UNIVERSITY OF CAPE COAST

NUTRITIONAL VALUE OF TURKEY BERRY

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2015

UNIVERSITY OF CAPE COAST

NUTRITIONAL VALUE OF TURKEY BERRY

BY

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Thesis submitted to the Department of Vocational and Technical Education of the College of Education Studies, University of Cape Coast, in partial fulfilment of the requirements for the award of Master of Philosophy Degree in Home Economics.

JULY 2015

DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own research and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature:............................

Date:.......................................

Name: Mabel Ogah

Supervisors' Declaration

We hereby declare that the preparation and the presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Principal Supervisor's Signature...................... Date............................

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Co-supervisor's Signature........................... Date............................

Name: Prof. Joseph K. Ogah

ABSTRACT

The study determined the amount of selected nutrients in the fruits of Turkey berry*(Solanum torvum sw.)* and any significant difference(s) heathad on nutrient content. Samples of Turkey berries were bought from the market, cleaned, ground (raw, boiled or roasted) and tested. Results were then analysed using means, percentages and ANOVA. A survey was also conducted to ascertain the level of consumption and knowledge froma sample of pregnant women inCape Coast Metropolis. Proximate analysis of the Turkey berries showed high levels of minerals such as potassium, iron, calcium, phosphorus and magnesium but low levels of major nutrients such as carbohydrates, fats and protein. However,the percentages Daily Value of most nutrients were high with the exception of carbohydrate (3.86%). Boiling caused a significant decrease in most of the nutrients in the Turkey berries(potassium and iron decreased from 1673.67mg to 1527.87mg and 18.30 to 17.07mg subsequently) with the exception of Fibre (p=.06). From the survey, it was ascertained that 90% of pregnant women in the Cape Coast Metropolis consumeTurkey berries. However between 65% and 84% of the respondents reported have little knowledge on the nutritional value of Turkey berries.

A conclusion was drawn that Turkey berries is nutritious. It was also concluded that boiling affects the nutritional value of Turkey berry. Therefore it was recommended that 100g or more may be consumed daily and if possible in the raw state. Pregnant women should increase their consumption ofTurkey

berry in the right way to enable them meet their extra iron requirement.

ACKNOWLEDGEMENTS

I sincerely thank my mainacademic supervisor, Prof. (Mrs.) Sarah Darkwa for her immeasurable assistance and good guidance. Out of her very busy schedules, she still found time to give me the maximum attention I needed in the study. I am also grateful to Prof. Joseph Ogah of the Department of Health, Physical and Recreation and Mr Stephen Adu of the Agric Technology Village, UCC for their enormous support to me during the study. I extend my thanks to my husband Mr. Gabriel Apotey and my siblings for their moral and financial support during the study.

DEDICATION

To my entire family.

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LIST OF ABBREVIATIONS

AAS	Atomic Absorption Spectrophotometer
AFPA	African fitness professional and associates
AI	Adequate Intake
ALV	African leafy vegetables
ANOVA	Analyses of variance
AOAC	Association of Official Analytical Chemists
ATP	Adenosine triphosphate
AV	African vegetables
cAMP	Cyclic adenosine monophosphate
Conc	Concentration
CuZnSOD	Copper-zinc superoxide dismutase
DGA	Dietary Guidelines for Americans
DHSS	Department of Health and Social Security
DM	Dry matter
DNA	Deoxyribonucleic acid
DV	Daily Value
EBT	Erichrome Black T
EDTA	Ethylene diaminetetra-acetic acid
FAO	Food and Agriculture Organization
g	Grams
GABA	Gamma-aminobutyric acid
GhC	Ghana cedi
Gp	Ghana pesewas

GSS	Ghana statistical service
Hb	Haemoglobin
HIF	Hypoxia inducible factors
HSD	Honest significance difference
IAV	Indigenous African vegetable
IITA	International Institute of tropical Agriculture
ILV	Indigenous leafy vegetable
IOM	Institute of Medicine
Mg ATP	Magnesium Adenosine triphosphate
Ml	Millilitres
NADH	Nicotinamide adenine dicleotide
RDA	Recommended Dietary Allowance
RDI	Recommended daily intake
RNA	Ribonucleic acid
ROS	Reactive oxygen species
SSA	Sub Sahara African
TALV	Traditional African leafy vegetable
TAV	Traditional African vegetable
TDF	Total dietary fibre
TEA	Triethanolamine
TLV	Traditional leafy vegetables
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

In tropical Africa, especially among poor societies where the daily diet is often dominated by a limited number of starchy staples and coarse grains, African indigenous vegetables are the cheapest and most readily available sources of vitamins especially vitamin A, minerals and proteins from some nuts and legumes (Martin & Meitner, 1998; Bosland & Votava, 2000). Though staple foods are often low in fat and high in fibre and thus contribute to the health of individuals, they do offer less variety than vegetables do. Several different types of vegetables grow in the wild or are grown in home gardens and consumed in Ghana.

Background to the Study

Turkey berry is one vegetable that grows in the wild in Ghana and has been used in food preparation over the centuries. Traditionally, it is added to palm fruits to make soup. Although it has taken a while for its true nutritional and medicinal values to be recognized in Ghana (Asiedu-Darko, 2010), it has in recent times been vigorously sought after for its medicinal properties (Asiedu-Darko, 2010). Compared to other regions like Thailand, India, and South America, where it has been consumed for medicinal purposes for so long, (Agrawal, Bajpei, Patil & Bavaskar, 2010) there are hardly any documented recipes that use the Turkey berry in Ghana. The sale of Turkey berry in Ghana has moved from selling on tables in the market to being packaged in polythene bags and sold not just in the market but in stores and shopping malls. Packaging the berry and making them more attractive and acceptable to the average Ghanaian consumer may help increase its consumption. Asiedu-Addo (2014), reports that Turkey berry is believed to boost blood levels and is often used in preventing and treating anaemia. The rise in the consumption of the berry has also been attributed to the fact that doctors, midwives and traditional healers often recommend it for patients who are anaemic to help improve blood haemoglobin levels and general immune function.

However, there is no documented scientific evidence in the Ghanaian literature that Turkey berry (*Solanum torvum sw.*) improves blood levels though research elsewhere has reported some health benefits of. Arthan, Kittakoop, Esen and Svasti (2009), reported a moderate α-glucosidase inhibitory action of the berry, making it a possible anti-diabetic agent. They further explained that the berry decrease postprandial hyperglycemia where glucose absorption is reduced by preventing carbohydrate hydrolysis through reduction of α-amylase and α-glucosidase in the digestive organs. Other studies also report the steroidal compounds and antiviral activities of Turkey berry as well as the anticancer properties of the glycoalkaloids and molluscidal activity of crude extract of the solanum fruits which make it act as potential immunomodulators (Umamaheswari, Shreevidya & Nuni, 2008; Silva, Batista, Camara & Agra, 2005).

Statement of the Problem

Although Turkey berry is often recommended to anaemic patients and pregnant women by doctors, midwives and traditional healers in Ghana (Asiedu-Addo, 2014), its therapeutic value is seen more as a myth than documented scientific fact. The farthest some researchers in Ghana have gone is to report the beliefs and perceptions of consumers (Asiedu-Darko, 2010; Asiedu-Addo, 2014) about the nutritional and medicinal properties of the berry with very little documented scientific information on the constituents and the pharmacological elements.Whether it is a myth or not, coupled with the rising cost of medications in developing countries where majority of individuals still rely on traditional medicines, it is necessary to investigate the potential of using Turkey berry for the said medicinal purposes. This can be successfully done by identifying the chemical constituents of Turkey berry growing in Ghana. It will also be important to determine the level of consumption of the berry among the Ghanaian populace and also the various forms in which they eat the berry.

Purpose of the Study

The first purpose of this study was to determine the nutritional composition of Turkey berry grown in Ghana, specifically in the Cape Coast Municipality in the Central Region of Ghana, and ascertain how the identified nutrients relate to the stated medicinal and nutritional benefits. The second purpose was to explore the extent of knowledge and consumption of Turkey berry from a survey of a group of pregnant women living in the Cape Coast Metropolis and attending antenatal care in the Cape Coast metropolitan health care centres..

Objectives of the Study

The objectives of the study were to:

1. determine the nutritional constituents of Turkey berry

2. identify the form in which these berry present the optimal levels of nutrients (i.e. raw, parboiled and, boiled.)
3. what is the nutritional value of turkey berry as compared to other vegetables
4. find out from a sample of pregnant women their consumption levels of the berry
5. find out from a sample of pregnant women their knowledge of the uses and benefits of Turkey berry

Research Questions

The study addressed the following research questions:

1. What are the nutritional constituents of Turkey berry?
2. Does the form in which turkey berry is prepared and eaten affect the availability of nutrients?
3. What is the consumption level of Turkey berry among pregnant women?
4. What is the knowledge level of pregnant women on the uses and benefits of Turkey berry?

Significance of the Study

It is hoped that findings from this study will help:

1. promote consumption of these berry
2. compliment the scanty documented information on the nutritional and medicinal benefits of eating Turkey berry

3. consumers know the best form in which to prepare and consume turkey berry to obtain the maximum nutritional and medicinal benefits
4. highlight the need for further studies and form the basis on which other studies would build.

Delimitation of the Study

Food contains a number of nutrients ranging from micro to macro nutrients including phytochemicals that are considered important in the metabolism of other nutrients. This research is delimited to the search of only the following nutrients: carbohydrate, protein, fibre, fats and oils, iron, calcium, potassium, phosphorus, magnesium, zinc and copper in turkey berry. In turkey berry preparation prior to consumption, it could be dried as used in sundakkai (an Indian food) or cooked fresh as well as eaten raw. For the purpose of this research, only the fresh raw and fresh cooked berry was tested. Even though Turkey berry grows wild and could sometimes be obtained from backyards or disturbed lands, the one used for the study was bought from the market at Abura in the Cape Coast Metropolis in the Central Region of Ghana. This is because 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 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. Also Soetan et al. (2010) stated that location has been reported to influence the mineral and trace element compositions of rice, wheat, oats and barley. 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. The survey was also delimited to only pregnant women because it is believed it gives blood and pregnant women are one group that has high iron needs.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

Introduction

This chapter presents a review of literature related to the medicinal and nutritional benefits of Turkey berry. It also presents information on uses and consumption of the berry in other parts of the world where they have been used over the years in Ghana.

Background of Wild Vegetables

Knowledge of wild gathered foods has been passed on from previous generations. In different regions of the world, there is a great variation in species, in preparations and use of such foods. They can be used throughout the whole year, but more often they are used during a time of scarcity. They are important during periods of famine. Although there seems to be an increase in the interest for, and understanding of, wild gathered foods as an important resource, including as food, the potential nutritive values of most of these foods have not been analyzed systematically. It is difficult to find literature and food composition tables which include gathered wild foods (Nordeide et al*.,* 1994). The first comprehensive composition tables of Australian Aboriginal foods have been reported by Miller et al. (1993). The information in Miller's book is not only used by Aborigines themselves but by a variety of professionals like dietitians, school teachers, anthropologists, epidemiologists and agricultural scientists (Nordeide et al*.,* 1994).

Review of the literature reveals that there is some documentation on the use of wild foods in Africa. Grivetti et al. (1987) gives a systematic assessment of published literature on the dietary use of wild plants in many African societies. From West Africa, Diarra (1977) lists more than 40 edible plants used in different seasons near Bamako in Mali. Glew et al. (1997) in a study of 24 indigenous plants of Burkina Faso found out that these plants were good sources of protein (some three plants had as high as 20-37 % protein), essential amino acids, essential fatty acids such as linoleic and linolenic acids and micronutrients such as iron and zinc. A study carried out by Kim and colleagues (1997) in the Republic of Niger on the seeds of *Boscia senegalensis*, which is used as a famine food, revealed that these seeds contain substantial quantities of arginine, tryptophan and essential fatty acids such as linoleic acid, as well as zinc and iron. Ogle and Grivetti (1985) in their articles on wild gathered foods discussed the dietary utilization of edible wild plants in the kingdom of Swaziland, Southern Africa. Salih et al. (1992) compared wild grasses with local staple cereals in an area of Western Sudan. They found that wild grains of *C. biflorus* were particularly high in protein concentration. Becker (1983; 1986) studied the contribution of wild plants to human nutrition in Northern Senegal and the Sahelian Zone. Among the plants growing in Northern Senegal, 50% have valuable edible parts. They also found out that these plants were important sources of vitamins A, C and riboflavin.

Despite all the documentation on the identity, distribution and uses of edible wild foods in Africa in general, and in Ghana in particular, there is a paucity of information on their chemical composition. Most of the work on wild foods documented from Ghana has been on edible wild fruits (FAO, 1983). Smith (2002), in her listing of 'useful plants in Ghana' does include vegetables. *Solanum nigrum* is listed as being edible in some parts of the country. There is, however, no mention ofTurkey berry. In general, there is little, if any information on the wild fruit vegetable, Turkey berry, which is eaten widely in the southern part of the country. This study therefore, was undertaken to obtain basic data on the chemical composition for this wild vegetable, Turkey berry, and to begin the process of compiling data on the chemical composition of wild indigenous wild vegetables of Ghana.

Turkey Berry as a vegetable

According to Arthan, et al (2002), Turkey berry is also called pea aubergine or the Devil's Fig and scientifically called *Solanum torvum sw.* Turkey berry is widely used for culinary and medicinal purposes in Thailand (Arthan, et al 2002). There are several vegetables that grow in the wild in Ghana which are well patronized by individuals such as "kontomire' or Colossia leaves. There are others such as the Turkey berry which also grow in the wild but although eaten by individuals, has not been popular like 'kontomire'. It is usually the berry or fruits of the plant that are eaten, although some individuals pick the leaves, boil and drink. Vegetables in general and green leafy ones specifically are usually known to have higher concentrations of vitamins, minerals, fibre and other beneficial compounds which are used in addition to staple foods for a balanced meal. The use of turkey berry as vegetable in dishes may provide some nutrients derived from vegetables in general. Most green leafy vegetables are good sources of iron and when consumed with a variety of foods, help to achieve optimum body and brain growth, development and maintenance, and general good health (Beard

&Dawson, 1997). They also concluded that vegetables tend to reduce the glycemic load when eaten with high-energy foods like bread and polished rice making it ideal for weight loss. Knowledge of the health promoting and protecting attributes of some vegetables is clearly linked to their nutritional and non-nutrient bioactive properties. Vegetables are full of water, especially when eaten raw, and this water aids their digestion when eaten thus reducing the pressure often exerted on the digestive systems (Lussier, 2010). This implies that the body uses less energy and resources to digest and assimilate nutrients from vegetables easily. Vegetables are high in cellulose and fibres similar to fruits, thus help in the prevention of several diseases including colon cancer when consumed in right amounts repeatedly (Lussier, 2010). Kwenin, Wolli and Dzomeku (2011), report that Amaranthus leaves "Aleefu" an example of green leafy vegetable is grown for its leaves which are rich in beta-carotene, calcium, iron and vitamin C.

Green vegetables are also a source of minerals such as zinc, iron and potassium. In Willett(1995) and Liu (2003), there are reports of vegetables containing non-nutrient bioactive phytochemicals that have been linked to protection against cardiovascular and other degenerative diseases. Similarly, Kannan, Dheeba, Gurudevl and Singh, (2012) identified phytochemical, antibacterial and antioxidant properties of Turkey berry. Roger (2011), suggests that the role of vegetables and fruits in preventing heart disease is a protective one. Risk reduction has been estimated as high as 20-40% among individuals who consume substantial amounts of fruits and vegetables. People living with coronary heart disease are able to reduce blockage modestly through exercise and an extremely low-fat, diet rich in fruits and vegetables.

Definition of Indigenous Vegetables

The word *indigenous* is used to describe vegetables that have their natural habitat in a country and those that were introduced from other regions of the world. The introduced vegetables due to long use became part of the food culture in that country (Chweya & Eyzaguirre, 1999**).** There are two main classes of vegetables in Sub Saharan Africa urban and peri-urban agriculture. One group is exotic vegetables that originate from outside of the continent, and the second group comprises indigenous or traditional African vegetables. Providing a single and widely accepted definition of a traditional African vegetable is fraught with difficulty, and is open to as much, if not more, debate than that surrounding definitions of urban agriculture. There are a host of terms describing traditional African vegetables, including indigenous African vegetable (IAV); indigenous leafy vegetable (ILV); African leafy vegetable (ALV); traditional African vegetable (TAV); traditional African leafy vegetable (TALV or TLV) – and all are subject to contested meanings (Odhav et al., 2007)

According to the United Nations Food and Agriculture Organization (FAO, 1988), traditional vegetables are all categories of plants whose leaves, fruits or roots are acceptable and used as vegetables by urban and rural communities through custom, habit and tradition. Before the introduction of exotic crops and associated weeds, traditional vegetables would have been found in the wild or were semi-domesticated varieties of the indigenous flora.

