-7.7 % has been reported for *Cleome gynandra* L. (Chweya and Mnzava, 1997). On the other hand, Hassan *et al*. (2007) reported protein content of 14.30 %-dry weight.

Protein helps in building and maintaining all tissues in the body, Forms an important part of enzymes, fluids and hormones of the body. It helps form antibodies to fight infection and supplies energy (Jonhson, 1996). How much protein is needed in a person's daily diet is determined in large part by overall energy intake, as well as by the body's need for nitrogen and essential amino acids. Physical activity and exertion as well as enhanced muscular mass increase the need for protein (Protein- www.wikipedia.com, 2010a).

The World Health organization (WHO's) protein figures translate into 56 g of protein a day for a (75 kg) man, and 48g for a (64 kg) woman. The recommendations of the UK Department of Health and Social Security (DHSS) are slightly higher, at about 68 g a day for sedentary or moderately active men, and 54 g a day for women. Both these official recommendations suggest that eating 10 % of our daily energy as protein will provide an adequate amount.

Plant proteins may be less digestible because of intrinsic differences in the nature of the protein and the presence of other factors such as fibre, which may reduce protein digestibility by as much as 10 %. Nevertheless, dietary studies show the adequacy of plant foods, as sole sources of protein (AFPA, 2010). Requirements are also greater during childhood for growth and development, during pregnancy or when breast-feeding in order to nourish a baby, or when the body needs to recover from malnutrition or trauma or after an operation. Protein deficiency is a serious cause of ill health and death in developing countries. Symptoms of kwashiorkor include apathy, diarrhoea, inactivity, failure to grow, flaky skin, fatty liver, and edema of the belly and legs (Protein-www.wikipedia.com, 2010a).

Heat denatures protein (Morris *et al.*, 2004). Food processing has inevitable consequences on the nutritional value of foods. The macro- and micro-nutrients (carbohydrate, protein, fats, vitamins and minerals) contained within foods all show varying degrees of stability when foods are stored or processed and the degree of stability depends largely on the type and structure of the food/nutrient, food chemistry and the severity and duration of processing (Henry and Massey, 2001).

2.9.3 Dietary Crude Fibre

Dietary crude fibre is the edible parts of plants or analogous carbohydrates that are resistant to digestion and absorption in the human small intestine with complete or partial fermentation in the large intestine. Dietary crude fibre includes polysaccharides, oligosaccharides, lignin, and associated plants substances. It promotes beneficial physiological effects including laxation, and/or blood cholesterol attenuation, and/or blood glucose attenuation. Dietary fibre consists of non-digestible carbohydrates and lignin that are intrinsic and intact in plants. Functional fibre consists of isolated, non-digestible carbohydrates which have beneficial physiological effects in humans. Total fibre is the sum of dietary and functional fibre (CFW, 2003).

'Dietary fibre', 'unavailable carbohydrate' or 'roughage' are the different terms used to define that part of the plant food which is not digested by the endogenous secretions of the human digestive system. The sum total of all these fractions, which go unhydrolysed, was first known as "Unavailable Carbohydrate". Since lignin is not a carbohydrate, Trowell introduced "dietary fibre" as a preferable term though pectic substances are not fibrous. Recently the term "Plantix" has been given to this totally undigestible material. Dietary fibre may be classified into three major groups according to structure and properties. The groupings are cellulose, non-cellulose and lignin (Komal and Kaur, 1992).

Dietary fibre or foods containing a high amount of dietary fibre are very low in caloric content. Dietary fibre yields only 2-3 calories /g. Thus a high fibre diet is recommended for weight reducing regimes (Komal and Kaur, 1992). Mensah *et al.* (2008) reported crude fibre content of *Amaranthus cruentus, Cochorus olitorius* and *Basella rubra* as 1.8, 8.5 and 0.6 g/100 g D M respectively. Spider flower has a crude fibre content of 1.3-1.4 % (Chweya and Mnzava, 1997).

Increasing the fibre content of the diet increases the faecal energy excretion, principally in the form of fat and nitrogen. By virtue of its water holding capacity, fibre also helps in the formation of soft stools with bulk, which can be easily evacuated (Komal and Kaur, 1992). An increased intake of dietary fibre appears to be useful for the treatment of both obesity and diabetes mellitus. Fibre-rich food is usually satisfying without being calorically dense. Gel forming fibres are particularly effective in reducing elevated cholesterol. The impaired glucose tolerance of manifest diabetes is also improved.

2.9.4 Crude Fat content

Dietary fats represent the most compact chemical energy available to man. They contain twice the caloric value of an equivalent weight of sugar. However dietary fats should not be thought of solely as providers of unwanted calories as fats are as vital to cell structure and biological function as protein. Dietary fats provide the essential linoleic acid which seems to have both a structural and functional role in animal tissue. However, leafy vegetables are not noted for contributing significantly to the fat supply in foods (Kummerow, 2007). Kwenin *et al.* (2011) reported crude fat contents of 3.19 %, 3.0 %, 1.33 % and 1.50 % in *Xanthosoma sagittifolia, Amaranthus cruentus, Talinum triangulare and Moringa oleifera* respectively.

2.9.5 Ash content

Ash is the inorganic residue remaining after the water and organic matter have been removed by heating in the presence of oxidizing agents, which provides a measure of the total amount of minerals within a food (McClement, 2003). Higher ash content predicts the presence of an array of mineral elements as well as high molecular weight elements (Onot *et al.,* 2007). Ejoh *et al.* (2007) reported that *Vernonia amygdalina* has ash content of 7.7 g/100 g. A study by Nnamani *et al.* (2009) on *Zanthoxylum zanthoxyloides, Vitex doniana* and *Adenia cissampeliodes* stated that Ash content of the test vegetables ranged from 8.10 - 6.30 %. *Cleome gynandra* L. has a Total Ash content of 2.1-3.0 % (Chweya and Mnzava, 1997).

2.9.6 Carbohydrate

The term "carbohydrate" from the French "hydrate de carbon" was originally defined to include all organic compounds containing C, H and O with the latter occurring in the same ratio as in water (2:1) with the exception of deoxyribose with the formula $C_5H_{10}O_4$. The modern definition is that carbohydrates are polyhydroxy aldehydes or ketones and their derivatives and other compounds that yield them on hydrolysis. Carbohydrates are the most abundant organic material on earth and in vegetable matter may form 50-80 % of the dry matter in the form of non-starch polysaccharides including cellulose, hemicelluloses and lignin (Osei, 2003). Carbohydrate is the most important food energy provider among the macronutrients, accounting for between 40 and 80 percent of total energy intake. Foods containing carbohydrates are part of a healthful diet because they provide dietary fibre, sugars, and starches that help the body function well. The sugars and starches in foods supply energy to the body in the form of glucose, which is the preferred fuel for your brain and nervous system. It's important to choose carbohydrates wisely (DGA, 2005). Mensah *et al.* (2008) reported carbohydrate content of *Amaranthus cruentu*, *Cochorus olitorius* and *Basella rubra* as 7.0, 26.6 and 2.9 g/100 g DM respectively. *Cleome gynandra* has a carbohydrate 4.4-6.4 % (Chweya and Mnzava, 1997). No specific carbohydrate requirements exist in humans (Osei, 2003).

2.10 Mineral nutrients of Leafy Vegetables

2.10.1 Phosphorus

Phosphorus is part of every cell of the body and is vitally concerned with many metabolic processes, including those involving the buffers in body fluids (Hays and Swenson, 1985). It functions as a constituent of bones, teeth, adenosine triphosphate (ATP), phosphorylated metabolic intermediates and nucleic acids. It as aids the buffering system (phosphate buffers, functions in the formation of high energy compounds), and is involved in the synthesis of phospholipids and phosphoproteins. Practically, every form of energy exchange inside living cells involves the forming or breaking of high-energy bonds that link oxides of phosphorus to carbon or to carbon-nitrogen compounds. Phosphorus is an essential macronutrient for plants and one of the three nutrients generally added to soils in fertilizers because of its vital role of energy transfer in living organisms and in plants. Adequate phosphorus availability stimulates early growth and hastens maturity in plants. Phosphorus is also needed for soil fertility. The phosphorus content of the plant is influenced markedly by the availability of phosphorus in the soil.

Decrease in serum phosphorus is found in rickets, hyperparathyroidism, De Toni-Fanconi Syndrome. Deficiency disease or symptoms in children causes rickets and in adults, it causes osteomalacia. Increase in serum phosphorus is found in chronic nephritis and hypoparathyroidism. Toxicity disease or symptoms include low serum Ca^{2+} - P ratio. It may also lead to bone loss.

Important sources of phosphorus include phosphate food additives, green leafy vegetables and fruits, especially banana (Soetan *et al.*, 2010). Spider flower has been reported to have phosphorus content of 12 mg/100 g (Chweya and Mnzava, 1997). A study by Mepba *et al.* (2007) indicated that blanching and cooking significantly ($P \leq 0.05$) decreased levels of phosphorus in the leafy vegetables studied.

2.10.2 Potassium

Potassium is the principal cation in intracellular fluid and functions in acid-base balance, regulation of osmotic pressure, conduction of nerve impulse, muscle contraction particularly the cardiac muscle, cell membrane function and Na+/K+-ATPase. Potassium is also required during glycogenesis. It also helps in the transfer of phosphate from ATP to pyruvic acid and probably has a role in many other basic cellular enzymatic reactions. Its metabolism is regulated by aldosterone. Hyperkalaemia is increased level in serum potassium and this occurs in Addison's disease, advanced chronic renal failure, shock and dehydration (Soetan *et al.*, 2010). Toxicity disease or symptoms include dilatation of the heart, cardiac arrest, small bowel ulcers. Hypokalaemia is low level of serum potassium and this occurs in diarrhoea, metabolic alkalosis and familial periodic paralysis. Deficiency disease or symptoms occurs secondary to illness, functional and structural abnormalities including impaired neuromuscular functions of skeletal, smooth, and cardiac muscle, muscular weakness, paralysis, mental confusion (Others are cardiac arrythmias, impaired carbohydrate tolerance, altered electrocardiogram in calves. Potassium deficiency affects the collecting tubules of the kidney, resulting in the inability to concentrate urine, and also causes alterations of gastric secretions and intestinal motility.

Plant products contain many times as much potassium as sodium. Sources include vegetables, fruits, nuts (Soetan *et al.* 2010). Mensah *et al.* (2008) reported potassium content of *Amaranthus cruentu, Cochorus olitorius* and *Basella rubra* as 4.82, 3.83 and 5.8 mg/100 g DM respectively. *Cleome gynandra* has been reported to have potassium content of 410 mg/100 g (Chweya and Mnzava, 1997). A study by Mepba *et al.* (2007) indicated that blanching and cooking significantly (P≤0.05) decreased levels of potassium in vegetables.

2.10.3 Calcium

Calcium is an important constituent of bones and teeth and is involved in regulation of nerve and muscle function. In blood coagulation, calcium activates the conversion of prothrombin to thrombin. It plays a vital role in enzyme activation. Calcium activates large number of enzymes such as adenosine triphosphatase (ATPase), succinic dehydrogenase and lipase. It is also required for membrane permeability, involved in muscle contraction, normal transmission of nerve impulses and in neuromuscular excitability (Soetan *et al.*, 2010). Reduced extracellular blood calcium increases the irritability of nerve tissue, and very low levels may cause spontaneous discharges of nerve impulses leading to tetany and convulsions (Hays and Swenson, 1985). Calcium absorption requires calcium-binding proteins and is regulated by vitamin D, sunlight, parathyroid hormone and thyrocalcitonin. Thyrocalcitonin decreases plasma calcium and phosphate levels whereas parathyroid hormone increases them. Dietary calcium and phosphorus are absorbed mainly in the upper small intestine, particularly the duodenum and the amount absorbed is dependent on source, calcium-phosphorus ratio, intestinal pH, lactose intake and dietary levels of calcium, phosphorus, vitamin D, iron, aluminium, manganese and fat. The greater the need, the more efficient is the absorption (Soetan *et al.*, 2010). The low pH of the duodenum accounts for the greater absorption in that area. Lactose also enhances the absorption of calcium (Hays and Swenson, 1985). In plants, calcium is taken up in the ionized form (as Ca^{2+}). The leafy parts are relatively high in calcium and low in phosphorus, whereas, the reverse is true of the seeds. Legumes, in general, have higher calcium content than grasses (Merck, 1986).

In children, calcium deficiency causes rickets due to insufficient calcification by calcium phosphate of the bones in growing children. The bones therefore remain soft and deformed by the body weight. In adults, it causes osteomalacia, a generalized demineralization of bones. It may also contribute to osteoporosis, a metabolic disorder resulting in decalcification of bone with a high incidence of fracture, that is, a condition where calcium is withdrawn from the bones and the bones become weak and porous and then breaks (Hays and Swenson, 1985; Malhotra, 1998; Murray *et al.*, 2000). Calcium deficiency also affects the dentition of both children and adult. Toxicity symptoms occur with excess absorption due to hypervitaminosis D or hypercalcaemia due to hyperparathyroidism, or idiopathic hypercalcaemia. Excess calcium depresses cardiac activity and leads to respiratory and cardiac failure; it may cause the heart to stop in systole, although, normally, calcium ions increase the strength and duration of cardiac muscle contraction. Excess calcium and phosphorus are excreted by the kidney. Ca and P excreted in faeces are largely the unabsorbed dietary minerals; some comes from the digestive juices, including bile (Hays and Swenson, 1985). Growing, pregnant and especially lactating humans and animals require liberal amounts of calcium and phosphorus. Parturient paresis, or milk fever, in cows is associated with calcium metabolism. This illness usually occurs with the onset of profuse lactation and the most common abnormality is acute hypocalcaemia with decline in blood calcium level from normal. Serum magnesium levels may be elevated or depressed, low levels being accompanied by tetany and high levels by a flaccid paralysis.

Sources of calcium include Beans, lentils, nuts, leafy vegetables, dairy products, small fishes including sardines, bones, etc (Soetan *et al.*, 2010) Mensah *et al.* (2008) reported Calcium content of *Amaranthus cruentu, Cochorus olitorius* and *Basella rubra* as 2.05, 1.26 and 2.32 mg/100 g DM respectively. Spider flower has a Calcium content of 213-434 mg/100 g (Chweya and Mnzava, 1997). A study by Mepba *et al.* (2007) indicated that blanching and cooking significantly ($P \leq 0.05$) decreased levels of Calcium in the test vegetables.

