KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY,

KUMASI

COLLEGE OF SCIENCE

DEPARTMENT OF FOOD SCIENCE AND TECHNOLOGY

QUALITY ATTRIBUTES OF SOME ORGANIC VERSUS CONVENTIONAL FRUITS AND VEGETABLES IN GHANA

BY

LAWRENCIA AFOLEY NTIM

A THESIS SUBMITTED TO THE DEPARTMENT OF FOOD SCIENCE AND TECHNOLOGY, COLLEGE OF SCIENCE IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MSc FOOD QUALITY MANAGEMENT

JUNE, 2017

DECLARATION

"I declare that I have wholly undertaken this study reported therein under the supervision of Dr. Jacob Agbenorhevi and that except portions where references have been duly cited, this Thesis is the outcome of my research".

……………………….. ………………………..

Lawrencia Afoley Ntim Date

Certified by:

…………………………… ………………………..

Dr. Jacob Agbenorhevi Date

(Supervisor)

Certified by:

…………………………… ………………………..

Mr. John Barimah Date

(Head of Department)

ABSTRACT

The choice between organic and conventional food with regards to safety and quality has received attention over the last decade and this has become an important debate among professionals and scientists. The objectives of this work were to assess and compare the nutritional and physicochemical properties of some selected organic and conventional fruits and vegetables, and to determine the perception of consumers on organic and convention fruits and vegetables. Some organic samples (pawpaw, okro and pepper) were obtained from an organic farm in the Brong Ahafo Region and their corresponding conventional samples were also obtained from other farms. These samples were subjected to various forms of sample analysis to ascertain nutritional content, mineral composition and physicochemical properties. 200 questionnaires were also administered randomly to the general population to ascertain consumer perception on organic and conventional fruits and vegetables. On the perception index, majority of the respondents 89.50% had knowledge about organic foods whereas some section representing 10.5% did not know of it at all. Also, for conventional foods, 63.64% had knowledge of it whereas 36.36% did not know of it at all. In relation to the possible health risks, 9.24% and 34.45% admitted there could be health risk associated with organic and conventional foods respectively, whereas 53.78% and 27.73% respectively thought otherwise. In terms of moisture, there was a significant difference between organic and conventional samples of pepper (*Capsicum annum L*) and okro (*Abelmoschus esculentus L.*). There was no significant difference between moisture content of organic pawpaw (OPP) and conventional pawpaw (IPP) samples. Among the samples investigated, IPP had the highest protein content, followed by OP, OK, IK, OPP and IPP. There was significant difference between both organic and conventional samples in terms of ash and fat contents. The organic samples had averagely a good fiber-carbohydrate balance. With the exception of organic and conventional pawpaw samples, there was a significant difference between organic and conventional pepper and okro samples at $p \leq 0.05$ in terms of the fiber-carbohydrate content. The potassium content of two (IK and IPP) out of the three conventional samples was very high as compared to their organic counterparts. This result underscores the fertilizer application mode of most conventional farming practices especially the application of the popular NPK (Nitrogen, Phosphorus and Potassium) fertilizer. On the average, the sodium content of all samples fell within the range most of which are close to the mean point. With the exception of organic and conventional pepper, there was a significant difference in pH value between pawpaw and okro samples. Despite the fact that both organic and conventional samples were of the same stage of ripening, their brix and refractive indices differed significantly as well at their acidity. The titrable acidity of the conventional sample was higher than the organic sample. Phenolics of both organic and conventional pawpaw samples were very close. This survey indicated that most people perceived that products from organic sources are not only safer but also much more enriched with nutrients for good health while on the contrary perceived conventional foods to have high risk of health related issues. Nutritionally, the proximate and physicochemical studies proved that the organic samples in most instances had higher contents of nutritional constituents specifically protein, fiber and carbohydrates and high phenolic and brix contents and the antioxidant potency of organic foods to be quite higher when compared to the conventional ones. The conventional samples however had higher constituents of the specific minerals (Potassium, sodium, magnesium and calcium).

DEDICATION

This work is dedicated to the Almighty God for his faithfulness in my life and also to my entire family especially my husband, Michael Ntim.

ACKNOWLEDGEMENT

Many people have contributed immensely to the success of this thesis and filled with so much joy to acknowledge their valuable support.

I am highly grateful foremost to the Almighty GOD for His incomprehensible grace and favour throughout my pursuit of this degree.

I am very grateful to my supervisor Dr. Jacob Agbenorhevi, Department of Food Science and Technology, who showed profound interest in this research and meticulously guided me through all the various stages of my work up to this of the final thesis.

I am equally grateful to Nana Osei Bonsu Boakye for his assistance in analyzing the samples and also Nana Kwaw Adams, The Executive Director of Abono Organic Farming Project (ABOFAP) for providing me with Organic and Conventional samples from his farms. I cannot forget Mr. Isaac William Ofosu of Department of Food Science and Technology for his encouragement and guidance.

Last but not the least, I am grateful to my friend and husband Mr. Michael Ntim for inspiring me to come this far.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

1.1 Background

Traditional farming was the only existing farming method practiced in the olden days (several thousand years ago). There were several kinds of this farming method. Out of these, conventional system of food production is regarded as oldest throughout the world (Douglas, 2003). Food-related choices made by individuals are influenced by a complex array of factors and processes. These include biological determinants (hunger, appetite and taste) (Stubbs *et al*. 1996, Sorensen *et al*. 2003), economic determinants (cost, income and availability) (Donkin *et al*. 2000, Dibsdall *et al.* 2003), physical determinant (access, education, skills and time) (Kearney *et al*. 2000), social determinants (culture, family, peers and meal patterns)(Devine *et al*. 2003, Sorensen *et al*. 1998, Anderson *et al*. 1998), psychological determinants (mood, stress and guilt) (Dewberry & Ussher, 1994) and attitudes; belief; and knowledge about food. (Gibney, 2004, Glanz *et al.* 1998).

Diet plays a crucial role in health and diseases. The food one chooses to eat can help in the prevention of many illnesses, thus increasing our quality of life. There are a lot of foods decisions than ever before in our markets and this typically cause confusion in determining what food decisions are the healthiest. Some individuals are selecting organically grown foods over conventionally grown foods (Dangour *et al*. 2009). Organically grown goods are preferred to conventionally grown foods for several reasons. It is environmentally friendly. Moreover, it does not build up chemical residues. It is also rich in nutrients, among other things.

Individuals must therefore take into consideration the proposed health benefits of consuming organic as against conventional foods (Smith-Spangler *et al*. 2012).

Conventional foods are defined as those foods that are grown with the application of synthetic fertilizers, waste product sludge, irradiation, genetic modification, pesticides, or drugs (American Dietetic Association, 2012). Conventional methods of agricultural practice were widely adopted in the aftermath of Second World War.

A typical farmer does not perceive the term organic (introduced in the 1940s) as something that is deliberately inculcated into farming practice, but rather sees it as a natural system (in modern terminology) comprising all the living components such as insects and microorganisms as well as parts of living organisms, such as leave and remains of dead plants and animals among other things. These components function holistically to produce a stable condition in the soil (Howard, 1940; Balfour, 1943).

Organic foods are defined as those foods that are grown by adopting natural means of obtaining nutrients, such as manure, crop residues and compost. It also involves the natural methods of controlling weed. Synthetic substances are completely avoided. Foods that are organic are fruits, vegetables, grains, dairy foods, eggs, and may include meats and poultry products (American Dietetic Association, 2012).

Organic farming also enhances food quality and genetic diversity by improving soil fertility (IFOAM, 1998). In essence, it promotes ecological as well as socio-economic stability (Samman *et al.* 2009).

Increased public perception regarding the adverse effect of agrochemicals on health and the environment informed the rise in consumer demand for organic foods in the last twenty years.

1.2 Problem Statement

Food safety and food quality as well as nutritional differences between organic and conventional foods has received increased attention over the last decades as some health professionals and policy makers believe organic products have measurable health benefits than conventional products. This has brought about an important part of debates and divided opinions among the public, health professionals and policy makers.

1.3 Objectives

The main objective of the study was to assess the quality of some organic versus conventional fruits and vegetables. The specific objectives were:

- To assess and compare the nutritional contents of some selected organic and conventional fruits and vegetables.
- To determine and compare the physicochemical properties of organic and convention fruits and vegetables.
- To assess the perception of consumers on organic and convention fruits and vegetables.

1.4 Research Questions/ Analyses

The research questions to be addressed by the general public include:

- What are the perceptions on organic/ conventional fruits and vegetables by the general public?
- How knowledgeable are people on organic/ conventional fruits and vegetables?
- Analysis conducted to check if Organic Foods are better (Safer or Healthier) than Conventional counterparts.

CHAPTER TWO

LITERATURE REVIEW

2.1 Organic Farming

Organic farming is a type of farming which makes use of techniques like crop rotation, manuring, compost and the management of pest. This method of farming precludes the utilization of synthetic fertilizers and pesticides such as insecticides. Moreover chemical growth inducements such as food additives, genetically modified organisms, human waste matter sludge, and nanomaterials are strictly avoided. Organic farmers restrict themselves to principles such as the use natural fertilizers and pesticides. One of the well known natural pesticides used by organic farmers is pyrethrin, extracted from Chrysanthemum flower. Technology and ecology are important in the practice of organic farming. Organic agriculture is concerned with many issues and not just end products of the farming method (Paull, 2011).

The National Organic Standards Board (NOSB) of USDA defines organic agriculture as “an ecological production management system that promotes and enhances diversity, biological cycles, and soil biological activity”. Ecological harmony is attained as a result of the minimum utilization of off-farm inputs and good management practices. Organic farming is mainly aimed at maximizing the health all natural communities (NOSB, 1995).

According to the FAO/WHO, Organic agriculture is defined as a holistic production management system that promotes and enhances agro-ecosystem health, including biological diversity, biological cycles, and soil biological activity. It stresses on the implementation of management practices over the use of off-farm inputs, giving consideration to the fact that regional conditions require domestically adapted systems. This can be achieved through the use of, if feasible, agronomic, biological, and mechanical processes, in place of synthetic approach to ensure the proper function of the system (FAO⁄WHO, 2007).

The IFOAM also describes organic agriculture as a system of food production that ensures quality soil, favourable ecosystem as well as the wellbeing of people. Organic agriculture uses scientific discoveries to better the lots of mankind in particular and life in general (IFOAM, 1998).

The key components of organic agriculture, such as the avoidance of chemical usage, preservation of the environment and crop rotations for many years back, had been practiced in the traditional way (Heckman, 2006).

Organic farming was developed by two renowned botanists, Sir Albert Howard the early 1940s. Their work was motivated by their experience in Indian traditional farming methods as well as their background in science (Paull, 2006). Sir Albert Howard was the first scientist to use scientific knowledge and principles in these various traditional and more natural methods and was therefore seen to be the "father of organic farming"(Stinner, 2007).

Organic foods are known to set standards for top quality freshness, texture, flavor, and variety (http://www.wholefoodsmarket.com).

Many policy-makers in developing countries contemplate organic agriculture as a procedure that uses strict rules and complicated practices that allow marketing of food products which are certified (Nadia, 2000).

In recent years, the farming method has been a consistently growing phenomenon, with 120 countries growing 31 million hectares, mainly by households and family groups (Willer & Yussefi, 2006).

USA is currently experiencing a steady growth in organic farming by 20% annually, which earns the nation about 10 billion USD. Similarly, Europe experiences 25% annual growth, roping in as much as 10.5 billion USD annually (SOEL, 2003).

Globally, 37 million hectares of land is devoted to organic agriculture accounting for about 0.9% of global agricultural land. One-third of organic agricultural land and less than three-quarters of organic producers are found in transition and developing nations (OTA 2011; Willer & Kilcher, 2011).

A study conducted in 2009 on organic production, in Ghana, discovered that about organic farming was being practiced on about 0.19% of the country's agricultural land (http://www. agricinghana.com/tag/organic-farming-in-ghana/)

In the year 2010 alone, produce from organic farming yielded a whopping fifty-nine billion US dollars on the global market which was 300% higher than that 2000. The market was dominated by Europe and North-America jointly constituting over ninety-six percent of the world market (OTA 2011; Willer & Kilcher, 2011).

In Europe, Organic farming is usually 'ecological' or 'biological' in nature. The farming practice is self-sustaining through the use of ecological and biological mechanisms (Vogt, 2000). These phenomena are manifested in four basic organic agriculture values namely; fairness, health, care and ecological consciousness (IFOAM, 2005). The proponents of these values (IFOAM) attained this feat by consulting key players and members whose views were accepted independently. Members are to strictly follow the values.

Organic farming and Health

Organic Agriculture, if strictly followed, is expected to promote a healthy soil, living organism and the planet as a whole (IFOAM, 2005). Health is tightly attached to this farming method because a healthy people and for that matter a healthy community is indistinguishable from a healthy ecosystem. This is so because people become healthier when they eat healthy food. Health is not just the absence of illness, bust encompass physical, environmental, socio-economical as well as mental wellbeing of an individual. Immunity, resilience and rejuvenation are key issues considered in health. No single organism is left out when it comes to the health benefits of organic agriculture. Organic agriculture guarantees highly nutritious food. This makes it unnecessary to use food additives, fertilizers and other chemicals that have adverse health effect on man in particular and animals in general.

(http://www.ifoam.org/about_ifoam/principles/index.html).

Organic farming and Ecology

Organic Agriculture relies greatly on stable ecological systems and cycles. For this farming practice to be effective the farmer needs to study and understand how to maintain a stable ecological system (IFOAM, 2005).

Per the principle of ecology, organic food production emanates from living ecological systems which make use of ecological methodology and recycling. The ecological specificity of an environment, to a large extent, determines the nature of food and for that matter the health status of the people. For instance, it is the nature of the soil that matters as far as crops are concerned; in the case of animals it is the ecosystem of the farming environment; the aquatic ecosystem is considered for aquatic organisms (http://www.ifoam.org/about_ifoam/principles/index.html).

The cycles in ecological agriculture are universal in nature though their methods of operation are dependent on the site. This suggests that in the practice of this farming method the farmer should also consider the prevailing condition which embodies geography and culture of the people. Reprocessing and recycling are the necessary tools needed for efficient utilization of resources and protection of the environment. To ensure an ecological balance, genetic diversity and proper planning must be encouraged. Environmental protection efforts should not be limited to farmers alone, but agricultural marketers and consumers as well. Their activities should promote and safe-guard a pure atmosphere, clean water bodies and other habitats and protect the inhabitants of the habitats (IFOAM 2005, Principles of Organic Agriculture).

Organic agriculture and Fairness

Organic cultivation should depend on interactions that sustain fairness with regard to the normal environment and the opportunity to be in existence (IFOAM, 2005).

Fairness is described as equity, justice, respect and stewardship of the collective world amongst people and in their association to other living beings.

The principle of fairness stresses that those who are concerned in organic agriculture ought to carry out their human interactions in a way that guarantees fairness at all levels and equity to all involved (processors, farmers, traders, workers, distributors and consumers). Organic agriculture should contribute to the reduction of poverty, sovereignty and offer good quality life to everybody involved. Its objective is to provide adequate provision of quality produces. This principle ensures that good conditions and life opportunities are provided to animals in accordance with their physiology, natural conduct and well-being. Environmental and natural resources used in production and consumption should be ecologically and socially acceptable and must be in good state for upcoming generations. Fairness requires transparent and impartial systems of production, distribution and trade. It also needs systems which can actually cater for social and environmental costs (http://www. infohub. ifoam. bio/en/what-organic/principles-organic-agriculture#Health).