For some academics and practitioners, this means that ‘traditional African vegetables’ are defined as ‘wild’ plants, or semi-domesticated species that are part of traditional diets and may often be relied on as foods during periods of crop failure or famine. Gockowski et al. (2003) define traditional leafy vegetables as those leafy green vegetables that have been originally domesticated or cultivated in Africa for the last several centuries. As time has passed, however, those vegetables which are now used ‘according to custom and tradition’ may include introduced species, so that for some people the term African traditional vegetables goes as far as including exotic produce such as tomatoes which are now customarily used by African populations. The distinction continues to be made with separate green leafy vegetables, casually referred to as ‘African spinaches’, as a particular group with stronger ties to the indigenous flora and with specific nutritional characteristics(Ejoh et., 2007).

African indigenous vegetables or traditional African vegetables as names that refer to those plants which originate on the continent, or those which have such a long history of cultivation and domestication to African conditions and use that they have become ‘indigenized’. To be specific, the predominant exotic vegetables found in SSA metropolitan areas are carrot (*Daucus carota var*.), tomato (*Lycopersicon esculentum var*.), green beans (*Phaseolus vulgaris*), onions (*Allium spp*.), cabbage (*Brassica oleracea*), lettuce (*Lactuca sativa*), and chard (*Beta vulgaris var*.). Important indigenous or traditional African vegetables include okra (*Abelmoschus esculentus*), sweet potato (*Ipomoea batatas*), cowpea (*Vigna unguiculata*), yams (*Discorea spp*.), and taro tubers (*Colocasia esculenta and Xanthasoma spp*.).

In terms of the leafy species alone, a range of species from several major families of plants are used, with the genera *Amaranthus, Agathosma, Bidens, Cleome, Chenopodium, Corchorus, Crotalaria, Cucurbita, Ipomoea, Solanum, Vernonia* and *Vigna* being the most conspicuous (Coetzee et al*.*, 1999; Shackleton, 2003; Pichop, 2007). There is variation in the dominant plant families and species utilized by region and country according to the interplay of ecology and cultural preference. In West and Central African cities, the most common and popular leafy vegetables are sweet potato leaves (*Ipomoea spp*.), pumpkin (*Cucurbita spp*.) and wild spinach (*Amaranthus spp.*); in East and Southern Africa the African nightshades (*Solanum spp*.), wild spinach (*Amaranthus spp*.), spider plant (*Cleome spp*.) and pumpkins (*Cucurbita spp.*) predominate (Pichop, 2007). It is also worth noting the increasing significance of Ethiopian kale (*Brassica carinata*), which is being promoted in urban agriculture across the continent as a more nutritious indigenous alternative to exotic cabbage. Despite this variety of African indigenous vegetables, the focus of contemporary urban and peri-urban vegetable production in most Sub Sahara African (SSA) cities has turned to the production of exotic crops and varieties.

Role of African Vegetables in Health Promotion and Protection

Quite a large number of African indigenous vegetables have long been known and reported to have health protecting properties. Several of these indigenous vegetables continue to be used for prophylactic and therapeutic purposes by rural communities (Ayodele, 2005). Indigenous knowledge of the health promoting and protecting attributes of African Vegetables (AVs) is clearly linked to their nutritional and non-nutrient phytochemical properties. AVs have long been, and continue to be reported to significantly contribute to the dietary vitamin and mineral intakes of African populations (Mulokozi et al., 2004).

More recent reports have shown that African indigenous vegetables also contain non-nutrient bioactive phytochemicals that have been linked to protection against cardiovascular and other degenerative disease. However, Orech, Akenga, Ochora, Friis and Aagaard-Hansen (2005), observed that some of these phytochemicals found in some African vegetables consumed in Western Kenya may pose toxicity problems when consumed in large quantities or over a long period of time. In spite of this body of evidence confirming the nutritional contribution of African vegetables to local diets, and their health maintenance and protective properties, there has been very little concerted effort towards exploiting this biodiversity nutritional and health resource to address the complex food, nutrition and health problems of Ghana.

Nutritional Importance of African Vegetables

Wild food plants play a very important role in the livelihoods of rural communities as an integral part of the subsistence strategy of people in many developing countries (Zamede et al., 2001). Locally available wild food plants serve as alternatives to staple food during periods of food deficit, are a valuable supplement for a nutritionally balanced diet and are one of the primary alternative sources of income for many poor rural communities (Scoones et al., 1992). Millions of people in many developing countries do not have enough food to meet their daily requirements and a further more people are deficient in one or more micronutrients (Campbell, 1987). In most cases, rural communities depend on wild resources including wild edible plants to meet their food needs in periods of food crisis. The diversity in wild species offers variety in family diet and can contribute to household food security (Zinyama et al., 1990; Zamede et al., 2001). Guerreroet al. (1998) compiled a comprehensive nutrient report of wild vegetables consumed by the first European farmers, and nearly all the species had significant amounts of several micronutrients such as copper, magnesium, zinc, iron, vitamin E, carotenoids and vitamin C. Turan,et al (2003) reported that the potassium, calcium, magnesium and protein contents of wild vegetables in Turkey were all higher than cultivated species. The cultivated species analysed and compared to the wild vegetables were spinach, pepper, lettuce, and cabbage. Concentrations of iron, manganese, zinc and copper were similar in both vegetable types. Studies conducted by Booth,et al (1992) and Freyre et al. (2000) in South America have confirmed the importance of wild vegetables as sources of micronutrients. Studies conducted on wild South African vegetables by Freiberger et al. (1998) and Vainio-Mattila (2000) in Tanzania underscored the wild plants' significant contribution as sources of micronutrients. However, the nutritional quality of four wild vegetables analysed in Ghana was found to be in the same range as conventional vegetables (Wallace et al., 1998). All the researches showed that wild plants are essential components of many Africans' diets, especially in periods of seasonal food shortage. A study conducted in Zimbabwe revealed that some poor households rely on wild plant foods as an alternative to cultivated food for a quarter of all dry season meals (Kabuye, 1997).

Use of Indigenous Food Crops

Although modern agriculture and the food supply of industrial societies is based on a handful of plant species, traditional agriculturalists, pastoralists and hunters/gatherers in most African countries use a myriad of plants for food, medicine, construction, etc. Central to such practices is the exploitation of wild food resources. However, dietary utilization of non-domesticated plants has received very little attention in economic development efforts. Paralleling this omission has been the revelation that despite increased food production in some sectors, there has been a drastic narrowing of the food base in many traditional societies. By focusing on a limited number of cultivars of a few staple food crops, a vulnerable position is created, not only because diversification assures dietary balance and facilitates intake of micro-nutrients but through danger of domesticated crop destruction by drought or insect pests (Ogle & Grivetti, 1985). Although indigenous crops may not be as high yielding as crops of global importance, they can provide stable production under adverse ecological conditions, such as high aridity. Alternatively, they may be harvestable during seasons when other foods are scarce (Johns, 1994). Turkey berry for example, suffers relatively few diseases and pests, is tolerant to soil moisture stress and has excellent storage qualities (Barbeau & Hilu, 1993). It also has a growth cycle of only three months and thus can provide two harvests a year if cultivated.

Although nutrient composition of most indigenous crops has not been analyzed, these species may be rich sources of vitamins, minerals or amino acids that complement other components of the diet. (FAO, 1983). The nutrient data on those species that have been analysed, reveal that they are often comparable, superior in some instances, to most staple foods. For example, finger millet has been found to be a good nutrient source with relatively high calcium content (Barbeau & Hilu, 1993). Carr (1958), reported high calcium and phosphorus values for *Adenia gummifera, Amaranthus gummiferria, Amaranthus thunbergii, Bidens pilosa, Corchorus tridens and Gynandropsis gynandra.* Some indigenous leafy vegetables have been found to be particularly valuable sources of provitamin A, vitamin C, folate, iron and protein. Examples include *Amaranthus caudutus, Amaranthus gracilis, Amaranthus thunbergii, Bidens pilosa, Corchorus tridens*, *Momordica balasania and Gynandropsis gynandra* which provide a complement to diets high in carbohydrate (Akhtar, 1987). It has also been found that an increased incidence of chronic diseases, such as diabetes, is experienced by many indigenous people as they adopt western diet and lifestyles. Plant foods in traditional diets are higher in fibre than western diets and the carbohydrates they contain are digested more slowly (Thorburn et al*.*, 1987). Hence, dietary incorporation or maintenance of indigenous food crops could be highly advantageous to marginal populations or to specific vulnerable groups within populations. In addition, researchers have, during the last 20 years, documented declining interest among younger people for traditional food sources. This change has led to substantial losses in knowledge about edible wild resources. Rapid economic and technological development may further contribute to a decline in the customary use of indigenous dietary resources. When this occurs, lost is both the knowledge and skills of recognition and identification of climatically adapted food resources that have previously sustained societies (Ogle & Grivetti, 1985).

Patterns of Consumption of African Vegetables

Information on the *per capita* consumption of African indigenous Vegetables is just as scarce as data on their production levels. It is generally believed that the introduction of exotic vegetable varieties contributed to the decline in the production and consumption of indigenous vegetables (Adedoyin & Taylor, 2000). Reports of a steady decline in dietary intakes of the African vegetables with the emergence of simplified diets are based on the assumption of declining use as a result of declining availability (Okeno et al., 2003; Community Technology Development Trust, 2000). Contrary to the view of declining use as a result of declining availability, Maziya-Dixon et al. (2004) reported that in Nigeria, vegetables are relatively available and affordable particularly during the rainy seasons but were found to be among the least consumed foods. Ruel et al. (2004) reported the consumption of vegetables in sub-Saharan Africa and in the study the reported common vegetables included onions, carrots, tomatoes and cabbage.

Proximate Compositions of Indigenous Vegetables

Proximate and nutrient analyses of indigenous vegetables play a crucial role in assessing their nutritional significance (Pandey et al., 2006).

Proximate analysis is used to estimate the relative amounts protein, lipid, water, ash and carbohydrate in an organism. This is the proximate composition of the organism. Protein, lipid and carbohydrate each contribute to the total energy content of an organism while water and ash only contribute mass. Determining the proximate composition of vegetables can be used to create quality controls for various materials, ensure that they do not contain hazardous chemicals, and check whether they are healthy enough to be consumed by humans or animals (Hall, Frrall & Ripen, 1978). In this sturdy proximate composition of some indigenous vegetables are discussed to understand the relevance of each component in food.

Moisture Content

Moisture refers to the presence a small quantity of liquid especially water (Webster,s Encyclopedic unabridged dictionary, 1994). 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 & 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.

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: simple 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 vegetablesVitex 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 (Vaclavik & Christian, 2008). The World Health Organization (WHO) protein figures translate into 56 g of protein a day for a (75 kg) man, and 48 g 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 & Massey, 2001).

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 & 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 & 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 & 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.

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.

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. They also 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 & Mnzava, 1997).

Carbohydrate Content

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 $C\ H_1\ O_4$. 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 & Mnzava, 1997). No specific carbohydrate requirements exist in humans (Osei, 2003).

Importance of some Macro and Micronutrients

Minerals are inorganic substances, present in all body tissues and fluids and their presence is necessary for the maintenance of certain physicochemical processes which are essential to life. They are used by the body in many ways. Although they yield no energy, they have important roles to play in many activities in the body (Malhotra, 1998; Eruvbetine, 2003). Every form of living matter requires these inorganic elements or minerals for their normal life processes (Ozcan, 2003). Minerals may be broadly classified as macro (major) or micro (trace) elements. The macro-minerals include calcium, phosphorus, sodium and chloride, while the micro-elements include iron, copper, cobalt, potassium, magnesium, iodine, zinc, manganese, molybdenum, fluoride, chromium, selenium and sulphur (Eruvbetine, 2003). The macro-minerals are required in amounts greater than 100 mg/dl and the micro-minerals are required in amounts less than 100 mg/dl (Murray et al., 2000).

The importance of mineral elements in human, animal and plantnutrition has been well recognized (Darby, 1976). Deficiencies or disturbances in the nutrition of an animal cause a variety of diseases and can arise in several ways (Gordon, 1977). When a trace element is deficient, a characteristic syndrome is produced which reflects the specific functions of the nutrient in the metabolism of the animal. The trace elements are essential components of enzyme systems. Simple or conditioned deficiencies of mineral elements therefore have profound effects on metabolism and tissue structure. To assess the dietary intake and adequacy of minerals, information needs to be collected on mineral element content of foods, diets and water (Simsek & Aykut, 2007). There is limited information on the trace element content of water and numerous plant foods consumed in some less developed countries.

The significance of the mineral elements in humans, animals and plants nutrition cannot be overemphasized. Mineral elements play important roles in health and disease states of humans and domestic animals. For example, iron deficiency anaemia and goitre due to iodine deficiency are reported to be problems of public health importance in some communities (Deosthale & Belavady, 1978).

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.

Iron has the longest and best described history among all the micronutrients. It is a key element in the metabolism of almost all living organisms. In humans, iron is an essential component of hundreds of proteins and enzymes (Beard & Dawson, 1997; Wood & Ronnenberg, 2006). Haeme is an iron-containing compound found in a number of biologically important molecules. Haemoglobin and myoglobin are haeme-containing proteins that are involved in the transport and storage of oxygen. Haemoglobin is the primary protein found in red blood cells and represents about two thirds of the body's iron. The vital role of hemoglobin in transporting oxygen from the lungs to the rest of the body is derived from its unique ability to acquire oxygen rapidly during the short time it spends in contact with the lungs and to release oxygen when needed during its circulation through the tissues. Myoglobin functions in the transport and short-term storage of oxygen in muscle cells, helping to match the supply of oxygen to the demand of working muscles (Yip & Dallman, 1996; Brody, 1999). Cytochromes are haeme-containing compounds that have important roles in mitochondrial electron transport; therefore, cytochromes are critical to cellular energy production and thus life. They serve as electron carriers during the synthesis of ATP, the primary energy storage compound in cells. Cytochrome P450 is a family of enzymes that functions in the metabolism of a number of important biological molecules, as well as the detoxification and metabolism of xenobiotics.

Non-haeme iron-containing enzymes, such as NADH Dehydrogenase and Succinate dehydrogenase, are also critical to energy metabolism (Yip

&Dallman, 1996).Catalase and peroxidases are haeme-containing enzymes that protect cells against the accumulation of hydrogen peroxide, a potentially damaging reactive oxygen species (ROS), by catalyzing a reaction that converts hydrogen peroxide to water and oxygen. As part of the immune response, some white blood cells engulf bacteria and expose them to ROS in order to kill them. The synthesis of one such ROS, hypochlorous acid, by neutrophils is catalyzed by the haeme-containing enzyme myeloperoxidase (Yip & Dallman, 1996; Brody, 1999). Inadequate oxygen, such as that experienced by those who live at high altitudes or those with chronic lung disease, induces compensatory physiologic responses, including increased red blood cell formation, increased blood vessel growth, and increased production of enzymes utilized in anaerobic metabolism. Under hypoxic conditions, transcription factors known as hypoxia inducible factors (HIF) bind to response elements in genes that encode various proteins involved in compensatory responses to hypoxia and increase their synthesis. Research indicates that an iron-dependent prolyl hydroxylase enzyme plays a critical role in regulating HIF and, consequently, physiologic responses to hypoxia (Ivan et al*.,* 2001; Jaakkola et al*.,* 2001). When cellular oxygen tension is adequate, newly synthesized HIFa subunits are modified by a prolyl hydroxylase enzyme in an iron-dependent process that targets HIFa for rapid degradation. When cellular oxygen tension drops below a critical threshold, prolyl hydroxylase can no longer target HIFa for degradation, allowing HIFa to bind to HIFb and form an active transcription factor that is able to enter the nucleus and bind to specific response elements on genes.

Ribonucleotide reductase is an iron-dependent enzyme that is required for DNA synthesis (Beard & Dawson, 1997; Fairbanks, 1999). Thus, iron is required for a number of vital functions, including growth, reproduction, healing, and immune function. The Recommended Dietary Allowance (RDA) for iron is based on the prevention of iron deficiency and maintenance of adequate iron stores in individuals eating a mixed diet (FNB, 2001).