2.10.4 Magnesium

Magnesium is an active component of several enzyme systems in which thymine pyrophosphate is a cofactor. Oxidative phosphorylation is greatly reduced in the absence of magnesium. Magnesium is also an essential activator for the phosphate-transferring enzymes myokinase, diphophopyridinenucleotide kinase, and creatine kinase. It also activates pyruvic acid carboxylase, pyruvic acid oxidase, and the condensing enzyme for the reactions in the citric acid cycle. It is also a constituent of bones, teeth and enzyme cofactor (Murray *et al.*, 2000). The health status of the digestive system and the kidneys significantly influence magnesium status. Magnesium is absorbed in the intestines and then transported through the blood to cells and tissues. Approximately one-third to one-half of dietary magnesium is absorbed into the body. Gastrointestinal disorders that impair absorption such as Crohn's disease can limit the body's ability to absorb magnesium. These disorders can deplete the body's stores of magnesium and in extreme cases may result in magnesium deficiency. When a magnesium-deficient diet is fed to young chicks, it leads to poor growth and feathering, decreased muscle tone, ataxia, progressive incoordination and convulsions followed by death (Soetan *et al.*, 2010).

Chronic or excessive vomiting and diarrhea may also result in magnesium depletion. Deficiency diseases or symptoms are secondary to malabsorption or diarrhoea, alcoholism. Acute magnesium deficiency results in vasodilation, with erythemia and hyperaemia appearing a few days on the deficient diet. Neuromuscular hyperirritability increases with the continuation of the deficiency, and may be followed eventually by cardiac arrhythmia and generalized tremours. A common form of magenesiumdeficiency tetany in ruminants is called grass tetany or wheat wheat-pasture poisoning. This condition occurs in ruminants grazing on rapidly growing young grasses or cereal crops and develops very quickly. The physiological deficiency of magnesium can be prevented by magnesium supplementation of a salt or grain mixture and adequate consumption is also very important (Hays and Swenson, 1985). Toxicity disease or symptoms of magnesium deficiency in humans include depressed deep tendon reflexes and respiration (Murray *et al.* 2000). Sources include leafy green vegetables (containing chlorophyll) (Soetan *et al.*, 2010).

Mensah *et al.* (2008) reported magnesium content of *Amaranthus cruentu*, *Cochorus olitorius* and *Basella rubra* as 2.53, 0.59 and 0.06 mg/100 g DM respectively. Cleome gynandra has a magnesium content of 86 mg/100 g (Chweya and Mnzava, 1997). The human body contains about 760 mg of magnesium at birth, approximately 5 g at age 4–5 months, and 25 g when adult. Of the body's magnesium, 30–40 % is found in muscles and soft tissues, 1 % is found in extracellular fluid and the remainder is in the skeleton, where it accounts for up to 1 % of bone ash. Soft tissue magnesium functions as a cofactor of many enzymes involved in energy metabolism, protein synthesis, RNA and DNA synthesis, and maintenance of the electrical potential of nervous tissues and cell membranes. Of particular importance with respect to the pathological effects of magnesium depletion is the role of this element in regulating potassium fluxes and its involvement in the metabolism of calcium (FAO/WHO, 2004).

2.10.5 Iron

Iron functions as haemoglobin in the transport of oxygen. In cellular respiration, it functions as essential component of enzymes involved in biological oxidation such as cytochromes C, C1, and A1 (Malhotra, 1998). Iron is an important constituent of succinate dehydrogenase as well as a part of the haeme of haemoglobin (Hb), myoglobin and the cytochromes (Chandra, 1990). Iron is required for proper myelination of spinal cord and white matter of cerebellar folds in brain and is a cofactor for a number of enzymes involved in neurotransmitter synthesis (Soetan *et al.*, 2010). Iron is involved in synthesis and packaging of neurotransmitters, their uptake and degradation into other iron-containing proteins which may directly or indirectly alter brain function. Iron exists in the blood mainly as haemoglobin in the erythrocytes and as transferrin in the plasma. It is transported as transferrin; stored as ferritin or haemosiderin and it is lost in sloughed cells and by bleeding. Iron is required for making Hb and it is a prooxidant which is also needed by microorganisms for proliferation. Biologically important compounds of iron are haemoglobin, myoglobin, cytochromes, catalases and peroxidase. Factors affecting the absorption of iron are: low phosphate diet which increases iron absorption, whereas high phosphate diet decreases iron absorption by forming insoluble iron phosphates. Adrenocortical hormones (glucocorticoids) play a role in regulating the level of plasma iron. During stress, when the hypothalamus, adenohypophysis, and adrenal cortex are activated, regardless of the source, the plasma iron decreases. Iron in ferrous form is more soluble and is readily absorbed than the ferric form. Phytic acid and oxalic acid decreases iron absorption by forming iron phytate and iron oxalate. The absorption of iron is inhibited by profuse diarrhoea, malabsorption syndrome, achlorohydria, dissertion of small intestine and partial or total gastrectomy.

The plasma iron content is determined by the extent of blood losses, role of erythropoeisis, rate of apoferritin synthesis, rate of iron absorption from intestines and rate of red blood cell destruction. Deficiency disease or symptoms include anaemia, (hypochromic, microcytic). Iron deficiency has been reported to have a role in brain development and in the pathophysiology of restless legs syndrome. Also, iron deficiency is associated with alterations in many metabolic processes that may impact brain functioning, among whom are neurotransmitter metabolism, protein synthesis and organogenesis. Early iron deficiency has also been reported to affect GABA metabolism in adult rats. Iron accumulation has been related to some neurologic disorders such as Alzheimer disease, Parkinson disease, type-1 neuro-degeneration with brain iron accumulation and other disorders. Brain is quite sensitive to dietary iron depletion and uses a host of mechanisms to regulate iron flux homostatically. The pig is born with low iron stores and develops iron deficiency anaemia if not provided with supplementary iron. The factors causing the onset of anaemia in piglets are its relatively low iron stores at birth, its high growth rate early in life, and the low level of iron in sow milk. If the pig is given iron supplements at birth, the total red cell mass or volume per unit of body weight increases from birth to three weeks of age (Soetan *et al.*, 2010) .

Excessive accumulation of iron in the liver, pancreas, heart, lungs and other tissues cause haemosiderosis and when this is accompanied by bronze pigmentation of the skin, the condition is called haemochromatosis (Malhotra, 1998; Murray *et al.*, 2000). Sources include red meat, spleen, heart, liver, kidney, fish, egg yolk, nuts, legumes, molasses, iron cooking ware, dark green leafy vegetables (Soetan *et al.*, 2010). Mensah *et al.* (2008) reported Iron content of *Amaranthus cruentu*, *Cochorus olitorius* and *Basella rubra* as 0.12, 0.04 and 0.04 mg/100 g DM respectively. *Cleome gynandra* has an iron content of 1-11 mg/100 g (Chweya and Mnzava, 1997). A study by Mepba *et al.* (2007) indicated that Blanching and cooking significantly ($P \leq 0.05$) decreased levels of iron in the test vegetables.

3.0: MATERIALS AND METHODS

3.1Survey

3.1.1Questionnaire Administration

Structured questionnaires were used as survey tools to interview housewives/consumers, farmers, and traders of traditional leafy vegetable in the Upper East Region. In all, 120 questionnaires were administered and distributed as follows; (housewives =30, farmers=30, traders=30 and consumers=30). Information generated respondent's perception as well as postharvest handling, including processing methods used for the leafy vegetables. Other information included was the socio-cultural, economic and nutritional importance of the vegetables.

3.1.2 Experimental Design

A completely Randomized Block Design was used with a 2 x 2 factorial treatment combinations and three replications.

3.1.3 Study Area

Experimental plots were located in Bolgatanga in the Upper East Region and on campus of the Kwame Nkrumah University of Science and Technology, Kumasi in the Ashanti Region, The locations are in two different agro-ecological zones of the country namely; Sudan Savannah zone and Semi-deciduous forest zone, Bolgatanga and Kumasi respectively. The survey was also conducted in the Upper East Region.

3.1.3.1 Bolgatanga

Upper East Region is one of the warmest parts of the country with a temperature variation of 14^{o} C for night and 40^{o} C during the day and an annual rainfall range of 750-1050 mm. The vegetation consists of grassland especially of Savannah with clusters of draught resistant trees. This region experiences a single wet season which begins in May and ends in October (DOG, 2009).

3.1.3.2 Kumasi

Kumasi lies in the semi-deciduous forest zone of Ghana. The rainfall pattern is bimodal (two wet and two dry seasons). The mean annual rainfall is 1563 mm of which about 55 % occurs from March and July and 30% occurs between September and November. There is usually a short dry season in August and a long one between December and March. Monthly temperature averages range from 27^{o} C to 29^{o} C in the year with February, March and April usually being the hottest months (A. M. D.-KNUST, 2010).

3.2 Planting

Seeds of Spider flower (*Cleome gynandra* L.) were purchased from the Bolgatanga central market and planted in drills of 20cm apart on experimental plots of 12 m^2 in each of the locations.

3.3 Growth/Yield Parameters

Data was taken for days to 50 % Germination and days to 50 % flowering by counting from the day of planting to the day 50 % of seedlings were seen on the experimental plots and the day 50 % of plants were observed to have flowered respectively. Height of plant at flowering in was also determined by measuring heights of experimental plants centimeters whiles number of leaves on plants at the ages of six and seven weeks of experimental plants were determined by observation and counting. Data collected on yield and growth parameters from the two different locations were subjected to analysis of variance using the Statistix software.

3.4 Harvesting

First harvest was done six weeks from date of planting and the second in the seventh week from date of planting in each of the locations.

3.5 Post Harvest Parameters Studied

Parameters measured included: moisture, crude protein, crude fat, crude fibre, ash content, carbohydrate, calcium, iron, potassium, magnesium and phosphorus content.

3.6 Drying of *Cleome gynandra*

Oven and sun drying methods were used to dry samples.

3.6.1 Sun Drying

Edible portions of the samples (leaves and tender shoots) were chopped into small pieces and 1kg of each sample were kept under the sun (ambient temperature 35-39° C) in July, between 9.00 am-5.30 pm daily till the leaves attained constant weight. 1g of each sample was then taken for laboratory analysis (Hassan *et al.*, 2007).

3.6.2 Oven Drying

For oven-drying, edible portions of the samples (leaves and tender shoots) were chopped into small pieces and 1kg sample from each treatment packaged in well-labeled brown paper envelopes and completely dried out in a (Magtech oven) at 60° C for 24 hours. 1 g of each sample was then taken for laboratory analysis (Hassan *et al.*, 2007)

3.7 Proximate Analysis

3.7.1 Moisture Content Determination

Moisture content was determined by weighing 2 g of each sample in triplicates into well labeled petri dishes using an electronic weighing scale (ADAM AAA 100LE scale) and samples dried to constant weights for about 24 hours at 60° C in a (Magtech Oven). Percentage moisture and dry matter content were then determined using the method described by McClements (2003) below:

$$\%\text{Moisture} = \frac{M_{\text{INITIAL}} - M_{\text{DRIED}}}{M_{\text{INITIAL}}} \times 100$$

Where, M_{INITIAL} and M_{DRIED} are the mass of the sample before and after drying, respectively.

The chemical analysis of percentage crude protein, crude fiber, moisture, ash, fat and carbohydrate were carried out using methods described by Pearson, (1976). The crude protein was obtained by determining the organic nitrogen content of the sample using the micro-Kjeldahl method and multiplying the nitrogen by a protein conversion factor of 6.25. The ash content of the leaves was estimated by igniting the weighed sample in a weighed crucible at a temperature of 500° C for about 3 hours in a muffle furnace, while the moisture content was determined using the oven method. The crude fiber and fat determination were done by hydrolyzing the sample with 0.128 ml of H_2SO_4 and 0.223 ml of KOH and Soxhlet extraction method, respectively. The carbohydrate content was determined as difference.

3.7.2 Mineral Analysis

The mineral contents namely, phosphorus, potassium iron, calcium and magnesium were determined using dry ashing procedure as described by Association of Analytical Chemist (AOAC) (1990).About 2 g of the sample was pre-ashed in a crucible for 1 - 2 h until the sample is completely charred on a hot plate. The pre-ashed sample was then placed on a muffle furnace and ashed at 500°C for about 3 h or until the ash turned white. After ashing, the sample was cooled and weighed and then transferred into a 50 ml volumetric flask by carefully washing the crucible with 5 ml of 30 % HCl. The solution was diluted to the 50 ml volume with iodized water. The solution was then used for individual mineral determination using spectrophotometer and flame photometer.

3.7.2.1 Determination of Phosphorus (P) Concentration

5 ml of the digest of each sample was measured and put into 50 ml volumetric flasks. 10 ml of vanadomolybdate was then added to each sample and the volumes of the 50 ml volumetric flasks made up with distilled water. The flask content was thoroughly mixed by shaking and kept for 30 minutes. A yellow colour which developed was read at 430 mm wavelength on a spectrophotometer. Percentage transmittance was recorded and absorbance level determined. The Phosphorus content was then determined using a standard curve developed from a standard phosphorus solution (AOAC, 1990).

3.7.2.2 Determination of Potassium (K) Concentrations

The Flame Photometry method was used to determine the potassium concentrations. The digest was diluted and the potassium emissions measured in air-acetylene flame. A calibration curve of potassium emission against concentration was drawn and compared to that of a standard solution (AOAC, 1990).

3.7.2.3 Determination of Iron (Fe) Concentration

Aliquots of standard sample and blank were pipetted into test tubes and absorbance measured at 248 nm using air-acetylene flame. Calibration curve of absorbance was then drawn against the concentration of iron to determine the iron concentration (AOAC, 1990).

3.7.2.4 Determination of Calcium (Ca) Concentration

5 ml aliquot of the sample solution was measured and 10 ml of 10 % KOH solution

added followed by 1ml of 30% triethanolamine. Three drops of 10 % KCN solution and a few crystals cal-red of indicator were added and mixed thoroughly by shaking. The mixture was then titrated with 0.02 N EDTA solution from a red to blue end point. Calcium concentrations were then calculated (AOAC, 1990).

3.7.2.5 Determination of Magnesium (Mg) Concentration

5 ml aliquot of the sample solution was measured into a 100ml conical flask. 5 ml ammonium chloride – ammonium hydroxide buffer solution was then added followed by 1 ml of triethanolamine. Three drops of 10 % KCN solution and few drops of EBT indicator solution were then added. The flask content thoroughly mixed by shaking and then titrated with 0.02 N EDTA solution from a red to blue end point. Magnesium concentrations were then calculated (AOAC, 1990).

3.8 Analysis of Data

Data collected from the survey was analyzed using the Statistical Package for Social Scientists (SPSS version 16) and those from the laboratory mineral and proximate analysis were analyzed using the General Analysis of Variance of Genstat (Discovery Edition 3) Statistical software.

4.0 RESULTS

4.1 Survey Results

Table 4-1 shows the demographic information on farmers, traders and consumers of Traditional African Leafy vegetables (TLVs). The results show that 50.2 % of the farmers and traders who responded had no formal education and very few of the traders (3.6 %) had secondary education. None of respondents had education beyond secondary level. The farmers and traders were predominantly female (83.3 %). Fifty percent (50 %) of the farmers were aged between 31 and 40 years while 46.4% of the traders were between 18 and30 years.