The Principle of Care

Organic Agriculture should protect the well-being and health of present and future generations and the environment in a responsible and preventative manner (IFOAM, 2005).

Organic farming is sensitive to internal and external conditions and demands because it may be a system which is dynamic and living. Those who practice organic farming can improve efficiency to boost production, but this should not have negative effect on health and well-being, hence, new technologies must be evaluated and existing ones reviewed. Care must be taken when tackling these issues because of the scanty knowledge of agriculture and ecosystems. With this principle, responsibility and precaution are considered most in development, management and technology options in organic cultivation. Science is a necessity to ensure that organic cultivation is safe, healthy and ecologically acceptable. However, scientific knowledge obtained alone is not enough. Knowledge with practice, builds up wisdom as well as indigenous and traditional knowledge put forward applicable suggestion, proved by time. Organic farming must avoid major risks by taking on acceptable technologies and refusing those that cannot be predicted. All decisions ought to reflect the needs and values of all those who may be affected, through stakeholder consultation processes and transparent.

These principles have a powerful ethical aspect and show a much wider perspective of agriculture compared with the Good Agricultural Practice which can serve as a guide to conventional farming (DARD, 2008).

Mechanical cultivation, crop rotation, biological pest control and green manures and compost, form part of the key methods of organic farming. These methods improve agricultural productivity by means of creating healthy natural environment. For instance, in order to enhance soil nitrogen quality, leguminous crops are planted between other crops. In overcoming pests, biological control methods as well as crop rotation are resorted to. Organic substances such potassium bicarbonate and mulching material are used for weed and disease control (U.S. EPA, 2013).

2.1.1 Importance of Organic Farming

Organic farming is a many-sided development in the area of food production and agriculture. On one side, it makes use of small external contribution production method coming from both alternative and traditional farming whiles on the other side; it demonstrates what society argues on about the agriculture sustainability on quality of food and dietary behaviour and on ethical matters like animal wellbeing. A growing number of policy makers and scientists define organic agriculture as a holistic and efficient approach to achieve the numerous goals of agriculture together with food security, continuous use of natural resources and the dignity of creatures (Jaber, 2000).

Organic agriculture contributes to future paradigm for food cultivation which depends on sociology, biology and ecology other than more one-way physical and chemical management approaches (Doran *et al*. 2007). Organic agriculture is trusted to produce relevant economic, environmental and social benefits.

2.1.2 Environmental Importance

Organic systems used in farming harmoniously cooperate with nature and therefore do not need chemical inputs. This characteristic of organic system makes it environmentally friendly. It can offer further means for climate change improvement through measures like enhanced soil carbon appropriation (Haas *et al.* 2000). Organic agriculture uses a single approach to land management that stresses on the land's natural ecosystem maintenance for example the regulation of water quality and flow, regulation of the climate and the preservation of biodiversity (Foley *et al.* 2005). It decreases the risk associated with pesticide use and can enhance species diversity (Bengtsson *et al.* 2005; Hole *et al.* 2005).

Organic farming, thus seeks to provide realistic option to conventional practices in the light of ever-growing issues concerning environmental degradation and climate changes. Organic methods improve soil fertility (Leifeld & Fuhrer, 2010) and reduce the incidence of soil erosion which makes the soil healthy (Azadi & Ho, 2010). It uses little power and decreases gas emissions from agricultural greenhouse (Gomiero *et al.* 2008), and also decreases the losses of nitrogen from the system (Drinkwater *et al.* 1998).

In broad terms, it is also considered friendly to the ecosystem because it emphasizes on less tillage and the use of synthetic fertilizers, pesticides and herbicides are reduced. Organic agriculture is also expected to play an important role in preventing desertification, biodiversity keeping, adding on to sustainable progress and supporting plant and animal health (IFOAM, 2005).

The avoidance of using pesticides indiscriminately which can contaminate water and soil, resulting in generalized ecosystem pollution makes it an achievement for organic agriculture (Azadi & Ho, 2010).

Organic farming supports wildlife than conventional farms. A typical organic farm has five times as many wild plant species (57%) and 44% more bird species in cultivated areas than a regular farm (Soil Association, 2000).

2.1.3 Social importance

More job is created for people in rural communities from organic farming as it involves additional manual labour to make up for the loss of synthetic pesticides and fertilizers (Green *et al.* 2006; Bray *et al.* 2002; Bakewell-Stone *et al.* 2008).

Organic cooperatives often provide training and extension services, encourage social networks, and offer means to credit and health programs (Valkila 2009).

In addition, organic cash crops are often part of a varied mixed farming system which includes rearing of livestock and growing of other crops for home use and other markets (Bacon 2005). This varied system can assist in the reduction of vulnerability by decreasing the economic dependence on just one crop.

2.1.4 Economic importance

Organic farmers usually get prices which are higher and stable for their products (Bolwig *et al.* 2009; Valkila 2009) and their inputs are naturally cheaper with lower total cost of production (Valkila 2009).

Organic production is expensive due to the fact that its start-up costs is high, for instance organic farmer will need higher labour requirements which the local resources cannot provide, the demand for advanced knowledge and attainment of skill, cost of significant certification and at times the need to get costly organic inputs (Bray *et al.* 2002; Calo & Wise 2005; Chongtham *et al.* 2010).

In developing countries, organic farmers focus more on export. The farmers thus depend on access to foreign markets; they need to go through certification process in which they are strictly required to meet international standards. The overdependence on global markets can generate major impediments to the small farmers and these farmers can be potentially vulnerable. There could be considerable delays in many developing countries, before farmers are fully paid for their organic produce also organic farmers often put up for sale parts of their organic produce on cheaper conventional markets to get instant payments at expense of higher profit (Bacon, 2005). The organic products that cannot be exported are sometimes sold on the conventional markets which usually have a rather low demand and high quality-requirements (Bacon, 2005; Valkila 2009; Chongtham *et al.* 2010).

The process of organic certification is somewhat discriminatory. It favours small scales farmers more (Gómez *et al.* 2005; Getz & Shreck, 2006). The monitoring and control that underlie organic certification limits farmer's freedom to trade on their own terms and conditions (Mutersbaugh, 2002).

2.2 Conventional Farming

Conventional farming, also referred to as industrial agriculture, refers to methods of farming which include the use of synthetic chemical fertilizers, pesticides and herbicides and genetically modified organisms (USDA). It is the type of agriculture that uses high external energy resources to achieve increased yields and generally relies upon technological innovation and fossil fuels to support the required energy. Many agricultural practices fall under this system of plant cultivation.

This modern / sustainable type of farming is a system of growing a single plant species under controlled and intensified also known as industrial farming. Conventional intensifies agricultural methods have only existed since the late Nineteenth Century, and did not become popular until after World War 2 (http://www.appropedia.org/Conventional_farming).

2.2.1 Importance of Conventional Farming

Conventional farming is attributed to producing larger quantities of food on less land which allows for out of season growing, and creates a longer shelf life. Larger quantities of food produced from Conventional farming may reduce the rising cost of food and make it more affordable, and also save lives of people starving from hunger (Wisniewski *et al.* 2002). It is also leads to rapid technological innovation and large-scale farms.

Conventional farming can lead to decline in soil productivity and this can be due to exposed topsoil; soil compaction; loss of soil organic matter, water holding capacity.

Conventional farming can lead to pollution of the environment and water bodies because of the extensive use of salts, fertilizers (nitrates and phosphorus), manures and pesticides. Pesticides from the various chemical classes have been found in groundwater and are mainly found in groundwater under agricultural lands due to nutrient runoff thereby compromising the water quality.

Due to conventional farming, over four hundred insects and seven hundred fungal pathogens have developed resistance to one or more pesticides. There is also loss of wetlands and wildlife habitat.

Destruction of tropical forests and other local vegetation for agricultural production has a role in high levels of carbon dioxide and other greenhouse gases in the atmosphere (http://www.nal.usda.gov/afsic/AFSIC_pubs/srb9902.htm#toc3).

Conventional farming needs large capital investments in order to apply production and management technology; extensive use of pesticides, fertilizers; high labor efficiency; and dependency on agribusiness.

In the U. S, agricultural sector has a track record of increasingly large federal expenditures and corresponding government involvement in planting and investment decisions this broadens disparity among farmer incomes; and escalating concentration of agribusiness–industries involved with manufacture, processing, and distribution of farm products– in the hands of fewer individuals. Market competition is therefore limited with farmers having little or no control over their farm prices, since they get smaller amount of money from consumers on their agricultural products (http://www.nal.usda.gov/afsic/AFSIC_pubs/srb9902.htm#toc3).

2.3 Possible Health Risk of Pesticides

Farmers apply pesticides to protect their crops pests and pathogens in order to obtain increased yield. Adversely, non-organic products applied to the crops may control pests however with time may become poisonous to the consumer. The negative implications on consumers are enormous: the amount of food ingested over time correlates to the accumulation of the chemical traces in the body PG 1545. Many of agricultural and veterinary (AgVet) chemicals have been accepted for use to support continuous food production (Haddad, 2009; Owens, 2009). These agricultural toxicants include but not limited to: synthetic fertilizers, pesticides (herbicides, insecticides, fungicides), fumigants, mycotoxins, hormonal growth promotants, anthelmintics, antibiotics, and other medications.

Richter in 2002 presented a data which shows that the acute pesticide poisoning account for over 200,000 losses of lives worldwide. Eddleston *et al.* 2008, in their data on Asian industrial regions also showed that about 300,000 deaths per year occur in places where sensitization to the adverse effects of these toxicants is not adequate. Chronic Poisoning is also a serious risk to consumer health as it is resulted from continual accumulation of traces of the toxicants. It often occurs that pathological lesions of the body, which have been as a result of such exposure, cannot be reversed. This kind of poisoning is the most dangerous.

The growing agreement among scientists is that very little doses of these pesticides and other chemicals can cause lasting damage to human health, especially during fetal and early childhood formation. Studies show that chemical residue less than the Minimum Residual Limit (MRL) is not poisonous / hazardous to the consumer. Nevertheless, there had been incidents where even at such insignificant limits, such toxicants have been known cause illnesses, innate impairments and other malignant/ benign growths (Howard, 2005).

Chemical residues accumulation weakens the body's inherent ability to fight against diseases and lowers its natural response to stimuli. It may also lead to abnormal tissue growths on the human body. To date, many of the known hazardous chemicals which have been observed to have caused defects in functioning of the human body are still accessible to farmers (Ansar, 2000).

Some studies proved that the use of pesticides even at low doses can increase the risk of certain cancers**,** such as leukemia, lymphoma, brain tumors, breast cancer and prostate cancer (Costello *et al.*, 2009).

2.4 Consumer Perception

Consumers believe that organic foods are healthier, safer, and more piquant than conventional food (White *et al.* 2013; Lea & Worsley, 2005; Lockie *et al.* 2002) they also belief that organic food preserves the natural environment. Consumers also prefer the organic products to the conventional ones because they believe that organic foods are safer (Berlin *et al.* 2009; Bond *et al.* 2008; Onozaka *et al.* 2010; Yue & Tong, 2009).

The production and consumption of organic food has therefore increased rapidly over the last 20 years (Soil Association, 2006) due to increase in global demand for organic food (Datamonitor Ltd, 2008). The demand for organic food and related products is believed to have grown rapidly, amounting to about $63 billion in world in 2012 (IFOAM, 2013).

The high preference for such products has motivated equivalence in organically cultivated lands. Such increases had been realized over the period between 2001 and 2011 at an increasing rate of 8.9% every year (Paull, 2011).

Consumers have become very particular about their health and this has impacted on their eating behaviour.

The "lasting impression" which is psychologically influenced by the preference and demand of organic food is quite stimulating towards buying organic food. Consumers perceive that organic foods have low calorie levels and hence are healthy foods (Blair, 2012).

They believe that organic products are better in promoting well- being of consumers. They also believe that organic foods contain higher amount of vitamins, minerals and several other health properties than the conventional foods (FSA, 2009; Robinson-O'Brien *et al.* 2009).

Consumers are looking for quality foods which are safe and have nutritional values (Hughner *et al.* 2007) and this has led to the continuous growth of organic cultivation. Nutritional value can be explained as when food contains less impurities (residues of pesticides, nitrates, heavy metals, etc.) at optimum content of important constituents such as vitamins, mineral compounds and proteins (FiBL, 2009; Willer, 2011).

Organic products are also known to produce higher mineral compounds; including iron, magnesium and phosphorus which are also necessary for the human body than the conventional products (Worthington, 2001).

They are also found to contain higher content of total sugars which makes them tastier than conventional ones (Rembiałkowska, 2000). Consumers believe that organic foods have lower pesticides levels (herbicides, fungicides, insecticides) thus make them safer than conventional foods (Baker *et al.* 2002). Consumers believe organic products are free from pesticides and are characterised as having higher nutritional quality with adequate content of substances, such as proteins, carbohydrates, lipids, vitamins (vitamin C, E and A) and other antioxidants (Batte *et al*. 2007; Luthria *et al*. 2010).

Maximum Residue Level/Limit (MRL) of pesticides has been determined to be used in food to reduce any negative impact on human health; however, pesticides are known to or suspected to affect health adversely at even lower concentrations (Howard, 2005). Rats are generally used in determining the MRL for pesticides by testing specific remedies over a relatively short period of time. Very little knowledge exists about the impact of consuming hundreds of different pesticides during a life span.

Consumers believe that the production of organic products is environmentally friendly. They perceive organic farming plays key roles in ecological, production, aesthetic and health functions of the environment. The ecological function entails sustaining biodiversity and homeostasis. The aesthetic and health value of organic farming ensures the harmonious existence of humans with nature. With organic farming, the random and uncontrolled use of pesticides which pollutes soil and water and negatively affects ecosystem is minimised. Soil erosion and environmental pollution are also prevented during organic farming (Azadi & Ho, 2010).

Some consumers believe that organic products give off better flavor than the conventional ones (Carvalho *et al*. 2005; Batte *et al*. 2007). These have resulted in higher demand for organic foods despite the higher prices and the difficulty of scientifically ascertaining claimed benefits (Magkos *et al*. 2006; Canavari *et al*. 2009; Smith-Spangler *et al*. 2012; Barański *et al*. 2014).

2.5 Review of Differences between Organic and Conventional Farming

2.5.1 Health

According to research conducted by Lundegårdh and Mårtensson, organic products produce natural protective substances representing an essential element of daily human diet known as secondary metabolites which are bioactive substances and are known to play important role for human health (Lundegårdh & Mårtensson, 2003).

Organic products produce phenolic compound, a metabolite which is known to play the role as antioxidants (Di Renzo *et al.* 2007) with chemoprotective, neuroprotective and cardioprotective properties, such as those that have the tendency of reducing the incidence of cancer (Brandt & Molgaard, 2001; Frei & Higdon, 2003; Kampa *et al.* 2007; Carlson *et al.* 2007; Ortuno *et al.* 2007).