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 homeostatically. 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 & Mnzava, 1997). A study by Mepba et al. (2007) indicated that blanching and cooking significantly (P 0.05) decreased levels of iron in the test vegetables.

Zinc

Zinc is an essential trace element for all forms of life. Clinical zinc deficiency in humans was first described in 1961, when the consumption of diets with low zinc bioavailability due to high phytic acid content was associated with "adolescent nutritional dwarfism" in the Middle East (Prasad et al., 1961). Since then, zinc insufficiency has been recognized by a number of experts as an important public health issue, especially in developing countries (Prasad, 1998). Numerous aspects of cellular metabolism are zinc-dependent. Zinc plays important roles in growth and development, the immune response, neurological function, and reproduction. On the cellular level, the function of zinc can be divided into three categories namely, catalytic, structural and regulatory (Cousins, 2006). Nearly 100 different enzymes depend on zinc for their ability to catalyze vital chemical reactions. Zinc-dependent enzymes can be found in all known classes of enzymes (FNB, 2001).

Zinc plays an important role in the structure of proteins and cell membranes. A finger-like structure, known as a zinc finger motif, stabilizes the structure of a number of proteins. For example, copper provides the catalytic activity for the antioxidant enzyme copper-zinc superoxide dismutase (CuZnSOD), while zinc plays a critical structural role (FNB, 2001; King & Cousins, 2006). The structure and function of cell membranes are also affected by zinc. Loss of zinc from biological membranes increases their susceptibility to oxidative damage and impairs their function (O'Dell, 2000).

Zinc finger proteins have also been found to regulate gene expression by acting as transcription factors. Zinc also plays a role in cell signalling and has been found to influence hormone release and nerve impulse transmission. Zinc has been found to play a role in apoptosis, a critical cellular regulatory process with implications for growth and development, as well as a number of chronic diseases (Truong-Tran et al*.,* 2000).

Since a sensitive indicator of zinc nutritional status is not readily available, the RDA for zinc is based on a number of different indicators of zinc nutritional status and represents the daily intake likely to prevent deficiency in nearly all individuals in a specific age and gender group (FNB, 2001).

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 & 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 & Swenson, 1985). In plants, calcium is taken up in the ionized form (as Ca). 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 & 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 & 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 & 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

Calcium is the most common mineral in the human body. About 99% of the calcium in the body is found in bones and teeth, while the other 1% is found in the blood and soft tissue. Calcium levels in the blood and fluid surrounding the cells must be maintained within a very narrow concentration range for normal physiological functioning. The physiological functions of calcium are so vital to survival that the body will demineralize bone to maintain normal blood calcium levels when calcium intake is inadequate. Thus, adequate dietary calcium is a critical factor in maintaining a healthy skeleton (Weaver & Heaney, 1999).

Calcium is a major structural element in bones and teeth. The mineral component of bone consists mainly of hydroxyapatite [Ca_1 (PO_4) $(OH)_2$] crystals, which contain large amounts of calcium and phosphate (Heaney, 2000). Bone is a dynamic tissue that is remodelled throughout life. Bone cells called osteoclasts begin the process of remodelling by dissolving or reabsorbing bone. Bone-forming cells called osteoblasts then synthesize new bone to replace the bone that was reabsorbed. During normal growth, bone formation exceeds bone resaborption. Osteoporosis may result when bone reabsorption chronically exceeds formation (Weaver & Heaney, 1999). Calcium plays a role in mediating the constriction and relaxation of blood vessels, nerve impulse transmission, muscle contraction, and the secretion of hormones like insulin (FNB, 1997). Excitable cells, such as skeletal muscle and nerve cells, contain voltage-dependent calcium channels in their cell membranes that allow for rapid changes in calcium concentrations. For example, when a muscle fibre receives a nerve impulse that stimulates it to contract, calcium channels the cell membrane to open to allow a few calcium ions into the muscle cell. These calcium ions bind to activator proteins within the cell, which release a flood of calcium ions from storage vesicles inside the cell. The binding of calcium to the protein, troponin-c, initiates a series of steps that lead to muscle contraction.

The binding of calcium to the protein, calmodulin, activates enzymes that breakdown muscle glycogen to provide energy for muscle contraction (Weaver & Heaney, 1999). Calcium is necessary to stabilize a number of proteins and enzymes, optimizing their activities. The binding of calcium ions is required for the activation of the seven vitamin K-dependent clotting factors in the coagulation cascade.

The term, coagulation cascade, refers to a series of events, each dependent on the other that stops bleeding through clot formation (Brody, 1999). Updated recommendations for calcium intake based on the optimization of bone health were released by the Food and Nutrition Board (FNB) of the Institute of Medicine in 1997. The setting of an Adequate Intake level (AI) rather than a Recommended Dietary Allowance (RDA) for calcium reflects the difficulty of estimating the intake of dietary calcium that will result in optimal accumulation and retention of calcium in the skeleton when other factors such as genetics, hormones, and physical activity, also interact to affect bone health (FNB, 1997).

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 in coordination and convulsions followed by death (Soetan et al*.,* 2010). Chronic or excessive vomiting and diarrhoea 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 magnesium-deficiency 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 & Mnzava, 1997).

Magnesium plays important roles in the structure and the function of the human body. The adult human body contains about 25 grams of magnesium. It contains 760 mg of magnesium at birth, approximately 5 g at age 4–5 months, and 25 g when adult. Of the body's magnesium, Over 60% of all the magnesium in the body is found in the skeleton, 30–40 % is found in muscles and soft tissues, 1 % is found in extracellular fluid (Shils, 1997). 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).

Magnesium is involved in more than 300 essential metabolic reactions, some of which are discussed below (Spencer et al*.,* 1994). The metabolism of carbohydrates and fats to produce energy requires numerous magnesium-dependent chemical reactions. Magnesium is required by the adenosine triphosphate (ATP)-synthesizing protein in mitochondria. ATP, the molecule that provides energy for almost all metabolic processes, exists primarily as a complex with magnesium (Rude & Shils, 2006). Magnesium is required for a number of steps during nucleic acid and protein synthesis. Several enzymes participating in the synthesis of carbohydrates and lipids require magnesium for their activity. Glutathione, an important antioxidant, requires magnesium for its synthesis (Rude & Shils, 2006). Magnesium plays a structural role in bone, cell membranes, and chromosomes (Rude & Shils, 2006). Magnesium is required for the active transport of ions like potassium and calcium across cell membranes. Through its role in ion transport systems, magnesium affects the conduction of nerve impulses, muscle contraction, and normal heart rhythm (Rude & Shils, 2006). Cell signaling requires MgATP for the phosphorylation of proteins and the formation of the cell-signaling molecule, cyclic adenosine monophosphate (cAMP). cAMP is involved in many processes, including the secretion of parathyroid hormone from the parathyroid glands (Rude & Shils, 2006). Calcium and magnesium levels in the fluid surrounding cells affect the migration of a number of different cell types. Such effects on cell migration may be important in wound healing (Rude & Shils, 2006).

In 1997, the Food and Nutrition Board of the Institute of Medicine increased the recommended dietary allowance (RDA) for magnesium, based on the results of tightly controlled balance studies that utilized more accurate methods of measuring magnesium (FNB, 1997).. Balance studies are useful for determining the amount of a nutrient that will prevent deficiency; however, such studies provide little information regarding the amount of a nutrient required for chronic disease prevention or optimum health.

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 & Swenson, 1985). Phosphorus helps to maintain normal acid-base balance by acting as one of the body's most important buffers. It functions as a constituent of bones, teeth, adenosine triphosphate (ATP), phosphorylated metabolic intermediates and nucleic acids. It 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 mineral that is required by every cell in the body for normal function (Knochel, 2006). The majority of the phosphorus in the body is found as phosphate (PO_4). Approximately 85% of the body's phosphorus is found in bone (FNB, 1997). Phosphorus is a major structural component of bone in the form of a calcium phosphate salt called hydroxyapatite. Phospholipids are major structural components of cell membranes. All energy production and storage are dependent on phosphorylated compounds, such as ATP and creatine phosphate. Nucleic acids, which are responsible for the storage and transmission of genetic information, are long chains of phosphate-containing molecules. A number of enzymes, hormones, and cell-signaling molecules depend on phosphorylation for their activation. Additionally, the phosphorus-containing molecule 2, 3-diphosphoglycerate (2, 3-DPG) binds to haemoglobin in red blood cells and affects oxygen delivery to the tissues of the body (Knochel, 2006).

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. 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. 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 Ca2+ - 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 & 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.

The recommended dietary allowance (RDA) for phosphorus was based on the maintenance of normal serum phosphate levels in adults, which was believed to represent adequate phosphorus intake to meet cellular and bone formation needs (FNB, 1997).

Potassium

Potassium is an essential dietary mineral and electrolyte. The term electrolyte refers to a substance that dissociates into ions in solution, making it capable of conducting electricity. 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. Normal body function depends on tight regulation of potassium concentrations both inside and outside of cells (Peterson, 1997). Potassium is the principal positively charged ion in the fluid inside of cells, while sodium is the principal cation in the fluid outside of cells. Potassium concentrations are about 30 times higher inside than outside cells, while sodium concentrations are more than ten times lower inside than outside cells. The concentration differences between potassium and sodium across cell membranes create an electrochemical gradient known as the membrane potential. A cell's membrane potential is maintained by ion pumps in the cell membrane, especially the sodium, potassium-ATPase pumps. These pumps use ATP to pump sodium out of the cell in exchange for potassium. Their activity has been estimated to account for 20% to 40% of the resting energy expenditure in a typical adult (Sheng, 2000). The large proportion of energy dedicated to maintaining sodium/potassium concentration gradients emphasizes the importance of this function in sustaining life.

Tight control of cell membrane potential is critical for nerve impulse transmission, muscle contraction, and heart function (Brody, 1999; Sheng, 2000). A limited number of enzymes require the presence of potassium for their activity therefore the activation of sodium, potassium-ATPase requires the presence of sodium and potassium. The presence of potassium is also required for the activity of pyruvate kinase, an important enzyme in carbohydrate metabolism (Sheng, 2000). In 2004, the Food and Nutrition Board of the Institute of Medicine established an adequate intake level (AI) for potassium based on intake levels that have been found to lower blood pressure, reduce salt sensitivity, and minimize the risk of kidney stones (FNB, 2004).

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 dilation of the heart, cardiac arrest, small bowel ulcers. Low levels of serum potassium may lead to hypokalaemia 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 ($P \leq 0.05$) decreased levels of potassium in vegetables.

Copper

Copper (Cu) is an essential trace element for humans and animals. In the body, copper shifts between the cuprous (Cu^{1+}) and cupric (Cu^{2+}) forms, though the majority of the body's copper is in the Cu^{2+} form. The ability of copper to easily accept and donate electrons explains its important role in oxidation-reduction reactions and in scavenging free radicals (Linder & Hazegh-Azam, 1996). Although Hippocrates is said to have prescribed copper compounds to treat diseases as early as 400 B.C. (Turnlund, 2006), scientists are still uncovering new information regarding the functions of copper in the human body. Copper is a critical functional component for a number of essential enzymes known as cuproenzymes. Some of the physiologic functions known to be copper-dependent are discussed below.

The copper-dependent enzyme, cytochrome *c* oxidase, plays a critical role in cellular energy production. By catalyzing the reduction of molecular oxygen to water, cytochrome *c* oxidase generates an electrical gradient used by the mitochondria to create the vital energy-storing molecule, ATP (Uauy et al*.,* 1998). Another cuproenzyme, lysyl oxidase, is required for the cross-linking of collagen and elastin, which are essential for the formation of strong and flexible connective tissue. The action of lysyl oxidase helps maintain the integrity of connective tissue in the heart and blood vessels and also plays a role in bone formation (Turnlund, 2006).

Two copper-containing enzymes, ferroxidase I and ferroxidase II have the capacity to oxidize ferrous iron (Fe2+) to ferric iron (Fe3+), the form of iron that can be loaded onto the protein transferrin for transport to the site of red blood cell formation. Although the ferroxidase activity of these two cuproenzymes has not yet been proven to be physiologically significant, the fact that iron mobilization from storage sites is impaired in copper deficiency supports their role in iron metabolism (Harris, 1997; Turnlund, 2006).

A number of reactions essential to normal function of the brain and nervous system are catalyzed by cuproenzymes (FNB, 2001). The myelin sheath is made of phospholipids whose synthesis depends on cytochrome *c* oxidase activity (Turnlund, 2006). The cuproenzyme, tyrosinase, is required for the formation of the pigment melanin. Melanin is formed in cells called melanocytes and plays a role in the pigmentation of the hair, skin, and eyes

(Turnlund, 2006).

Copper-dependent transcription factors regulate transcription of specific genes. Thus, cellular copper levels may affect the synthesis of proteins by enhancing or inhibiting the transcription of specific genes. Genes regulated by copper-dependent transcription factors include genes for copper/zinc superoxide dismutase (Cu/Zn SOD), catalase, and proteins related to the cellular storage of copper (Uauy et al., 1998).

Mineral Components Derived From Commonly Consumed Ghanaian Foods

In view of the paucity of reliable food composition data on the mineral content of locally grown and prepared Ghanaian foods, a study was done by Ferguson and others in 1989 in the southern region of Ghana. These data were collected as part of a larger investigation of the nutritional status of rural Ghanaian children. Ferguson et al. (1989) analysed 44 raw and cooked Ghanaian foods for zinc, copper, manganese, calcium, phosphorus, magnesium, sodium, potassium content expressed in milligrams per 100 g edible portion.

Zinc and Iron

Zinc is an essential trace element in the diets of humans for optimal health and growth. Signs and symptoms of mild zinc deficiency in young children include impaired linear growth, poor weight gain, reduced deposition of lean body tissue, anorexia, hypogeusia and impaired immune competence (Ferguson et al., 1993). Widespread suboptimal zinc nutriture constitutes a notable health risk for children in terms of growth and development. Zinc adequacy depends on both the amount and bioavailability in the diet in relation to physiological requirements. Certain dietary components, such as phytic acid, dietary fiber, calcium, and protein also affect zinc absorption. Of these, phytic acid has the greatest inhibitory effect on zinc absorption. Ultimately, the amount of zinc absorbed depends on the complex interactions among these dietary constituents, as well as on the zinc status and health of the individual. Rural African children consuming cereal-based diets high in phytic acid and low in animal products are likely to be particularly vulnerable to suboptimal zinc nutriture (Ferguson et al., 1993).

Phytate, Zinc and Calcium

The paucity of food composition data on phytic acid contents of African foods is unfortunate, since the habitual diets in many African countries are high in cereals. Consequently, calcium, phytate and zinc contents of 30 representative raw and cooked foods consumed by 4 -6-year old children living in rural Ghana were analyzed and the corresponding Zn: phytate, Ca:phytate, and (Ca:phytate/Zn) molar ratios were calculated (Ferguson et al., 1988). The phytate content of foods in the legume and cereal groups was markedly higher than those of vegetables, roots and fruits. Phytic acid contents expressed on a freshweight basis ranged from 166- 1297 mg/100 g for legumes; 211-1089 mg/100 g for cereals; 4-97 mg/100 g for leaves; 10-59 mg/100 g for roots and 11-25 mg/100 g for fruits (Ferguson et al., 1988). All food groups showed marked variability in phytic acid content. Groundnuts, fresh kidney beans, cowpeas, and maize bran had the highest content (i.e. greater than 1000 mg/100 g DM). In contrast, bananas, avocados, sweet potatoes, and chinese cabbage had the lowest phytate content. Conversely, the more refined maize flour (*ekuegbemi*) analyzed in the study had lower phytate and zinc contents compared to the less refined maize flour (*corn dough*). This was not unexpected, as the zinc and phytate fractions of maize are concentrated in the germ, which is removed by milling. In the Ghanaian diet, however, a leaf, legume or fish relish is always consumed with the cooked cereal flours. Such relishes, with the exception of legumes, are high in calcium (i.e. pumpkin leaf, chinese cabbage, and amaranthus sp.). Hence, the calcium content of the relishes in these diets may be high enough to promote a phytate-induced decrease in zinc bioavailability.

Absorption and Bioavailability of Iron

Dietary factors that influence iron absorption, such as phytate, polyphenols, calcium, ascorbic acid, and muscle tissue, have been shown repeatedly to influence iron absorption in single-meal isotope studies, whereas in multi meal studies with a varied diet and multiple inhibitors and enhancers, the effect of single components has been, as expected, more modest. The importance of fortification iron and food additives such as erythorbic acid on iron bioavailability from a mixed diet needs clarification. The influence of vitamin A, carotenoids, and nondigestible carbohydrates on iron absorption and the nature of the "meat factor" remain unresolved. The iron status of the individual and other host factors, such as obesity, play a key role in iron bioavailability, and iron status generally has a greater effect than diet composition. It would therefore be timely to develop a range of iron bioavailability factors based not only on diet composition but also on subject characteristics, such as iron status and prevalence of obesity.