Table 4-1: Demographic Information of Respondents; gender, age and level of education

		FARMERS (%)	TRADERS (%)	HOUSEWIVES (%)	CONSUMERS (%)	TOTAL (%)
Sex	Male.	26.7	6.7	-	76.7	27.5
	Female	73.3	93.3	100.0	23.3	72.5
Age	Less than 18 yrs.	3.3	3.6	-	3.3	2.6
	18-30 yrs.	36.7	46.4	7.1	36.7	31.7
	31-40 yrs.	50.0	39.3	60.7	50.0	50.0
	41-50 yrs.	10.0	-	10.7	6.7	6.9
	More than 50 yrs.	-	10.7	21.4	3.3	8.9
Education	No formal Education.	43.3	57.1	46.7	10.3	39.4
	Basic education.	33.3	39.3	23.3	6.9	25.7
	Secondary Education.	13.3	3.6	26.7	6.9	12.6
	Beyond Secondary Education	10.0	-	3.3	75.9	22.3

Table 4-2: List of some Traditional Leafy Vegetables (TLVs) consumed in the Upper East Region of Ghana.

NO.	COMMON NAME	SCIENTIFIC NAME	FAMILY NAME
1.	Roselle	*Hibiscus sabdariffa* L.	Malvaceae
2.	Kenaf	*Hibiscus cannabinus*	Malvaceae
3.	Spider flower	*Cleome gynandra* L.	Capparaceae
4.	Cowpea Leaves	*Vigna unguiculata* L.	Leguminasae
5.	Okra Leaves	*Abelmoschus esculentus* L.	Malvaceae
6.	Jute mallow	*Corchorus tridens*	Tiliaceae
7.	Bush okra	*Corchorus olitorius*	Tiliaceae
8.	Sesamum	*Sesamum angustifolium*	Pedaliaceae
9.	Bitterleaf	*Venonia amygdalina* Del.	Compositae
10.	Pumpkin Leaves	*Cucurbita maxima*	Cucurbitaceae
11.	African Foetid cassia	*Senna obtusifolia*	Leguminasae
12.	African spinach	*Amaranthus cruentus*	Amaranthaceae
13.	Baobab Leaves	*Adansonia digitata* L.	Bombacaceae
14.	Moringa Leaves	*Moringa oleifera*	Moringaceae

Information on level of production, consumption and losses of T LVs in the Upper East Region is presented in Table 4-3. Over seventy percent (72.4 %) of the respondents indicated that traditional leafy vegetables are produced in the Upper East region. Almost all the respondents (98.3 %) indicated they consumed Traditional African leafy vegetables. According to the respondents the farmers lose about 20 % of the vegetables produced to pests and diseases.

Table 4- 3: Level of production, consumption and percentage losses of the TLVs to pests and diseases

		FARMERS (%)	TRADERS (%)	HOUSEWIVES (%)	CONSUMERS (%)	TOTAL (%)
Produce More TLVs than Exotic Vegetables	YES.	93.3	100.0	42.9	53.3	72.4
	NO.	6.7	-	57.1	46.7	27.6
More TLVs eaten than exotic Vegetables	YES	100.0	100.0	100.0	93.3	98.3
	NO.	-	-	-	6.7	1.7
Percentage losses to pests and diseases	<10%.	20.7	34.5	25.0	33.3	28.4
	10-20%.	24.1	27.6	37.5	27.8	29.3
	21-30%.	20.7	17.2	6.2	22.2	16.6
	> 30%.	31.0	20.7	31.2	16.7	24.9
	Others	3.4	-	-	-	0.9

Table 4-4 presents information on harvesting method, mode of transport and percentage losses during transport to market centres of traditional leafy vegetables in the Upper East Region. The primary method used to harvest leafy vegetables in the region was by hand (41.6 %) and harvested vegetables were generally carried on the head (60.4 %) to the market centres for sale. Other modes of transporting vegetables to the market centres for sale are the use of donkey carts (33.1 %), bicycles (2.8 %) and motor vehicles (3.7 %).

Table 4-4: Harvesting method, mode of transport and percentage losses during transportation to market centres

ITEM		FARMERS (%)	TRADERS (%)	HOUSEWIVES (%)	CONSUMERS (%)	TOTAL (%)
Harvesting Method	Use of hand.	57.1	27.6	12.5	69.0	41.6
	Use of simple tools.	7.1	20.7	-	6.9	8.7
	More than one method.	21.4	41.4	81.2	24.1	42.0
	Other methods not listed.	14.3	10.3	6.2	-	7.7
Mode of transport of TLVs to market centres	Carry on the head.	14.3	60.7	100.0	66.7	60.4
	Carry in donkey carts.	85.7	35.7	-	11.1	33.1
	Carry in vehicles.	-	3.6	-	11.1	3.7
	Carry on bicycles.	-	-	-	11.1	2.8
Percentage losses in transport	Less than 10%	64.0	95.2	100.0	71.4	82.7
	10-20%	36.0	4.8	-	28.6	17.4

Information on processing method, packaging materials used and period of storage of traditional leafy vegetables in the Upper East Region are presented in table 4-5. Respondents generally processed traditional leafy vegetables in the region by drying in the sun (98.6 %). According to the respondents, the processed vegetables were mainly packaged in polypropylene sacks (59.9 %) and stored up to a period of 1-3 months.

Table 4-5: Processing method, containers used in storing and Period of storage of Traditional Leafy Vegetables

		FARMERS (%)	TRADERS (%)	HOUSEWIVES (%)	CONSUMERS (%)	TOTAL (%)
Processing method	Sun-drying	100.0	100.0	100.0	94.4	98.6
	Blanching	-	-	-	5.6	1.4
Storage containers used	Jute sacks.	25.9	7.1	8.3	21.1	15.6
	Polypropylene sacks.	48.1	60.7	83.3	47.4	59.9
	Pots.	7.4	3.6	-	31.6	10.7
	Basins.	3.7	-	-	-	0.9
	Others not Listed.	14.8	28.6	8.3	-	12.9
Period of storage	1-3 months.	63.0	71.4	25.0	78.9	59.6
	4-6 months.	22.2	25.0	75.0	15.0	34.5
	7-9 months.	3.7	3.6	-	-	1.8
	10-12 months	3.7	-	-	5.3	2.2
	Other not Listed	7.4	-	-	-	1.9

Table 4-6 contains information on season of abundance and uses of traditional leafy vegetables of the Upper East Region. Respondents indicated that the rainy season (64.1 %) was the main season when more traditional leafy vegetables are produced in the Upper East Region of Ghana. According to most of the respondents (85 %), the traditional leafy vegetables produced in the region were used to prepare soups, cakes, sauces and as well as for medication.

Table 4-6: Season of abundance and uses of Traditional Leafy Vegetables of the Upper East Region.

		FARMERS (%)	TRADERS (%)	HOUSEWIVES (%)	CONSUMERS (%)	TOTAL (%)
Season of Abundance	Rainy season	13.8	58.6	87.5	96.4	64.1
	Dry season	86.2	41.4	12.5	3.6	35.9
Uses	To prepare soups	13.3	-	3.6	40.0	14.2
	To prepare sauces	-	-	-	3.3	0.8
	For all uses listed	86.7	100.0	96.4	56.7	85.0

4.2 Proximate Composition of *Cleome gynandra* L. from Kumasi and Bolgatanga

4.2.1 Proximate nutrients of the samples harvested from Kumasi

The effects of harvest times on proximate compositions of *Cleome gynandra* L. grown in Kumasi is presented on Table 4-7. Time of harvest at harvest significantly ($P<0.05$) influenced proximate composition of *Cleome gynandra* L. Samples harvested at the 6th week after planting had significantly ($P<0.05$) higher moisture (15.90 g/100 g) and crude fibre contents (15.67 g/100 g) than that harvested in the 7th week. On the contrary, crude protein (28.85 g/100 g), ash content (10.75 g/100 g) and carbohydrates (32.13 g/100 g) were higher in samples harvested in the 7th week from planting.

Table 4-7: Effects of harvest times on proximate compositions of *Cleome gynandra* L. grown in Kumasi (g/100 g)

Harvesting Stage	**Moisture Content**	**Crude Protein**	**Crude Fibre**	**Fat Content**	**Ash Content**	**Carbohydrates**
Harvest Stage 1 (6th week)	15.90	25.60	15.67	3.25	10.00	29.59
Harvest Stage 2 (7th week)	13.60	28.85	11.67	3.00	10.75	32.13
LSD	1.00	0.82	0.37	0.61	0.74	1.75
CV %	5.5	1.5	0.3	10.6	2.1	3.2

Drying methods significantly (P<0.05) influenced the proximate composition of *Cleome gynandra* L. grown in Kumasi (Table 4-8). Crude protein (28.50 g/100 g), crude fibre (14.71 g/100 g) and ash content (10.75 g/100 g) were significantly higher in samples dried in the oven than that dried in the sun while sun drying resulted in higher levels of crude fat (3.50 g/100 g) and carbohydrate (33.17 g/100 g) than oven drying.

Table 4-8: Effects of Drying methods on proximate compositions of *Cleome gynandra* L. grown in Kumasi (g/100 g).

Drying Method	**Moisture Content**	**Crude Protein**	**Crude Fibre**	**Fat Content**	**Ash Content**	**Carbohydrates**
Oven-Drying	14.75	28.50	14.71	2.75	10.75	28.55
Sun-Drying	14.75	25.95	12.63	3.50	10.00	33.17
LSD	1.00	0.82	0.37	0.61	0.74	1.75
CV %	5.5	1.5	0.3	10.6	2.1	3.2

Harvesting stages and drying methods had significant (P<0.05) effects on proximate composition of *Cleome gynandra* L. grown in Kumasi (Table 4-9). Week six harvest, oven dried, had significantly higher level of crude fibre (18.13) than that harvested in the 7th week. Crude protein content (29.80) was however higher in the oven dried 7th week harvest than that of the 6th week harvest oven dried.

Table 4-9: Effects of harvesting stages and drying methods on proximate compositions of *Cleome gynandra* L. grown in Kumasi. (g/100 g)

	Moisture Content		**Crude Protein**		**Crude Fibre**	
Harvesting	**Oven-Dried**	**Sun-Dried**	**Oven-Dried**	**Sun-Dried**	**Oven-Dried**	**Sun-Dried**
Harvest Stage 1	15.90	15.90	27.20	24.00	18.13	13.20
Harvest Stage 2	13.60	13.60	29.80	27.90	11.28	12.06
LSD	1.42		1.16		0.52	
CV %	5.5		1.5		0.3	

Harvesting stages and drying methods had significant (P<0.05) effects on proximate composition of *Cleome gynandra* L. grown in Kumasi (Table 4-10). Sun drying harvest stage 1 samples resulted in significantly higher level of carbohydrate (33.90 g/100 g) than that oven dried while sun drying harvest stage 2 samples was better in crude fat content (3.50 g/100 g) than oven drying harvest stage 2 samples (2.50 g/100 g).

Table 4-10: Effects harvesting stages and drying methods on proximate compositions of *Cleome gynandra* L. grown in Kumasi (g/100 g)

	Fat Content		**Ash Content**		**Carbohydrate**	
Harvesting	**Oven-Dried**	**Sun-Dried**	**Oven-Dried**	**Sun-Dried**	**Oven-Dried**	**Sun-Dried**
Harvest Stage 1	3.00	3.50	10.50	9.50	25.27	33.90
Harvest Stage 2	2.50	3.50	11.00	10.50	31.82	32.44
LSD	0.87		1.04		2.47	
CV %	10.6		2.1		3.2	

4.2.2 Proximate composition of the *Cleome gynandra* L harvested from Bolgatanga

The effects of times of harvest on proximate compositions of *Cleome gynandra* L. grown in Bolgatanga is presented in Table 4-11. Time of harvest at harvest significantly (P<0.05) affected levels of proximate composition of *Cleome gynandra* L. Samples harvested at the 6th week after planting had significantly (P<0.05) higher moisture (16.47 g/100 g), crude protein (31.95 g/100 g) and crude fat contents (2.50 g/100 g) than that harvested in the 7th week. On the contrary, crude fibre (17.42 g/100 g) and carbohydrate (27.87 g/100 g) were higher in samples harvested in the 7th week from planting.

Table 4-11: Effects time of harvest on proximate compositions of *Cleome gynandra* L. grown in Bolgatanga (g/100 g)

Harvesting Stage	**Moisture Content**	**Crude Protein**	**Crude Fibre**	**Fat Content**	**Ash Content**	**Carbohydrates**
Harvest Stage 1	16.47	31.95	12.32	2.50	12.00	24.76
Harvest Stage 2	14.57	25.15	17.42	1.75	12.25	27.87
LSD	1.36	1.36	0.96	0.71	0.35	2.74
CV %	5.7	1.3	1.3	11.8	5.2	3.8

Drying methods significantly (P<0.05) affected the proximate composition of *Cleome gynandra* L. grown in Bolgatanga (table 4-12). Crude protein (29.80 g/100 g), crude fat (2.75 g/100 g) and ash contents were significantly (P<0.05) higher in samples dried in the oven than that dried in the sun while sun drying resulted in higher level of crude fibre (16.72 g/100 g).

Table 4-12: Effects of drying methods on proximate compositions of *Cleome gynandra* L. grown in Bolgatanga (g/100 g)

Drying Method	**Moisture Content**	**Crude Protein**	**Crude Fibre**	**Fat Content**	**Ash Content**	**Carbohydrates**
Oven-Drying	15.52	29.80	13.02	2.75	12.50	26.41
Sun-Drying	15.52	28.30	16.72	1.50	11.75	26.22
LSD	1.36	1.36	0.96	0.71	0.35	2.74
CV %	5.7	1.3	1.3	11.8	5.2	3.8

The time of harvest and method of drying significantly (P<0.05) affected proximate composition of *Cleome gynandra* L. grown in Bolgatanga (Table 4-13). Oven drying 6th week harvest resulted in significantly higher level of crude protein than that harvested in the 7th week. Crude fibre (19.29 g/100 g) was however higher in the sun dried 7th week harvest.

Table 4-13: Effects of harvesting stages and drying methods on proximate compositions of *Cleome gynandra* L. grown in Bolgatanga (g/100 g)

	Moisture Content		Crude Protein		Crude Fibre	
	Oven-Dried	**Sun-Dried**	**Oven-Dried**	**Sun-Dried**	**Oven-Dried**	**Sun-Dried**
Harvest Stage 1	16.47	16.47	32.10	31.80	10.50	14.14
Harvest Stage 2	14.57	14.57	27.50	24.80	15.54	19.29
LSD	1.92		1.92		1.36	
CV %	5.7		1.3		1.3	

Time of harvests and drying methods used significantly (P<0.05) affected proximate composition of *Cleome gynandra* L. grown in Bolgatanga (Table 4-14). Sun drying 6th week harvest resulted in significantly higher level of crude fat content (3.50 g/100 g) than when samples were oven dried while sun drying samples at the 7th week led to higher carbohydrate content (28.84 g/100 g). Ash content (13.50 g/100 g) was however higher in oven dried 7th week harvest.