High antioxidant content contained in fruits and vegetables are beneficial to human health because they are associated with longer life expectancy (Brandt & Molgaard, 2001).

The Food Standards Agency (FSA) in the UK and other researchers conducted meta-analysis on organic and conventional products to investigate whether organic products have measurable health benefits than conventional products because consumers repeatedly based their reason for purchasing organic foods on health. The benefits of organic products are considered to be the vitamins, minerals and other health-giving properties that they embody, whereas non-organic foods are associated with the presence of harmful artificial chemicals that are introduced during production, processing and storage. Current studies do not provide any evidence to prove that organic foods are healthier than conventionally grown products (Burton, 2006; Benbrook *et al.* 2008; FSA. 2009).

There is a research challenge when attempting to link organic food composition to direct health outcomes because of the inconclusive nature of conducting this type of research. The confounding problems embrace the vast intrinsic variability in organic systems, which create it problematic to draw inferences from short comparisons of paired organic and non-organic farms. Production systems, as a result, usually have to be observed closely at the same sites over a number of years to obtain significant results (Mitchell *et al.* 2007). The strict adherence to what is required for organic certification other than the actual management can have a major impact on the quality of the organic product (Butler *et al.* 2007). Different crop varieties vary in the way they respond differently to environmental conditions (Wolfe *et al.* 2008).

In as much as consumers consistently cite health as a reason for buying organic food, this perception is not supported enough by scientific research (Benbrook *et al*. 2008; Burton, 2006; http://www.organiccenter.org).

For more than fifty years, scientists have been doing their best to find out whether organic foods are healthier than conventional foods, but they are unable to find any evidence that organic foods are better than non-organic ones healthwise (Dangour *et al*. 2010).

2.5.2 Nutrients

Researchers at London School of Hygiene & Tropical Medicine, UK, conducted a systematic review of literature published from 1958 to 2008 on nutritional content and other substances in organic versus conventional foodstuffs. There was no significant difference found in contents of the following nutrients which were vitamin C, potassium, sodium, calcium, total soluble solids, copper, iron, nitrates, manganese, ash, specific proteins, plant non-digestible carbohydrates, β-carotene and sulphur. However, there was lower nitrogen and higher phosphorus content in organic produce compared to conventionally grown foodstuffs.

Meta-analysis of 237 studies, which was published in the September 2012 *Annals of Internal Medicine,* mainly focused on nutrient content and viral/bacterial/fungal contamination of organic as against conventionally grown foods. The authors finalised that the studies reviewed do not support what they call the "widespread perception" that organic foods overall are nutritionally better than conventional ones, although consuming an organic diet may decrease exposures to pesticides and antibiotic-resistant bacteria (Smith-Spangler *et al*. 2012).

After analyzing the data, the researchers found very little significant difference in health benefits between organic and conventional foods. No consistent differences were observed in the vitamin content of organic products, and only one nutrient which is phosphorus was significantly higher in organic versus conventionally grown produce.

A Stanford press release quoted senior author Dena Bravata as saying, “There isn’t much difference between organic and conventional foods if you’re an adult and making a decision based solely on your health” (Brandt, 2012). According to some research conducted on the nutritional value of organic products, it was found that organic foods is made up of less nitrates and pesticide residues, but contains more dry matter, vitamin C which is known to play very important role in the immune system, secondary substances, essential amino acids, certain mineral components and total sugars (Rembiałkowska, 2000; Worthington, 2001). According to Weibel *et al*. 2000, research conducted to assess the vitamin C content in both organic and conventional vegetables showed no difference. Report from Dangour *et al.* showed no significant differences could be placed on production procedures in relation to mineral content (Mg, Ca, K, Zn and Cu), even if this type of foods seemed to contain a higher content of phosphorus and a lower of nitrate (Dangour *et al*. 2009). Some researchers showed that there are no significant differences in the content of b-carotene and ascorbic acid in some plants like lettuce, tomato and collard greens (Borguini, 2006; Ismail & Fun, 2003). Fjelkner-Modig *et al*., after six years of research found no significant differences in vitamin C content, expressed as dry matter, between organically grown vegetables and those bred by conventional method (Fjelkner-Modig *et al.* 2000). Other studies showed that the cultivation method did not have any effect on the lycopene content (Juroszek *et al*. 2009). Nitrogen content in some vegetables (leafy vegetables and tubers), however has been found to occur at lower levels in products grown organically than conventionally grown ones (Magkos *et al*. 2006).

According to Rembiałkowska and Worthington, organic products have the lower amounts of total proteins than the conventional products due to high amount of nitrogen found in conventional products. They argued that even though lower amount of proteins were found in organic foods, organic foods have proteins which are of good quality because of the amount of basic amino acids present (Rembiałkowska, 2000; Worthington, 2001). A study conducted in 2012 by Barański *et al*. also found no significant differences in the vitamin content of organic and conventional plant or animal products, and established that results differed from study to study (Smith-Spangler, 2012). In 2014, however, meta-analysis of 343 studies discovered that crops cultivated organically had 17% more concentrations of polyphenols than conventionally grown crops., the concentrations of anthocyanins, stilbenes, flavones, flavanones, flavonols, and Phenolic acids were raised. Flavanones were 69% more (Barański, *et al*. 2014).

According to Forman J. and his team there is no definite evidence that organic food has higher nutritional value than conventional food (Forman *et al*. 2012). Winter & Davis (2006) reported that with issues of safety and nutritional quality, it is too hasty to conclude that organic food is richer than a conventional counterpart.

In the American Journal of Clinical Nutrition (September 2009), researchers settled in a published systematic review that foodstuffs produced organically do not contain more vitamins and minerals than foods produced conventionally.

A study conducted by London School of Hygiene and Tropical medication (from February 2008 to December 2008) to review accessible published literature to determine the connectedness to health of any variations in nutrients and other substances in organically and conventionally cultivated crops and farm animal product and to give consumers accurate information about their food, based on the most up-to-date science.

A systematic review was carried out on all papers published over the past 50 years that related to the nutrient content of, and health differences between, organic and conventional food. A total of 162 relevant published articles were reviewed. From the observations gathered it was not established that there is a difference between organic and conventional produce for some nutrients such as vitamin C, calcium, sodium, phosphorus, potassium, total soluble solids, titratable acidity, copper, iron, nitrates, manganese, ash, specific proteins, plant non-digestible carbohydrates, β-carotene and sulphur. However, significant differences were observed in some minerals (nitrogen was higher in conventional crops; whereas phytochemicals, magnesium and zinc, and sugars were also higher in organic crops). A significant difference was also found in nitrogen content (higher in conventional crops), phosphorus (higher in organic crops) and titratable acidity (higher in organic crops) (Dangour *et al*. 2010).

2.5.3 Quality

Consumers do attribute organic products as of good quality because they claim the fruits and vegetables are fresh and also of better taste along the supply chain. But the quality of a specific product is subjected to a lot of variables. Hence, product quality is a problem as it changes according to the consumer's own expectations and this often relates to a single product, bought at a particular time and for a particular purpose.

Barrett *et al.* (2007) found total soluble solids (SS) content, titrable acidity and firmness to be higher in organic tomatoes than in conventional ones. Weibel *et al*. (2000) also indicated that internal fruit quality of organic apples was similar or a little bit better than the conventional. According to Roussos & Gasparatos (2009), there is no difference regarding quality of food and no significant correlation between quality parameters in organic and conventional apples. They also observed no significant difference in titratable acidity (TA), total soluble solids (TSS), pH, starch content and TSS ⁄TA ratio. Almost the same results were reported by Juroszek *et al*. (2009) on the quality of tomato based on their pH, ascorbic acid, SS and TA. The 162 published articles that were reviewed by London School of Hygiene and Tropical Medicine focusing on the products quality showed that organic foods had much higher levels of phytochemicals than the conventional foodstuffs. They explained that the differences are very unlikely to be of any significance to human health (Dangour *et al*. 2010).

2.5.4 Pesticide Residues

According to Benbrook, “Pesticide dietary risk is as result of many factors, including the number of residues, their levels, and pesticide toxicity,” not just whether contamination was present (Benbrook, 2012).

The Environmental Protection Agency implements stringent rules for the regulation of pesticides by setting an allowable limit on the amount of pesticide residue that is acceptable to be in or on any particular food (US EPA, 2014).

Meta-analysis conducted in 2012 from the European Union revealed that traceable pesticide residues were detected in 7% of organic produce samples and 38% of conventional produce samples. This result was statistically different, mainly due to the variable level of detection used in these studies. Only three studies showed the contamination prevalence being more than permitted limits (Smith-Spangler *et al*. 2012). In 2014, meta-analysis showed that produce cultivated conventionally was four times more likely to contain pesticide residue than organically grown crops (Barański *et al*. 2014).

A published report shows that there is a less possibility of organic food containing pesticide residues than conventional food (13 percent of organic produce samples versus 71 percent of conventional produce samples contained a pesticide residue when long-banned persistent pesticides were removed). Yet, conclusions from the National Research Council shows the traces of pesticides left on conventionally grown products are very unlikely to cause an increase in the risk of getting cancer. Also, if fruits and vegetables are thoroughly washed, quite a number of these chemicals can be removed (http: // www science.howstuffworks.com/environmental/ green-science/organic-food7.htm). Several studies have demonstrated that there is no confirmed scientific information or evidence that organic produce is indeed safer than conventionally produced fruits and vegetables (Bourn & Prescott, 2002; Magkos *et al.* 2006; Winter & Davis, 2006). The American Cancer Society has stated that there is no existing evidence that indicate that the presence of small quantities of pesticide residue on conventional foods will make the consumer vulnerable to cancer, though it advocates that fruit and vegetables should be thoroughly washed. In addition, no study so far has shown that consuming organic food reduces one's risk of getting cancer as compared to foods grown with conventional farming methods (http://www.cancer.org/ healthy/eathealthygetactive-guigelines-physical-activity-for-cancer). From a scientific opinion, the most crucial factor to insist on safety is not the attributes of local or organic but that individual farmers are meticulously sticking to Good Agricultural Practices. Some pesticides which have been approved for use in organic farming in Europe failed to pass the European Union's safety evaluation that is mandated by law (EFSA, 2009). Rotenone was among the chemicals that failed the test and has been banned in Europe. This was so because in 2007 more than 1% of the organic foodstuffs produced in that year were tested and were found to contain illegal amounts of inorganic pesticides. The tests were carried out by the European Food Safety Authority. (EFSA, 2007). According to a study by Canadian scientists, soybean pest (aphid) control, artificial pesticides were more efficacious. They also indicated organic pesticides caused mortality in other organisms as well (Bahlai *et al*. 2010). They made a case that doing away with pesticides does not mean the food is free from other harmful substances. By Thin- Layer Chromatographic analysis, Rossetto *et al*. (2009) found the occurrence of organo-chlorides, organo-phosphates and carbamates in leaves and peels of conventionally grown beets. They observed that pesticides disappeared when food was cooked, possibly due to boiling in water resulting in the leaching of these substances. The intake of such water, with unknown origin, may have adverse effect on human health. While organic is basically different from conventional because of the use of carbon based fertilizers compared with synthetic based fertilizers that are highly soluble and biological pest management instead of artificial pesticides, large-scale conventional farming and organic farming are not completely mutually exclusive. Conventional farming has currently adopted a lot of techniques that are identifiable with organic farming. Integrated Pest Management, for instance is a multifaceted technique that makes use of various organic methods of pest control whenever applicable, but in conventional farming could include synthetic pesticides only as a last resort (U.S. EPA, 2013).

2.5.5 Taste

A scientific literature reviewed in 2002 concluded there is proof that some organic fruits are drier than fruits that are grown conventionally thus organic fruits may have a more flavor owing to the higher amounts of flavoring substances and this makes the fruits tastier. (Fillion & Arazi, 2002). Organic products are also found to contain higher content of total sugars which makes them tastier than the conventional ones (Rembiałkowska, 2000). According to a study by Zhao *et al*. (2007), consumer sensory analysis of a number of different vegetables produced in carefully managed replicated plots did not show any significant differences between organically and conventionally grown vegetables. Only tomatoes showed significant results with respect to flavor. Researchers subjected that organic consumers to blind mouth test with both organic and conventional food because over two-thirds of respondents made a case that organic food tastes better than the conventional ones. At the end of the study, they concluded that people couldn't distinguish between the two in the blind taste tests (Basker, 2009).

2.5.6 Environment

Researchers have discovered that negative effect of organic farming on the environment is relatively small (Mader *et al.*; Fuller *et al*. 2005). The United Kingdom government gives financial assistance to organic farmers due to the environmental benefits obtained from organic farming (Defra, 2004). Tyburski and Żakowska-Biemans (2007) have made comparisons on the impacts of organic and conventional farming on the environment and they observed that organic farming is less energy-intensive, which is highly essential particularly in an era when the world is faced with energy crisis. Organic farming consumes less energy because; artificial fertilisers and pesticides which require high energy inputs are not used, among other aspects. Besides, one of the effects of conventional farming is water eutrophication and contamination with agrochemical residue, whereas organic farming does not introduce such pollutants, thereby, protecting ground and surface water.

2.5.7 Bacterial Contamination

It has been suggested that the application of manure and the decreased use of fungicides and antibiotics in organic farming can augment the level of microbial and/or microbial product contamination in organic foods (Williams, 2002). Meta-analysis conducted in 2012 showed that the prevalence of *E. coli* contamination was statistically insignificant between organic and conventional products (7% occurring in organic produce whereas 6% occurred in conventional produce (Smith-Spangler *et al*. 2012). A research work conducted on Microbiological quality of organic and conventional vegetables sold in Brazil showed that, *E. coli* was found in 41.5% of organic and 40.0% of conventional vegetables. Nine out of ten organic loose leaf lettuce investigated had the highest *E. coli* contamination. On the other hand, collard greens had the lowest incidence of contamination, with *E. coli* which was found in only one conventional sample (Mukherjee *et al.* 2004; Oliveira *et al.* 2010). Organically grown lettuce was found to be contaminated with *E. coli* and *L. monocytogenes* (Oliveira *et al*. 2010). According to Loncarevic *et al*. (2005), *Escherichia coli* O157 and *Salmonella spp*. can be found in fertilizer made from animal dung due to their presence in the intestinal tract of animals. *Listeria monocytogenes* are ubiquitous bacteria, but are often found in decaying plants, soil and animal manure. As a consequence, they could easily contaminate vegetables growing in the field.

A study showed that between 1990 and 2001, more than 10,000 people got ill from consuming organic foods which were contaminated *E. coli* among other pathogens (Mukherjee *et al.* 2004). Deoxynivalenol (vomitoxin) contamination was noticed to be higher in organic wheat; however the comparison of the levels of contamination conventionally grown raw materials and organic foods showed no conclusive evidence (Malmauret *et al*., 2002).

2.5.8 Cost

In a systematic review published in September 2009 in the American Journal of Clinical Nutrition, Organic foods naturally cost more than conventional foods. In part, the higher price is often related to natural fertilizer as well as the labor-intense pest control tactics. The price of organic produce is 10-40% more than conventional produce because of higher production costs associated with it. The USDA is therefore alarmed that people might decrease their consumption of fruits and vegetables rather than spend more on organic produce (www.choosemyplate.gov/foodgroups/).