Hunt, Zito and Johnson (2009), reports that to obtain an estimate of daily iron losses per kilogram of body weight, there is a need to evaluate further the extent to which obligatory iron losses vary with ethnicity, age, and sex groups and with iron status. On the basis of the sum of obligatory and menstrual iron losses and iron needed for growth, the World Health Organization/Food and Agriculture Organization of the United Nations (WHO/FAO), the Institute of Medicine (IOM), and other national organizations have calculated iron requirements for different population groups. To translate these requirements into recommendations for daily dietary iron intakes requires an estimate of iron bioavailability, defined as the extent to which iron is absorbed from the diet and used for normal body functions. This review describes the dietary and host factors reported to influence iron bioavailability, the way in which these factors have been used to establish iron bioavailability factors for the estimation of dietary reference values (DRVs), and the extent to which the bioavailability factors could be refined further.

Inhibitors of Iron Absorption

In plant-based diets, phytate (myo-inositol hexakisphosphate) is the main inhibitor of iron absorption. The negative effect of phytate on iron absorption has been shown to be dose dependent and starts at very low concentrations of 2–10 mg/meal (Hurrell, et al*.,* 1992). The molar ratio of phytate to iron can be used to estimate the effect on absorption. The ratio should be 1:1 or preferably 0.4:1 to significantly improve iron absorption in plain cereal or legume-based meals that do not contain any enhancers of iron absorption, or 6:1 in composite meals with certain vegetables that contain ascorbic acid and meat as enhancers (Hurrell, 2004). Food processing and preparation methods, which include milling, heat treatment, soaking, germination, and fermentation, can be used to remove or degrade phytate to a varying extent (Hurrell, 2004; Egli, Davidsson, Juillerat, Barclay, Hurrell 2002).

Polyphenols. Polyphenols occur in various amounts in plant foods and beverages, such as vegetables, fruit, some cereals and legumes, tea, coffee, and wine. The inhibiting effect of polyphenols on iron absorption has been shown with black tea and herb teas (Hurrell, Reddy, Cook, 1999). At comparable amounts, the polyphenols from black tea were shown to be more inhibiting than the polyphenols from herb teas and wine (Cook, Reddy & Hurrell, 1995). The fact that polyphenol quantity, as well as type, influences iron absorption was also shown in a study with spices. Chili, but not turmeric, inhibited iron absorption in Thai women, although turmeric contained more polyphenols than chili (Tuntipopipat et al*.,* 2006). In cereals and legumes, polyphenols add to the inhibitory effect of phytate, as was shown in a study that compared high and low polyphenol sorghum. After complete phytate degradation, iron absorption from low-polyphenol sorghum increased significantly, whereas iron absorption from high-polyphenol sorghum was not improved (Hurrell, Reddy, Juillerat& Cook 2003).

Calcium: Calcium has been shown to have negative effects on nonheme and heme iron absorption, which makes it different from other inhibitors that affect nonheme iron absorption only (Cook, Dassenko & Whittaker, 1991). Initially, the inhibitory effect was suggested as occurring during the transport of iron across the basolateral membrane from the enterocyte to the plasma because absorption of both forms of iron equally inhibited, but more recently, it was suggested that the inhibition takes place during the initial uptake into the enterocytes (Hallberg, Rossander-Hulten, Brune & Gleerup, 1992). Dose-dependent inhibitory effects were shown at doses of 75–300 mg when calcium was added to bread rolls and at doses of 165 mg calcium from milk products (Hallberg, Brune, Erlandsson, Sandberg & Rossanderhulten, 1991). It is proposed that single-meal studies show a negative effect of calcium on iron absorption, whereas multiple-meal studies, with a wide variety of foods and various concentrations of other inhibitors and enhancers, indicate that calcium has only a limited effect on iron absorption (Lynch, 2000).

Proteins: Whereas animal tissues have an enhancing effect on nonheme iron absorption, animal proteins, such as milk proteins, egg proteins, and albumin, have been shown to inhibit iron absorption (Cook & Monsen, 1976). The 2 major bovine milk protein fractions, casein and whey, and egg white were shown to inhibit iron absorption in humans (Hurrell, Lynch, Trinidad, Dassenko & Cook, 1988). Proteins from soybean also decrease iron absorption. Phytate was shown to be the major inhibitor in soy protein isolates, but even after complete phytate degradation iron absorption from soy protein isolates was only half that of the egg white control (which allows inter study comparison), which suggests that soy protein itself is inhibiting. In another study with soy protein isolates, iron absorption increased 19-fold when the protein was extensively enzyme hydrolyzed and phytate degraded. The authors concluded that phytate and a protein related moiety contained in the conglycinin fraction were the main inhibitors of iron absorption in soy protein (Lynch, Dassenko, Cook, Juillerat & Hurrell, 1994).

Enhancers of Iron Absorption

According to Hurrell (2004), the body regulates iron homeostasis by controlling absoption and not by modifying excretion as with most metals. Absorption is increased during deficiency and decreased when erythropoeisis depressed. The body has a limited capacity to excrete Fe and in excess of needs is stored as ferritin. Factors that increase iron absorption are reviewed below.

Ascorbic acid: Many single-meal radioisotope studies in human volunteers have shown convincingly the dose-dependent enhancing effect of native or added ascorbic acid on iron absorption (Lynch & Cook, 1980). The enhancing effect is largely due to its ability to reduce ferric to ferrous iron but is also due to its potential to chelate iron. Ascorbic acid will overcome the negative effect on iron absorption of all inhibitors, which include phytate, polyphenols (Siegenberg et al*.,* 1991), and the calcium and proteins in milk products (Stekel et al*.,* 1986.) and will increase the absorption of both native and fortification iron. In fruit and vegetables the enhancing effect of ascorbic acid is often cancelled out by the inhibiting effect of polyphenols (Ballot et al*.,* 1987). Ascorbic acid is the only main absorption enhancer in vegetarian diets, and iron absorption from vegetarian and vegan meals can be best optimized by the inclusion of ascorbic acid–containing vegetables (Hallberg & Rossander, 1982). Cooking, industrial processing, and storage degrade ascorbic acid and remove its enhancing effect on iron absorption. Teucher et al. (2004) and Pizarro et al. (2006) recently reported that ascorbyl palmitate retains its enhancing effect on iron absorption after it is baked into iron-fortified bread.

Erythorbic acid, an ascorbic acid derivative, is widely used as an antioxidant in processed foods in industrialized countries. In the United States, its intake from processed foods may reach 200 mg/d (Sauberlich, Tamura, Craig, Freeberg, Liu, 1996), and erythorbic acid intake could be as high, if not higher, than ascorbic acid intake. Although it has little vitamin C activity, its enhancing effect on iron absorption appears to be almost double that of ascorbic acid (Fidler, Davidsson, Zeder, Hurrell, 2004). The abundance of such compounds in the American diet might help explain why it has not been possible to demonstrate clearly the enhancing effect of vitamin C on iron absorption in multiple-meal studies of self-selected diets (Cook, Reddy, 2001).

Muscle tissue: Single-meal radioisotope studies have consistently shown an enhancing effect of meat, fish, or poultry on iron absorption from vegetarian meals (Lynch, Hurrell, Dassenko & Cook, 1989), and 30 g muscle tissue is considered equivalent to 25 mg ascorbic acid (Monsen et al., 1978). Bjorn-Rasmussen and Hallberg (1979) reported that the addition of chicken, beef, or fish to a maize meal increased nonheme iron absorption 2–3-fold with no influence of the same quantity of protein added as egg albumin. More recently, Baech et al, (2003) reported a dose-response increase in iron absorption when pork meat was added to a high phytate, low–ascorbic acid meal. As with ascorbic acid, it has been somewhat more difficult to demonstrate the enhancing effect of meat in multiple meals and complete diet studies. Reddy et al. (2006) reported only a marginal improvement in iron absorption (35%) in self-selected diets over 5 d when daily muscle tissue intake was increased to 300 g/d, although, in a similar 5-d study, 60 g pork meat added to a vegetarian diet increased iron absorption by 50% (Bach Kristensen et al*.,* 2005). The nature of the “meat factor” has proved elusive.

Most evidence indicates that it is within the protein fraction of muscle tissue; however, it is also possible that other muscle tissue components are involved (Hurrell et al*.,* 2006). There is good evidence to support the enhancing effect of cysteine-containing peptides (Layrisse, Martinez-Torres, Leets, Taylor & Ramirez, 1984), which are rich in digests of myofibrillar proteins and which, like ascorbic acid, could both reduce and chelate iron. Storcksdieck and Hurrell (2007), however, suggested that the “meat factor” may not be due to a single peptide fraction but more likely to a multitude of small peptides. Unlike other proteins, myofibrillar proteins are digested extensively by pepsin in the stomach and thus could bind iron and prevent its precipitation at the higher pH of the duodenum. Studies with Caco-2 cells have indicated that glycosaminoglycans (Huh, Hotchkiss, Brouillette & Glahn, 2004) and L-a glycerophosphocholine (Armah, 2008) might also contribute to the enhancement of nonheme iron absorption by meat. It is difficult, however, to extrapolate from Caco-2 cells to humans (Fairweather-Tait, 2005), and purified sulfated and unsulfated glycosaminoglycans did not increase iron absorption from a liquid formula meal in young women (Storcksdieck, Walczyk, Renggli & Hurrell, 2007), although it is possible that other glycosaminoglycans that occur naturally may be enhancing. Armah et al.(2008) reported that purified L-a-glycerophosphocholine increased iron absorption in women who consumed a vegetable lasagna low in inhibitors, although to a lower extent than ascorbic acid. The enhancing effect of L-a-glycerophosphocholine was not confirmed in women who consumed a high-phytate maize meal, although iron absorption from this meal was increased by ascorbic acid (and EDTA).

Iron Status: The iron status of individuals mainly influences the absorption of nonheme iron, whereas heme iron absorption is generally less affected (Miret, Simpson & McKie, 2003). There is an inverse correlation between iron status and iron absorption, and with the use of ferritin as an indicator of iron status the relation can be described mathematically (Cook, Dassenko & Lynch, 1991). A study in young women showed that the regulation of iron absorption by ferritin was less pronounced when iron was added as a water-insoluble compound (micronized dispersible ferric pyrophosphate), compared with ferrous sulfate (Moretti et al*.,* 2006). These findings are important for fortification practices because they show that the different compounds are more or less suitable for repletion of iron-deficient subjects. Further studies should be performed in iron-deficient and iron-replete individuals and with different fortification compounds. A study in Indian women investigated the effect of enhancers (ascorbic acid) and inhibitors (tea polyphenols) of iron absorption in an iron-deficient anemic group, compared with a non anaemic iron-replete control group. The difference in iron absorption between the groups was defined by the iron status, but the magnitude of the enhancing and inhibiting effect was shown to be independent of iron status (Thankachan, Walczyk, Muthayya, Kurpad &Hurrell, 2008).

Nutritional deficiencies: Vitamin A and riboflavin deficiencies have been shown to influence iron metabolism and absorption. Human studies showed that the correction of riboflavin deficiency improved the response to iron supplements (Powers, 2003). An absorption study in Gambian men indicated that the efficiency of iron use is impaired in riboflavin deficiency but that iron absorption is unaffected (Fairweather et al*.,* 1992). The effect of vitamin A and vitamin A deficiency on iron absorption is discussed in the following section.

Genetic disorders: Hemochromatosis is a disorder of excessive iron accumulation that affects up to 1 in 150 people in populations of Northern European origin. The effect of the disorder on iron absorption has been studied in control subjects and in homozygous and heterozygous subjects (Lynch, Skikne & Cook, 1989). Homozygous subjects showed increased heme and nonheme iron absorption, whereas the nonheme iron absorption of heterozygous subjects from meals with moderate iron content was not shown to be different from control subjects. However, increased absorption was seen in heterozygous subjects from meals highly fortified with iron. These results were not confirmed in later studies in male C282Y heterozygotes and were suggested to be related to improved methods of genotyping and feeding of test meals (i.e, single compared with multiple meals) (Hunt & Zeng, 2004). The other important group of genetic disorders that leads to iron overload is thalassemias and related hemoglobinopathies, which occur mainly in South and Southeast Asia, the Middle East, and the Mediterranean (Weatherall & Clegg, 2001). Thalassemia homozygotes have ineffective erythropoiesis that stimulates iron absorption even if iron stores are adequate, which leads to a risk of iron excess when regular transfusions are given to correct anemia (Pootrakul et al., 2000).

Nondigestible carbohydrates: Nondigestible carbohydrates are widely present in plant foods. They resist digestion in the small intestine but are fermented in the colon to short-chain fatty acids with a variety of reported health benefits, which include increased colonic iron absorption (Yeung, Glahn, Welch & Miller, 2005). Although most dietary iron is absorbed in the duodenum, the colon mucosa also expresses the iron absorption proteins divalent metal transporter, ferritin, and ferroportin, as shown in pigs (Blachier, Vaugelade, Robert et al., 2007). Kim & Atallah (1992) have reported that infused ferrous iron was absorbed by humans from the colon with 30% of the efficiency of the total iron absorption (duodenum and colon). Pectin (Kim & Atallah, 1992) and inulin (Ohta et al., 1995) have been reported to increase hemoglobin repletion in iron-deficient rats and a mixture of inulin and oligofructose increased hemoglobin repletion in iron-deficient pigs (Yasuda, Roneker, Miller, Welch & Lei, 2006). Possible mechanisms for increased colonic iron absorption are the generation of a lower pH, formation of soluble iron complexes, reduction of ferric to ferrous iron by gut microflora, a proliferation of the absorptive area in the colon, and an increase in iron-absorption proteins. Human studies have consistently shown that insulin and oligofructose increase colonic calcium absorption (Abrams et al., 2005), but a balance study (Coudray et al*.,* 1997) and a stable isotope study (van den Heuvel, Schaafsma, Muys & van Dokkum, 1998) failed to demonstrate an enhancing effect of insulin on iron absorption. The influence of nondigestible carbohydrates on colonic iron absorption merits further investigation.

Medicinal and Nutritional benefits of Turkey berry

Prior to the recent sale of packaged Turkey berry in stores and malls, Ghanaians consumed turkey berry as a vegetable for its nutritional properties and not necessarily for its medicinal properties as is being promoted now. Turkey berry is an ancient herb used in many Ayurvedic treatments. It has sedative, diuretic and digestive properties, stimulating regular bowel movement and killing harmful bacteria in the stomach and intestines. Turkey berry is also used worldwide to treat various ailments like piles, asthma, chest phlegm, tuberculosis and severe cough. Cook et al*.*(1997), reports that asthmatic children in Britain who consumed vegetables and fruits more than once a day had better lung function. The higher intake of vegetables and fruits seemed to increase the ventilation function of the lungs. A powder made out of dried heated Turkey berry mixed with little oil is used in treating people who cough or habour excessive mucus in their respiratory track (Royal Horticultural Society, 2001).

Asiedu-Addo (2014) reports the use of turkey berry in soups, sauces and stews by Ghanaian consumers. This report also highlights the use of Turkey berry in healing night blindness when roasted and mixed with food grains such as millets. Kannan et al. (2012) reports of antibacterial properties of the berry and its potential to remove bacterial infestations in the intestine, and take care of regular bowel movement. The green fresh fruits are edible and used by Ghanaian women in preparing palm nut soup and "kontomire" stew (Royal Horticultural Society, 2001). Similar uses of the berry have been reported in other West African countries such as Ivory Coast where the fruits are also incorporated into soups and sauces (Gautier-Béguin, 2001). In parts of Asia, specifically India, the berry is consumed either raw or cooked. It is usually soaked in curd, dried and fried to make sundaikkai vattral which is known to improve digestion. Vegetables do impart their own characteristic flavour, colour, and texture to diets and undergo changes during storage and cooking.