Table 4-14: Effects of the harvesting stages and drying methods on proximate compositions of *Cleome gynandra* L. grown in Bolgatanga (g/100 g)

	Fat Content		**Ash Content**		**Carbohydrate**	
Harvesting Stage	**Oven-Dried**	**Sun-Dried**	**Oven-Dried**	**Sun-Dried**	**Oven-Dried**	**Sun-Dried**
Harvest Stage 1	3.50	1.50	11.50	12.50	25.93	23.59
Harvest Stage 2	2.00	1.50	13.50	11.00	26.89	28.84
LSD	0.99		0.50		3.88	
CV %	11.8		5.2		3.8	

4.3 Mineral Composition of Spider flower from Kumasi and Bolgatanga

4.3.1 Mineral nutrients of the Samples harvested from Kumasi

Time of harvest at harvest had no significant (P<0.05) effect on mineral composition of *Cleome gynandra* L. grown in Kumasi (Table 4-15). Levels of the minerals observed in the study under the different harvest times are: phosphorus (0.56 and 0.60 g/100 g), potassium (2.94 and 2.96 g/100 g), calcium (2.41 and 2.79 g/100 g), magnesium (1.83 and 1.95 g/100 g) and iron (11.16 and11.80 mg/100 g).

Table 4-15: Effects of harvest times on some mineral nutrient content of *Cleome gynandra* L. grown in Kumasi.

Harvesting Stage	Phosphorus g/100g	Potassium g/100g	Calcium g/100g	Magnesium g/100g	Iron mg/100g
Harvest Stage 1 (6 Weeks Old)	0.60	2.96	2.41	1.83	11.16
Harvest Stage 2 (7 Weeks Old)	0.56	2.94	2.79	1.95	11.80
LSD	0.06	0.31	0.57	0.21	31.38
CV %	1.9	5.2	5.6	2.1	15.7

Drying methods had no significant ($P<0.05$) effect on mineral composition of *Cleome gynandra* L. grown in Kumasi (Table 4-16). Levels of the minerals observed in the study under drying method are: phosphorus (0.55 and 0.61 g/100 g) potassium (2.92 and 2.97 g/100 g) calcium (2.49 and 2.71 g/100 g), magnesium (1.89 and 1.90 g/100 g) and iron (11.33 and11.63 mg/100 g).

Table 4-16: Effects of drying methods on some mineral nutrient content of *Cleome gynandra* L. grown in Kumasi.

Drying Method	Phosphorus g/100 g	Potassium g/100 g	Calcium g/100 g	Magnesium g/100 g	Iron mg/100 g
Oven-Dried	0.61	2.97	2.49	1.90	11.63
Sun-Dried	0.55	2.92	2.71	1.89	11.33
LSD	0.06	0.31	0.57	0.21	31.38
CV %	1.9	5.2	5.6	2.1	15.7

Harvest stage and drying methods had no significant (P<0.05) effect on mineral composition of *Cleome gynandra* L. grown in Kumasi as presented on (Table 4-17). Ranges of nutrient content observed in the study for the different stages of maturity at harvest and drying methods were: phosphorus (0.54-0.64 g/100 g), potassium (2.83-3.08 g/100 g) and calcium (2.37-2.99 g/100 g).

Table 4-17: Effects of harvesting stages and drying methods on some mineral content of *Cleome gynandra* L. grown in Kumasi (g/100 g)

	Phosphorus		**Potassium**		**Calcium**	
	Oven-Dried	**Sun-Dried**	**Oven-Dried**	**Sun-Dried**	**Oven-Dried**	**Sun-Dried**
Harvest Stage 1	0.64	0.55	3.08	2.83	2.37	2.44
Harvest Stage 2	0.58	0.54	2.86	3.01	2.60	2.99
LSD	0.08		0.44		0.81	
CV %	1.9		5.2		5.6	

Harvest stage and drying methods had no significant (P<0.05) effect on mineral composition of *Cleome gynandra* L. grown in Kumasi as presented on (Table 4-18). Ranges of mineral contents observed in the study for the different time of harvest at harvest and drying methods were: magnesium (1.72-2.03 g/100 g) and iron (9.46-13.79 mg/100 g).

Table 4-18: Effects of harvesting stages and drying methods on some mineral content of *Cleome gynandra* L. grown in Kumasi.

	Magnesium g/100 g		**Iron mg/100 g**	
	Oven-Dried	**Sun-Dried**	**Oven-Dried**	**Sun-Dried**
Harvest Stage 1	1.92	1.72	9.46	12.86
Harvest Stage 2	1.87	2.03	13.79	9.81
LSD	0.30		44.37	
CV %	2.1		15.7	

4.3.2 Mineral composition of the *Cleome gynandra* L harvested from Bolgatanga

Time of harvest at harvest of had no significant (P<0.05) influence on mineral composition of *Cleome gynandra* L. grown in Bolgatanga (Table 4-19). Levels of the minerals observed in the study under time of harvest at harvest are: Phosphorus (0.58 and 0.60 g/100 g) Potassium (2.96 and 2.99 g/100 g) calcium (2.88 and 3.11g/100 g), Magnesium (1.98 and 2.10g/100 g) and Iron (7.0 and 7.5 mg/100 g).

Table 4-19: Effects of harvest times on some mineral nutrient content of *Cleome gynandra* L. grown in Bolgatanga.

Harvesting stage	**Phosphorus g/100 g**	**Potassium g/100 g**	**Calcium g/100 g**	**Magnesium g/100 g**	**Iron mg/100 g**
Harvest Stage 1 (6 Weeks Old)	0.60	2.99	2.88	1.98	7.5
Harvest Stage 2 (7 Weeks Old)	0.58	2.96	3.11	2.10	7.0
LSD	0.12	0.22	0.26	0.14	59.2
CV %	4.6	2.2	4.8	3.5	27.0

Drying methods had no significant ($P<0.05$) effect on mineral composition of *Cleome gynandra* L. grown in Bolgatanga (Table 4-20). Concentration of minerals observed in the study under drying method were: phosphorus (0.55 and 0.62g/100g) potassium (2.95 and 2.99g/100g) calcium (2.92 and 3.07g/100g), magnesium (1.97 and 2.10g/100g) and iron (5.30 and 9.30mg/100g).

Table 4-20: Effects of drying methods on some mineral nutrient content of *Cleome gynandra* L. grown in Bolgatanga.

Drying method	**Phosphorus g/100 g**	**Potassium g/100 g**	**Calcium g/100 g**	**Magnesium g/100 g**	**Iron mg/100 g**
Oven-Dried	0.62	2.99	3.07	2.10	9.30
Sun-Dried	0.55	2.95	2.92	1.97	5.30
LSD	0.12	0.22	0.26	0.14	59.2
CV %	4.6	2.2	4.8	3.5	27.0

Harvest stage and drying methods had no significant ($P<0.05$) effect on mineral composition of *Cleome gynandra* L. grown in Bolgatanga as presented on (Table 4-21). Ranges of mineral contents observed in the study for time of harvest at harvest and drying methods were: phosphorus (0.44-0.71 g/100 g) potassium (2.91-3.07 g/100 g) and calcium (2.79-3.17 g/100 g).

Table 4-21: Effects of harvesting stages and drying methods on some mineral content of *Cleome gynandra* L. grown in Bolgatanga (g/100 g)

	Phosphorus		**Potassium**		**Calcium**	
	Oven-Dried	**Sun-Dried**	**Oven-Dried**	**Sun-Dried**	**Oven-Dried**	**Sun-Dried**
Harvest Stage 1	0.53	0.66	3.07	2.91	2.97	2.79
Harvest Stage 2	0.71	0.44	2.93	2.99	3.17	3.05
LSD	0.17		0.31		0.36	
CV %	4.6		2.2		4.8	

Time of harvest and drying methods had no significant (P<0.05) effect on mineral composition of *Cleome gynandra* L. grown in Bolgatanga as presented on (Table 4-22). Ranges of mineral nutrients observed in the study for maturity at harvest and drying methods were: magnesium (1.91-2.17 g/100 g) and iron (3.30-10.70 mg/100 g).

Table 4-22: Effects of harvesting stages and drying methods on some mineral content of *Cleome gynandra* L. grown in Bolgatanga.

	Magnesium g/100g		**Iron mg/100g**	
	Oven-Dried	**Sun-Dried**	**Oven-Dried**	**Sun-Dried**
Harvest Stage 1	2.04	1.91	7.90	7.20
Harvest Stage 2	2.17	2.02	10.70	3.30
LSD	0.20		83.7	
CV %	3.5		27.0	

4.3.3 Agronomic Performance of *Cleome Gynandra*

The height at flowering, and number of leaves at 6th and 7th weeks from planting were used as indicators for yield. The number of days taken to germinate as well as days to flowering were determined, the results (Table 4-23) show that there were no significant differences in any of the parameters measured. This suggests that the *Cleome gynandra* did equally well in both locations. Interestingly, the differences in mineral content did not vary significantly. This result indicates that *Cleome gynandra* would perform equally well in both savannah and forest zones. Farmers could be educated to adopt the plant and grow it for both income and nutrition.

Table 4-23 Show analyzed results of agronomic data taken during production of *Cleome gynandra* in both Kumasi and Bolgatanga.

Location	**Days to 50% Germination**	**Days to 50% Flowering**	**Height at Flowering (cm)**	**No of leaves at 6th week**	**No of leaves at 6th week**
Kumasi	11.33a	24.33a	29.00a	22.00a	23.33a
Bolgatanga	11.67a	25.00a	27.00a	22.33a	23.67a

5.0: DISCUSSION

5.1 Survey

Indigenous African vegetables are increasingly being consumed by African populations and they play important roles in crop diversity, poverty alleviation and food security (Bary *et al.* 2008). A survey carried out to assess the use of indigenous leafy vegetables in the Upper East Region of Ghana revealed that majority of the traditional leafy vegetable farmers and traders (50.2 %) involved in the industry had no formal education and were predominantly female (83.3 %). historically, women have dominated the collection as well as marketing of leafy vegetables and it has become part of culture (Jansen *et al.*,2007). Similarly, Vorster *et al.* (2007) reported that women are the original food producers worldwide and play vital roles in developing countries. However, the low level of formal education of the female workforce is a disincentive to the industry as it could affect their identification and level of adoption of improved technologies that are essential for sustained production of traditional leafy vegetables. Again, since women do not own farm lands in the Upper East Region sustainable production may not be assured for the future. As a result the commercial potential of these vegetables have not been fully exploited.

It was also observed from the survey that more traditional leafy vegetables are produced (72.4 %) and consumed (98.3 %) in the region as compared to the exotic. The reasons may be due to the fact that many homes produce their own traditional leafy vegetables and thus they are abundant, readily available and relatively cheap in the region. Chadha

(2003) has attributed the high consumption of indigenous vegetables in Africa to among others, the great variety and quantity of indigenous vegetables as against the exotic. On the other hand there is a general preference for traditional leafy vegetables as they are considered cheaper and more nutritious than the exotic and have culturally been consumed by indigenes. This observation is similar to that reported by Ogle *et al.* (1990) who indicated that traditional vegetables are consumed by between 52 % and 95 % of Zambians.

Though much traditional leafy vegetables are produced (72.4 %) in the Upper East Region of Ghana, up to 20 % is lost to pests and diseases. These loses are quite high and can be reduced if optimum pre-harvest and postharvest handling practices are followed.

Chwewe and Mnzava (1997) indicated that *Cleome gynandra* is harvested when the plants reach a height of about 15cm and they can be harvested by uprooting whole plants or by topping, cutting back to ground level or picking individual leaves or leafy branches at frequent intervals. The primary method used to harvest leafy vegetables in the Upper East Region is the use of hand (41.6 %) and included uprooting and other methods (42 %) and topping using knives (8.7 %). Harvested vegetables were generally carried on the head (60.4 %) to the market centres mostly exposed to the sun, wind and other harsh ambient conditions

Since the Upper East Region has a single rainy season (spanning through only four months in a year), traditional leafy vegetables are produced in during this season as indicated by 64.1 % of the respondents. The vegetables produced during the rainy season are commonly dried and stored when in abundance. According to Vorster *et al.* (2005) many leafy vegetables, especially those that grow as weeds or in the wild, are seasonal and highly perishable. Drying therefore, ensures extended shelf life and availability of the vegetables in alternative forms during the off seasons. According to the respondents sun-drying (98.6 %) is the main method used to process vegetables for storage in the region and the dried vegetables are commonly stored in polypropylene sacks (59.9 %) for a period of 1-3 months. According to Keding *et al.* (2007) sun drying of leafy vegetables is an inexpensive and effective method of preserving surplus micronutrient-rich foods.

The respondents indicated that the vegetables have varying uses including the preparation of soups, cakes, sauces as well as for medicinal purposes. In Kenya, *Cleome gynandra* is used for treatment of scurvy, improve eyesight, cure marasmus, reduce dizzy spells in pregnant women, provide energy and be marinated in sour milk for 2-3 days and eaten as a nutritious meal (Chweya and Mnzava, 1997).

5.2 Proximate Composition

5.2.1 Moisture Content

The moisture content of fresh samples of *Cleome gynandra* leaves varied between 13.60 % and 16.47 %. There were significant differences (p<0.05) in moisture content between stages of maturity at harvest at both locations. Significant differences were observed between moisture contents of the 6th week harvest (15.90 %) and 7th week (13.60 %) harvest from Kumasi (Table: 4-9). Similarly, there was significant difference between the 6th week (16.47 %) and 7th week (14.57 %) harvests from Bolgatanga (Table: 4-13). These differences in moisture content of *Cleome gynandra* under different harvesting stages may be due to structural changes in plants as they grow older. According to Florkowski *et al.* (2009), maximum water content of vegetables varies among vegetable types and is influenced by cultivation condition and structural differences. The results obtained in the study did not compare well with the 81.8-89.6 %, 86.6 % and 90 % reported in *Cleome gynandra* L. in earlier studies by Chweya and Mnzava (1997), Silue (2009) and Hassan *et al.* (2007) respectively. This could be due to the different environmental conditions for growing the vegetable, time of harvest differences at harvest and varietal differences. On the other hand the results obtained were close to that reported for *Vernonia amygdalina* (21.6 %). (Mensah *et al.* 2008). High moisture content in vegetables is indicative of its freshness as well as easy perishability (Adepoju and Oyewole, 2008). Similarly, George (2003) stated that moisture content makes an important contribution to the texture of the leaves and helps in maintaining the protoplasmic content of the cells; it also makes them perishable and susceptible to spoilage by micro-organism during storage.

Water is also known to play important role in the consumer's body as reported by Johnson (1996) who stated that water is an important part of all cells and, fluids in the body and carries nutrients to and waste products from cells in the body, aids in digestion and absorption of food and helps to regulate body temperature.

5.2.2 Crude Protein

Proteins are essential organic compounds of high molecular weight found in all living tissues (Osei, 2003). Protein helps in building and maintaining all tissues in the body, forms an important part of enzymes, fluids and hormones of the body and also helps form antibodies to fight infection and Supplies energy (Jonhson, 1996).