2.6 Regulation of Organic and Conventional Foods

At a glance, organic foods cannot be physically distinguished from conventional products. Consumers therefore depend wholly on third-party certification (public or private certification bodies) to provide assurance that organic products have been produced and handled according to applicable standards. With these consumers trust the organic system and also give organic farming a distinct identity and makes market access easier (Kalypso, 2000).

Organic standards were first developed by the private sector in the form of recommendations; producers would be visited often and would get feedback from other organic farmers and/or advisors. This was done to protect consumers and producers of organic products.

With the expansion of the sector and longer supply chains, the relationship that existed between consumer and producer became less personal, hence the need for a more aggressive independent quality assurance system to protect both the producer and the consumer (Schmid, 2007).

Currently, the European Union, Canada, the United States, among other developed nations have passed laws which mandate producers to acquire unique certification based on standards defined by government to before they can market food as organic within their territories. The regulations ensure that foods marketed as organic are produced in a manner that is in consonance with national and international standards (https://www.en.wikipedia.org/wiki/Organic_food). Organic production methods are regulated in Europe by Council Regulation (EC) No. 834/2007 of June 28, 2007 on organic production and labeling of organic products, repealing Regulation (EEC) No. 2092/91. On September 5, 2008, the Commission Regulation (EC) No. 889/2008 established guiding principles for the implementation of the Regulation (EC) No. 834/2007 on organic production and labeling of organic products as far as organic production, labeling and control are concerned.

When food product is under the guidelines of Regulation No. 834/2007 or both the guidelines of the Regulation and the directives of various organic farming associations (e.g. IFOAM). An organic product, under Regulation No. 834/2007, must be labelled with an identification number (code) and the European organic farming logo.

In Ghana, organic agriculture certification arises from the following basic principles:

1. Organic certification is a system of institutionalized trust, allowing consumers to identify and reward people who are consciously protecting the natural environment.

2. Organic certification is a privilege to be acquired and not a right to be withdrawn.

3. No other person understands the farm system more than a farmer does.

4. Organic production places emphasis on natural processes and their management: materials and products are an adjunct to, not a replacement for, effective management.

5. Diversity, interaction, adaptability and competition are characteristically the natural factors to be regarded in the organic system.

6. In order to curtail soil degradation, organic farming must be adequately managed and structured.

7. The stakeholders (producers, handlers, and consumers) greatly rely on organic farming to enhance product value and reduce the extent of environmental degradation as well.

CHAPTER THREE

METHODOLOGY

3.1 Study Area

3.1.1 Geographic Area

Ghana has a land area of 238,539 km^2 and lies on the south-central coast of West Africa between latitudes 4.5^oN and 11.5^oN and longitude 3.5^oW and 1.3^oE (Owusu-Boateng *et al.*, 2013).

3.1.2 Greater Accra Region

The Greater Accra region is among the ten administrative regions of Ghana. It lies in the South East of the country along the Gulf of Guinea and has coastal savannah, a little forest area inland towards the Eastern region in the Ga district, and miles of beautiful coastline especially in the rural parts of the region.

In terms of population, however, the region is the second most populated region, after the Ashanti Region, with a population of 4,010,054 as at 2010 (2010 census http://www.ghana.gov.gh). The Greater Accra region was part of the Eastern Region before 1982 and Greater Accra region was created from the Eastern Region in 1982 and currently the seat of government is in Accra (http://www.ghana.gov.gh).

3.1.2 Brong Ahafo Region

The Brong Ahafo region is the second largest region in Ghana with a land area of 39,558 km^2 with 22 administrative districts/municipalities (http://mofa.gov.gh). It is predominantly a farming region and samples used for the analysis were collected from the region.

3.2 Organic and Conventional farmers

In Ghana, crop sector forms 66.2 per cent of the entire Agriculture sector (Ghana Statistical Service, Accra). The middle and upper parts of Ghana are known to have the biggest land areas for crop cultivation with a measurement 39.56 and 70.38 (000 sq. km.) which is 16.6 % and 29.5% respectively (http://mofa.gov.gh).

Organic farming in Ghana can be divided into two different levels based on certification: certified organic production and non-certified or agro-ecological farming. The certified organic farm products are normally exported beyond Africa's shores and these normally require certification.

Ghanaian organic farmers rarely certify their products because most of them do not fully meet the international standards for organic farming; however, majority of farmers in Ghana by default practice organic farming.

The activities of these farmers are regulated and supported by Food and Agriculture Organization (FAO), Ministry of Food and Agriculture (MOFA) and other organizations. Non-Governmental Organizations (NGOs) also support these farmers to achieve standards.

3.3 Data Collection Methods and Sampling Approach

Data collection and sampling methods were done in two Regions which were Greater Accra Region and Brong Ahafo Region. There were two sampling approaches. One sampling approach was to seek for consumers' perception on organic and conventional fruits and vegetables. This sampling approach was done in the Greater Accra Region with some selected tertiary schools. Others from the general public too were given the opportunity to express their views. For the purposes of taking a representative sample nationwide, students coming from other regions were involved in the survey.

The second approach of sampling was to conduct analysis on some organic and conventional fruits and vegetables by comparing their physical parameters, minerals, fibre and total phenol content.

Due to time and financial constrain, 200 consumers were involved in the interview with regards to consumer perception on the organic and conventional fruits and vegetables. The Simple Random Sampling Approach was used in the selection of the consumers for the survey.

Abono Organic Farming Project (ABOFAP), a local NGO located in the Brong Ahafo Region which supervises organic farmers from Techiman Municipality, Kintampo, Nkoranza, Wenchi and Tain districts was contacted and based on the season of farming and the type of product available at that season provided organic pawpaw,pepper and okro with their equivalence conventional products for the analysis.

3.3.1 Questionnaire Design and Pre-Testing

Questionnaires were pre-tested, both by self administration as well as by interview done by field assistants who were recruited from Accra Polytechnic and University of Ghana-Legon. A day training session was organized for the field assistants to get them understand the objectives of the project. They were to ascertain the perception of the consumers in terms of their knowledge and attitude.

3.4 Laboratory Analysis of samples

3.4.1 Determination of K, Na, Ca, and Mg by Atomic Absorption Spectrometry

The atomic absorption spectrometry was used in the determinations. Two grams of sample were weighed into a conditioned porcelain crucible and ashed at 550^{o}C for four hours. The ash was cooled and dissolved in 20ml 10% HNO_3.The solution was filtered through an acid washed filter paper into a 100ml volumetric flask and made to volume with 10% HNO_3. A 100mg/l solution was prepared by pipetting 10ml of the stock standard solution into a 100ml volumetric flask and made to volume with 10% HNO_3.

From the 100mg/l solution, 10mg/l solution was prepared by pipetting 10ml into a 100ml volumetric flask to the mark. One mg/l, 2 mg/l and 3 mg/l concentrations were prepared by pipetting 5 ml, 10 ml and 15 ml respectively into separate 100 ml flask and made to volume with10% HNO_3.Using a calibrated spectrometer (S Series 711239v1.27, USA) at a specific wavelength of the mineral to be analysed, and air-ethane flame type, the mineral contents for each of the samples were analysed and calculated using a standard curve. Potassium was analysed at a wavelength of 766.5 nm, sodium at 589 nm, calcium at 422.7 nm and magnesium at 285.2 nm respectively (Perkin, 1982; Buchanan & Muraoka, 1964).

3.4.2 Physical measurements

pH Measurement

The pH reading was carried out using Mettler Toledo pH meter (FE20; GB/T111165). Twenty grams each of the samples were milled and strained to obtain juice with. The resulting solution was sieved with a cheese cloth and pH measured on the filtrate obtained.

Measurement of Titrable Acidity

A concentration of 0.1M solution of NaOH was used with a Mettler Toledo pH meter (FE20; GB/T111165) for the determination. The base was carefully titrated against 10 ml of sample juice while constantly checking the pH till pH value read 8.10 which is the point of neutrality.

The volume of NaOH used was recorded and used in the calculation as follows.

Calculation of the Percentage Acid

This was based on the citric acid factor 0.0064 (Citrus fruit) w*here 1ml 0.1M NaOH is equivalent to 0.0064g* citric acid.

Results expressed as percentage acid:

$$Percentage\ acid = \frac{\text{Titre x acid factor x 100}}{10\ ml\ juice}$$

Total Soluble Sugars (°Brix)

Total soluble solid (TSS) of the sample juice was measured using a digital Refractometer (Reichert AR 200) which was standardized with distilled water (Salvador *et al.* 2007). Extracted sample juice was prepared two drops placed on the surface of the Refractometer of a temperature correction factor (TC) of 25^{o}C to determine the Total Soluble Sugar content measured in °Brix.

Refractive Index

Refractive Index of the sample juice was measured using a digital Refractometer (Reichert AR 200) which was standardized with distilled water (Salvador *et al.* 2007). Extracted sample juice was prepared two drops placed on the surface of the Refractometer of a temperature correction (TC) factor of 25^{o}C to determine the Refractive index of samples measured in nd-TC.

3.4.3 Protocol for Proximate Analysis

Ash Determination

Ashing is defined as the heating of a food substance to leave only non-combustible ash, which is analysed for its elemental composition. The term ash refers to the residue left after the combustion of an oven dried food

Ash is the inorganic residue obtained by burning a sample at 500^oC - 600^oC. Ashing of feed sample will remove all organic contents and leave behind the non-volatile mineral elements. The temperature that is used for this determination can also affect some of the elements such as selenium and arsenic, which form volatile oxides when present. These losses experienced can be avoided by adding specific quantities of calcium oxide before ashing.

To do this procedure, 5 grams of sample was weighed into porcelain crucible and duplicated. The weighed samples were heated in a muffle furnace for 4 hours at 550^oC. After heating, the furnace was allowed to cool below 200^oC and this was maintained for 20 minutes. The ash crucible was then removed from the furnace, placed in desiccators (with magnesium per chlorate desiccant), cooled and weighed.

Calculations

(A + B) – A = B

(A + C) - A = C

% Ash = C/B x 100   where A = crucible weight, B = sample weight, C = ash weight.

Ether Extract (Fat) Determination

Ether extract (fat) is a fatty acid ester of glycerol. The term lipid is used for all ether-soluble materials. Fats are those glycerol esters, which are solid, while oils are liquids at ordinary temperatures. Seeds like groundnut, soyabean and cotton contain oil as reserve food material.

Ether extract is determined by extracting the dry sample with ether. The weight of the extract is determined after distilling the ether and weighing the residue. The ether extraction may be conducted with a suitable apparatus such as Soxhlet or a Goldfish extractor.

To prepare the samples for the procedure, 5 grams of each sample placed in a drying dish was dried at 130^oC 20 minutes in an oven. The dried samples were cooled to a room temperature and then ground. The ground samples were each mixed well and 2grams of each was weighed into a whatman No.42 filter paper and folded.

For the procedure, an extraction flask was placed in an oven for about 5 minutes at $110\,^oC$ then cooled and weighed. The samples prepared and folded in the filter papers were wrapped with other filter papers to hold them. The filters were made to open at the tops like thimble. A piece of absorbent cotton wool was placed at the top of the filters to spread evenly the solvent as it dropped on the samples during extraction. The sample packets were placed in the butt tubes of the Soxhlet extraction apparatus. Petroleum ether was extracted by gentle heating for 3 hours without any interruption. The extraction flask was allowed to cool and dismantled. The ether was allowed to evaporate on a steam or water bath until no odour of ether remained and cooled at room temperature. The extraction flask and its extract were re-weighed and weight recorded.

<u>Calculations</u>

$(A + B) – A = B$ % ether extract = $B/C \times 100$

where A = flask weight, B = ether extract weight, C = sample weight

Crude Fibre Determination

The carbohydrate of food is contained in 2 fractions: (1) the crude fibre and (2) the nitrogen-free extractives. Crude fibre refers to the organic residue of food sample that is insoluble after successive boiling with 0.255 N H_2SO_4 and 0.312 N NaOH solutions according to specified procedures. The determination of crude fibre is an attempt to separate the more readily digestible carbohydrates from those less readily digestible. The crude fibre fraction contains cellulose, lignin and hemicelluloses. Boiling a sample with dilute acid and alkali is an imitation of the process that takes place in the gut. The assumption, on which this method is based, is that carbohydrates, which are readily dissolved by this procedure, will as well be easily digested by animals. The ones which are insoluble under these conditions are not easily digested. This is supposed to give a rough estimate of the amount of indigestible components of food. Ruminants, on the other hand are capable of digesting most of them. Evaluation of crude fibre is, nevertheless, resorted to in determining the energy content of food samples. Moreover, its correlation with food digestibility makes it very useful.

To determine the crude fibre, the residue from the ether extract was transferred into a 750ml Erlenmeyer (digestion) flask. 200ml of H_2SO_4 boiled solution and anti-foaming agent (N-tributyl citrate) were added to the extract. The digestion flask, now connected with a condenser was heated. The flask was then disconnected following a long heating (about 30 minutes) and filtered immediately through linen and washed with boiling water until washings were no longer acid.

An of NaOH solution was boiled for some time. The boiling temperature was maintained under the reflux condenser awaiting its used.

The residue was washed back into a flask with 200 ml of the boiled NaOH solution. The flask was connected with reflux condenser and boiled for 30minutes. The flask was removed and filtered immediately through the Gooch crucible and washed with boiling water. It was also washed with 15ml of 95% ethanol. The crucible and its contents was then dried at 110°C to constant weight, cooled in a desiccator and weighed.

The contents of the crucible were incinerated in a muffle furnace at 550°C for 30minutes until the carbonaceous matter was consumed. The contents were then cooled in a desiccator and weighed. Loss in weight was recorded as the crude fibre.

Calculation

% crude fibre = $\frac{A - B}{C}$ x100 where A = wt. of dry crucible and sample

B = wt. of incinerated crucible and ash, C = sample weight.

Crude Protein Determination

Nitrogen (N) is one of the major elements in found in living organisms. It is only next to C, H and O_2. N makes up 16% of the total make-up of most proteins. N is used in determining the content of protein in food. This is done by a modified technique devised originally by Kjeldahl. The micro-Kjeldahl technique is used in estimating the total amount of N a wide range of biological samples. The method involves the use of H_2SO_4 in converting N-containing samples to ammonium sulphate. Ammonia is released as a product of steam distillation of ammonium sulphate. The NH_3 is collected in boric acid solution and titrated against standard acid. 1ml of 0.1N acid is equivalent to 1.401mg N. The N content can therefore be calculated. Protein content ×

100/16. Three methods were used in evaluating crude protein content. The first method was the digestion of sample. With this method, 2 grams of the samples were weighed and transferred into 500/650ml Kjeldahl (digestion) flasks. 10ml of distilled water and a digestion tablet (acted as catalyst) were added to the weighed samples. 20ml concentrated H_2SO_4 was also added to the digestion flasks. Boiling chips were added to the samples and allowed to digest till the solution became colourless.

Distillation of digest was the second method that was used in the determination of the crude protein.

The digested sample was allowed to cool and diluted with distilled ammonia-free water to 100ml. 10ml of the 100ml digested samples were pipetted into the distillation flask and topped with 90ml of distilled water. 20ml of 40% NaOH was then added to the solution. Few drops of mixed indicator were placed in a conical flask containing 10ml of boric acid solution. The solution was distilled and ammonia collected on the boric acid. 100ml to 150ml of distillate was collected.