Chemical Constituents of Turkey Berry

Phytochemical screening of methanolic extract of sun dried Turkey berry (Turkey berry)tested positive for alkaloids, flavonoids, saponins, tannins, glycosides, fixed oil, vitamin B group, vitamin C and iron salts (George, Patrick & Terrick, 2011). They further report a number of chemical constituents like neochlorogenin 6-O-β-D-quinovo pyranoside, neochlorogenin 6-O-β-D-xylopyranosyl-(1→3)-β-D quinovopyranoside, neochlorogenin 6-O- α-L- rhamnopyranosyl-(1→3)-β-Dquinovopyranoside, sola-genin 6-O-β Dquinovopyranoside, solagenin 6-O-α-Lrhamnopyranosyl-(1→3)-β-Dquinovopyranoside, isoque-rcetin, rutin, kaempferol and quercetin. Other studies report that the flavonoid content of Turkey berry is mainly responsible for its antioxidant, antihypertensive, metabolic correction and nephro protectiveactivities.

The Percent Daily Value (%DV) of Nutrients

There are two sets of reference values for reporting nutrients in nutrition labeling: 1) Daily Reference Values (DRVs) and 2) Reference Daily Intakes (RDIs). These values assist consumers in interpreting information about the amount of a nutrient that is present in a food and in comparing nutritional values of food products. The daily values for the required nutrients are shown in Table 1 below. DRVs are established for adults and children four or more years of age, as are RDIs, with the exception of protein. DRVs are provided for total fat, saturated fat, cholesterol, total carbohydrate, dietary fibre, sodium, potassium, and protein. RDIs are provided for vitamins and minerals and for protein for children less than four years of age and for pregnant and lactating women. In order to limit consumer confusion, however, the label includes a single term (i.e., Daily Value (DV)), to designate both the DRVs and RDIs. The Food and Drug Administration, USA, has not set a Daily Value for trans-fat, and health experts recommend/ avoiding trans-fat to lower the risk of cardiovascular disease. Similarly, there is no established DV for sugar because there is no recommended amount of sugar for a healthy population.

Table 1: The Daily Values of Nutrients

Food Component	DV
Total Fat	65 (g)
Saturated Fat	20 g
Cholesterol	300 (mg)
Sodium	2,400 mg
Potassium	3,500 mg
Total Carbohydrate	300 g
Dietary Fiber	25 g
Protein	50 g
Calcium	1,000 mg
Iron	18 mg
Iodine	150 µg
Magnesium	400 mg
Zinc	15 mg
Copper	2 mg
Manganese	2 mg

Source: USA FDA (2013)

The Percent Daily Value (%DV) of foods is a guide to the nutrients in one serving of food. It is calculated by dividing the amount of the nutrient contained in the serving size of a food product by its Daily Value and then multiplying that number by 100. For example, if a food product has 3 mg of iron and the Daily Value for iron is 18 mg, the % DV for iron would be 16%, that is, (3 mg ÷ 18 mg) × 100 = 16% DV. Likewise if a food contains 15% of calcium, it means that one serving provides 15 percent of the calcium needed each day. The Percent Daily Values are based on a 2,000-calorie diet for healthy adults. The % DV shows the specific amount of nutrient a food contains (whether a little or a lot). For example, it helps in determining whether a food is high or low in specific nutrients: If a food has 5% or less of a nutrient, it is considered to be low in that nutrient. If it has 20% or more, it is considered to be high in that nutrient. The % DV is not meant to track total nutrient intake for the day. This is because some of the foods eaten (like vegetables, fruit, and fresh meat) do not have a Nutrition Facts table. To get the most benefit from Percent Daily Values, one has to use it to choose foods that are higher in the nutrients that must be consumed more, that is vitamins, minerals and fiber and to limit foods high in fat, cholesterol and sodium (Zeratsky, 2013). It is also used to compare two different food products to make healthier food choices.

The % DV column on the Nutrition Facts table does not add up to 100%. Each nutrient in the Nutrition Facts table has its own Daily Value. The Daily Values for nutrients are based on the highest recommended intakes. They apply to most people ages 2 and over, but do not include extra nutrient needs for women who are pregnant or breastfeeding.

Summary

As stated in the introduction, vegetables are a source of nutrients to compliment staple foods eaten in the country. Two types of vegetables exist in the SSA agriculture. The exotic vegetables which originate from outside the continent and wild or indigenous vegetables which have their origin from the continent or have been introduced and accepted by the people for years. One of such wild or African indigenous vegetable is turkey berry consumed mainly by the people in southern part of Ghana. There are a number of pharmacological and health benefits associated with turkey berries. Despite the recognition and consumption of turkey berries in Ghana there is limited literature on the nutritional value of it. It is believed to boost haemoglobin levels. Turkey berries contain phytochemicals like steroids, polyphenols, tannin, phytic acids, anti-inflammatory substances, antioxidants that render its potency of curing diseases like cough and cold, astma, anaemia, cancer diabetes etc. There is some documentation on the use of wild foods as medicine and as food in Africa.

These plants are good sources of protein, essential amino acids, essential fatty acids such as linoleic and linolenic acids and micronutrients such as iron and zinc.Several of these indigenous vegetables continue to be used for prophylactic and therapeutic purposes by rural communities. Indigenous knowledge of the health promoting and protecting attributes of African Vegetables (AVs) is clearly linked to their nutritional and non-nutrient phytochemical properties.

Despite the recognition of African vegetables to be beneficial to human health, dietary utilization of non-domesticated plants has received very little attention in economic development efforts. Attention is given to a limited number of cultivars of a few staple food crops, a vulnerable position is created, not only because diversification assures dietary balance and facilitates intake of micro-nutrients but through danger of domesticated crop destruction by drought or insect pests.

In order to ascertain how much nutrients are in a particular food being eaten a number of dietry references are used. One of such dietry reference is the %DV which indicates the percentage of nutrient in a particular portion size of a food in relation to the daily nutrient requirement. This helps in deciding on which nutrients are more or less in a particular food in order to combine and eat variety of dishes to meet the nutritional requirement. Having nutritional knowledge is essential in choosing and eating right.

CHAPTER THREE

METHODOLOGY

This chapter deals with the methods employed to achieve the objectives of the study. It begins with a description of the research design, population as well as the study area and sampling procedure for the study. How data was collected and analysed is also described in this chapter.

Research Design

A mixed method approach was used to collect both quantitative and qualitative data with theaim of describing a phenomenon. A laboratory experiment was conducted to determine the chemical constituents of Turkey berry which represented the quantitative data. A survey was also conducted to find out knowledge and use of Turkey berry among a group of pregnant women in the Cape Coast Metropolis.

Study Area

The study was conducted in Cape Coast in the Central Region of Ghana and it is one of the one hundred and seventy administrative districts in Ghana. It is the district capital of Cape Coast metropolis as well as the administrative capital of central region. It was the first national capital of the then Gold coast now Ghana. The central region in general and the Cape Coast metropolis are known for their high tourist potential. A large number of beach resorts, hotels and guest lodges warrant a high and unceasing demand for vegetables within this area. A survey conducted by Obuobie et al. (2006) showed that there is almost no irrigated vegetable farming taking place within Cape Coast. The bulk of vegetables consumed in the metropolis come as far as from Togo or Kumasi and rural areas surrounding Cape Coast. These vegetables are brought to the principal market places in Cape Coast namely Kotokuraba, Abura, Kotoka, and Yawda guamu.

The metropolis occupies an area of 1700 square kilometres, is made up of 79 settlements.

Population

In 2000 the metropolis had a total population of 118,106 comprising 57,367 males and 60,741 females with a growth rate of 1.4% (Ghana Statistical service, 2002). There is a large floating population because of the existence of many educational institutions. This increasing population adds to the foods supply trend and the dependency on the health facilities in the metropolis.

In the 2000 census, about 90% of the populace aged 11 years and above were classified literates indicating that 10% are non-literate. The proportion of literate males is higher (94.10%) than that of females (85.60%). About seven out of ten people (67.20%) indicated they could speak and write both English and Ghanaian languages (GSS, 2003).

The total fertility rate for the metropolis 2.20% is the lowest in the region. The general fertility rate is 59.20 births per 1000 women aged 15-49 years which is also the lowest for the region. In view of these, pregnant women may seek antenatal care in health centres within the Cape Coast metropolis. There are in total seven public or government health centres in Cape Coast. These are Cape Coast regional hospital, Cape Coast metropolitan hospital, University of Cape Coast hospital, Ankaful psychiatric hospital, Ankaful leprosarium hospital, Adisadel health centre and Ewim health centre.

The population was also made up of all pregnant women. They could be at any stage of their pregnancy be it first, second or third trimester. They could also be first timers or those who have had children already. Pregnant women were targeted because they are one of the groups of people with special nutritional needs especially for the intake of iron. Also for the fact that Asiedu (2014) categorically stated that it is being recommended to pregnant women to consume because of the belief that it improves haemoglobin level and since haemoglobin or iron store are needed in high volumes during pregnancy. However, the population size was indefinite.

Sample and Sampling Procedure

Fresh berry were purchased from Abura market one of the principal market centres in the Cape Coast Metropolis in the Central Region of Ghana. Various forms of turkey berry (raw, boiled and parboiled) were prepared and analysed for different chemical constituents.

The district in which the study was carried out was purposively selected for its convenience because the researcher was staying and working there. The simple random lottery method was used to select three out of the seven government hospitals in the metropolis. Each of the selected hospitals had days earmarked for antenatal care. The accidental sampling was then used to sample pregnant women who attended antenatal care in these hospitals at the scheduled days. A total of 186 pregnant women were sampled from the three hospitals.

Age distribution was normal and homogenous as shown in Figure 1 below. The minimum age was 15 years whereas the maximum age was 45 years. An average age of 30.74 was obtained which was approximated to 31 years. This means that the respondents were fairly grown and mature in terms of age and therefore are adults.

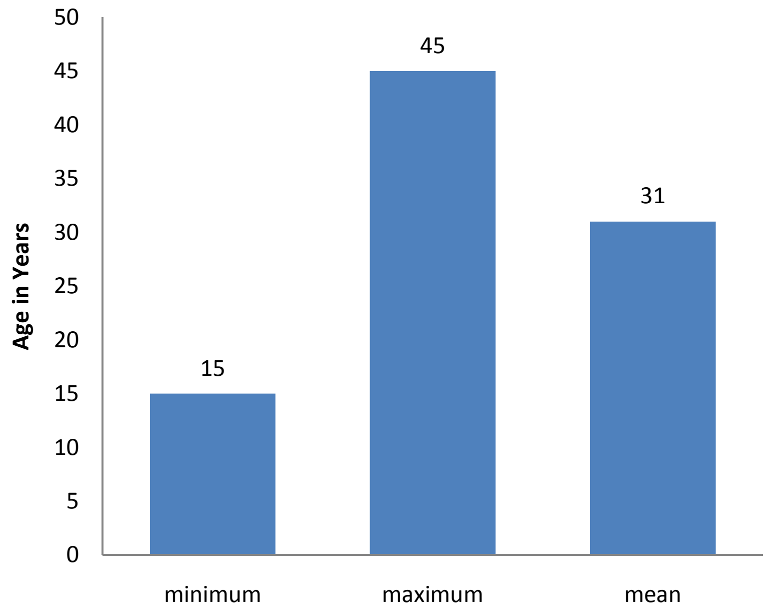

Figure 1: Age Distribution of Pregnant women in Cape Coast metropolis

Adult women are mainly those who cook for the family even though the act of cooking may start from adolescent stage. They are also responsible for purchasing of ingredients that will be used in cooking. In other words the respondents may have experience in cooking with regards to the ingredients used and how cooking is done.

Level of Education

The level of education of the pregnant women is shown in Table 2.The result indicated that most of the pregnant women who attended antenatal service in the Cape Coast metropolis have attained at least Junior high school education indicated by 54 (29.0%). Only 18 respondents representing 9.7%

had tertiary education.

Table 2: Distribution of Educational level of pregnant women

Level of Education	F	Percentage
Primary	29	15.6
Junior high	54	29.0
Senior high	37	19.9
Tertiary	18	9.7
No formal education	48	25.8
Total	186	100.0

With minority of the respondents attaining at least basic education, they could read and respond to the questions given except for a quarter of respondents who had no formal education (25.8%, n= 48). Also most of the respondents understood the concepts of this study.

Instrument

The instrument used for the survey was a questionnaire consisting of 16 closed ended questions. Since the study is mainly a quantitative research. The questionnaire was divided into three parts. Part one collected data on the demographic data of the respondents, part was collected data on the consumption level of turkey berry and finally the third part was made of questions on the knowledge of turkey berry.

Data Collection Procedure

One portion of 150 g of the berry was cooked under normal cooking temperature and allowed to boil for 30 minutes. It was cooled and ground using Philips food blender to a semi smooth paste without the addition of water. This sample was placed in a clean plain plastic bag, labelled and stored in a laboratory refrigerator. The second portion also of 150 g was parboiled for approximately 1 minute and cooled. The sample was then ground to a semi solid paste, placed in a clean plain plastic bag, labelled and stored prior to laboratory analysis. That of the raw samples was also blended to a semi-solid paste, placed in a plastic bag and sent to the laboratory.

A proximate analysis procedure described by AOAC (1990) was used in determining the nutrient content. Data collected included percentage protein, minerals, moisture content and percent complex carbohydrate (which represents fibre). The Kjedhall method was used in determining the protein content of the prepared Turkey berry samples. Atomic Absorption Spectrophotometric (AAS) method was used in ascertaining iron and mineral content of the prepared Turkey berry samples. For Carbohydrate content, the colorimetric method specifically the anthrone method was used. The various extracts from the samples were subjected to further analysis. The following are detailed methods in testing for the various nutrients under study.

Determination of Moisture and Dry matter contents

Porcelain crucibles were washed dried and weighed (X). About 10-12 g of the fresh samples were weighed and placed into the clean oven-dried crucibles and reweighed (Y). The crucibles containing the sample were spread over the base of the oven to ensure equal distribution of heat and the temperature in the oven thermostatically controlled at 105 C for 48 hours. At the end of the period the samples were removed, cooled in desiccators and reweighed (Z). Samples were presented in triplicate. The moisture content was then calculated as the percentage water loss by the sample via equations 1 and 2 below

1. $\%\text{Dry matter} = \frac{\text{weight of sample after drying (Z)}}{\text{weight of sample taken (Y-X)}} \times 100$

2. $\%\text{Moisture content} = \frac{(Y-X)-Z}{Y-X} \times 100$

Determination of Ash

Crude ash was determined by ashing a sample of 2 g at 600° C for 2 hours (Midkiff, 1984; Petterson et al., 1999). The sample was completely burnt in the furnace to remove any possible organic matter. The residue obtained was basically made up of inorganic matter and represented the total mineral content in the Turkey berry sample. Although this method provides an approximate level of minerals in the sample, it does not give details of specific individual minerals in the sample. To determine the Ash content, the oven dried samples with known weight were subjected to ignition in a muffle furnace set at 550ºC and left for about four hours after which the samples were cooled in desiccators and reweighed. The percentage ash was calculated as follows:

3. $\%As\ \ content = \frac{weightofash}{Originalweightofsam\ ple} \times 100$

Determination of Crude Fat content

To determine the crude fat level in the samples, the Soxhlet apparatus method of extraction using ether as described by A.O.A.C. (2005) was used. The samples were dissolved in ether solvent. The organic ether dissolved and removed all lipid compounds within the sample after being subjected to continuous extraction using petroleum ether. For the purpose of a proximate analysis, it was enough to obtain an estimate of the total fat content by extraction with diethyl ether or petroleum spirit (40-60^0 C). The ether was then removed through evaporation and the residue reweighed to obtain an arbitraryresult because ether may not fully extract all the fats or oils but may extract in addition carotenoids. Drying was done at about 60^o C since drying at 105^o C could result in loss of fats and oil. The reagent used was petroleum spirit of boiling point 40^o-60^o C

Procedure. About 10-12 g of the milled samples was weighed into a 50 ×10mm Soxhlet extraction thimble. This was transferred to a 50 mL capacity Soxhlet extractor. A clean dry 250 mL round bottom flask was weighed. About 150 mL Petroleum spirit was added and connected to the Soxhlet extractor and extraction was done for 6 hours using a heating mantle as a source of heating. After 6 hours the flask was removed and placed in an oven at 60^o C for 2 hours. The round bottom flask was removed, cooled in a desiccator and weighed. The percentage fat/oil was calculated as followed.

4. $$\%Crudefat = \frac{W\,(g)}{weightofsam\,ple\,(g)} \times 100$$

Where W is the Weight of Oil

Determination of Carbohydrate

1. Glucose solution

Stock solution: (1 mL is equivalent to 0.25 mg glucose), 0.25 g D-glucose (dried in a vacuum oven at 70^o C oven P_2O_5) was dissolved in water and diluted to 1 litre working standards: a range from 0 – 20 mL stock solution was pipette into 50 mL flasks such that 2 mL of each standard gives a range from 0- 0.20 mg glucose and diluted..