The interactions between time of harvest at harvest and drying methods showed significant differences ($p<0.05$) in crude protein levels of *Cleome gynandr*a harvested from Kumasi. With regards to oven drying the differences between the 6th (27.20 g/100 g) and 7th (29.80 g/100 g) week harvests was significant. A similar observation was made for sun drying of 6th (24.00 g/100 g) and 7th (27.90 g/100 g) week harvests. The result suggests that harvesting at the 7th week and oven drying was better as far as protein content was concerned.

Contrary to the trend in Kumasi, the results from Bolgatanga showed that oven-drying of the 6th week harvest had the highest protein content. The differences in the observations may be environmental. The differences in the oven-dried 6th week harvest (32.10 g/100 g) and oven-dried 7th week harvest (27.50 g/100 g) was significant ($p<0.05$). Similarly, there was a significant difference between the sundried 6th week harvest (31.80 g/100 g) and 7th week harvest (24.80 g/100 g) (Table: 4-13). Generally the differences between oven drying and sun drying were significant for both 6th week and 7th week harvests. The differences may be attributable to differences in the length of exposure to light, oxygen and heat as similarly observed (Kiremire *et al.* 2010). According to Chweya and Mnzava (1997) the nutritional composition of plants may vary with soil fertility, environment, plant type, plant age, production techniques used and level of processing as similarly observed in this study. Earlier study by Hassan *et al* (2007) reported 18.58 g/100 g-fresh weight and 14.30 g/100 g-dry weight crude protein levels for *Cleome gynandra* L. On the contrary, Glew *et al,* (2009) reported 21.6 g/100 g protein level in his study. The protein content of *Cleome gynandra* L falls within range (13-30 g/100 g) of other vegetables such as *Zanthoxylum zanthoxyloides, Vitex doniana* and *Adenia cissampeliodes* (Mnamani *et al.*2009). The trend of the results in this study generally indicates that oven drying retains higher levels of crude protein than sun-drying. This may be due to the fact that that sun–dried vegetables are prone to dust and dirt contamination, attacks insects, and re-wetting of the drying vegetables by rain (Keding *et al.* 2007), which might affect the level of protein in them.

The high level of protein in *Cleome gynandra* recorded in this study suggests that the vegetable could be used as protein supplements. Consumption of 100 g of *Cleome gynandra* daily will be capable of providing 27 g of protein which satisfies the recommended daily allowance of protein for children (FAO, 1986). This observation is important as there is protein under-nutrition especially among people living in rural parts of the Upper East Region. With respect to retention of the nutrient content in *Cleome gynandra*, oven drying was found to be the better of the two drying methods. Based on this study, oven drying is recommended for *Cleome gynandra* if higher level of protein is to be retained in the dried vegetable.

5.2.3 Crude Fibre

Dietary fibre is the edible parts of plants or analogous carbohydrates that are resistant to digestion and absorption in the human small intestine with complete or partial fermentation in the large intestine. Dietary fibre includes polysaccharides, oligosaccharides, lignin, and associated plants substances.

Significant differences in crude fibre levels were obtained for *Cleome gynandra* harvested in Kumasi. There were significant interactions between oven-dried 6th (18.13 g/100 g) and 7th week (11.28 g/100 g) harvests. The sun-dried samples also showed a similar trend. Both oven-dried (15.54 g/100 g) and sun-dried (19.29 g/100 g) 7th week harvest were significantly higher in fibre content than the 6th week harvest (oven-dried, 10.50 g/100 g; sundried, 14.14 g/100 g) as indicated in Table: 4-13). The differences recorded could be due to differences in soil fertility, environment and plant age. According to Morris *et al.* (2004) several factors, including genetic make-up of a plant, the soil in which it is grown, use of fertilizer, prevailing weather condition and maturity at harvest influence the nutritional type and content of a plant and level of losses of the nutrients through processing. Kiremire *et al.* (2010) also indicated that differences in the length of exposure to light, oxygen and heat among the drying methods could be the cause for the significant difference in nutrient levels of *Cleome gynandra* recorded under such drying methods. .

The fibre contents recorded in this study are higher than the 6.0 g/100 g to 6.33 g/100 g reported by Hassan *et al.* (2007).

The high fiber (roughage) content may be advantageous since the vegetable could enhance digestion and prevent constipation when consumed. High crude fibre in the vegetable according to CFW (2003) could also help in blood cholesterol attenuation, as well as blood glucose attenuation when consumed. Increasing the fibre content of the diet increases the faecal energy excretion, principally in the form of fat and nitrogen and by virtue of its water holding capacity. Fibre also helps in the formation of soft stools with bulk, which can be easily evacuated (Komal and Kaur, 1992). An increased intake of dietary fibre appears to be useful for the treatment of both obesity and diabetes mellitus (Komal and Kaur, 1992).*Cleome gynandra,* like many other leafy vegetables, is a good source of crude fibre as this study suggests and would be of immense health benefit to its consumers.

5.2.4 Crude Fat

Crude fat content of *Cleome gynandra* of (3.50 g/100 g) recorded from samples harvested from Kumasi in the 7th week from date of planting and dried in the sun significantly ($P<0.05$) differed from that dried in the oven (2.50 g/100 g). Similarly, Hassan *et al.* (2007) reported that oven drying lowers lipid content. On the contrary, the harvest in Bolgatanga in the 6th week, dried in the oven recorded significantly higher level of crude fat (3.50 g/100 g) similar to that reported by Mepba *et al.* (2007). The variations observed at the different locations may be purely geographic and may be attributed to factors such as difference in location (soil condition) and weather as suggested by Soetan *et al.* (2010). Dietary fats represent the most compact chemical energy available to man (Kummerow, 2007). Nnamani *et al.* (2009) reported crude fat range of 3.50 to 2.10 g/100 g in *Zanthoxylum zanthoyloides Herms, Vitex doniana Sweet and Adenia cissamploides Zepernick.* The results of this study suggests that *Cleome gynandra* might not be a good source of fat (and have not been traditionally used as such) but might contribute to palatability.

5.2.5 Ash content

The ash content of a vegetable provides a measure of the total amount of minerals within it (McClement, 2003). Higher ash content predicts the presence of an array of mineral elements as well as high molecular weight elements (Onot *et al.* 2007). The interactions between time of harvest at harvest and drying methods did not show significant differences in ash content of *Cleome gynandr*a harvested under the different treatments in Kumasi. However, significant individual (time of harvest at harvest and drying methods) effects were recorded. Differences between the ash content of the 6th (10 g/100 g) and 7th (10.75 g/100 g) weeks were significant ($p<0.05$) as well as between oven (10.75 g/100 g) and sun-dried (10 g/100 g) samples. On the contrary, there were significant interactions in samples harvested from Bolgatanga. As regards the samples dried in the oven, the 7th week harvest (13.50 g/100 g) was higher in ash than the 6th week harvest (11.50 g/100 g). The trend observed in the sundried samples was different from the oven-dried. The differences in ash content observed from the different locations may be geographical as there were differences in mineral composition of the soils from the different locations (Appendix 2). This observation is similar to that of Chweya and Mnzava (1997) who reported a range of 2.1-3.0 g/100 g for *Cleome gynandra*.

The high ash content observed is indicative of high mineral content (McClement, 2003) as similarly recorded in this study. The high ash content is important as they may supply the mineral requirements of consumers of the vegetable. The results of this study suggest that delayed harvest of *Cleome gynandra* L. and drying in the oven could retain more minerals which may be to the benefit of consumer.

5.2.6 Carbohydrate

Carbohydrates are the most abundant organic material on earth and in vegetable matter may form 50-80 g/100 g of the dry matter in the form of non-starch polysaccharides including cellulose, hemicelluloses and lignin (Osei, 2003).

Significant differences in carbohydrate levels were obtained for *Cleome gynandra* harvested in Kumasi. The 6th week harvest dried in the sun (33.90 g/100 g) was significantly higher than that dried in the oven (25.27 g/100 g). With regards to oven drying the 7th week harvest was higher (31.82 g/100 g) than the 6th week harvest (25.27 g/100 g). *Cleome gynandra* produced at Bolgatanga showed significant interaction in sundried 6th (23.59 g/100 g) and 7th (28.84 g/100 g) week harvests. The differences observed could be due to differences in maturity levels (Flyman and Afoloyan, 2007).

According to the authors vegetable nutrient quality could be influenced by time of harvest. Henry and Massey (2001) indicated that micro nutrients show varying degree of stability when food is processed and this depend on the nutrient, processing method and degree of processing.

Generally there were higher levels of carbohydrate in the 7th week than the 6th week. This was to be expected as it is known that starch, the storage carbohydrate levels in plants increases with age. The carbohydrate levels (4.4-6.4 g/100 g) reported in *Cleome gynandra* by Chweya and Mnzava (1997) is far below that recorded in this study whiles levels reported in oven dried leaves (43.23 g/100 g) and in sun dried leaves (53.80 g/100 g) by Hassan *et al.* (2007) are far above what was recorded in this study. This could be attributed to differences in environment, genetic factors and methods employed in analysis as indicated by Hassan *et al.* (2007). The high carbohydrate levels recorded in samples in the study could mean high energy may be provided by the vegetable and this could be good for consumers of the vegetable. DGA (2005) reported that carbohydrate is the most important food energy provider among the macronutrients, accounting for between 40 and 80 percent of total energy intake.

5.3 Mineral Composition

Neither location, time of harvest at harvest nor drying method had significant effect on the mineral content of *Cleome gynandra*.

Phosphorus

The phosphorus content of *Cleome gynandra* in the study ranged between (0.44-0.71 g/100 g) which compares well with the (0.11g/100g) reported for *Solanum americana* leaves (Hassan *et al.* 2008).

Considering the daily requirement of 0.7 g/day (National Academy of Sciences, 2004) for an adult, *Cleome gynandra* will be a good source of phosphorus as 100g of the plant consumed daily will be adequate to provide almost 100 % of the daily requirement for an adult. *Cleome gynandra* therefore would be useful in providing the phosphorus needs of consumers. Since phosphorus is required for many metabolic processes in the body including bone mineralization, consumption of *Cleome gynandra* will promote strong bones of the consumers.

Potassium

The potassium content of *Cleome gynandra* in the study ranged between 2.83 – 3.08g/100g and slightly lower than the 11.6g/100g reported for *Solanum americana* leaves (Hassan *et al.* 2008).

Considering the daily requirement of 4.7 g/day for an adult and 3.0 g/100 g for a child of 1-3years old, *Cleome gynandra* will be a good source of potassium as 100 g of the plant consumed daily will be adequate to provides about 66 % of the daily requirement for an adult and 100 g/100 g of the daily required intake for a child of 1-3years as recommended (National Academy of Sciences, 2004). The plant consumed could therefore be a good supplement to other potassium sources.

Since potassium is known to promote good muscle contraction and also functions in acid base balance in the body (Soetan *et al.* 2010), consumption of *Cleome gynandra* will result in good muscle, heart and kidney functioning of the consumers.

Calcium

The calcium content of *Cleome gynandra* in the study varied between 2.37 g/100 g – 3.17 g/100 g and compares well with the 2.7 g/100 g and 1.7 g/100 g reported in *Amaranthus hybridus* and *Vigna unguiculata,* respectively (Walta *et al.* 2009).

Considering the daily requirement of 1.3g/day for an adult, *Cleome gynandra* will be a good source of calcium as 100 g of the plant consumed daily will be adequate to provides well above 100 % of the 1.3 g daily requirement for an adult as recommended by the National Academy of Sciences (2004). Since calcium is known to promote bone and teeth health, consumption of *Cleome gynandra* will result in strengthening of the bones and teeth of the consumers.

Magnesium

The magnesium content of *Cleome gynandra* in this study ranged between 1.72 - 2.17 g/100 g which compares well with the 1.4g/100g in *Amaranthus hybridus* and slightly higher than the 0.39 g/100 g in *Vigna unguiculata* (Walta *et al.* 2009).

Considering the daily requirement of 0.42 g/day (National Academy of Sciences, 2004) for an adult, *Cleome gynandra* will be a good source of magnesium as 100 g of the plant consumed daily will be capable of providing about 2 g of magnesium, well above 100 g/100 g of the 0.42 g daily requirement for an adult. . The plant is therefore an important source of magnesium.

Since magnesium is known to promote bone and teeth health, and also is essential in enzyme systems in the body consumption of *Cleome gynandra* will result in strengthening of the bones and teeth of the consumers and improve metabolism.

Iron

The iron content of *Cleome gynandra* in the study ranged between (3.3 - 13.8 mg/100 g) and compares well with the (14.8 mg/100 g) in *Amaranthus hybridus* but far lower than the (97.9 mg/100 g) in *Vigna unguiculata* (Walta *et al*. 2009).

Considering the daily requirement of 11mg/day for an adult male, *Cleome gynandra* will be a good source of iron as 100 g of the plant consumed daily will be capable of providing about 13 mg of iron, well above 100 % of the 11 mg daily requirement for an adult male as recommended by the National Academy of Sciences (2004). Since iron is known to be an essential part of red blood cells (haemoglobin) and enzymes (cytochromes), consumption of *Cleome gynandra* will improve on blood haemoglobin levels and reduce the rick of anaemia in the consumers considerably.

6.0: CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The results of the survey showed that more traditional leafy vegetables are produced and consumed in the Upper East Region than exotic leafy vegetables. It was also observed that sun-drying was the main method used to process leafy vegetables for long term preservation in the region. The dried vegetables were mainly packaged in polypropylene sacks for storage.

Traditional leafy vegetable farmers lose up to 20 % of their vegetables to pests and diseases. Harvesting and drying methods did not have significant ($P<0.05$) effect on mineral (potassium, calcium, magnesium and iron) content of the *Cleome gynandra* with the exception of phosphorus. The harvesting and drying methods however significantly influenced the proximate composition of *Cleome gynandra*. Harvesting *Cleome gynandra* at 6 weeks from planting date and drying in the oven resulted in better preservation of proteins as well as fibre in *Cleome gynandra*.

Considering the similar performance of *Cleome gynandra* at both geographic locations with regards to agronomic parameters (number of days to germination, plant height, number of leaves at flowering and days to flowering), *Cleome gynandra* would perform equally well in both the savanna and forest areas. *C. gynndra* could therefore be promoted for both cultivation and consumption in both savanna and forest zones of Ghana. This would enhance nutrition, food security and income.

6.2 Recommendation

Traditional leafy vegetable farmers should use other processing methods such as drying in the oven which relatively retain more of the nutrient in leafy vegetables.

Leafy vegetable farmers in the region should be assisted by Government and other stakeholder in the industry to reduce loses from pest and diseases.

The Upper East Region abounds in many traditional leafy vegetables and more should be carried out on them, especially on the wild ones, to make them popular to the entire nation and beyond.