The third method was titration of the distillate.

The solution was titrated against the standard 0.1N Hcl until it turned pink in colour (the end-point). An equal volume of distilled water was used to run a reagent blank. The titration volume was subtracted from that of the sample titration volume.

<u>Calculation</u>

The N content was evaluated using the formula:

$$\%\ \text{Nitrogen} = \frac{(\text{ml acid} \times \text{normality of standard acid})}{\text{wt of sample (g)}} \times 0.014 \times 100$$

therefore

% Crude Protein (CP) = Total Nitrogen (N_T) x 6.25(Protein factor)

Calculation of Nitrogen-Free Extract

The calculation of nitrogen-free extract (NFE) was made after completing the analysis for ash, crude fibre, ether extract and crude protein. The calculation was made by adding the percentage values on dry matter basis of the analysed contents and subtracting them from 100%.

Calculation

NFE (%) on DM basis = 100% - [%ash on DM basis + % crude fibre on DM basis + % ether extract on DM basis + % protein on DM basis}

3.4.4 Total Phenol Content

Preparation of Solutions

Sodium Carbonate (20% (w/v) NaCO3) Solution: A mass of 20g of anhydrous sodium carbonate was dissolved in 80mL of distilled water and continuously stirred to dissolve. This was topped up with distilled water to give a final volume of 100mL.

Gallic acid stock solution: A 500mg of dry gallic acid was weighed using electronic balance and dissolved in 10mL ethanol in a beaker. This was transferred into a 100ml volumetric flask and diluted to volume with distilled water.

Standard Calibration Curve for Phenol Analysis

In the preparation of standard curve, 0, 1, 2, 3, 5 and 10ml of the gallic acid stock solution prepared above was placed into separate 100mL volumetric flasks and then diluted to volume with distilled water to give a standard gallic acid solution of 0, 50, 100, 150, 250 and 500 mg/L respectively. An amount of 0.1mL of the standard gallic acid was pipetted into a 10 mL volumetric flask and 6.0mL distilled water added. A 0.5mL Folin Ciocalteu reagent (2N) was then added. The solution was well mixed and left for 5 minutes after which 1.5mL of 20% sodium carbonate solution was added. Finally, the solution was topped with distilled water to the 10mL mark and mixed thoroughly. The resulting solution was then incubated at room temperature for 2 hours.

Folin-Ciocalteu Method for Phenol Analysis

The total phenol content of samples was analysed using Folin-Ciocalteu method by Singleton and Rossi (1965) as used by Gardner *et al*. (2000) and adapted by Bailey (2007) with slight modifications. The Folin-Ciocalteu method is based on measuring the colour change from yellow to blue as a result of reduction of the tungstate-molebdate mixture in the Folin-Ciocalteu reagent by phenols present in the analyte solution.

A 0.1mL of sample or blank (distilled water) was pipetted into a 10mL volumetric flask and 6.0mL of distilled water added. This was followed by adding 0.5mL of Folin-Ciocalteu reagent (2N). It was well mixed and then left for 5 minutes. 1.5mL of 20% sodium carbonate solution was then added. The solution was filled to the 10mL mark with distilled water and mixed thoroughly. The solution, at this point, was then incubated at room temperature for 2 hours after which absorbance readings were taken at 750nm using Nanodrop (*ND 1000*) spectrophotometer in UV-Vis mode. Absorbance readings were taken for each of the duplicate determinations for each sample. The results were expressed as concentration of gallic acid equivalent (GAE, mg/L) using equation of line of best fit obtained from the standard calibration curve. The final concentration was calculated as;

$$C = \frac{c \times m}{V}$$

Where

C = total content of phenolics of sample in gallic acid equivalent (GAE)/g

c = concentration of gallic acid established from the calibration curve

V= volume of extract (ml)

m = weight of raw sample used (g)

NB; where samples are in liquid form, e.g. wine samples and fruit juice samples quote the final conc in mg/L GAE equivalent as Obtained from the standard curve (Figure 3.1).

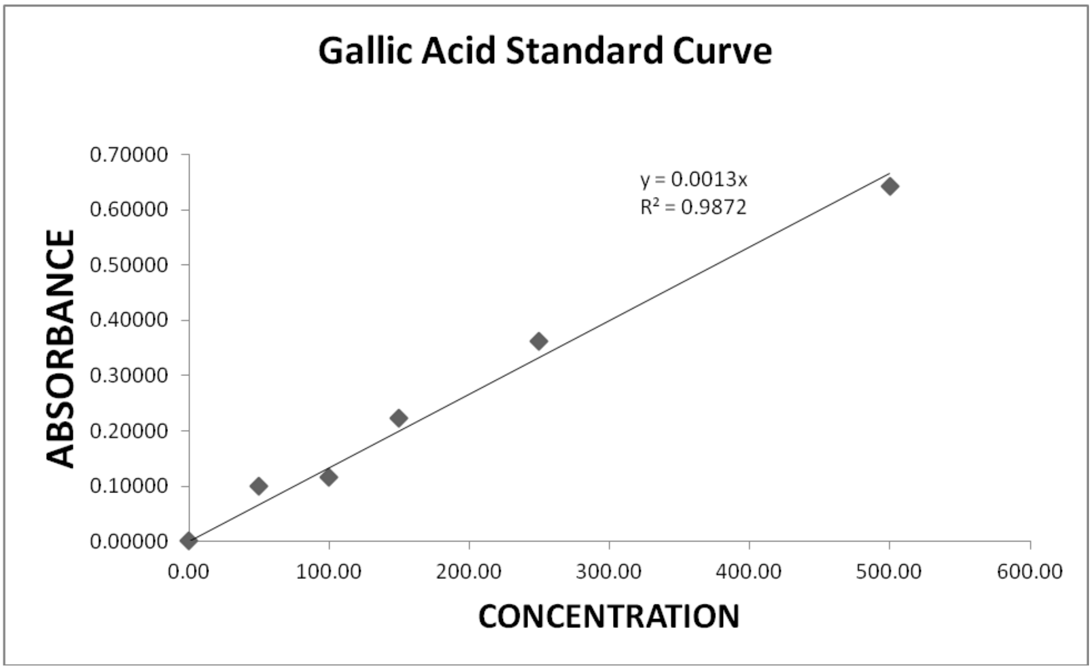

Figure 3.1 Gallic Acid Standard Curve

3.3.3 Statistical Analysis

Epidata software was used for the analysis of the consumers’ perception and Graphpad Prism software was used to analyse the sampled products.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Perception Index on Organic and Conventional Foods

Works by FiBL, (2009) and Willer, (2011) show that the market share of organic products continues to see growth in some parts of the world and within certain populations. Certainly, the vast spreading nature of consumption of organic foods is based on the knowledge persons in these populations have acquired about both organic and conventional foods. Prior to the analysis on samples, a survey to unveil the perception of Ghanaians on organic/ conventional fruits and vegetables was conducted. The total number of people interviewed was 200. Out of which 89 are males representing 44.72% and 111 are females representing 55.28% whose ages ranged from 17 to 48 years of various professions and trades. Majority of the respondents 89.50% had knowledge about organic foods whilst some section representing 10.5% did not know of it at all. Also, for conventional foods, 63.64% had knowledge of it whereas 36.36% did not know of it at all. An educational background check on these individuals revealed that, majority of those who agreed to know about organic foods had attained middle to higher education thus emphasizing the role of higher education in increasing the awareness of people regarding both organic and conventional foods. It is also a confirmation of the ever increasing spread of the market share of organic foods as indicated by FiBL, (2009) and Willer, (2011).

According to Smith-Spangler *et al*. (2012), most people perceive that products from organic sources are not only safer but also much more enriched with nutrients for good health even though this is not supported by evidence. This is clearly the case as the survey also revealed this perception by most consumers.

In relation to the possible health risks associated with organic foods only 9.24% admitted there could be health risk associated and as high as 53.78% disagreed. The rest were only unsure. But in the case of conventional foods, as high as 34.45% admitted there could be possible health risk associated with its consumption whereas only 27.73% disagreed.

4.2 Proximate Composition of Organic and Conventional Fruit and Vegetables

In this study, the differences in nutritional composition of both organic and conventional samples were accessed per their proximate composition. Results of proximate composition are displayed in Table 1.0. In terms of moisture, there lied a significant difference between organic and conventional samples of pepper (*Capsicum annum L*) and okro (*Abelmoschus esculentus L.*). Organic samples of both okro and pepper differed significantly with the exception of that of pawpaw (*Carica papaya L.*) samples. There was no significant difference between moisture content of organic pawpaw (OPP) and conventional pawpaw (IPP) samples. Moisture values obtained are 84.91%, 85.14%, 84.46%, 84.79%, 75.27% and 75.07% respectively for organic pepper (OP), conventional Pepper (IP), organic Okro (OK), conventional Okro (IK), organic pawpaw (OPP), and conventional pawpaw (IPP). The moisture content of okro values are close but slightly higher than 82.25% value recorded by Nwachukwu *et al*. (2014). According to Ogunlade *et al*. (2012) the moisture content recorded for some pepper varieties ranged from 82.54% to 85.19%. Ekpete *et al*. (2013) noted the moisture content of pawpaw to be 87.30 % suggesting a latter ripening stage state of the sample. Both organic and conventional pawpaw samples were not so close to that which was reported by Ekpete *et al*. (2013) due to the difference in the stage of ripening. The moisture content values obtained for both organic and conventional samples is an indication of optimum maturity of both organic and conventional pepper as moisture content reaches its peak.

Though fruits and vegetables are not a major source of protein, its presence in appreciable amounts compliments well to sum up to the tune of what the body requires. Amongst the samples investigated, conventional pepper (IP) gave the highest protein content, followed by organic pepper (OP), organic okro (OK), conventional okro (IK), organic pawpaw (OPP) and conventional pawpaw (IPP). The protein values ranged from 1.63% to 3.56%. These were close to values (range of 2.64% to 3.51%) reported by Ogunlade *et al*. (2012). There was significant difference between organic and conventional samples of pepper and okro samples with the exception of pawpaw.

The Ash and Fat contents ranged from, 1.19% to 5.41% and 0.29 %to 2.86% respectively. The Ash content is a reflection of the mineral deposits in the food samples. Higher ash content suggests high mineral deposits though not always a reflection of its availability. There was significant difference between both organic and conventional samples in terms of ash and fat contents. Fiber and carbohydrate contents of both organic and conventional samples ranged from 2.65% to 7.3% and 2.5% to 10.68% respectively.

The organic samples had averagely a good fiber-carbohydrate balance. Organic pawpaw (OPP) recorded the highest and followed by Organic pepper (OP) then organic okro (OK). This high carbohydrate –fiber balance is an indication of good bulk which helps to check high cholesterol and provides a big advantage as against conventional samples due to the ability to reduce risk of certain types of cancer. With the exception of organic pawpaw and conventional pawpaw samples, there was a significant difference between organic and conventional pepper and okro samples at $p \leq 0.05$.

Table 4.1 Proximate Composition of Organic and Inorganic Vegetables and Fruit Samples

Sample	Moisture (%)	Protein (%)	Ash (%)	Fat (%)	Fiber (%)	Carbohydrate (%)
OP	84.91±0.049^{a}	3.19±0.01^{a}	1.64±0.04^{a}	2.28±0.01^{a}	3.88±0.03^{a}	4.11±0.03^{a}
IP	85.14±0.035^{b}	3.56±0.01^{b}	1.26±0.02^{b}	2.86±0.01^{b}	4.70±0.02^{b}	2.50±0.01^{b}
OK	84.46± 0.06^{c}	2.57±0.01^{c}	1.36±0.04^{c}	0.30±0.01^{c}	2.65±0.21^{c}	8.67±0.20^{c}
IK	84.79±0.04^{d}	2.38±0.02^{d}	1.19±0.02^{d}	0.32±0.00^{d}	3.10±0.14^{d}	8.23±0.18^{d}
OPP	75.27±0.10^{e}	1.72±0.04^{e}	4.77±0.15^{e}	0.29±0.02^{e}	7.30±0.04^{e}	10.68±0.03^{e}
IPP	75.07±0.15^{e}	1.62±0.01^{e}	5.41±0.06^{f}	0.32±0.00^{f}	7.13±0.16^{e}	9.66±0.11^{e}

Organic Pepper = OP; Conventional Pepper = IP; Organic Okro = OK, Conventional Okro = IK; Organic Pawpaw = OPP; Conventional Pawpaw = IPP

Means in the same column not followed by the same letter (s) are significantly different from each other by Duncan's multiple range tests at the $p \leq 0.05$.

4.3 Mineral Composition of Organic and Inorganic Fruit and Vegetables

The results obtained for the mineral composition of both organic and conventional samples are shown in Table 2.0. Conventional Okro sample recorded the highest Potassium content of 2371 mg/100g followed by Organic Okro 2085 mg/100g, Conventional Pawpaw255.65 mg/100g, Organic Pawpaw 248.35 mg/100g, Organic Pepper 89 mg/100g Conventional Pepper 62.35 mg/100g.

The values recorded were in the range 26.15 mg/100g – 380.05 mg/100g provided by Ekpete *et al*., (2013). The potassium content of two out of three conventional commodities was very high as compared to their organic counterparts with the exception of Organic pepper. This underscores the fertilizer application mode of most conventional farming practices especially the practice of applying the popular NPK (Nitrogen, Phosphorus and Potassium) fertilizer (Järvan and Edesi, 2009). Generally, the sodium content of the organic samples was found to be higher than conventional samples with the exception of the pawpaw samples. Organic pawpaw sample recorded 15.2 mg/100g whilst conventional pawpaw recorded 17.5 mg/100g sodium constituent. According to Lintas (1992), sodium constituent of fruits and vegetables ranges from as low as 2.0 mg/ 100g and as high as 150 mg/ 100g. On the average, the sodium content of all samples fell within the range most of which are close to the mean point. The calcium content is between 10.68 and 666.5 mg/100g of which conventional okro recorded the highest. In terms of magenesium, Organic okro recorded the highest 431.5 mg/100g followed by Conventional okro with the least being organic pawpaw. With the exception of organic pawpaw and conventional pawpaw samples, there was a significant difference between organic and conventional pepper and Okro samples at $p \leq 0.05$.

Table 4.2 Mineral Composition of Organic and Conventional Vegetables and Fruit Samples

Sample	Potassium (mg/100g)	Sodium (mg/100g)	Calcium (mg/100g)	Magnesium (mg/100g)
OP	89.00±0.35[a]	82.53±0.05[s]	78.5±0.08[a]	71.34±0.03[a]
IP	62.35±0.04[b]	74.63±0.11[b]	80.46±0.06[b]	63.77±0.10[b]
OK	2085.00±5.66[c]	29.50±0.71[c]	560±5.66[c]	431.50±3.54[c]
IK	2371.00±4.24[d]	20.00±1.41[d]	666.5±6.36[d]	401.50±2.12[d]
OPP	248.35±0.35[e]	15.20±0.14[e]	11.45±0.50[e]	8.70±0.14[e]
IPP	255.65±0.30[e]	17.50±0.14[f]	10.68±0.03[e]	9.25±0.21e

Organic Pepper = OP; Conventional Pepper = IP; Organic Okro = OK, Conventional **Okro = IK; Organic Pawpaw = OPP; Conventional Pawpaw = IPP**

Means in the same column not followed by the same letter (s) are significantly different from each other by Duncan’s multiple range tests at the $p \leq 0.05$.