2. Anthrone reagent

Seven hundred and sixty milliliters of Conc. H_2SO_4 was carefully added to 330 mL water in a boiling flask and kept cool while mixing. 1 g of anthrone and 1 g of thiourea were added to dissolve using a magnetic stirrer. The mixture was then transferred to a dark bottle and left to stand for 2 hours before use. It was stored at + 1 C.

3. Extraction procedure

Exactly 50 mg of the milled sample was weighed into a 50 mL conical flask, 30 mL of distilled water was added and a glass bubble placed in its neck and left to simmer gently on a hot plate for 2 hours. It was topped up to 30 mL periodically and allowed to cool slightly, then filtered through a No.44 Whatman paper into a 50 mL volumetric flask and diluted to the required volume when it cooled. The extract was prepared shortly before colour development. A blank was also prepared by going through the same procedure.

4. Colour development

Two milliliters of each standard solution was pipetted into a set of boiling tubes and 2 mL of the extract and 2 mL water added. The blank was also pipetted into a boiling tube. Standards and samples were treated the same way. Ten milliliters of anthrone solution was added rapidly to each tube and contents mixed. The tubes were then immersed in running tap water or an ice bath. The tubes were then placed in a beaker of boiling water in a dark fume cupboard and boil for 10minutes. The tubes were then placed in cold water and allowed to cool in the dark. The optical density was measured at 625nm or with a red filter using water as a reference. A calibration graph was prepared from the standards and used to obtain mg glucose in the sample aliquot. The blank determination was treated the same way and subtraction was done where necessary.

$$5.\quad \%C = \frac{C(mg) \times extract\,volume\,(mL)}{10 \times aliquot\,(mL) \times sample\,wt\,(g)} \times 100$$

Where C (mg) = Carbohydrate concentration from the graph

Determination of Protein

This is the determination of total nitrogen (Micro-Kjedahl Method) using the Distillation procedure. Sulphuric Acid-Hydrogen Peroxide Digestion mixture was prepared.

The digestion mixture comprised 350 mL of hydrogen peroxide, 0.42 g of selenium powder, 14 g Lithium Sulphate and 420 mL sulphuric acid. The digestion procedure as outlined in FAO, (2008) was used. Between 0.10 to 0.2 g of the oven-dried ground sample was weighed using micro scale into a 100 mL Kjeldahl flask with which 4.4 mL of the digestion reagent measured using a volumetric flask. The digestion reagent was then added to the samples and digested at 360^{o} C for two hours.

Blank digestions (digestion of the digestion mixture without sample) were carried out in the same way. After the digestion, the digests were transferred quantitatively into 50 mL volumetric flasks and made up to the required volume. A steam distillation apparatus was set up and steam passed through it for about 20 minutes. After flushing out the apparatus, a 100 mL conical flask containing 5 mL of boric acid indicator solution was placed under the condenser of the distillation apparatus. An aliquot of the sample digest was transferred to the reaction chamber through the trap funnel. 10 mL of alkali mixture was added to commence distillation immediately and about 50 mL of the distillate was collected. The distillate was titrated against 1/140 mol HCL from green to the initial color of the indicator (wine red). Digestion blanks were treated the same way and subtracted from the sample titre value. The calculation is as follows:

6. $\%N = \frac{(T-B) \times M \times 14007}{weight of sample\ (mg)} \times 100$

Where

M = Molality of Acid

T = Sample titre value

B = Blank titre value

Protein = %N ×6.25

Determination of Crude Fibre

The reagents used were,

1) Sodium hydroxide, 1.25%: Exactly 12.5 g NaOH was dissolved in 700 mL distilled water in a 1000 mL volumetric flask and diluted to volume.
2) Sulphuric Acid, 1.25%: Exactly 12.5 g of concentrated. Sulphuric acid was added to a volumetric flask containing 400 mL distilled water and diluted to the required volume.

Procedure

Exactly 0.5000 g of the sample was weighed and placed in a boiling flask; 100 mL of the 1.25% sulphuric acid solution was added and boiled for 30mins. After boiling, it was filtered into a labelled sintered glass crucible.

The residue was transferred back into the boiling flask and 100 mL of the1.25% NaOH solution was added and boiled for 30mins. Filtration continued after the boiling and the residue washed with boiling water and methanol. The crucible was dried in an oven at 105 degrees overnight and weighed. The crucible was placed in a furnace at 500 degrees for about 3 hours. The crucible was slowly cooled to room temperature in a desiccator and reweighed.

$$7.\quad \%CrudeFibre = \frac{weight\,lost\,through\,ashing\ (Z)}{sample\,weight} \times 100$$

Preparation of sample solution for the determination of N, K, Na, Ca, Mg, P, Zn, Cu, Fe.

The preparation of sample solutions suitable for elemental analysis involves an oxidation process which is necessary for the destruction of the organic matter, through acid oxidation before a complete elemental analysis can be carried out.

Sulphuric acid-hydrogen peroxide digestion

The digestion mixture comprised of 350 mL hydrogen peroxide, 0.42 g of selenium powder, 14 g Lithium Sulphate and 420 mL sulphuric acid. The digestion procedure as outlined in Stewarte et al. (1974) was used. Between 0.10 g to 0.4 g of the oven-dried ground sample was weighed using a micro scale into a 100 mL Kjeldahl flask and 4.4 mL of the mixed digestion reagent was added and the samples digested at 360^{o} C for two hours.

Blank digestions (digestion of the digestion mixture without sample) were carried out in the same way. After the digestion, the digests were transferred quantitatively into 100 mL volumetric flasks and made up to volume.

Colorimetric determination of phosphorus using the ascorbic acid method

The procedure required preparation of colour forming reagent and P standard solutions. The colour forming reagent was made up of reagents A and B. Reagent A was made up of 12 g ammonium molybdate in 20 mL distilled water, 0.2908 g of potassium antimony tartrate in 100 mL distilled water and 1L of 2.5M H_2SO_4. All three solutions were mixed together in a 2L volumetric flask and made up to volume with distilled water. Reagent B was prepared by dissolving 1.56 g of ascorbic acid to every 200 mL of reagent A. A stock solution of 100 g P/mL solution was prepared from which 5 g P/mL solution a set of working standards of P with concentrations 0, 0.1, 0.2, 0.4, 0.6, 0.8 and 1.0μg P/mL in 25 mL volumetric flasks.

Two millilitres aliquot of the digested samples were pipetted into 25 mL volumetric flasks. Two millilitres aliquots of the blank digest were pipetted into each of the working standards to give the samples and the standards the same background solution. Ten millilitres of distilled water was added to the standards as well as the samples after which 4 mL of reagent B was added and their volumes made up to 25 mL with distilled water and mixed thoroughly. The flasks were allowed to stand for 15minutes for colour development after which the absorbance of the standards and samples were determined using a spectrophotometer at a wavelength of 882.nm. A calibration curve was plotted using standard concentrations and absorbances.

The concentrations of the sample solutions were extrapolated from the standard curve(IITA, 1985).

CALCULATION

If C = P μg/mL obtained from the graph

8. $P\ (\mu g/g) = \frac{Conc \times Dilution\ Factor\ m\ e}{weight\ of\ sam\ ple}$

Determination of Potassium and Sodium

Potassium and sodium elements in the digested samples were determined using a flame photometer. In this process the following working standards of both K and Na were prepared: 0, 2,4,6,8 and 10 μg/mL. The working standards as well as the sample solutions were aspirated individually into the flame photometer and their emissions (readings) recorded. A calibration curve was plotted using the concentrations and emissions of the working standards.

The concentrations of the sample solutions were extrapolated from the standard curve using their emissions The equations are as follows: (Stewarte et. al 1974).

9. $K\ (\mu g/g) = \frac{Conc \times solution volum\ e}{weightofsam\ ple}$

10. $Na\ (\mu g/g) = \frac{Conc \times solution volum\ e}{weightofsam\ ple}$

Determination of Calcium and Magnesium by EDTA titration Method

The method involved chelating of the cations with ethylene diaminetetra-acetic acid (EDTA). The procedure involved the determination of calcium and magnesium together and the determination calcium alone and magnesium found by difference.

Calcium and magnesium together were determined by placing an aliquot of 10 mL of the sample solution in a 250 mL conical flask and the solution was diluted to 150 mL with distilled water 15 mL of buffer solution and 1 mL each of potassium cynacide, hydroxylamine hydrochloride, potassium ferro-cyanide and triethanolamine (TEA). Five drops of erichrome Black T (EBT) were added and the solution was titrated against 0.005M EDTA. Calcium was determined by pipetting 10 mL of the sample solution into 250conical flask and diluted to 150 mL with distilled water. 1 mL each of potassium cyanide, hydroxyl-amine-hydrocloride potassium ferro-cyanide and TEA five drops of calcon indicator were added and the solution was titrated with 0.005M EDTA. The % Ca and Mg were as follows: (Page et al., 1992)

11. $\%Ca = \frac{0.005 \times 40.08 \times T}{weight of sample} \times 100$

12. $\%Mg = \frac{0.005 \times 24.9 \times T}{weight of sample} \times 100$

Where T = titre value

Determination of iron, copper and zinc using atomic absorption spectrophotometer

Standard solutions of 1, 2 and 5μg/ml solutions of Fe, Cu and Zn were prepared. The standard solutions were aspirated into the atomic absorption spectrophotometer (AAs) and the respective calibration curves were plotted on the AAS. As the sample solutions were aspirated, their respective concentrations were provided. The calculation is as follows:

13. Fe $\left(\frac{\mu g}{g}\right) = \frac{Conc \times solution volume}{weight of sample}$

14. $Cu\left(\frac{\mu g}{g}\right) = \frac{Conc \times solution volume}{weight of sample}$

15. $Zn\ (\mu g/g) = \frac{Conc \times solution volume}{weight of sample}$

Calculating the Percentage Daily Value (%DV) of the nutrients tested

In order to calculate the %DV of the nutrients, the ratio between the amount of the nutrient in a serving of food and the DV for the nutrient were determined. That is, the actual (unrounded) quantitative amount of the nutrient. The unrounded figure was used because there is no exchange list or serving size for turkey berries. Therefore 100 g of turkey berry was used as the portion size. The calculation for carbohydrate is given below.

$$16\%DV = \frac{Quantity\ of\ nutrient}{DV} \times 100$$

For the survey four trained research assistants from the Department of Vocational and Technical Education were used in collecting the data. The data were collected on the days scheduled for antenatal care for the three hospitals which were Mondays, Tuesdays, Wednesday and Thursday. All pregnant women who attended the antenatal dates on those days were used in the survey. A period of three weeks was used in collecting the data. Respondents were provided with the necessary logistics to save time since respondents were to complete the questionnaires instantly. This helped the respondents to complete the questionnaires on time so were attended to by the midwives on duty. Data was collected between the hours of 8 am and 12 noon that was the time period slotted for antenatal care. First all seated respondents were addressed on the purpose of the research. They were assured of anonymity and confidentiality. They were then given the questionnaires and the necessary logistics to use. Where respondents faced difficulties or could not read and write the research assistants helped in translating and writing their responses. There was a 100% retrieval rate of the questionnaires.

Data Analyses

Concentrations of all nutrients in test solutions were obtained from calculations using the listed standard equations and others calculated from the standard curve prepared. For each test, three readings were obtained and the average calculated. Percentages and means were used to describe the amount of different chemical constituents of food samples. Individual nutrients in the various forms of turkey berry (raw, parboiled and boiled) have been documented. To find out if the nutrients ascertained are in significant amount for human utilistaion % daily value was calculated and compared.

Results were expressed as per 100 g dry weight of the food. Mean values for triplicate analysis of each food determined by methods was calculated and results tabulated according to food samples. For each method of preparation, ANOVA was carried to determine if two or more food samples gave significantly different nutritive values (Wernimont, 1985). One-way ANOVA procedure was used to compare means between the forms or state of turkey berry to establish if differences in the amount of nutrient existed.. Before conducting the ANOVA, all assumptions for the procedure were verified. The assumptions are (a) the nutrients were independent of each other, (b) the quantities obtained for the nutrients were normally distributed, and (c) the variances were also homogeneous (Hancock, 1998). The assumptions were satisfied for each of the nutrients so the ANOVA was run.

Significant mean differences were detected for almost all the proximate and mineral composition therefore further evaluation was carried to identify exactly where the differences existed. A post hoc multiple comparisons was conducted to establish precisely which pairings had statistically significant mean differences. The Tukey HSD post hoc procedure was used because it is robust to unbalanced designs where there are a different number of participants in each subgroup (Lomax, 1992). To maintain an overall, experiment-wise alpha level of .05, the Tukey HSD procedureconducts each pair-wise comparison (t-test) at an alpha level of 0.05 over the number of comparisons. The result was then presented in tables.

Responses obtained from the survey were coded and into SPSS software version 20.0 and analysed. Both descriptive statistics of percentages and frequencies were generated. The result were then presented in tables and bar chart. Multiple responses of pregnant women on the knowledge on turkey berry were dichotomized to Yes or No before analysed using frequencies and percentages. Percentages were generated from the dichotomized categories, and the mean percentage of the chosen options were calculated to provide the knowledge level whether high or low, using the cut-off point of 50%, values above 50 conotes high knowledge and below as low knowledge. These were then presented in tables.

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter gives the details of the result obtained after the research was conducted. It further discusses the results in relation to other researches carried out within the same field of study.

What are the Nutritional Constituents of Turkey Berry

The proximate and mineral composition of the samples on dry weight basis is outlined in Tables 4 and 5, respectively. Turkey berry generally had high moisture contents indicated by 81.82%. It also had considerable high protein content with the value of 15.25%. Ash, Fat and fibre contents were relatively low 1.24%, 4.54% and 5.07% respectively.

Table 3: Proximate Composition of Turkey berry

	Mean %	Mean (g)	SD
Moisture	81.8255	81.8255	0.34
Ash	1.2361	1.2361	0.02
Protein	15.2561	15.2561	0.17
fats and oil	4.5363	4.5363	0.03
Carbohydrate	11.5728	11.5728	0.16
Fibre	5.0669	5.0669	0.06

All the eight minerals (though micro nutrients but essential) which were tested were present in turkey berry. Potassium was the most abundant mineral element found in turkey berry (1673.70 mg/100 g).Copper and zinc make the smallest percentage of turkey berry, that is, 0.0028% and 0.0029%.

The breakdown of proximate mineral composition is found in Table 4 below. The concentration of Phosphorus in the sample was estimated as 406.10 mg/100 g. This work gave an iron content of 18.30 mg/100 g. The concentration of Phosphorus in the sample was estimated as 406.10mg/100 g whereas iron content was 18.30 mg/100 g. The concentration of Phosphorus in the sample was estimated as 406.10 mg/100 g. The concentration of sodium in Turkey berry is 601.50 mg/100 g and calcium content was found to be 378.20 mg/100 g. The concentration of Magnesium in the sample is 61.10 mg/100 g.

Table 4: Mineral Composition of Raw Turkey berries

Content	Mean%	Mean (mg/100 g)	Std. Deviation
Iron	0.0183	18.30	.00
Copper	0.0028	2.80	.00
Zinc	0.0029	2.90	.00
Potassium	1.6737	1673.70	.01
Sodium	0.6015	601.50	.02
Calcium	0.3782	378.20	.03
Magnesium	0.0611	61.10	.00
Phosphorus	0.4061	406.10	.00

The %DV for each nutrient is shown in Table 5 below. It was evident that nutrient intake in every 100 g of turkey berry consumed was ranged between adequate and very high. The result showed that turkey berry provide high quantities of copper, iron and potassium in one portion of turkey berry indicated by their percentage values of 140%, 101% and 55% respectively in one serving portion of turkey berry. The %DV of carbohydrate of 3.86 was low but fat and oils of 6.98 was adequate.

Table 5: The Percentage Daily value of Nutrients in Raw Turkeyberry

Nutrients*	Content	% DV	Value
Protein	15.26 g	30.52	High
Fats & Oils	4.54 g	6.98	Adequate
Carbohydrate	11.57 g	3.86	Low
Fibre	5.07 g	20.28	High
Iron	18.30 mg	101.67	Very high
Copper	2.80 mg	140.00	Very high
Zinc	2.90 mg	19.33	Adequate
Potassium	1,673 mg	55.79	High
Sodium	601.50 mg	25.06	High
Magnesium	61.10 mg	34.38	High
Phosphorus	406.10 mg	15.28	Adequate

Turkey berry was found to be nutritious because it contains all the nutrients analysed. Moisture content of foods gives an indication of the available dry matter as well as plays a major role in determining the propensity of the food to spoil (Appiahet al., 2011). The high moisture content of turkey berry (81.82%) reflects the limited shelf-life. This figure is a little bit lower than most vegetables like cabbage 92.00 (0.12), lettuce 93.8(0.20) and tomatoes 93.50 (0.21) as reported by Hanif et al. (2006). The lower moisture content of a vegetable gives it a storage advantage. When harvested at physiological maturity and stored at room temperature, turkey berry can last up to five days as proposed by Lima and Alves, (2011) and Etebu, (2012). They reported that fruits and vegetables with moisture content between 82% and 84% can last between 2 and 7 days. For that matter turkey berry can last more days than lettuce, tomatoes or cabbage.