REFERENCES

Abbey L., Bonsu K.O., Glover-Amengor M. and Ahenkora K. (2006). Evaluation of some common leafy vegetables used in Ghana. Crop Research Institute, Kumasi. Ghana Journal of Horticulture. Volume 5. (2006) Page 23.

Adepoju O. T. and Oyewole O. E. (2008). Nutritional Importance and Micronutrient Potential of Two Non-Conventional Indigenous Green Leafy Vegetables from Nigeria. Agricultural Journal 3 (5): 365, 2008.

Adouko E. A., Dago G., Grah M. B., Lassina F. and Kouamé C. (2008). Maturity degree of four Okra fruits varieties and their nutrients Composition. Electronic Journal of Food and Plants Chemistry 3 (1) 2008 1-4.

AFPA (2010). Human Protein Requirements. www.afpafitness.com (Accessed in July, 2010).

A.M.D.-KNUST, (2010). Average Annual weather condition of Kumasi. Meteorological Department of the Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

DOG, (2009). Districts of Ghana. www.ghanadistricts.com. (Accessed in August, 2009)

AOAC (1990). Official methods of analysis, 14th edition, Association of Official Analytical Chemists, Washington DC. (pp.1137–1139), Arlington, Virginia, USA.

Barry I. N., Germain N. P., Hannah J. and Detlef V. (2008). Production and Marketing of African Indigenous Vegetables in Arumeru District of Tanzania: Assessing Postharvest Loss and Processing Potential. International Symposium "Underutilized plants for food, nutrition, income and sustainable development". Arusha, Tanzania, 3-7 March 2008.

BWI, (2004). Are we on track to end hunger? 14th Annual Report on the state of the world hunger. Hunger Report. Bread for the World Institute (2004). www.bread.org/learn. (Accessed in July, 2010).

C.F.W. (2003). All Dietary Fiber is Fundamentally Functional. C. F. W. aacc report. Publication no. W-2003-0407-01O. 128 / May-June, 2003, VOL. 48, NO. 3. www.aaccnet.org/news/pdfs/DFreport.pdf. (Accessed in July, 2010).

Chadha M. L. (2003). AVRDC's experiences within Marketing of Indigenous Vegetables – A Case Study on Commercialization of African Eggplant AVRDC-Regional Center for Africa P.O. Box 10, Duluti, Arusha, Tanzania.

Chandra R. K. (1990). Micro-Nutrients a. nd Immune Functions: An Overview. Annal New York Acad. Sci. 587: 9-16.

Chweya, J. A. and Eyzaguirre, P.B. (1999). The biodiversity of traditional leafy vegetables. International Plant Genetics Resources Institute. Rome.

Chweya, J. A. and Nameus A. M. (1997). Cat's whiskers (*Cleome gynandra* L.). Promoting the conservation and use of underutilized and neglected crops 11.Institute of plant Genetic and crop Plant Research, Gatersleben/International Plant Genetic Resource Institute, Rome, Italy.

DGA (2005). Dietary Guidelines for Americans. www.healthierus.gov/dietaryguidelines. (Accessed in August, 2009).

Diouf, M. (1997). Research on African vegetables at the Horticultural Development Center (CDH), Senegal. Pages 39 – 45.

Ejoh R. A., Nkonga D. V., Inocent G. and Moses M. C. (2007). Nutritional Components of Some Non-Conventional Leafy Vegetables Consumed in Cameroon. Pakistan Journal of Nutrition 6 (6): 712-717, 2007.

Ejoh A.R., Tanya A.N., Djuikwo N.V. And Mbofung C.M. (2005). Effect of Processing and Preservation Methods on Vitamin C and Total Carotenoid Levels of Some *Vernonia* (Bitter Leaf) Species. African Journal of Food and Nutritional Sciences: Volume 5 No 2, 2005.

FAO (1986). Compositional Analysis Method. In: Manuals of food quality control. Food 7: 203-232.

Florkowski J.W., Robert L. S., Bernhard B. and Stanley E. P. (2009). Postharvest Handling: A Systems Approach, Second Edition. Elsevier Inc. Academic Press.

Flyman M. V. and Afolayan A. J., (2007) Effect of Plant Maturity on The Mineral Content of The Leaves of *Momordica Balsamina* L. and *Vigna Unguiculata* Subsp. *Sesquipedalis* (L.) VERDC. Department Of Botany University of Fort Hare Alice 5700, South Africa. Journal of Food Quality.Volume 31, Issue 5. Pp 661-671.

George P. M. (2003). Encyclopedia of foods. Volume 1. Humane Press; Washington. p. 526.

Glew S.R., Amoako-Atta B., Ankar-Brewoo G., Presley J., Chuang L., Millson M., Smith B. R., Glew R. H. (2009). Non-cultivated Plant Food in West Africa: Nutritional Analysis of the Leaves of Three Indigenous Leafy Vegetables in Ghana. Food 3 (1) 39-42. 2009. Global Science Books.

Harrison J. A. and Andress E. L. (2000). Preserving food: Drying Fruits and Vegetables. University of Georgia cooperative Service. Page 2.

Hassan S.W., Umar R.A., Maishanu H.M., Matazu I.K., Faruk U.Z. and Sani A.A. (2007). The Effects of Drying Method on the Nutrients and Non-nutrients Composition of Leaves of Gynandropsis gynandra (Capparaceae). Asian Journal of Biochemistry 2 (5): 349-353, 2007 ISSN 1815-9923. 2007 Academic Journals Inc.

Hassan L.G, Umar K.J (2008). Nutritive value of Night shade (*Solanum americanum* L.) leaves. Electronic J. Food and Plants Chem., 3: 14-17.

Hays V.W., Swenson M.J. (1985). Minerals and Bones in: Dukes' Physiology of Domestic Animals, Tenth Edition pp. 449-466.

Henry, C.J.K. and Massey, D. (2000) Issues Paper 5, Micro-Nutrient Changes During Food Processing And Storage. The Crop Post-Harvest Research Programme U.K.

IPGRI (1997) "Traditional African Vegetables" Conservation and Use. Proceedings of IPGRI Workshop on Genetic Resources of Traditional Vegetables in Africa: 1997.

Jansen W.S., Averbeke W., Slabbert R., Faber M., Jaarsveld P., Heerden I., Wenhold F. and Oelofse A. (2007). African leafy vegetables in South Africa. Water SA Vol. 33 No. 3 (Special Edition) 2007.

Johnson R. S. (1996), Key Nutrients. Cooperative Extension Service, Iowa State University of Science and Technology, Ames, Iowa.

Keding G., Weinberger K., Swai I. and Mndiga H. (2007). Diversity, Traits and Use of Traditional Vegetables In Tanzania.Technical Bulletin No. 40. Shanhua, Taiwan: AVRDC- The World Vegetable Centre.53 pp.

Kiremire B.T., Musinguzi E., Kikafunda J.K. and Lukwago F.B. (2010). Effects of Vegetable Drying Techniques on Nutrient Content: A Case Study of South-Western Uganda. AJFAND Vol. 10 No 5 May 2010.

Khader V. and Rama S. (2003). Effect of maturity on macromineral content of selected leafy vegetables. *Asia Pacific J Clin Nutr 2003: 12 (1): 45-49.*

Khader V. and Rama S. (1998). Selected mineral content of common leafy vegetables consumed in India at different stages of maturity. Center for Advanced Studies in Foods and Nutrition, ANGR Agricultural University, Rajendranagar, Hyderabad 500 030, India.

Kimbi, D. and Atta-Krah, K. (2003). Plant Genetic resources in the global and African setting. Proc of the 1st PROTA Int. Workshop 23-25 September,2002, Nairobi, Kenya. Pp 269-270.

Komal M. and Kaur A. (1992). Reviews: Dietary Fibre. Dieticians, Adipostat Clinic, 103-104, Lady Ratan Tata Medical Centre, Bombay 400 021. INTL. J. DIAB. DEV. COUNTRIES (1992), VOL. 12.

Kummerow F. A. (2007). Fats in human nutrition . Department of Food Technology, University of Illinois, Urbana, Illinois.

Kwenin, W.K.J., Wolli M. and Dzomeku B.M. (2011). Assessing the nutritional value of some African indigenous green Leafy Vegetables in Ghana. Journal of Animal & Plant Sciences, 2011. Vol. 10, Issue 2: 1300- 1305.

Ladan, M.J., Abubakar M.G. and Lawal M. (1997). Effect of solar drying on the nutrient composition of tomatoes. Nig. J. Renew. Energy, 5: 67-69.

Malhotra V.K. (1998). Biochemistry for Students. Tenth Edition. Jaypee Brothers Medical Publishers (P) Ltd, New Delhi, India.

Mathenge, L. (1995). Nutritional value and utilization of indigenous vegetable in Kenya. Paper presented at the Workshop on Genetic Resources of Traditional Vegetables in Africa. Options for Conservation and Use, 29-31 August 1995, Nairobi, Kenya.

Mbugua G.W,Muriuki A.W., Anyango J.J., Ndungu B., Gathambiri C. and Manyeki L. (2007) Farmer-participatory promotion of African Nightshade (*Solanum scabrum*), Spider flower (*Cleome gynandra*) and Amaranthus (*Amaranthus cruentus*) production in Maragua district Central Kenya, Kenya Agricultural Research Institute-Thika, P.O. Box 220-01000 Thika.

Mcclements D. J. (2003). Analysis of Food Products. Chenoweth Lab, Room 238. Www-Unix.Oit.Umass.Edu/~Mcclemen/581rheology.Html

McCurdy S. M. (2003). Drying fruits and vegetables.School of Family and Consumer Sciences, University of Idaho, in collaboration with extension specialists at Oregon State University and Washington State University.

Medeiros L. and Remley D. (2009). Drying fruits and vegetables. Ohio State University Extension; and, Extension. Ohio State.

Mensah J.K., Okoli R.I., Ohaju-Obodo J.O. and Eifediyi K. (2008). Phytochemical, nutritional and medical properties of some leafy vegetables consumed by Edo people of Nigeria. African Journal of Biotechnology Vol. 7 (14), pp. 2304-2309, 18 July, 2008

Mepba H.D., Eboh L. and Banigo D. E.B. (2007). Effects of Processing Treatments on The Nutritive Composition and Consumer Acceptance of Some Nigerian Edible Leafy Vegetables. African Journal of Food, Agriculture, Nutrition and Development Volume 7 No. 1. 2007.

Merck V. M. (1986). The Merck Veterinary Manual. Sixth Edition. A Handbook of Diagnosis, Therapy and Disease Prevention and Control for The Veterinarian. Published By Merck and Co., Inc., Rahway, New Jersey, USA.

Mingochi, D.S. and Luchen, S.W.S. (1996). Traditional Vegetables in Zambia; Genetic Resources, Cultivation and Uses. Department of Agriculture, National Irrigation Research Station, Mazabuka, Zambia.

.

Morris, A., Barnett A. and Burrows O. (2004). Effect of processing on nutrient content of foods. Cajarticles, 37: 160-164.

Murray R.K., Granner D.K., Mayes P.A., Rodwell V.W. (2000). Harper's Biochemistry, 25th Edition, McGraw-Hill, Health Profession Division, USA.

Mwangi S. and Mumbi K. (2006). African Leafy Vegetables Evolves From Underutilized Species to Commercial Cash Crops. Research Workshop on Collective Action and Market Access for Smallholders, 2-5 October 2006, Cali, Colombia.

Narendhirakannan, R. T., Kandaswamy M. and Subramanian S. (2005). Anti-Inflammatory Activity of *Cleome gynandra* L. on Hematological and Cellular Constituents in Adjuvant-Induced Arthritic Rats. JOURNAL OF MEDICINAL FOOD. 8 (1) 2005, 93–99.

National Academy of Sciences (2004), Dietary References Intake (DRIs): Recommended Intakes for Individuals, Elements. Food and Nutrition Board, Institute of Medicine, National Academies. Available online at: http//www.nap.edu (Accessed in August 2010).

Nnamani, C. V., Oselebe, H. O. and Agbatutu, A. (2009), Assessment of nutritional values of three underutilized indigenous leafy vegetables of Ebonyi State, Nigeria African Journal of Biotechnology Vol. 8 (9), pp. 2321-2324, 4 May, 2009

Obel-Lawson E. (2005). The Contribution of the Awareness Campaign of the African Leafy Vegetables Project to Nutrition Behaviour Change Among the Kenyan Urban Population: The Case Of Nairobi. Biodiversity International. 2002-2005.

Ogle B.A, Malambo L., Mingochi D.S., Nkomesha A. and Malasha I. (1990). Traditional Vegetables in Zambia. A Study of Procurement, Marketing and Consumption of Traditional Vegetables in Selected Urban and Rural Areas in Zambia. Rural Development Studies No. 28. Swedish Univ. of Agric. Sciences, International Rural Development Centre, Uppsala Sweden. 77 pp.

Onot O. E., Umoh I. B. And Eka O. U. (2007). Effect of a Typical Rural Processing Method on The Proximate Composition and Amino Acid Profile of Bush Mango Seeds*(Irvingia gabonensis)*Agriculture, Nutrition And Development Volume 7 No. 1. 2007.

Osei S. (2003). Animal Nutrition-Lecture Notes. University of Education, Winneba. Faculty of Agriculture, Mampong-Ashanti.

Pearson D. (1976). The Chemical Analysis of Food. Churchil and Livingstone, London, New York.

Schippers, R.R. (2000). Economic and social importance of Indigenous African Vegetables: African Indigenous Vegetables, An overview of the cultivated species. Natural Resource Institute/ACP-EU Technical Centre for Agriculture and Rural Cooperation. Chatham, U.K.

Shei L. (2008). An Evaluation of native West African vegetables. Agriculture and Rural Development. www.tropentag.de. (Accessed in July, 2009).

Silué D. (2009). Spider flower**:** An indigenous species with many uses. AVRDC – The World Vegetable Center Regional Center for Africa PO Box 10 Duluti, Arusha, Tanzania.

Soetan K. O., C. O. Olaiya and O. E. Oyewole (2010). The Importance of Mineral Elements for Humans, Domestic Animals and Plants: A review. African Journal of Food Science Vol. 4(5) pp. 200-222, May 2010.

Vorster H. J., Jansen Van Rensburg W. S., Van Zijl J. J. B. And Van Den Heever E. (2002).Germplasm Management of African Leafy Vegetables for the Nutritional and Food Security Needs of Vulnerable Groups in South Africa. Progress Report. Arc-Vopi, Pretoria, South Africa. 130 Pp.

Vorster H. J, Jansen Van Rensburg W. S., Venter S. L. And Van Zijl J. J. L. (2005) Re-creating awareness of traditional leafy vegetables in communities. Regional workshop on African Leafy Vegetables for improved nutrition. Paper presented at Regional Workshop on African Leafy Vegetables for Improved Nutrition, 6-9 December 2005, IPGRI, Nairobi, Kenya.

Vorster I. H.J., Jansen van Rensburg W., Van Zijl J.J.B. and Sonja L. V. (2007). The Importance of Traditional Leafy Vegetables in South Africa. African Journal of Food, Agriculture, Nutrition and Development Volume 7 No. 4. 2007.