4.4 Physicochemical of Organic and Inorganic Vegetables and Fruit Samples

4.4.1 Physicochemical of Organic and Inorganic Fruit Sample

The pH, Titrable Acidity, Total Soluble Solids (TSS), Total Phenolic Content and Refractive Index are greatly influenced by the presence of organic acids (malic, tartaric, citric, malic, lactic and acetic acids) and phenolic compounds (Resveratrol, Gallic and vallinic acids). These organic acids impart food in three major ways: affect the appearance of food (slows down browning), enhances flavor and in terms of preservation allows food to stay safe (enhances shelf life) for a reasonable period. As reported in 2008 by Ali and Deokule, physiologically and biochemically, phenolic compounds have antioxidant, anti-inflammatory and anti-microbial effects. Table 3.0 illustrates results from Pawpaw fruit samples. The pH value ranged from for the organic pawpaw sample is 5.36 whilst the conventional gave a pH of 5.48. Both samples gave a corresponding ° Brix of 11.5 and 11.25. This suggests the presence of high natural sugars in the organic sample as compared to the conventional pawpaw. In terms of refractive index, the same trend is observed. The refractive index for organic pawpaw was higher than that of conventional pawpaw. It is a well established scientific fact that as the ripening of a particular fruit moves from one stage to the other the brix and refractive indices increase whereas the acids reduce (Mahmood *et al*. 2012). Despite the fact that both organic and conventional samples were of the same stage of ripening, their brix and refractive indices differed significantly as well at their Acidity. This could be as a result of the organic and conventional nature of the samples. The titrable acidity of the conventional sample was higher than the organic sample. Phenolics of both organic and conventional pawpaw samples were very close. Values obtained are 281.3 mg GAE/100g and 282.5 mg GAE/100g respectively for both organic and conventional samples. There was no significant difference between the two.

Table 4.3 Physicochemical of Organic and Conventional Fruit Sample

Sample	TPC mgGAE /100g	TA (%)	pH	% TSS (° Brix)	Refractive Index (nD-TC)
OPP	281.3±1.13[a]	0.081±0.00[a]	5.36±0.01[a]	11.5±0.00[a]	1.56±0.01[a]
IPP	282.5±1.13[a]	0.089±0.00[b]	5.48±0.01[b]	11.25±0.10[b]	1.53±0.00[b]

Organic Pawpaw = OPP; Inorganic Pawpaw = IPP; TPC= Total Phenol Content; TA= Titrable Acidity; TSS = Total Soluble Solids

Means in the same column not followed by the same letter (s) are significantly different from each other by Duncan's multiple range tests at the $p \leq 0.05$.

4.4.2 Physicochemical of Organic and Conventional Vegetable Samples

Results from the physicochemicals of the vegetables are shown in Table 4.4. The phenoloic content of pepper samples was generally higher than that of okro samples. In relation to this, some works carried out have proven higher phenolics for pepper in comparison to okro. Marinova *et al*. (2005) reported pepper as having 5.96% more than okro. Comparing organic samples to the conventional samples, the total phenol content of conventional samples were slightly lower than organic samples. Organic pepper samples gave a TPC of 104.4 mg GAE / 100g whilst the conventional sample yielded 90.85 mg GAE / 100g. There was no significant difference between them. The pH of organic pepper was slightly lower than that of the conventional pepper with a corresponding % Titrable acidity of 0.14 and 0.18 respectively. The Total Phenol Content of the samples is 60.50 and 50.81 mg GAE / 100g respectively for organic and conventional okro. The high TPC of organic sample is close to what was recorded by Kortebortor-ASR an organic variety in work carried out by Ahiakpa *et al*. (2013).

The organic okro sample gave a pH of 6.35 whereas the conventional gave a higher pH of 6.55. The corresponding titrable acidity values are 3.1 and 3.6 respectively.

Table 4.4 Physicochemical of Organic and Conventional Vegetable Samples

Sample	TPC mgGAE /100g	TA (%)	pH
OP	104.4±0.28[a]	0.14±0.00[a]	5.10±0.00[a]
IP	90.85±0.07[b]	0.18±0.01[a]	5.25±0.07[a]
OK	60.50±0.02[a]	3.10±0.14[a]	6.35±0.07[a]
IK	50.81±0.03[b]	3.60±0.14[b]	6.55±0.07[b]

Organic Pepper = OP; Conventional Pepper = IP; Organic Okro = OK, Conventional Okro = IK; TPC= Total Phenol Content; TA= Titrable Acidity; TSS = Total Soluble Solids

Means in the same column not followed by the same letter (s) are significantly different from each other by Duncan's multiple range tests at the $p \leq 0.05$.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Investigations carried out during the survey indicated that most people admit that products from organic sources are not only safer but also much more enriched with nutrients for good health while on the contrary perceived conventional foods to have high risk of health related issues.

On the basis of nutrition, the proximate and physichochemical studies proved that the organic samples in most instances had higher contents of nutritional constituents specifically protein, fiber and carbohydrates and high phenolic and brix contents which estimate both nutritional quality and the antioxidant potency of organic foods to be quite higher when compared to the conventional ones. The only exception is with mineral content where on the average the conventional samples tend to have higher constituents of the specific minerals (Potassium, sodium, magnesium and calcium).

5.2 Recommendation

It is recommended that:

- Further studies to ascertain the vitamin contents of organic versus conventional fruits and vegetables.

- There should be ways such as enforcement of labelling so that the general public can easily differentiate between organic and conventional products in the open market

REFERENCES

ACS Guidelines on Nutrition and Physical Activity for Cancer Prevention (18th June, 2015). Retrieved from http://www.cancer.org/healthy/eathealthygetactive-guigelines-physical-activity-for-cancer

Ahiakpa, J.K., Kaledzi, P.D., Adi, E.B., Peprah, S. and Dapaah, H.K., 2013. Genetic diversity, correlation and path analyses of okra (Abelmoschus spp.(L.) Moench) germplasm collected in Ghana. *Int. J. Dev. Sustain*, *2*(2), pp.1396-1415.

Agbenyegah S. 2013. Total flavonoid, phenolic contents and antioxidant scavenging activity in 25 accessions of Okra (Abelmoschus spp L.). *African Journal of Food Science and Technology*, *4*(5), pp.129-135.

American Dietetic Association 2012. Is There Truth in Packaging? American Dietetic Association Offers Help in Translating Food Marketing Terms Retrieved from: http:// www.eatright.org/Media/content.aspx?id=4294967999#. Ud3VFNrn8hk.

Anderson, A.S., Cox, D.N., Reynolds, J., McKellar, S., Lean, M.E. and Mela, D.J., 1998. Take Five, a nutrition education intervention to increase fruit and vegetable intakes: impact on consumer choice and nutrient intakes. *British Journal of Nutrition*, *80*(02), pp.123-131.

Anderson, W.A., 2000. The future relationship between the media, the food industry and the consumer. *British medical bulletin*, *56*(1), pp.254-268.

Ansar, S.A., 2000. The immune system as a potential target for environmental estrogens (endocrine disrupters): a new emerging field. *Toxicology*, *150*(1), pp.191-206.

Azadi, H. and Ho, P., 2010. Genetically modified and organic crops in developing countries: A review of options for food security. *Biotechnology Advances*, *28*(1), pp.160-168.

Bacon, C.2005., Confronting the coffee crisis: can fair trade, organic, and specialty coffees reduce small-scale farmer vulnerability in northern Nicaragua? *World development* 33(3) pp. 497-511.

Bahlai, C.A., Xue, Y., McCreary, C.M., Schaafsma, A.W. and Hallett, R.H., 2010. Choosing organic pesticides over synthetic pesticides may not effectively mitigate environmental risk in soybeans. *PLoS One*, *5*(6), p.e11250.

Bailey, D.T., Dalton, C., Daugherty, F.J. and Tempesta, M.S., 2007. Can a concentrated cranberry extract prevent recurrent urinary tract infections in women? A pilot study. *Phytomedicine*, *14*(4), pp.237-241.

Baker, B.P., Benbrook, C.M., III, E.G. and Benbrook, K.L., 2002. Pesticide residues in conventional, integrated pest management (IPM)-grown and organic foods: insights from three US data sets. *Food Additives & Contaminants, 19*(5), pp.427-446.

Bakewell-Stone, P., Lieblein, G. and Francis, C., 2008. Potentials for organic agriculture to sustain livelihoods in Tanzania. *International Journal of Agricultural Sustainability*, *6*(1), pp.22-36.

Balfour, E.B., 1943. The living soil: evidence of the importance to human health of soil vitality, with special reference to post-war planning. *The living soil: evidence of the importance to human health of soil vitality, with special reference to post-war planning.*

Barański, M., Średnicka-Tober, D., Volakakis, N., Seal, C., Sanderson, R., Stewart, G.B., Benbrook, C., Biavati, B., Markellou, E., Giotis, C. and Gromadzka-Ostrowska, J., 2014. Higher antioxidant and lower cadmium concentrations and lower incidence of pesticide residues in organically grown crops: a systematic literature review and meta-analyses. *British Journal of Nutrition*, *112*(05), pp.794-811.

Barrett, D.M., Weakley, C., Diaz, J.V. and Watnik, M., 2007. Qualitative and nutritional differences in processing tomatoes grown under commercial organic and conventional production systems. *Journal of food science*, *72*(9).

Basker, D.,2009. Comparison of taste quality between organically and conventionally grown fruits and vegetables. *American Journal of Alternative Agriculture, 7*(03), pp.129-136

Batte, M.T., Hooker, N.H., Haab, T.C. and Beaverson, J., 2007. Putting their money where their mouths are: Consumer willingness to pay for multi-ingredient, processed organic food products. *Food policy*, *32*(2), pp.145-159.

Benbrook, C., 2012. Initial Reflections on the Annals of Internal Medicine Paper "Are Organic Foods Safer and Healthier than Conventional Alternatives? A Systematic Review.". *A Systemic Review*, *4*.

Benbrook, C., Zhao, X., Yanez, J., Davies, N., and Andrews, P., 2008. State of Science Review: Nutritional Superiority of Organic Foods: The Organic Center, University of Arizona. Available at Web site http://www. organiccenter.org (accessed June 27, 2010).

Bengtsson, J., Ahnström, J. and WEIBULL, A.C., 2005. The effects of organic agriculture on biodiversity and abundance: a meta- analysis. *Journal of applied ecology*, *42*(2), pp.261-269.

Berlin, L., Lockeretz, W. and Bell, R., 2009. Purchasing foods produced on organic, small and local farms: A mixed method analysis of New England consumers. *Renewable Agriculture and Food Systems*, *24*(04), pp.267-275.

Blair, R., 2012. *Organic production and food quality: A down to earth analysis*. John Wiley & Sons.

Bolwig, S., Gibbon, P. and Jones, S., 2009. The economics of smallholder organic contract farming in tropical Africa. *World Development*, *37*(6), pp.1094-1104.

Bond, C.A., Thilmany, D. and Keeling Bond, J., 2008. Understanding consumer interest in product and process- based attributes for fresh produce. *Agribusiness*, *24*(2), pp.231-252.

Borguini, R.G., 2006. Antioxidant potential and physicalchemical characteristics of organic tomato (Lycopersicon esculentum) in comparison with conventional tomato. *São Paulo: Universidade de São Paulo*.

Bourn, D. and Prescott, J., 2002. A comparison of the nutritional value, sensory qualities, and food safety of organically and conventionally produced foods. *Critical reviews in food science and nutrition*, *42*(1), pp.1-34.

Brandt, K. and Mølgaard, J.P., 2001. Organic agriculture: does it enhance or reduce the nutritional value of plant foods? *Journal of the Science of Food and Agriculture*, *81*(9), pp.924-931.

Brandt, M., 2012. Little evidence of health benefits from organic foods, Stanford study finds. *Inside Stanford Medicine*.

Bray, D.B., Sanchez, J.L.P. and Murphy, E.C., 2002. Social dimensions of organic coffee production in Mexico: lessons for eco-labeling initiatives. *Society &Natural Resources*, *15*(5), pp.429-446.

Brong Ahafo Region, March, 2005. Ministry of Food and Agriculture. Retrieved from http://www.mofa.gov.gh

Buchanan, J.R. and Muraoka, T.T., 1964. Determination of zinc and manganese in tree leaves by atomic absorption spectroscopy. *Atomic Absorption Newsletter, Perkin-Elmer, Norwalk, CN*.

Burton, S., 2006. Contrasting organic and conventional food products: Consumers' subjective perceptions and objective evaluations of nutrition and taste. *Journal of the International Society of Business Disciplines Spring*, pp.37-47.

Butler, G., Stergiadis, S., Eyre, M., Leifert, C., Borsari, A., Canever, A., Slots, T. and Nielsen, H.J., 2007. Effect of production system and geographic location on milk quality parameters. In 3rd International Congress of the European Integrated Project Quality Low Input Food (QLIF) Hohenheim, Germany, pp. 100–103

Calo, M. and Wise, T.A., 2005. Revaluing peasant coffee production: Organic and fair trade markets in Mexico. *Global Development and Environment Institute, Tufts University*.

Canavari, M., Asioli, D., Bendini, A., Cantore, N., Gallina Toschi, T., Spiller, A., Obermowe, T., Buchecker, K. and Lohmann, M., 2009. Summary report on sensory-related socio-economic and sensory science literature about organic food products.

Carlson, J.R., Bauer, B.A., Vincent, A., Limburg, P.J. and Wilson, T., 2007, June. Reading the tea leaves: anticarcinogenic properties of (-)-epigallocatechin-3-gallate. In *Mayo Clinic Proceedings*, 82(6), pp. 725-732.

Carvalho, A., Junqueira, A., Vieira, J., Botelho, R., 2005. Sensory analysis of carrot genotypes grown under organic system and conventional. *Horticultura Brasileira*, Brasília, 23(3), pp.805-809.

Chongtham, I.R., de Neergaard, A. and Pillot, D., 2010. Assessment of the strategies of organic fruit production and fruit drying in Uganda. *Journal of Agriculture and Rural Development in the Tropics and Subtropics (JARTS), 111*(1), pp.23-34.

Codex Alimentarius Commission. **FAO /WHO.** 1999. *Understanding the Codex Alimentarius*. International Federation of Organic Agriculture Movements (IFOAM).

Conventional Farming (15th March,2015) Retrieved from http://www.appropedia. org/ Conventional_farming

Costello, S., Cockburn, M., Bronstein, J., Zhang, X. and Ritz, B., 2009. Parkinson's disease and residential exposure to maneb and paraquat from agricultural applications in the central valley of California. *American journal of epidemiology*, *169*(8), pp.919-926.

Dangour, A.D., Dodhia, S.K., Hayter, A., Allen, E., Lock, K. and Uauy, R., 2009. Nutritional quality of organic foods: a systematic review. *The American journal of clinical nutrition*, *90*(3), pp.680-685.