The protein content of turkey berry of 15.26% found in this study is higher than that of garden eggs 7.8 (0.21) suggesting that turkey berry can serve as a secondary source of protein. The percentage ash of the sample gives an idea on the inorganic content of the samples from where the mineral content could be obtained. The ash content in turkey berry of 1.24% is a little higher than that of spinach 1.1%. This value is lower than most green vegetables but higher than the range 0.6-1.1 of vegetables reported by Hanif et al. (2006).

Carbohydrates and fats are major sources of energy but though available carbohydrate content of the turkey berry of 11.70 g in this study is closer to that of onions which contain 11.60 g of carbohydrate in a 100 gram portion as reported by Weiner (2010) turkey berry cannot be used as a major source.

Magnesium is a constituent of bone and teeth and is closely associated with calcium and phosphorus. Magnesium is necessary for the release of parathyroid hormone and for its action in the backbone, kidney and intestine and for the reactions involve in converting vitamin D to its active form.

Iron performs several functions in the body; it helps in the formation of blood, it also helps in the transfer of oxygen and carbon dioxide from one tissue to another. The concentration of Copper in sample was found to be 2.80 mg/100 g. Turkey berry presented fairly low value for Zinc (2.90 mg/100 g).

Comparing the nutrient available in turkey berry with the DV of the various nutrients, it was evident that turkey berry are highly nutritious in a serving. All nutrients are high in quantity in every 100 g except carbohydrate which provides just 3.86% of the DV. Since turkey berry are used in stews and sources they are mostly accompanied with a carbohydrate dish and this will make up for the carbohydrate needs of the consumer. Iron requirement for all healthy people is estimated to be 18 mg per day and turkey berry provides more than 18 mg in every 100 g. This means that if more than 100 g of turkey berry is consumed in a meal then there no need to add any other iron rich food ingredient in that particular meal.

Again if a healthy person consumes about 100 g of turkey berry in a day there is the likelihood to attain the required nutrient needs. On the other hand, some groups of people, like pregnant women and anaemic patients, need extra iron to meet their requirement. Also depending on the health status certain nutrients need to be consumed in low quantities like sodium in the case of hypertensive people whereas potassium need to be consumed in high quantities by the same group of people. Therefore such groups of people may have to vary the amount consumed in a day depending on what nutrients they want to consume more or less to meet their requirement. However the iron may be bioavailable due to the presence of some phytochemicals like tannin and phytic acid (Hurrel, 2004). The type of iron (non heme) and the quantity of fibre also play a role in the absorption rate of iron when consumed.

Does the form in which Turkey Berry is prepared and eaten affect the Availability of Nutrients?

In Ghana, Turkey berry are eaten in cooked form and sometimes raw for a particular purpose. Proximate composition of protein, fat and ash of turkey berry was varied in all the forms, that is, raw, parboiled and boiled. The effect of cooking or heat on the proximate composition with the corresponding p-values is shown in Table 6. A significant difference was recorded for all the proximate composition except for fibre which showed no difference in the heat treatment given ($p > .05$). Significantly higher protein content ($15.3 \pm .17$) was recorded in raw followed by parboiled ($14.72 \pm .15$) in parboiled and cooked ($14.26 \pm .21$) cooked turkey berry ($p < 0.05$). Significantly higher fat content ($5.52 \pm .01$) was observed in parboiled turkey berry followed by $4.54 \pm .03$ in raw than cooked turkey berry ($p < 0.05$).

Cooking caused significant changes ($p < 0.05$) in all the mineral elements tested inTurkey berry. In this study minerals tested were reduced significantly when heat was applied. Significantly highest K, Ca, P, M and zinc content were recorded for raw turkey berry followed by parboiled and cooked. The Na content of raw turkey berry was found to be 601 mg/100 g DM. The highest Na content (516 mg/100 g DM) was observed in parboiled turkey berry followed by 498 mg/100 g DM in cooked turkey berry.The mineral content of the raw, parboiled and cooked turkey berry with the corresponding *p*-values are shown in Table 7.

Table 6: Proximate Composition of Raw, Parboiled and Cooked Turkey berry

Component	Mean (%)	Mean (g)	SD
Moisture	81.8255	81.8255	0.34
Ash	1.2361	1.2361	0.02
Protein	15.2561	15.2561	0.17
fats and oil	4.5363	4.5363	0.03
Carbohydrate	11.5728	11.5728	0.16
Fibre	5.0669	5.0669	0.06

Table 7: Mineral Composition of Raw, Parboiled and Cooked Turkey berry

Component		Mean	SD	Df	F	p value
Iron	Raw	18.30^{a}	0.00	2	7.00	0.03
	Parboiled	17.07^{a}	0.00			
	Cooked	17.40	0.00			
Copper	Raw	2.77^{a}	0.00	2	36.85	0.00
	Parboiled	1.97^{a}	0.00			
	Cooked	1.43^{a}	0.00			
Zinc	Raw	2.87^{ab}	0.00	2	16.32	0.00
	Parboiled	2.10^{a}	0.00			
	Cooked	1.93^{b}	0.00			
Potassium	Raw	1673.67^{ab}	0.01	2	24.35	0.00
	Parboiled	1572.07^{a}	0.04			
	Cooked	1527.87^{b}	0.02			
Sodium	Raw	601.50^{ab}	0.02	2	57.54	0.00
	Parboiled	516.00^{a}	0.01			
	Cooked	498.20^{b}	0.00			
Calcium	Raw	378.17^{ab}	0.03	2	14.01	0.00
	Parboiled	333.83^{a}	0.01			
	Cooked	303.90^{b}	0.01			
Magnesium	Raw	61.13^{ab}	0.00	2	7.89	0.02
	Parboiled	55.73^{a}	0.00			
	Cooked	54.80^{b}	0.00			
Phosphorus	Raw	406.10^{ab}	0.00	2	557.48	0.00
	Parboiled	280.10^{a}	0.01			
	Cooked	288.87^{b}	0.00			

*the mean values are g/100 g dry weight
ab — values with the same superscripts are significantly different from each other

Increased ash content was noticed in parboiled as compared to raw and cooked turkey berry. Leaching and heat may have affected the ash content in turkey berry. There was a significant different between raw and cooked turkey berry as well as raw and parboiled but there was no difference in parboiled and cooked turkey berry. This means that just a little application of heat affects the amount of carbohydrate in foods. Depending on the type of carbohydrate present in turkey berry, the reduction of carbohydrate content could be as a result of gelatinization (if it is starch) or sugar solution (if there are sugars).

An insignificant decrease in the fibre content of turkey berry was observed. Although cooking of plant tissues alters the physical and chemical properties of plant cell walls, which in turn affects their performance as dietary fibre (McDougallet al*.,* 1996) the results of this study shows that the fibre content was more stable. This is in agreement with Puupponen-Pimiäet al. (2003) who reported no significant change in soluble, insoluble and total dietary fibre contents of blanched spinach. This could be due to the stability of dietary fibre components found in the spinach. However, this is in contrast with Kala and Prakash (2004) who reported that cooking caused a slight increase in the total dietary fibre (TDF) content of Indian indigenous vegetables, which was attributed to the hydration or polymerization of TDF fractions.

Cooking was reported to have variable effects on micronutrients in indigenous vegetables ranging from no effect on iron and zinc content due to leaching (Uusiku et al*.,* 2008). There was a significant difference between raw and parboiled as well as raw and cooked but there was no difference between parboiled and cooked. Again, water and heat may be the cause of the decrease in sodium content which is as a result of leaching and solution formation since sodium is soluble in water. There was a decrease in the potassium content when heat was applied to turkey berry. On the other hand there was no significant difference in potassium with regards to the amount of heat applied ($P > 0.05$).

The result indicated that there was a significant decrease of iron between raw and parboiled. The result also showed that after turkey berry were boiled, there was a slight increase in the iron content compared to that of parboiled but the increase was insignificant leading to an insignificant difference between cooked and raw as well ($P > 0.05$). Even though Ganz & Nemeth, (2006) reported that heat made heme iron more bio available the study goes contrary to the study carried by Armah (2008), on non-heme iron in meat. There was a significant difference of Cu content among the three samples. The copper content reduced when it was parboiled. It again reduced to 1.93 mg per 100 g.

What is the Consumption level of Turkey berries among Pregnant Women?

This research question sought to determine the consumption level of turkey berry among pregnant women. The consumption level is shown in Table 8. The study indicated that majority of pregnant women who attended antenatal clinics in the Cape Coast Metropolis consume turkey berry. Out of the 186 pregnant women questioned, 127 (68.28%) said they eat turkey berry very often. Only 4 pregnant women representing 2.8% have never eaten turkey berry. This is depicted in Table 9.

Table 8: Distribution of how often Turkey berry is consumed by pregnant women who attend antenatal care in Cape Coast Metropolis

Response	Frequency	Percentage
Very often	127	68.28
Occasionally	48	25.81
Once	7	3.76
Never	4	2.15
Total	**186**	**100**

It was evident that they consume turkey berries in a number of ways or methods. This is also shown in Table 9. Most of the pregnant women use a variety of ways to prepare turkey berries prior to consumption. Majority (n = 102) of the women boil, blend or grind turkey berries and add to any food they prepare be it soup or stew or sauce. The 102 pregnant women, who said they boil, grind and add to any food continued to explain that they don't strain before adding to the food. On the other hand, out of the remaining 84 pregnant women, 54 said they sometimes strain before adding to their soup but in stew and sauces they use it in whole.

In order to determine how much of turkey berry are consumed by these pregnant women in a day, respondents were asked to state how much of turkey berry they buy and use in their meals per day. This is shown in Table 10. It was given that most of the pregnant women, that is, 159 representing 87.36% use not more than 1 Ghana cedi worth of turkey berry in a meal in a day.

Table 9: How Turkey berry is prepared before consumption

Preparation before consumption	Yes		No		TOTAL	
	F	%	F	%	F	%
Extract raw juice, add milk and drink	37	19.89	149	80.11	186	100
Extract raw juice add pineapple juice and drink	7	3.76	179	96.24	186	100
Boil berry, grind and add to any food	102	54.84	84	45.16	186	100
Boil, extract juice and add to soup only	57	30.65	129	69.35	186	100
Extract raw juice, add tomato puree and drink	16	8.60	170	91.40	186	100
Boil, grind and add to stew or sauce only	72	38.71	114	61.29	186	100

Table 10: The amount of Turkey berry consumed in a day

Price(Gh.cedis)	Frequency	Percentage
0.50	88	48.35
1.00	71	39.01
1.50	21	11.54
2.00	2	1.10
Total	**182**	**100**

Table 11 below shows that, majority of the respondents 157 (84.4%) out of 186 respondents consume turkey berry because it is nutritious. Just a few of the respondents, 7, representing 3.76% stated other reasons why they consume turkey berry. Whilst some said they ate turkey berry because it was edible, others also said they were recommended by people to eat it.

Table 11: Reasons why Pregnant women consume Turkey berry

Reasons	Yes		No		TOTAL	
	F	%	F	%	F	%
Turkey berry is a vegetable	22	11.83	164	88.17	186	100
Turkey berry is nutritious	157	84.41	29	15.59	186	100
Turkey berry tastes good	37	19.89	149	80.11	186	100
Turkey berry is an essential ingredient in certain foods	56	30.11	130	69.89	186	100
My mother uses it in cooking	23	12.37	163	87.63	186	100
Recommendations from people	7	3.76	3.76	96.24	186	100

It was also observed from the survey that pregnant women consume turkey berry. One reason for this high consumption level could be that turkey berry is always available and cheaper than other vegetables. Chadha (2003) has attributed the high consumption of indigenous vegetables in Africa to be 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 vegetables as they are considered and more nutritious as indicated by most of the pregnant women (84.41%) 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 indegenes between 52 % and 95 % of Zambians. The small amount of buying turkey berry by these pregnant women could be linked to the fact that it is cheaper as compared to other vegetables like garden eggs, okro and tomatoes.

Generally, indigenous/traditional food plants are used to fill in the relish gaps and in so doing they contribute to the food security and also provide dietary diversity for the people. Turkey berry were mainly used as food as in a relish (soup and sauce). Turkey berry are consumed by over 90% of pregnant women in Cape Coast metropolis. It should be noted that all the respondents knew turkey berry because it was shown to them therefore no confusion was created especially for which particular vegetable they were being questioned. Many of the respondents indicated that they use turkey berry in any food that they cook. Mnzava (1997), reported that people use indigenous vegetables whenever other relishes are in short supply or when famine strikes, thereby providing an alternative in times of need. This is not so in the case of turkey berry consumption in Ghana. This is seen in the frequency of consumption which can provide a clue on how important turkey berry are regarded in households. Generally, the pregnant women used traditional food preparation methods, that is, boiling and mashing or grinding, straining or not straining and then adding to the food. Over three-quarters of the respondents (93.55 %) used boiling and adding to food without straining, whereas a few (32.25%) use the extraction of raw juice and drink methods of food preparation. Because the eating habits of Ghanaians have been changing fairly fast, some respondents mentioned the use of a combination of cooking methods such as boiling prior to stewing or boiling, extraction of the juice and boiling again as in the preparation of soups.

Although locally, Turkey berry is a chief ingredient in the preparation of stews and sauces (Osborne & Voogt, 1978) especially kontomire stew or sauce and palmnut soup (Berko & Tayie, 2001) a few of the respondents which is indicated by 56(30.11%) consume turkey berry because it is an essential ingredient in certain foods. There are a number of ingredients or food stuffs that are added to foods to enhance flavour and give taste. For example ground shrimps are usually added to foods to give taste and flavour. This is not so for turkey berry since only 19% of the respondents indicated that turkey berry make food tasty. This is in agreement with Hoevl et al. (2013). Their study concluded adults and children refused to consume indigenous vegetables because of the taste. They further stated that indigenous vegetables tasted bland and do not make food taste good even when mixed with other vegetables. Turkey berry naturally has a bitter taste especially when eaten raw but it is reduced when cooked. Despite its bitterness this study shows that a lot of pregnant women consume turkey berry ignoring the taste but rather considers the nutritive value.

What Knowledge do Pregnant Women have on Turkey Berry?

Table 12 shows the frequency and percentage of the respondents who stated the nutrients that may be derived from the consumption of Turkey berries. As indicated earlier by the respondents that they consume Turkey berry because it is nutritious, a further investigation was carried to know which particular nutrient or nutrients can be found in Turkey berry are known by the respondents. There was a fair distribution of the nutrients indicating that all the stated nutrients can be found in Turkey berries. Whilst 62, 58 and 41 representing 33.33%, 31.18% and 22.04% respectively of the pregnant women said Turkey berries contain vitamins, proteins and minerals.

Respondents also gave the health benefits as well as the diseases that Turkey berries can cure. This is shown in Tables 13 and 14.

Table 12: What Nutrients can be found in Turkey berry?

Nutrient	Yes		No		TOTAL	
	F	%	F	%	F	%
Carbohydrates	31	16.67	155	83.33	186	100
Protein	58	31.18	128	68.82	186	100
Fats and oil	28	15.05	158	84.95	186	100
Vitamins	62	33.33	124	66.67	186	100
Minerals	41	22.04	145	77.96	186	100
Water	34	18.28	152	81.72	186	100
Fibre	40	21.51	146	78.49	186	100

Table 13 shows the knowledge pregnant women have on the health benefit of consuming Turkey berries. It is evident that almost all respondents stated that Turkey berries improve haemoglobin level. This is indicated by 149 respondents out of 186, representing 80.11% of the total respondents.

Table 13: Pregnant women's perceived health benefits of Turkey berry

Health Benefits	Yes		No		Total	
	F	%	F	%	F	%
Prevents colon cancer	7	3.76	179	96.24	186	100
Improves haemoglobin level	149	80.11	37	19.89	186	100
Reduces blood pressure	35	18.82	151	81.18	186	100
Reduces the absorption of blood glucose	19	10.22	167	89.78	186	100
Increases appetite	2	1.07	184	98.93	186	100

A further investigation to find out the knowledge of pregnant women with regards to the sicknesses or diseases Turkey berries can be used to cure showed that anaemia was the major disease known by majority, 158(84.95%). This is exhibited in table 14 below.