Walta A.M., Loots D.T., Ibrahima M.I.M. and Bezuidenhout C.C. (2009). Minerals, trace elements and antioxidant phytochemicals in wild African dark-green leafy vegetables (*morogo*). South African Journal of Science **105**, November/December 2009.

WHO and FAO (2004). Vitamin and mineral requirements in human nutrition. Second edition. World Health Organization and Food and Agriculture Organization of the United Nations 2004.

Wikipedia, (2010). Meaning of Protein. www.wikipedia.com (Accessed in July, 2010).

Wikipedia, (2010). Meaning of Moisture. www.wikipedia.com (Accessed in July, 2010).

APPENDIX 1:

SURVEY QUESTIONNAIRE

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

COLLEGE OF AGRICULTURE AND NATURAL RESOURCES

FACULTY OF AGRICULTURE

RESEARCH QUESTIONNAIRE

The purpose of this questionnaire is to collect information on indigenous leafy vegetables used for food in the Upper East Regions of Ghana. Information provided would be treated confidentially.

Please Tick the appropriate check box below to indicate what you answer the questionnaire as:

1. Vegetable farmer ☐ 2. Housewife ☐
3. Vegetable trader ☐ 4. Vegetable consumer ☐

PART I

PERSONAL INFORMATION OF RESPONDENT

(1) Name of respondent (optional) ……………………………………………………………….

(2) Community of respondent…………………………………………….

(3) District……………………………………………………………………..

(4) House number ☐

(5) Sex of respondent Male ☐ Female ☐

(6) Age of respondent

Less than 18 years	
18 – 30 years	
31 – 40 years	
41 – 50 years	
More than 50 years	

7. Respondent's marital status:

Married ☐ Single ☐ Divorced ☐ Widowed ☐

(8) Respondent's level of education

No formal Education	
Basic education	
Secondary education	
Beyond secondary education	

(9) Occupation of respondent……………………..…………………….…………….………………

(10) Native Language of Respondent …………………………………………………………………

PART II

GENERAL INFORMATION OF INDIGENOUS LEAFY VEGETABLES IN THE REGION

(11) Name any traditional, indigenous or local leafy vegetables of the upper East Region you have eaten, farmed, sold or cooked. (Local names allowed).

……

……

……

(12) Are traditional leafy vegetables commonly eaten in the region than the exotic or foreign vegetables?

a) Yes ☐ b) No ☐

(13) State possible reasons for the answer or situation in question 12 above………………………………

………

………

FARMING OF INDIGENOUS LEAFY VEGETABLES IN THE REGION

(14) Do you farm traditional leafy vegetables?

a) Yes ☐ b) No ☐

(15) If yes, name the vegetables you farm. (Local names can be used)

………

………

………

(16) How long have you been farming these vegetables?

………..

(17) Do you farm on (a) commercial bases ☐ (b) For home consumption ☐

(c) For both home consumption and for sale ☐

(18) In which of the seasons are traditional leafy vegetables mostly produced in the region?

(a) Raining season ☐ (b) Dry season ☐

(19) State the possible reasons for the answer in question 18 above.

………

………

………

(20) Do you face problems of pests and diseases attack on the vegetables?

a) Yes ☐ b) No ☐

(21) If yes, what percentage of the vegetables is lost to pest and diseases?

a) Less than 10% ☐ b) 10 -20% ☐ c) 21 – 30% ☐ d) More than 30% ☐

(22) What other major challenges or problems do leafy vegetable farmers face in the region?

....

....

....

(23) Is it profitable to farm traditional leafy vegetables in the region?

a) Yes ☐ b) No ☐

POSTHARVEST HANDLING OF THE VEGETABLES

(24) What method is used in harvesting edible part of plant?

a) Use of hand ☐ b) Use of simple tools ☐

b) Use of machines ☐ d) More than one method ☐

(25) Do you transport vegetables from the farm to the market?

a) Yes ☐ b) No ☐

(26) If yes, by what means do you transport the vegetables

a) Carry on the head ☐ b) In donkey carts ☐ c) In vehicles ☐ d) On bicycles ☐

e) On motor cycles ☐

(27)Do you lose some of the vegetables during transportation?

a) Yes ☐ b) No ☐

(28) If yes, what percentage of the vegetables is lost during transportation?

a) Less than 10% ☐ b) 10 -20% ☐ c) 21 – 30% ☐ d) More than 30% ☐

(28) Do you store some of the vegetables for future use?

a) Yes ☐ b) No ☐

(29) If yes, for how long?

………

(30) In what containers do you store the vegetables?

a) Jute sacs ☐ b) Nylon sacs ☐ c) Pots ☐ d) Basins ☐ e) Barrels ☐

f) Any other containers ……………………………..

....

....

(31) Do you process the vegetables before storage?

a) Yes ☐ b) No ☐

(32) If yes, what processing methods are used?

a) Sun-drying ☐ b) Oven-drying ☐ c) Blanching ☐ d) Refrigeration ☐

e) State any other processing methods used………………………………………….……………………

………

………

MARKETING AND USES OF TRDITIONAL LEAFY VEGETABLES IN THE REGION

(33) How long does it you to sell you vegetables?

a) 1 day ☐ b) 2 days ☐ c) 3 days ☐ d) More than 3 days ☐

(34) How do you maintain the freshness of your vegetables if they are not sold in good time?....................

....

....

(35) What are the problems faced by leafy vegetable sellers in the region?...

....

(36) State the uses of the leafy vegetables in the region.

………

………

………

Thank you.

APPENDIX 2:

RESULTS OF SOIL ANALYSIS

LOCATION	SAMPLE	Org. Carbon %	Org. Matter %	Total Nitrogen %	Exchangeable cations cmol/kg			Avai-lable Phos-phorus mg/kg	PH
					Cal-Cium (Ca)	Magne-Sium (Mg)	Potas-Sium (K)		
KNUST	TOPSOIL	1.44	2.48	0.15	5.40	1.60	1.36	20.82	5.36
BOLGATANGA	TOPSOIL	0.96	1.66	0.13	4.00	0.60	0.41	21.53	6.56

APPENDIX 3:

Analysis of Variance (ANOVA) Tables

Analysis of Variance (ANOVA) Tables for Mineral nutrients of samples from Kumasi

Variate: MAGNESIUM

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	2	0.01222	0.00611	0.28	
BLOCK.*Units* stratum					
DRYING_METHOD	1	0.00021	0.00021	0.01	0.925
HARVEST_STAGE	1	0.03968	0.03968	1.81	0.227
DRYING_METHOD.HARVEST_STAGE					
	1	0.08167	0.08167	3.73	0.102
Residual	6	0.13132	0.02189		
Total	11	0.26509			

***** Tables of means *****

Variate: MAGNESIUM

Grand mean 1.891

DRYING_METHOD	OVEN-DRIED	SUN-DRIED
	1.895	1.887

HARVEST_STAGE	SPH1	SPH2
	1.833	1.948

DRYING_METHOD	HARVEST_STAGE	SPH1	SPH2
OVEN-DRIED		1.920	1.870
SUN-DRIED		1.747	2.027

*** Least significant differences of means (5% level) ***

Table	DRYING_METHOD	HARVEST_STAGE	DRYING_METHOD HARVEST_STAGE
rep.	6	6	3
d.f.	6	6	6
l.s.d.	0.2090	0.2090	0.2956

Variate: PHOSPHORUS

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	2	0.000950	0.000475	0.31	
BLOCK.*Units* stratum					
DRYING_METHOD	1	0.012675	0.012675	8.28	0.028
HARVEST_STAGE	1	0.004408	0.004408	2.88	0.141
DRYING_METHOD.HARVEST_STAGE					
	1	0.002408	0.002408	1.57	0.256
Residual	6	0.009183	0.001531		
Total	11	0.029625			

* MESSAGE: the following units have large residuals.

BLOCK 1 *units* 1 -0.058 s.e. 0.028

***** Tables of means *****

Variate: PHOSPHORUS

Grand mean 0.577

DRYING_METHOD	OVEN-DRIED	SUN-DRIED
	0.610	0.545

HARVEST_STAGE	SPH1	SPH2
	0.597	0.558

DRYING_METHOD	HARVEST_STAGE	SPH1	SPH2
OVEN-DRIED		0.643	0.577
SUN-DRIED		0.550	0.540

*** Least significant differences of means (5% level) ***

Table	DRYING_METHOD	HARVEST_STAGE	DRYING_METHOD HARVEST_STAGE
rep.	6	6	3
d.f.	6	6	6
l.s.d.	0.0553	0.0553	0.0782

Variate: POTASSIUM

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	2	0.18465	0.09232	1.89	
BLOCK.*Units* stratum					
DRYING_METHOD	1	0.00750	0.00750	0.15	0.709
HARVEST_STAGE	1	0.00120	0.00120	0.02	0.881
DRYING_METHOD.HARVEST_STAGE	1	0.11213	0.11213	2.29	0.181
Residual	6	0.29382	0.04897		
Total	11	0.59930			

* MESSAGE: the following units have large residuals.

BLOCK 1 *units* 1 -0.319 s.e. 0.156

***** Tables of means *****

Variate: POTASSIUM

Grand mean 2.945

DRYING_METHOD	OVEN-DRIED	SUN-DRIED
	2.970	2.920

HARVEST_STAGE	SPH1	SPH2
	2.955	2.935

DRYING_METHOD	HARVEST_STAGE	SPH1	SPH2
OVEN-DRIED		3.077	2.863
SUN-DRIED		2.833	3.007

*** Least significant differences of means (5% level) ***

Table	DRYING_METHOD	HARVEST_STAGE	DRYING_METHOD HARVEST_STAGE
rep.	6	6	3
d.f.	6	6	6
l.s.d.	0.3126	0.3126	0.4421

Analysis of Variance (ANOVA) Tables for Minerals in samples from Bolgatanga

Variate: CALCIUM

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	2	0.16747	0.08373	2.57	
BLOCK.*Units* stratum					
DRYING_METHOD	1	0.07053	0.07053	2.17	0.191
HARVEST_STAGE	1	0.16333	0.16333	5.02	0.066
DRYING_METHOD.HARVEST_STAGE					
	1	0.00333	0.00333	0.10	0.760
Residual	6	0.19520	0.03253		
Total	11	0.59987			

*** MESSAGE: the following units have large residuals.**

BLOCK 1 *units* 3 0.280 s.e. 0.128

******* Tables of means *******

Variate: CALCIUM

Grand mean 2.997

DRYING_METHOD	OVEN-DRIED	SUN-DRIED
	3.073	2.920

HARVEST_STAGE	SPH1	SPH2
	2.880	3.113

DRYING_METHOD	HARVEST_STAGE	SPH1	SPH2
OVEN-DRIED		2.973	3.173
SUN-DRIED		2.787	3.053

***** Least significant differences of means (5% level) *****

Table	DRYING_METHOD	HARVEST_STAGE	DRYING_METHOD HARVEST_STAGE
rep.	6	6	3
d.f.	6	6	6
l.s.d.	0.2548	0.2548	0.3604

Variate: IRON

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	2	3086.	1543.	0.88	
BLOCK.*Units* stratum					
DRYING_METHOD	1	4896.	4896.	2.79	0.146
HARVEST_STAGE	1	83.	83.	0.05	0.835
DRYING_METHOD.HARVEST_STAGE	1	3414.	3414.	1.95	0.213
Residual	6	10528.	1755.		
Total	11	22008.			

* MESSAGE: the following units have large residuals.

BLOCK 1 *units* 3 -60. s.e. 30.

***** Tables of means *****

Variate: IRON

Grand mean 73.

DRYING_METHOD	OVEN-DRIED	SUN-DRIED
	93.	53.

HARVEST_STAGE	SPH1	SPH2
	75.	70.

DRYING_METHOD	HARVEST_STAGE	SPH1	SPH2
OVEN-DRIED		79.	107.

SUN-DRIED	72.	33.

*** Least significant differences of means (5% level) ***

Table	DRYING_METHOD	HARVEST_STAGE	DRYING_METHOD HARVEST_STAGE
rep.	6	6	3
d.f.	6	6	6
l.s.d.	59.2	59.2	83.7

Analysis of Variance (ANOVA) Tables for Mineral nutrients of samples from Bolgatanga

Variate: MAGNESIUM

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	2	0.040850	0.020425	2.05	
BLOCK.*Units* stratum					
DRYING_METHOD	1	0.056033	0.056033	5.61	0.056
HARVEST_STAGE	1	0.043200	0.043200	4.33	0.083
DRYING_METHOD.HARVEST_STAGE					
	1	0.000133	0.000133	0.01	0.912
Residual	6	0.059883	0.009981		
Total	11	0.200100			

***** Tables of means *****

Variate: MAGNESIUM

Grand mean 2.035

DRYING_METHOD	OVEN-DRIED	SUN-DRIED
	2.103	1.967

HARVEST_STAGE	SPH1	SPH2
	1.975	2.095

DRYING_METHOD	HARVEST_STAGE	SPH1	SPH2
OVEN-DRIED		2.040	2.167
SUN-DRIED		1.910	2.023

*** Least significant differences of means (5% level) ***

Table	DRYING_METHOD	HARVEST_STAGE	DRYING_METHOD HARVEST_STAGE
rep.	6	6	3
d.f.	6	6	6
l.s.d.	0.1411	0.1411	0.1996

Variate: PHOSPHORUS

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	2	0.005850	0.002925	0.40	
BLOCK.*Units* stratum					
DRYING_METHOD	1	0.012033	0.012033	1.64	0.248
HARVEST_STAGE	1	0.001200	0.001200	0.16	0.700
DRYING_METHOD.HARVEST_STAGE	1	0.120000	0.120000	16.36	0.007
Residual	6	0.044017	0.007336		
Total	11	0.183100			

***** Tables of means *****

Variate: PHOSPHORUS

Grand mean 0.585

DRYING_METHOD	OVEN-DRIED	SUN-DRIED
	0.617	0.553

HARVEST_STAGE	SPH1	SPH2
	0.595	0.575

DRYING_METHOD	HARVEST_STAGE	SPH1	SPH2
OVEN-DRIED		0.527	0.707
SUN-DRIED		0.663	0.443

*** Least significant differences of means (5% level) ***

Table	DRYING_METHOD	HARVEST_STAGE	DRYING_METHOD HARVEST_STAGE
rep.	6	6	3
d.f.	6	6	6
l.s.d.	0.1210	0.1210	0.1711

Variate: POTASSIUM

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	2	0.03435	0.01718	0.70	
BLOCK.*Units* stratum					
DRYING_METHOD	1	0.00801	0.00801	0.33	0.588
HARVEST_STAGE	1	0.00301	0.00301	0.12	0.738
DRYING_METHOD.HARVEST_STAGE					
	1	0.03741	0.03741	1.53	0.262
Residual	6	0.14665	0.02444		
Total	11	0.22943			

* MESSAGE: the following units have large residuals.