Dangour, A.D., Lock, K., Hayter, A., Aikenhead, A., Allen, E. and Uauy, R., 2010. Nutrition-related health effects of organic foods: a systematic review. *The American journal of clinical nutrition*, *92*(1), pp.203-210.

DARD, 2008. The code of good agricultural practice for the prevention of pollution of water, air and soil (COGAP), UK Department of Agriculture and Rural Development. Available on-line at: http:// www.ruralni.gov.uk.

Datamonitor, 2008. Organic food: global industry guide. London, United Kingdom: Datamonitor Ltd

Defra. 2004. Action Plan to Develop Organic Food and Farming in England – Two years on. Department of Environment Food and Rural Affairs, London.

Department of Epidemiology Population Health, London School of Hygiene & Tropical Medicine, London, UK. alan.dangour@lshtm.ac.uk

Deokule S. S and **Ali** A., 2008. Comparison of Phenolic Compounds of Some Edible Plants of Iran and India.Pakistan Journal of Nutrition .7(4)

Devine, C.M., Connors, M.M., Sobal, J. and Bisogni, C.A., 2003. Sandwiching it in: spillover of work onto food choices and family roles in low-and moderate-income urban households. *Social Science & Medicine*, *56*(3), pp.617-630.

Dewberry, C. and Ussher, J.M., 1994. Restraint and perception of body weight among British adults. *The Journal of social psychology*, *134*(5), pp.609-619.

Di Renzo, L., Di Pierro, D., Bigioni, M., Sodi, V., Galvano, F., Cianci, R., La Fauci, L. and De Lorenzo, A., 2007. Is antioxidant plasma status in humans a consequence of the antioxidant food content influence? *European review for medical and pharmacological Sciences*, *11*(3), p.185.

Dibsdall, L.A., Lambert, N., Bobbin, R.F. and Frewer, L.J., 2003. Low-income consumers' attitudes and behaviour towards access, availability and motivation to eat fruit and vegetables. *Public health nutrition*, *6*(02), pp.159-168.

Donkin, A.J., Dowler, E.A., Stevenson, S.J. and Turner, S.A., 2000. Mapping access to food in a deprived area: the development of price and availability indices. *Public health nutrition*, *3*(01), pp.31-38.

Doran, J.W., Kirschenmann, F. and Magdoff, F., 2007. Balancing food, environmental and resource needs. *Renewable Agriculture and Food Systems*, *22*(02), pp.77-79.

Douglas John McConnell, 2003. The Forest Farms of Kandy: And Other Gardens of Complete Design.

Drinkwater, L.E., Wagoner, P. and Sarrantonio, M., 1998. Legume-based cropping systems have reduced carbon and nitrogen losses. *Nature*, *396*(6708), pp.262-265.

EC/834/2007 Council Regulation (EC) No 834/2007 on organic production and labelling of organic products and repealing Regulation (EEC) No 2092/91 Official Journal of the European Union, L189 (20.07.2007): 1-23.EC/765/2008 Regulation (EC) No 765/2008 of the European Parliam

Eddleston, K., Kellermanns, F.W., & Sarathy, R. 2008. Resource configuration in family firms: Linking resources, strategic planning and environmental dynamism to performance. *Journal of Management Studies*,*45*(1), pp. 26–50.

EFSA, 2007. Journal Paper- Annual Report on Pesticide Residues according to Article 32 of Regulation (EC) No 396/2005 [1],

EFSA, 2009. Study finds no additional nutritional benefit in "organic" food. European Food Safety Authority (EFSA). Available from: www.ecpa.eu (Viewed Jul 2011)

Ekpete O. A.; Edori O. S. and Fubara E. P., 2013, Proximate and Mineral Composition of Some Nigerian Fruits, British Journal of Applied Science and Technology, 3(4), pp. 1447-1454

FAO & WHO, 2007. Codex Alimentarius - Organically Produced Foods. Rome, World Health Organization (WHO) & Food and Agriculture Organization of the United Nations (FAO)

FiBL – Research Institute of Organic Agriculture. 2009. Organic Farming in Europe – A Brief Overview. Prepared for the European Organic Congress "Organic Food and Farming in times of Climate Change, Biodiversity loss and Global Food Crisis"

Fillion, L. and Arazi, S., 2002. Does organic food taste better? A claim substantiation approach. *Nutrition & Food Science*, *32*(4), pp.153-157.

Fjelkner-Modig, S., Bengtsson, H., Nystrõm, S. and Stegmark, R., 2000. The influence of organic and integrated production on nutritional, sensory and agricultural aspects of vegetable raw materials for food production. *Acta Agriculturae Scandinavica, Section B-Plant Soil Science*, *50*(3), pp.102-113.

Foley, J.A., DeFries, R., Asner, G.P., Barford, C., Bonan, G., Carpenter, S.R., Chapin, F.S., Coe, M.T., Daily, G.C., Gibbs, H.K. and Helkowski, J.H., 2005. Global consequences of land use. *science*, *309*(5734), pp.570-574.

Forman, J. and Silverstein, J., 2012. Organic foods: health and environmental advantages and disadvantages. *Pediatrics*, *130*(5), pp. e1406-e1415.

Frei, B. and Higdon, J.V., 2003. Antioxidant activity of tea polyphenols in vivo: evidence from animal studies. *The Journal of nutrition*, *133*(10), pp.3275S-3284S.

FSA, 2009. Comparison of putative Health Effects of Organically and Conventionally Produced Foodstuffs: A Systematic Review. Food Standards Agency, London

Fuller, R.J., Norton, L.R., Feber, R.E., Johnson, P.J., Chamberlain, D.E., Joys, A.C., Mathews, F., Stuart, R.C., Townsend, M.C., Manley, W.J. and Wolfe, M.S., 2005. Benefits of organic farming to biodiversity vary among taxa. *Biology letters*, *1*(4), pp.431-434.

Gardner, P.T., White, T.A., McPhail, D.B. and Duthie, G.G., 2000. The relative contributions of vitamin C, carotenoids and phenolics to the antioxidant potential of fruit juices. *Food Chemistry*, *68*(4), pp.471-474.

Getz, C. and Shreck, A., 2006. What organic and Fair Trade labels do not tell us: towards a place- based understanding of certification. *International Journal of Consumer Studies*, *30*(5), pp.490-501.

Ghana Statistical Service, 2000. Ghana Living Standards Survey Report of the Fourth Round (GLSS 4), October, 2000.

Gibney, M.J., 2004, June. European consumers' attitudes and beliefs about safe and nutritious foods: concepts, barriers and benefits. In *Proceedings of the International Food Conference:'Thinking beyond tomorrow'held in Dublin June* (Vol. 4).

Glanz, K., Kristal, A.R., Tilley, B.C. and Hirst, K., 1998. Psychosocial correlates of healthful diets among male auto workers. *Cancer Epidemiology and Prevention Biomarkers*, *7*(2), pp.119-126.

Gómez Tovar, L., Martin, L., Manuel Angel Gómez Cruz, G. A. M., Mutersbaugh, T., 2005. Certified organic agriculture in Mexico: Market connections and certification practices in large and small producers. *Journal of Rural Studies* 21(4), pp. 461-474.

Gomiero, T., Paoletti, M.G. and Pimentel, D., 2008. Energy and environmental issues in organic and conventional agriculture. *Critical Reviews in Plant Sciences*, *27*(4), pp.239-254.

Green, A.S., Rafaeli, E., Bolger, N., Shrout, P.E. and Reis, H.T., 2006. Paper or plastic? Data equivalence in paper and electronic diaries. *Psychological methods*, *11*(1), p.87.

Haas, G., Wetterich, F. and Köpke, U., 2000. Life cycle assessment of intensive, extensified and organic grassland farms in southern Germany. In *IFOAM 2000: the world grows organic. Proceedings 13th International IFOAM Scientific Conference, Basel, Switzerland, 28 to 31 August, 2000*. vdf Hochschulverlag AG an der ETH Zurich.

Haddad, G., 2009. Supervisor, Application Management & Enquiries Team. Australian Pesticides and Veterinary Medicines Authority. (Personal communication)

Hartman, Murray. "Direct Seeding: Estimating the Value of Crop Residues". Government of Alberta: Agriculture and Rural Development. Retrieved (22 March 2011).

Heckman J. Winter, 2006. A history of organic farming: transition from Sir Howard's war in the soil to the USDA National Organic Program. Wise Traditions in Food, Farming and the Healing Arts. Retrieved from http://www. westonaprice.org/farming/history-organic-farming.html

Helga Willer, Julia Lernoud and Robert Home The World of Organic Agriculture: Statistics & Emerging Trends, 2013. Research Institute of Organic Agriculture (FiBL) and the International Federation of Organic Agriculture Movements (IFOAM, 2013).

Hole, D.G., Perkins, A.J., Wilson, J.D., Alexander, I.H., Grice, P.V. and Evans, A.D., 2005. Does organic farming benefit biodiversity? *Biological conservation*, *122*(1), pp.113-130.

Howard, V., 2005. Pesticides and Health: International Congress: Organic Farming, Food Qualityand Human Heath, Newcastle, UK.

Howard, A., 1940. An Agricultural Testament, London, Oxford University Press.

Hughner, R.S., McDonagh, P., Prothero, A., Shultz, C.J. and Stanton, J., 2007. Who are organic food consumers? A compilation and review of why people purchase organic food. *Journal of consumer behaviour*, *6*(2- 3), pp.94-110.

IFOAM, 1998. Basic standards for organic production and processing. In: IFOAM General Assembly, Argentina.

IFOAM, 2005. *The principles of organic farming*. Available as a web-publication on http://www.ifoam.org/organic_facts/principles/pdfs/Principles_Organic_Agriculture.pdf

IFOAM, 2013. Our earth, our mission. Consolidated Annual Report of the IFOA M Action Group 2013

"**Integrated** Pest Management". U.S. Environmental Protection Agency. (1 January 2013) Retrieved from http://www.sciencedirect.com /science/article /pii/S0048969713001897

Is Organic Food Better than Conventional Food? (9th March, 2015) Retrieved from http: // www science.howstuffworks.com/environmental/green-science/ organic-food7.htm)

Ismail, A. and Fun, C.S., 2003. Determination of vitamin C, β-carotene and riboflavin contents in five green vegetables organically and conventionally grown. *Malaysian journal of nutrition*, *9*(1), pp.31-39.

Jaber, D., 2000. Human dignity and the dignity of creatures. *Journal of Agricultural and Environmental Ethics*, *13*(1), pp.29-42.

Järvan, M. and Edesi, L., 2009. The effect of cultivation methods on the yield and biological quality of potato. *Agron. Res*, *7*, pp.289-299.

Juroszek, P., Lumpkin, H.M., Yang, R.Y., Ledesma, D.R. and Ma, C.H., 2009. Fruit quality and bioactive compounds with antioxidant activity of tomatoes grown on-farm: comparison of organic and conventional management systems. *Journal of agricultural and food chemistry*, *57*(4), pp.1188-1194.

Kalypso, N., 2000. Non-discriminatory mutual recognition: an oxymoron in the new WTO lexicon. *Regulatory Barriers and the Principle of Non-Discrimination of World Trade Law: Past, Present and Future*.

Kampa, M., Nifli, A.P., Notas, G. and Castanas, E., 2007. Polyphenols and cancer cell growth. In *Reviews of physiology, biochemistry and pharmacology* (pp. 79-113). Springer Berlin Heidelberg.

Kearney, M., Kearney, J.M., Dunne, A. and Gibney, M.J., 2000. Sociodemographic determinants of perceived influences on food choice in a nationally representative sample of Irish adults. *Public health nutrition*, *3*(02), pp.219-226.

Lea, E. and Worsley, T., 2005. Australians' organic food beliefs, demographics and values. *British food journal*, *107*(11), pp.855-869.

Leifeld, J. and Fuhrer, J., 2010. Organic farming and soil carbon sequestration: what do we really know about the benefits? *Ambio*, *39*(8), pp.585-599.

Lintas, C., 1992. Nutritional aspects of fruits and vegetables consumption. *Options Mediterraeennes*, *19*, pp.79-87.

Lockie, S., Lyons, K., Lawrence, G. and Mummery, K., 2002. Eating 'green': motivations behind organic food consumption in Australia. *Sociologia ruralis*, *42*(1), pp.23-40.

Loncarevic, S., Johannessen, G.S. and Rørvik, L.M., 2005. Bacteriological quality of organically grown leaf lettuce in Norway. *Letters in Applied Microbiology*, *41*(2), pp.186-189.

Lundegårdh, B. and Mårtensson, A., 2003. Organically produced plant foods-evidence of health benefits. *Acta Agriculturae Scandinavica, B*, *53*(1), pp.3-15.

Luthria, D., Singh, A.P., Wilson, T., Vorsa, N., Banuelos, G.S. and Vinyard, B.T., 2010. Influence of conventional and organic agricultural practices on the phenolic content in eggplant pulp: plant-to-plant variation. *Food Chemistry*, *121*(2), pp.406-411.

Mäder, P., Fliessbach, A., Dubois, D., Gunst, L., Fried, P. and Niggli, U., 2002. Soil fertility and biodiversity in organic farming. *Science*, *296*(5573), pp.1694-1697.

Magkos, F., Arvaniti, F. and Zampelas, A., 2006. Organic food: buying more safety or just peace of mind? A critical review of the literature. *Critical reviews in food science and nutrition*, *46*(1), pp.23-56.

Malmauret, L., Parent-Massin, D., Hardy, J.L. and Verger, P., 2002. Contaminants in organic and conventional foodstuffs in France. *Food Additives & Contaminants*, *19*(6), pp.524-532.

Marinova, D., Ribarova, F. and Atanassova, M., 2005. Total phenolics and total flavonoids in Bulgarian fruits and vegetables. *Journal of the university of chemical technology and metallurgy*, *40*(3), pp.255-260.

Mitchell, A.E., Hong, Y.J., Koh, E., Barrett, D.M., Bryant, D.E., Denison, R.F. and Kaffka, S., 2007. Ten-year comparison of the influence of organic and conventional crop management practices on the content of flavonoids in tomatoes. *Journal of Agricultural and Food Chemistry*, *55*(15), pp.6154-6159.

Mahmood, T., Anwar, F., Iqbal, T., Bhatti, I.A. and Ashraf, M., 2012. Mineral composition of strawberry, mulberry and cherry fruits at different ripening stages as analyzed by inductively coupled plasma-optical emission spectroscopy. *Journal of plant nutrition*, *35*(1), pp.111-122.

Mukherjee, A., Speh, D., Dyck, E. and Diez-Gonzalez, F., 2004. Preharvest evaluation of coliforms, Escherichia coli, Salmonella, and Escherichia coli O157: H7 in organic and conventional produce grown by Minnesota farmers. *Journal of food protection*, *67*(5), pp.894-900.

Mutersbaugh, T., 2002. The number is the beast: a political economy of organic-coffee certification and producer unionism. *Environment and Planning A*, *34*(7), pp.1165-1184

Nadia S., 2000, August. Factors influencing organic agriculture policies with a focus on developing countries. In *IFOAM 2000 Scientific Conference, Basel, Switzerland* (pp. 28-31).