Table 14: Pregnant women's perceived medicinal benefits of Turkey berry

Diseases	Yes		No		Total	
	F	%	F	%	F	%
Fever	28	16.67	155	83.33	186	100
Asthma	17	9.14	169	90.86	186	100
Anaemia	158	84.95	28	15.05	186	100
Cough and cold	21	11.29	165	88.71	186	100
Cancer	4	2.15	182	97.85	186	100
Epilepsy	4	2.15	182	97.85	186	100
Hypertension	2	1.08	184	98.92	186	100

Good nutrition is essential throughout all the stages of the lifespan. Some groups of people need more nutrients than others. With the perceived health and medicinal benefits of Turkey berries an investigation was carried out to ascertain the knowledge on which group or groups of people that have to consume Turkey berries.. From Table 15, 71.51% of the pregnant women indicated that everybody needs to consume more. Only 4.30% and 2.69% of the respondents stated adults and the elderly to consume more of Turkey berries respectively.

Table 15: Groups of people who should consume more of Turkey berry

Categories of people	Yes		No		Total	
	F	%	F	%	F	%
Children	18	9.68	168	90.32	186	100
Adults	8	4.30	178	95.70	186	100
Pregnant women	36	19.36	150	80.64	186	100
Sick people	15	8.06	171	91.94	186	100
The elderly	5	2.69	181	97.31	186	100
Everybody	133	71.50	53	28.05	186	100

With reference to what consequences or effect that may occur as result of consuming too much of Turkey berries, almost all the respondents stated declined to each of the the stated side effects.. On the other hand just 3 and 4 out of the 186 respondents indicated that too much consumption may lead to constipation and nutrient toxicity respectively. This is represented in Table 16.

Table 16: The side effect of excess or overconsumption of Turkey berry

Effect	Yes		No		Total	
	F	%	F	%	F	%
Diarrhoea	13	6.99	173	93.01	186	100
Nutrient Toxicity	4	2.15	182	97.85	186	100
Bitterness	23	12.37	163	87.63	186	100
Constipation	3	1.61	183	98.39	186	100
High blood volume	6	3.22	180	96.78	186	100

Knowledge on foods and nutrition helps us to make the right choices of food, right combination and preparation methods to attain the maximum nutrients needed by the body. As in most diets with a significant proportion of vegetables consumed, protein, carbohydrate and fat quality and quantity are major nutritional concerns. Most plants do not supply all the nutrients required by humans and as a result combining different plant foods may improve the situation. The data in the present study provide evidence of the potential nutritional value of Turkey berries which does not go contrary to what the respondents stated during the survey. Respondents stated at least one of the seven nutrients provided in the questionnaire. Even though respondents chose more than one nutrient it was evident that they had diverse knowledge on the particular nutrients that may be available. On the other hand no nutrient was chosen by more than half of the respondents which means that one cannot rely solely on what was said by the respondents.

Most of the respondents have high knowledge on the haemoglobin improvement quality of Turkey berries. It is not surprising for this high figure because the nutritional analysis brought to light that Turkey berry is high in iron. However the test indicated a high fibre content (20.28% DV), which gives free movement of the bowel thereby preventing constipation and reduce the amount of glucose absorbed into the blood stream (Brown, 2007).

The incidence of dietary inadequacies as a result of dietary habits and patterns in pregnancy is higher during pregnancy than at any other stage of the life cycle. Thoughnutrition knowledge is predictive of change in dietary habits and health advices encourage expectant women to advance their food intake, this study revealed that more than half (77.42%) of the respondents didn't have knowledge on the nutritional value of Turkey berries but were consuming it.. The study pointed out that the knowledge of pregnant women about the nutrients that can be found in Turkey berries as: (33.33%), (31.18%), (22.04%) and (21.51%) had the knowledge that Turkey berries contain vitamins, protein, minerals and fibre. The result of this study was lower than the study conducted in America that more than half of women in the study lacked the basic and the essential knowledge regarding the importance and sources of most of vitamins and minerals (Fouda et al*.,*2012). This can be attributed to the fact that women lack better access to information about nutrition during pregnancy because they were housewives in the study area. Although in this study the reason for consuming Turkey berries by pregnant women was due to its nutritive value, the knowledge on Turkey berries as a food source of protein, carbohydrates and most important minerals and vitamin was low. The low nutritional knowledge level of Turkey berries may be due to low nutritional awareness or nutrition information and low socio economic status of the study participants.

Most (80.11% and 84.95%) of the respondents knew the health benefit and medicinal benefit of consuming Turkey berries to be improvement of haemoglobin level and curing of anaemia respectively. Majority ranging from 81.18-98.93% did not know the other health and medicinal benefits of Turkey berries like reduction in the absorption of blood glucose due to high fibre and the presence of some phytochemicals thereby using it to cure diabetes (Gandhi et al*.,* 2011). This low knowledge could again be attributed to low awareness and lack of information provided by experts. Since this study showed that Turkey berries is high in potassium it could a possible chief ingredient in the preparation of medicine for hypertensive patients and the prevention and cure of pre-eclemsia as reported by Fui (1992).

This study revealed that only 34.8% respondents had the knowledge on the special groups of people with special nutritional needs. This could be associated to the fact that they pregnant women lack knowledge on the specific nutrients and quantities that are in Turkey berries. Notwithstanding the fact that the respondents believed or knew that Turkey berries improve haemoglobin level and can therefore be used to cure anaemia, they didn't know that they (pregnant women) are one of the groups of people who need good nutrition. This low nutritional knowledge may be due to low income, lack of information about nutrition during pregnancy and low educational status of the study participants. Inadequate nutrition knowledge and practice during pregnancy can cause miscarriage and preterm birth. A study conducted by Fouda, et al. (2012) in America at El-Menshawy Hospital categorically stated that lack of awareness of the consequences of inadequate nutrition during pregnancy on mother and fetus led to miscarriage and preterm birth. There is therefore the need for pregnant women to know what they eat and how it affects them(Fouda et al*.,* 2012).

Over consumption of Turkey berry may lead to some nutrient toxicity or nutrient overload due to its high nutrient content like iron, calcium and potassium. However, according to Armah, Sharp and Mellon (2008) fibre is one of the inhibiting factors that reduce the absorption of iron. Again, the type of iron found in Turkey berry which is the non heme iron may cause low absorption rate. The respondents had low knowledge on this aspect of nutrition too.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The main objectives of this study were to determine the content of some selected nutrients in the fruits of*Solanum torvum sw.* and to find out if there are significant differences in nutrient content with respect to heat application. Secondary objective was to find out if pregnant women in the Cape Coast Metropolis have knowledge on the nutritional and health benefits of Turkey berry. To be able to achieve these objectives, four research questions were formulated for this research. A laboratory experiment was conducted to collect quantitative data using proximate analysis given by AOAC and Atomic Absorption Spectrophotometeric (AAS) methods to determine major nutrients and mineral contents of three Turkey berry samples respectively. The lab results were then analysed using means, percentages and ANOVA. A survey was also conducted by the use of a questionnaire to ascertain the consumption level and the knowledge of some selected pregnant women in the cape coast metropolis where frequencies and percentages were used for the analysis.

Key Findings

The results obtained from the research revealed thatTurkey berry are a source of food nutrients. All nutrients assayed in this study were found to be present in Turkey berry in significant amounts with exception of zinc and copper. The results also show that Turkey berry are high in minerals but low in major nutrients like carbohydrates, fats and protein. However the %DV of all nutrients was high with exception of carbohydrate of 3.86%. Though protein content was low in Turkey berry it was high in terms of %DV. Since Turkey berry are habitually used in the preparation of stews, sauces and soups it can be classified as a vegetable.

Data from the study also revealed that the nutrient content Turkey berry was higher than most exotic vegetables. The micro-nutrient content of Turkey berry was higher than that of lettuce, okro, garden eggs, kontomire and amaranthus with the exception calcium which was higher in amaranthus than in Turkey berry. This also means that Turkey berry is a good substitute and/or complement for most vegetables eaten in Ghana in times of poor harvest and in times of famine.

The research also showed a significant difference in most nutrients content due to the application of heat. The ANOVA was significant for all nutrients with the exception of fibre. Cooking or boiling did not cause a change in the fibre content of Turkey berry. All minerals decreased significantly when parboiled or boiled. For example potassium decreased from 1673.67 to 1527.87 mg when cooked and iron from 18.30 to 17.07 mg when parboiled.

For the survey the consumption of Turkey berry was high among pregnant women who attended antenatal care in the Cape Coast metropolis as over 95% consume Turkey berry whereas just 2.15% have never eaten Turkey berry. Pregnant women ate between 50 gp-1Gc0 g worth of Turkey berry a day. This indicates a high consumption level among pregnant women in Cape Coast Metro. The result also indicates that most women boil Turkey berry before consumption. 54.84% of the respondents boil grind and add Turkey berry to any food they prepare be it stew, soup or sauce. Only a few of the respondents actually consume the raw juice by adding milk, tomato puree or pineapple juice.

Pregnant women in the Cape Coast municipality had limited knowledge on the nutritional, medicinal and health benefits of Turkey although most of them stated that it is nutritious. Between 65 and 84% of the respondents didn't know the specific nutrient found in Turkey berry. The vitamins were the most nutrients known by 33.33% of the respondents. The health benefits stated by most respondents was the ability of Turkey berry to improve haemoglobin (80.11%) and the cure for anemia (84.95) as the medicinal benefits of Turkey berry and only 1.08% stated the cure of hypertension as medicinal benefit.

Conclusions

It was evident that Turkey berry contain a number of nutrients including minerals. Turkey berry were high in protein, carbohydrate, fibre, potassium, iron, magnesium, phosphorus and calcium. The overall conclusion from data collected aboutTurkeyberries reveals that it is a good source of a number of nutrients such as proteins, carbohydrates, fibre and some selected minerals such as calcium, phosphorus, potassium and iron. It is not a good source of fat since it has less than 3% crude fat. Comparison of data from the study and literature values of other vegetables eaten in Ghana revealed that Turkey berry are good sources of mineral elements.

It was also evidenced that heat, cooking specifically boiling caused a significant decrease in the nutrient content of Turkey berry. However for the attainment of specific nutrients it will be appropriate to prepare Turkey berry in their raw state, parboiled or boiled. Also the reduction may not be significant when more than 100 g of Turkey berry are cooked and consumed to attain the required nutrients.

Though consumption level of Turkey berry is high among pregnant women their knowledge level pertaining to the nutritional and health benefit is low. The nutritional knowledge level of pregnant women in relation to the consumption of Turkey berry is low. Turkey berry are reported to be used for food as well as for medicine. The reported medicinal uses of Turkey berry include their use in treating diseases such as cough and cold, fever, epilepsy, cancer, hypertension, diabetes, constipation. The high potassium level may be beneficial in the treatment of hypertension. High fibre and iron may be beneficial in the treatment of diabetes and constipation.

Recommendations

Turkey berry were found to be rich sources of micronutrients and fibre. Therefore, the consumption of Turkey berry should be promoted by researchers, non-governmental organizations and other relevant government/non-governmental departments at all levels of society. Consumption may be promoted by finding ways to cultivate them and also organizations working with indigenous vegetables should conduct food festivals using Turkey berry in a variety of foods and the development of new recipes with the aim of preserving the indigenous knowledge of these vegetables. In addition to all these promotional activities, the government should be engaged by researchers towards the implementation of policies that will promote research on indigenous vegetables.

From the present results it is hypothesized that most mineral losses might be due to leaching of nutrients from the indigenous vegetables into the cooking water during prolonged exposure to water and heat. Therefore, it is recommended that water used in boiling Turkey berry must be added to food consumed.

More research needs to be done to determine the nutritional content of other species of the genus *solanum* growing in Ghana. Since this work started, attention has been drawn to the existence of two other Turkey berry species which are bitter-tasting and which are also eaten. Determination of the nutrient content of these other species would broaden the nutrient data base for this group of wild edible vegetables. Wild plants provide basic energy (caloric), vitamin, and mineral needs. Despite publication of nutritional composition tables for some African wild plants (Leung, 1968), data on most are unavailable. If compositional data were available, important decisions could be made by agriculturalists and economic planners.

Systematic efforts need to be initiated to develop a nutrient database to report energy, vitamin and mineral composition data as well as anti-nutrients edible wild plants like Turkey berry in Ghana, where there is a paucity of information on the nutrient content of most edible wild foods. It is also vital to develop a nutrient database for edible wild species not only in Ghana but the whole of sub-Saharan Africa. Such data could be of enormous nutritional and economic return.

If a data base is developed for these nutritional and health benefits of Turkey berry it can be recommended and documented in any nutritional information especially to groups of special nutritional needs like pregnant women, children, adolescents etc. Turkey berry can also be incorporated in the dishes cooked for children in schools and hospitals to boost their nutrient intake since it is highly nutritious

There is also the need to carry out further studies on different maturity levels of the vegetable to ascertain which type contains more nutrients. Mnamani, et *al*. (2009) stated that variations in the chemical compositions of vegetables, including quantity of compounds that are useful and detrimental to humans are influenced by environmental conditions and the age of plants at harvest.

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APPENDICES

UNIVERSITY OF CAPE COAST

COLLEGE OF EDUCATION STUDIES

DEPARTMENT OF VOCATIONAL AND TECHNICAL EDUCATION

QUESTIONAIRE FOR PREGNANT WOMEN

The purpose of this interview is to ascertain information on the knowledge pregnant women in the Cape Coast Metropolis have on the nutritional value of Turkey berries. This information hopefully will help highlight the importance of promoting the consumption of Turkey berries. The information collected will be used purely for academic purposes. Anonymity and confidentiality are assured. Thank you for participating.

PARTICIPANTS' DEMOGRAPHICS

1. Age or date of birth ……..

2. What is your highest level of education?

- Primary school (class 1-6) [ ]
- Junior high school (form 1-3) [ ]
- Senior high school (1-3) [ ]
- Tertiary education [ ]
- No formal education [ ]

Consumption level of Turkey berries

3. How often do you eat it?

Please tick the preferred option

- Often [ ]
- Occasionally [ ]
- Once [ ]
- Never [ ]

4. How much worth of Turkey berries do you buy and use in your food

- 50p [ ]

- 1.00 [ ]
- 1.50 [ ]
- 2.00 [ ]

6. Why do you eat Turkey berries?

- Because it is a vegetable [ ]
- Because it is nutritious [ ]
- Because it makes food taste good [ ]
- Because it is an essential ingredient in certain foods [ ]
- Because my wife uses it in cooking [ ]
- Because my mother uses it in cooking [ ]
- Other (specify)..

7. Do Turkey berries contain any nutrients? Yes [ ] no [ ]

If yes, what nutrients do they contain?

- Carbohydrate [ ]
- Protein [ ]
- Fats and oils [ ]
- Vitamins [ ]
- Minerals [ ]
- Water [ ]
- Fibre [ ]

8. Which category of people do you most recommend the consumption of Turkey berries (tick all that applies)

- Children [ ]
- Adults [ ]
- Pregnant women [ ]
- Sick people [ ]
- The elderly [ ]

9. Why do you recommend them to eat Turkey berries?

- Because it is nutritious [ ]
- Because it improves haemoglobin level [ ]

10. How do you prepare Turkey berries prior to consumption?

- Extract raw juice and add milk [ ]
- Extract raw juice and add pineapple juice [ ]
- Boil and use whole berries in food [ ]
- Add whole berries to any stew or sauce [ ]
- Boil, extract juice and add to soup [ ]
- Extract raw juice, add tomato puree and drink [ ]
- Other [specify] ....

Nutritional knowledge

11. What nutritional and health benefits can be derived from Turkey berries?

- Prevent colon cancer [ ]
- Improves haemoglobin level [ ]
- Reduces blood pressure [ ]
- Reduces the level of blood glucose [ ]
- Others [specify] ....

12. Which diseases or sicknesses can Turkey berries cure?

- Fever [ ]
- Asthma [ ]
- Anaemia [ ]
- Cough and cold [ ]
- Cancer [ ]
- Epilepsy [ ]
- Other [specify] ....

13. What could be the possible side effect of consuming too much of turkey berries

- Diarrhoea [ ]

- Toxicity/poisoning [ ]
- Bitterness in mouth
- Constipation
- Others [specify] ....