BLOCK 1 *units* 1 -0.225 s.e. 0.111

***** Tables of means *****

Variate: POTASSIUM

Grand mean 2.973

DRYING_METHOD	OVEN-DRIED	SUN-DRIED
	2.998	2.947

HARVEST_STAGE	SPH1	SPH2
	2.988	2.957

DRYING_METHOD	HARVEST_STAGE	SPH1	SPH2
OVEN-DRIED		3.070	2.927
SUN-DRIED		2.907	2.987

*** Least significant differences of means (5% level) ***

Table	DRYING_METHOD	HARVEST_STAGE	DRYING_METHOD HARVEST_STAGE
rep.	6	6	3
d.f.	6	6	6
l.s.d.	0.2209	0.2209	0.3123

Analysis of Variance (ANOVA) Tables for proximate nutrients of samples from Kumasi

Variate: MOISTURE_CONTENT

Grand mean 14.75

DRYING_METHOD	OVEN-DRIED	SUN-DRIED
	14.75	14.75

HARVEST_STAGE	SPH1	SPH2
	15.90	13.60

DRYING_METHOD	HARVEST_STAGE	SPH1	SPH2
OVEN-DRIED		15.90	13.60
SUN-DRIED		15.90	13.60

***** Least significant differences of means (5% level) *****

Table	DRYING_METHOD	HARVEST_STAGE	DRYING_METHOD HARVEST_STAGE
rep.	6	6	3
d.f.	6	6	6
l.s.d.	1.002	1.002	1.417

Variate: CRUDE_PROTEIN

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	2	1.2950	0.6475	1.94	
BLOCK.*Units* stratum					
DRYING_METHOD	1	19.5075	19.5075	58.38	<.001
HARVEST_STAGE	1	31.6875	31.6875	94.83	<.001
DRYING_METHOD.HARVEST_STAGE	1	1.2675	1.2675	3.79	0.099
Residual	6	2.0050	0.3342		
Total	11	55.7625			

*** MESSAGE: the following units have large residuals.**

BLOCK 2 *units* 4 -0.88 s.e. 0.41

***** Tables of means *****

Variate: CRUDE_PROTEIN

Grand mean 27.22

DRYING_METHOD	OVEN-DRIED	SUN-DRIED
	28.50	25.95

HARVEST_STAGE	SPH1	SPH2
	25.60	28.85

DRYING_METHOD	HARVEST_STAGE	SPH1	SPH2
OVEN-DRIED		27.20	29.80
SUN-DRIED		24.00	27.90

*** Least significant differences of means (5% level) ***

Table	DRYING_METHOD	HARVEST_STAGE	DRYING_METHOD HARVEST_STAGE
rep.	6	6	3
d.f.	6	6	6
l.s.d.	0.817	0.817	1.155

Variate: CRUDE_FIBRE

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	2	0.01545	0.00772	0.11	
BLOCK.*Units* stratum					
DRYING_METHOD	1	12.91687	12.91687	188.41	<.001
HARVEST_STAGE	1	47.88008	47.88008	698.38	<.001
DRYING_METHOD.HARVEST_STAGE					
	1	24.45308	24.45308	356.68	<.001
Residual	6	0.41135	0.06856		
Total	11	85.67683			

***** Tables of means *****

Variate: CRUDE_FIBRE

Grand mean 13.667

DRYING_METHOD	OVEN-DRIED	SUN-DRIED
	14.705	12.630

HARVEST_STAGE	SPH1	SPH2
	15.665	11.670

DRYING_METHOD	HARVEST_STAGE	SPH1	SPH2
OVEN-DRIED		18.130	11.280
SUN-DRIED		13.200	12.060

*** Least significant differences of means (5% level) ***

Table	DRYING_METHOD	HARVEST_STAGE	DRYING_METHOD HARVEST_STAGE
rep.	6	6	3
d.f.	6	6	6
l.s.d.	0.3699	0.3699	0.5231

Variate: ETHER_EXTRACT

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	2	0.8750	0.4375	2.33	
BLOCK.*Units* stratum					
DRYING_METHOD	1	1.6875	1.6875	9.00	0.024
HARVEST_STAGE	1	0.1875	0.1875	1.00	0.356
DRYING_METHOD.HARVEST_STAGE					
	1	0.1875	0.1875	1.00	0.356
Residual	6	1.1250	0.1875		
Total	11	4.0625			

* MESSAGE: the following units have large residuals.

BLOCK 1 *units* 4 0.62 s.e. 0.31

***** Tables of means *****

Variate: ETHER_EXTRACT

Grand mean 3.12

DRYING_METHOD	OVEN-DRIED	SUN-DRIED
	2.75	3.50

HARVEST_STAGE	SPH1	SPH2
	3.25	3.00

DRYING_METHOD	HARVEST_STAGE	SPH1	SPH2
OVEN-DRIED		3.00	2.50
SUN-DRIED		3.50	3.50

*** Least significant differences of means (5% level) ***

Table	DRYING_METHOD	HARVEST_STAGE	DRYING_METHOD HARVEST_STAGE

rep.	6	6	3
d.f.	6	6	6
l.s.d.	0.612	0.612	0.865

Variate: ASH_CONTENT

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	2	0.3750	0.1875	0.69	
BLOCK.*Units* stratum					
DRYING_METHOD	1	1.6875	1.6875	6.23	0.047
HARVEST_STAGE	1	1.6875	1.6875	6.23	0.047
DRYING_METHOD.HARVEST_STAGE					
	1	0.1875	0.1875	0.69	0.437
Residual	6	1.6250	0.2708		
Total	11	5.5625			

***** Tables of means *****

Variate: ASH_CONTENT

Grand mean 10.38

DRYING_METHOD	OVEN-DRIED	SUN-DRIED
	10.75	10.00

HARVEST_STAGE	SPH1	SPH2
	10.00	10.75

DRYING_METHOD	HARVEST_STAGE	SPH1	SPH2
OVEN-DRIED		10.50	11.00
SUN-DRIED		9.50	10.50

*** Least significant differences of means (5% level) ***

Table	DRYING_METHOD	HARVEST_STAGE	DRYING_METHOD HARVEST_STAGE
rep.	6	6	3
d.f.	6	6	6
l.s.d.	0.735	0.735	1.040

Analysis of Variance (ANOVA) Tables for proximate nutrients of samples from Bolgatanga

Variate: MOISTURE_CONTENT

Grand mean 15.52

DRYING_METHOD	OVEN-DRIED	SUN-DRIED
	15.52	15.52

HARVEST_STAGE	SPH1	SPH2
	16.47	14.57

DRYING_METHOD	HARVEST_STAGE	SPH1	SPH2
OVEN-DRIED		16.47	14.57
SUN-DRIED		16.47	14.57

*** Least significant differences of means (5% level) ***

Table	DRYING_METHOD	HARVEST_STAGE	DRYING_METHOD HARVEST_STAGE
rep.	6	6	3
d.f.	6	6	6
l.s.d.	1.357	1.357	1.920

Variate: CRUDE_PROTEIN

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.

BLOCK stratum	2	1.1250	0.5625	0.61	
BLOCK.*Units* stratum					
DRYING_METHOD	1	6.7500	6.7500	7.26	0.036
HARVEST_STAGE	1	100.9200	100.9200	108.61	<.001
DRYING_METHOD.HARVEST_STAGE					
	1	4.3200	4.3200	4.65	0.074
Residual	6	5.5750	0.9292		
Total	11	118.6900			

***** Tables of means *****

Variate: CRUDE_PROTEIN

Grand mean 29.05

DRYING_METHOD	OVEN-DRIED	SUN-DRIED
	29.80	28.30

HARVEST_STAGE	SPH1	SPH2
	31.95	26.15

DRYING_METHOD	HARVEST_STAGE	SPH1	SPH2
OVEN-DRIED		32.10	27.50
SUN-DRIED		31.80	24.80

*** Least significant differences of means (5% level) ***

Table	DRYING_METHOD	HARVEST_STAGE	DRYING_METHOD HARVEST_STAGE
rep.	6	6	3
d.f.	6	6	6
l.s.d.	1.362	1.362	1.926

Variate: CRUDE_FIBRE

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	2	0.2888	0.1444	0.31	
BLOCK.*Units* stratum					
DRYING_METHOD	1	40.9591	40.9591	88.52	<.001
HARVEST_STAGE	1	77.8771	77.8771	168.30	<.001
DRYING_METHOD.HARVEST_STAGE	1	0.0091	0.0091	0.02	0.893
Residual	6	2.7764	0.4627		
Total	11	121.9104			

***** Tables of means *****

Variate: CRUDE_FIBRE

Grand mean 14.87

DRYING_METHOD	OVEN-DRIED	SUN-DRIED
	13.02	16.72

HARVEST_STAGE	SPH1	SPH2
	12.32	17.42

DRYING_METHOD	HARVEST_STAGE	SPH1	SPH2
OVEN-DRIED		10.50	15.54
SUN-DRIED		14.14	19.29

*** Least significant differences of means (5% level) ***

Table	DRYING_METHOD	HARVEST_STAGE	DRYING_METHOD HARVEST_STAGE
rep.	6	6	3
d.f.	6	6	6
l.s.d.	0.961	0.961	1.359

Variate: ETHER_EXTRACT

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	2	0.5000	0.2500	1.00	
BLOCK.*Units* stratum					
DRYING_METHOD	1	4.6875	4.6875	18.75	0.005
HARVEST_STAGE	1	1.6875	1.6875	6.75	0.041
DRYING_METHOD.HARVEST_STAGE	1	1.6875	1.6875	6.75	0.041
Residual	6	1.5000	0.2500		
Total	11	10.0625			

* MESSAGE: the following units have large residuals.

BLOCK 1	*units* 3	0.75	s.e. 0.35
BLOCK 3	*units* 3	-0.75	s.e. 0.35

***** Tables of means *****

Variate: ETHER_EXTRACT

Grand mean 2.12

DRYING_METHOD	OVEN-DRIED	SUN-DRIED
	2.75	1.50

HARVEST_STAGE	SPH1	SPH2
	2.50	1.75

DRYING_METHOD	HARVEST_STAGE	SPH1	SPH2
OVEN-DRIED		3.50	2.00
SUN-DRIED		1.50	1.50

*** Least significant differences of means (5% level) ***

Table	DRYING_METHOD	HARVEST_STAGE	DRYING_METHOD HARVEST_STAGE
rep.	6	6	3
d.f.	6	6	6
l.s.d.	0.706	0.706	0.999

Variate: ASH_CONTENT

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	2	3.12500	1.56250	25.00	
BLOCK.*Units* stratum					
DRYING_METHOD	1	1.68750	1.68750	27.00	0.002
HARVEST_STAGE	1	0.18750	0.18750	3.00	0.134
DRYING_METHOD.HARVEST_STAGE	1	9.18750	9.18750	147.00	<.001
Residual	6	0.37500	0.06250		
Total	11	14.56250			

* MESSAGE: the following units have large residuals.

BLOCK 1	*units* 3	0.375	s.e.	0.177
BLOCK 3	*units* 3	-0.375	s.e.	0.177

***** Tables of means *****

Variate: ASH_CONTENT

Grand mean 12.125

DRYING_METHOD	OVEN-DRIED	SUN-DRIED
	12.500	11.750

HARVEST_STAGE	SPH1	SPH2
	12.000	12.250

DRYING_METHOD	HARVEST_STAGE	SPH1	SPH2
OVEN-DRIED		11.500	13.500
SUN-DRIED		12.500	11.000

*** Least significant differences of means (5% level) ***

Table	DRYING_METHOD	HARVEST_STAGE	DRYING_METHOD HARVEST_STAGE
rep.	6	6	3
d.f.	6	6	6
l.s.d.	0.3532	0.3532	0.4995

Variate: CARBOHYDRATE

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	2	7.975	3.988	1.06	
BLOCK.*Units* stratum					
DRYING_METHOD	1	0.114	0.114	0.03	0.868
HARVEST_STAGE	1	28.923	28.923	7.68	0.032
DRYING_METHOD.HARVEST_STAGE					
	1	13.803	13.803	3.66	0.104
Residual	6	22.604	3.767		
Total	11	73.420			

***** Tables of means *****

Variate: CARBOHYDRATE

Grand mean 26.32

DRYING_METHOD	OVEN-DRIED	SUN-DRIED
	26.41	26.22

HARVEST_STAGE	SPH1	SPH2
	24.76	27.87

DRYING_METHOD	HARVEST_STAGE	SPH1	SPH2
OVEN-DRIED		25.93	26.89
SUN-DRIED		23.59	28.84

*** Least significant differences of means (5% level) ***

Table	DRYING_METHOD	HARVEST_STAGE	DRYING_METHOD HARVEST_STAGE
rep.	6	6	3
d.f.	6	6	6
l.s.d.	2.742	2.742	3.878

Analysis of Variance (ANOVA) Tables for Agronomic data taken from both locations

Completely Randomized AOV for das50g

Source	DF	SS	MS	F	P
Treatment	1	0.16667	0.16667	0.50	0.5185
Error	4	1.33333	0.33333		
Total	5	1.50000			

Grand Mean 11.500 CV 5.02

Completely Randomized AOV for das50f

Source	DF	SS	MS	F	P
Treatment	1	0.66667	0.66667	1.00	0.3739

Error	4	2.66667	0.66667
Total	5	3.33333	

Grand Mean 24.667   CV 3.31

Completely Randomized AOV for Height

Source	DF	SS	MS	F	P
Treatment	1	6.0000	6.0000	0.27	0.6291
Error	4	88.0000	22.0000		
Total	5	94.0000			

Grand Mean 28.000   CV 16.75

Completely Randomized AOV for No

Source	DF	SS	MS	F	P
Treatment	1	0.1667	0.1667	0.01	0.9142
Error	4	50.6667	12.6667		
Total	5	50.8333			

Grand Mean 22.167   CV 16.06

Completely Randomized AOV for No~01

Source	DF	SS	MS	F	P
Treatment	1	0.1667	0.1667	0.01	0.9164
Error	4	53.3333	13.3333		
Total	5	53.5000			

Grand Mean 23.500   CV 15.54

APPENDIX 4: **Colour plates**

Colour plate 1: ***Corchorus olitorius***

Colour plate 1: Roselle (*Hibiscus sabdariffa* L.)

Colour plate 2: Spider flower (*Cleome gynandra* L.)

Colour plate 3; Kenaf (*Hibiscus cannabinus*)

Colour plate 4: Bitter leaf *(Venonia amygdalina* Del.*)*

Colour plate 5: Cowpea Leaves (*Vigna unguiculata* L.)

Colour plate 7: African Spinach (*Amaranthus cruentus*)

Colour plate 8: Pumpkin Leaves (*Cucurbita maxima*)

Colour plate 6: ***Saalimva-zagsika***

Colour plate 7: ***Saalim***

Colour plate 9: ***Frikaludaa***

Colour plate 10: ***Lebkoliko***