NOSB, 1995. This definition was passed by the NOSB at its April 1995 meeting in Orlando, Florida. *Ref:* Organic Trade Association website http://www.northcoast.com/~startrak/ota/legislat.htm

Nutrients and Health Benefits. Retrieved (15th March, 2015). from http://www.nal.usda.gov/afsic/AFSIC_pubs/srb9902.htm#toc3

Nutrients and Health Benefits Retrieved (1st June, 2015). from http://www.choosemyplate.gov/foodgroups/

Nutritional Superiority of Plant-Based Organic Retrieved 20th March,2015 from http://www.organiccenter.org

Nwachukwu, E.C., Nulit, R. and Go, R., 2014. Nutritional and biochemical properties of Malaysian okra variety. *Advancement in Medicinal Plant Research*, *2*(1), pp.16-19.

Ogunlade A., Alebiosu, A., Osasona. 2012. Proximate, mineral composition, antioxidant activity, and total phenolic content of some pepper varieties (Capsicum species) International Journal of Biological and Chemical Sciences, 6(5), pp. 2221-2227

Oliveira M, Usall J, Viñas I, Anguera M, Gatius F and Abadias M. 2010. Microbiological quality of fresh lettuce from organic and conventional production. Food of Microbiology 27 (5) pp. 679–684

Onozaka, Y., Nurse, G. and McFadden, D.T., 2010. Local food consumers: how motivations and perceptions translate to buying behavior. *Choices*, *25*(1), pp.1-6.

Organic Agriculture and Food Utilization (9th March, 2015) Retrieved from http://www.infohub.ifoam.bio/en/what-organic/principles-organic-agriculture#Health.

Organic Farming-Agriculture in Ghana (9th March, 2015). Retrieved from http://www. agricinghana.com/tag/organic-farming-in-ghana/

Organic Production/ Organic Food- Information Access Tool (18th June, 2015). Retrieved from https://www.en.wikipedia.org/wiki/Organic_food

Ortuno, A., Benavente-Garcia, O., Castillo, J., Alcaraz, M., Vicente, V. and Del Rio, J.A., 2007. Beneficial action of Citrus flavonoids on multiple cancer-related biological pathways. *Current cancer drug targets*, *7*(8), pp.795-809.

Organic Trade Association, 2011. Industry statistics and projected growth. *Washington, DC retrieved from: http://www. ota. com/organic/mt/business. html*.

Owens, S., 2009. Senior Communications Advisor. New Zealand Food Safety Authority. (Personal Communication)

Owusu-Boateng G, Ntim M and Plange-Rhule J., 2013. Ambient air quality in the Chirano gold mines limited, Bibiani Ghana. Global Advanced Research Journal of Physical and Applied Sciences, 2 (2), pp. 032-038.

Paull, J., 2006. The farm as organism: The foundational idea of organic agriculture. *Elementals: Journal of Bio-Dynamics Tasmania*, (80), pp.14-18.

Paull, J., 2011. Nanomaterials in food and agriculture: The big issue of small matter for organic food and farming. In *Proceedings of the Third Scientific Conference of ISOFAR* (Vol. 2, pp. 96-99). ISOFAR.

Pesticides and Food, 2014. What the Pesticide Residue Limits are on Food'. US Environmental Protection Agency. *Retrieved 28 October 2014*

Population and Housing Census, 2010. Ghana Statistical Service. Retrieved from http://www.ghana.gov,gh/ (2010 Population and Housing Census)

Perkin, E.,1982. Analytical Methods for Atomic Absorption Spectrophotometry, Norwalk, CT, U.S.A, pp. 132-181-102

Principles of Organic Farming (7th October,2015). Retrieved from (http://www. wholefoodsmarket.com).

Problems Associated with Conventional Farming (15th March,2015). Retrieved from http://www.nal.usda.gov/afsic/AFSIC_pubs/srb9902.htm#toc3

Promoting Sustainable Food Systems through Organic Agriculture: Past, Present and Future," Christine McCullum-Gomez, C., and Riddle, J. HEN Post: Hunger and Environmental Nutrition Practice Group of the American Dietetic Association, Spring 2009. www.hendpg.org

Reasoned opinion of EFSA prepared by the Pesticides Unit (PRAPeR) on the 2007 Annual Report on Pesticide Residues. EFSA Scientific Report (2009) 305, 1-106

Rembialkowska, E., 2000. The nutritive and sensory quality of carrots and white cabbage from organic and conventional farms. In *IFOAM 2000: the world grows organic. Proceedings 13th International IFOAM Scientific Conference, Basel, Switzerland, 28 to 31 August, 2000*. vdf Hochschulverlag AG an der ETH Zurich, pp297

Richter, E.D., 2002. Acute human pesticide poisonings. *Encyclopedia of pest management*, pp.3-6.

Robinson-O'Brien, R., Larson, N., Neumark-Sztainer, D., Hannan, P. and Story, M., 2009. Characteristics and dietary patterns of adolescents who value eating locally grown, organic, nongenetically engineered, and nonprocessed food. *Journal of nutrition education and behavior*, *41*(1), pp.11-18.

Rossetto, M.R.M.,Vianello, F., da Rocha, S.A. and Lima, G.P.P., 2009. Antioxidant substances and pesticide in parts of beet organic and conventional manure. *African Journal of Plant Science*, *3*(11), pp.245-253.

Roussos, P.A. and Gasparatos, D., 2009. Apple tree growth and overall fruit quality under organic and conventional orchard management. *Scientia Horticulturae*, *123*(2), pp.247-252.

Salvador, A., Sanz, T. and Fiszman, S.M., 2007. Changes in colour and texture and their relationship with eating quality during storage of two different dessert bananas. *Postharvest biology and technology*, *43*(3), pp.319-325.

Samman, S., Kung, F.P., Carter, L.M., Foster, M.J., Ahmad, Z.I., Phuyal, J.L. and Petocz, P., 2009. Fatty acid composition of certified organic, conventional and omega-3 eggs. *Food Chemistry*, *116*(4), pp.911-914.

Schmid, O.,2007. Development of Standard for Organic Farming In Organic Farming: An international History, pp.152-174 (Ed W. Lockeretz). Wallingford: CABI.

Singleton, V.L. and Rossi, J.A., 1965. Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents. *American journal of Enology and Viticulture*, *16*(3), pp.144-158.

Smith-Spangler, C; Brandeau, ML; Hunter, GE; Bavinger, JC; Pearson, M; Eschbach, PJ; Sundaram, V; Liu, H; Schirmer, P; Stave, C; Olkin, I; Bravata, D.M., 2012. "Are organic foods safer or healthier than conventional alternatives? a systematic review." *Annals of Internal Medicine*,157(5), pp.348–366.

SOEL,2003. Stifung Okologie and Landbau, available at http://www.soel.de/inhalte/publikationen/s/s_74.pdf.

Soil Association, 2006. Market Research Study Into Market Penetration of Scottish Organic Produce, http://www.scotland.gov.uk/publications/2006/02/08094741/031.

Soil Association, 2010. Organic farming, food quality and human health: a review of the evidence. Bristol, United Kingdom.

Sorensen, G., Hunt, M.K., Cohen, N., Stoddard, A., Stein, E., Phillips, J., Baker, F., Combe, C., Hebert, J. and Palombo, R., 1998. Worksite and family education for dietary change: the Treatwell 5-a-Day program. *Health Education Research*, *13*(4), pp.577-591.

Sørensen, L.B., Møller, P., Flint, A., Martens, M. and Raben, A., 2003. Effect of sensory perception of foods on appetite and food intake: a review of studies on humans. *International journal of obesity*, *27*(10), pp.1152-1166.

Stinner, D.H., 2007. "The Science of Organic Farming". In William Lockeretz. Organic Farming: An International History. Oxfordshire, UK & Cambridge, Massachusetts: CAB International (CABI). pp. 40–72.

Stubbs, R.J., Van Wyk, M.C., Johnstone, A.M. and Harbron, C.G., 1996. Breakfasts high in protein, fat or carbohydrate: effect on within-day appetite and energy balance. *European journal of clinical nutrition*, *50*(7), pp.409-417.

Sustainability and Quality of Organic Foods (20th April, 2015). Retrieved from https://shop.fibl.org/fileadmin/documents/shop/1413-organic-products.pdf

The IFOAM World Board's statement on the role of Organic Agriculture in the transition to a sustainable world (20thMarch,2015). Retrieved from http://www.ifoam.org/about_ifoam/principles/index.html

Toan P. V., Sebesvari Z., Bläsing M. , Rosendahl I., Renaud G. F., 2013. Science of The Total Environment, 452 (453), pp. 28–39

Tyburski J and Żakowska-Biemans S. 2007. Wprowadzenie do rolnictwa ekologicznego. WydawnictwoSzkoły Głównej Gospodarstwa wiejskiego, Warszawa

Tyburski, J., and Żakowska-Biemas, S., 2007. Wprowadzenie do rolnictwa ekologicznego. *Wydawnictwo SGGW, Warszawa*.

U.S. EPA, 2013. "The ruling on organic foods: are they worth the extra price?" "Healthy Years", 10 (11),p. 1

U.S EPA, 2014. Report on minor use of pesticides. Mandated by Section 31 of the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), as Amended by the Food Quality Protection Act (FQPA) of August 3, 1996.

United States Department of Agriculture, 2012. National Organic Program. Retrieved from:<http://www.ams.usdagov/AMSv1.0/ams.fetchTemplateData.do?template=TemplateC&navID=NationalOrganicProgram&leftNav=NationalOrganicProgram&page=NOPConsumers&descriptio n=Consumers&acct=nopgeninfo>.

Valkila, J., 2009. Fair Trade organic coffee production in Nicaragua—Sustainable development or a poverty trap? *Ecological Economics*, *68*(12), pp.3018-3025.

Vogt, G., 2000. *Entstehung und Entwicklung des ökologischen Landbaus im deutschsprachigen Raum*. Stiftung Ökologie & Landbau, Bad Dürkheim.

Weibel, F.P., Bickel, R., Leuthold, S. and Alföldi, T., 1998, August. Are organically grown apples tastier and healthier? A comparative field study using conventional and alternative methods to measure fruit quality. In *XXV International Horticultural Congress, Part 7: Quality of Horticultural Products 517* (pp. 417-426).

White, Kim K., Duram, Leslie A., 2013. *America Goes Green: An Encyclopedia of Eco-friendly Culture in the United States*. California: ABC-CLIO. p. 180. ISBN 978-1-59884-657-7.

Willer H., 2011. Organic Agriculture in Europe: Overview. The World of Organic Agriculture. Statistics and Emerging Trends 2011. FiBL-IFOAM Report. Eds.: Helga Willer and Lukas Kilcher. IFOAM, Bonn and FiBL, Frick

Willer, H. and Yussefi, M., L (2011) The World of Organic Agriculture. Statistics and Emerging Trends 2011. In *FiBL-IFOAM Report. Bonn: IFOAM and Frick: FiBL*.

Willer, H., Yussefi, M. and Sorensen, N., 2010. *The world of organic agriculture: statistics and emerging trends 2008*. Earthscan.

Williams, C.M., 2002. Nutritional quality of organic food: shades of grey or shades of green?. *Proceedings of the Nutrition Society*, *61*(01), pp.19-24.

Winter, C.K. and Davis, S.F., 2006. Organic foods. *Journal of food science*, *71*(9), pp.R117-R124.

Wisniewski, J.P., Frangne, N., Massonneau, A. and Dumas, C., 2002. Between myth and reality: genetically modified maize, an example of a sizeable scientific controversy. *Biochimie*, *84*(11), pp.1095-1103.

Wolfe, M.S., Baresel, J.P., Desclaux, D., Goldringer, I., Hoad, S., Kovacs, G., Löschenberger, F., Miedaner, T., Østergård, H. and Van Bueren, E.L., 2008. Developments in breeding cereals for organic agriculture. *Euphytica*, *163*(3), pp.323-346.

Worthington, V., 2001. Nutritional quality of organic versus conventional fruits, vegetables, and grains. *The Journal of Alternative & Complementary Medicine*, *7*(2), pp.161-173.

Yue, C. and Tong, C., 2009. Organic or local? Investigating consumer preference for fresh produce using a choice experiment with real economic incentives. *HortScience*, *44*(2), pp.366-371.

Zhao, X., Chambers, E., Matta, Z., Loughin, T.M. and Carey, E.E., 2007. Consumer sensory analysis of organically and conventionally grown vegetables. *Journal of Food Science*, *72*(2), pp.S87-S91.

APPENDIX

A.

SURVEY ON CONSUMERS PERCEPTION ON ORGANIC AND CONVENTIONAL FOODS

DERMOGRAPHIC INFORMATION

GENDER: ____ Male ____Female

1. **AGE:_____________**
2. **WEIGHT:________**
3. **OCCUPATION: _____________**
4. **HIGHEST LEVEL OF EDUCATION:** _____Primary _____Secondary _____Tertiary _____Other (Specify)

KNOWLEDGE BASED QUESTIONS

5. Have you heard about organic foods? ____ Yes No ____ (If No, Skip to Question 9)
   (i) If yes, what is the source of your information?
   a) _____ Media (radio, TV, news paper)
   b) _____Family/ friends
   c) _____Training (teaching, reading of journals/ articles)
   d) ________Other (specify)

6. What do you think is/are organic food(s)? _________________
8. **Please indicate how you agree with the following statements;**

(1) Strongly Disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly agree

Characteristics of organic fruits/vegetables	**1**	**2**	**3**	**4**	**5**
8a.The colour of organic fruits/vegetables should always be very bright.					
8b.The size of organic fruits/vegetables should be: i. Small					
ii. medium					
iii. large					
Iv. very large					
8c. Organic fruits/ vegetables should always look fresh					
8d. Organic fruits/ vegetables should always be solid					
8e. Organic fruits/vegetables should always be insect damage free.					
8f. Organic fruits/vegetables should always look clean					

9. Have you heard about conventional foods? ____ Yes No ____ (If No, Skip to Question 11)

(ii) If yes, what is the source of your information?

e) _____ Media (radio, TV, news paper)

f) _____Family/ friends

g) _____Training (teaching, reading of journals/ articles)

h) ________Other (specify)

10. What do you think is/are conventional food(s)?

____

11. Please indicate how you agree with the following statements;

(1) Strongly Disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly agree

Characteristics of conventional fruits/vegetables	**1**	**2**	**3**	**4**	**5**
11a.The colour of conventional fruits/vegetables should always be very bright.					
11b.The size of conventional fruits/vegetables should be: i. Small					
ii. medium					
iii. large					
Iv. very large					
11c. Conventional fruits/ vegetables should always look fresh					
11d. Conventional fruits/ vegetables should always be solid					
11e. Conventional fruits/vegetables should always be insect damage free.					
11f. Conventional fruits/vegetables should always look clean					

CONSUMERS PERCEPTION & ATTITUDE

12. Would you prefer organic foods to conventional foods? ______Yes ______No

13. If yes why? Because organic foods are____ than conventional foods.

a)____ safer(pesticide residue free)

b) ____healthier

c) ____tastier

d)____nutritious

e)____less costly

f)____other (specify) ________

14. If no why? Because organic foods are **NOT**_____than conventional foods.

a) ____ safer (pesticide residue free)

b) ____healthier

c) ____tastier

d)____nutritious

e)____less costly

f)____other (specify) ________

15. Where would you like to purchase your organic fruits/vegetables from?

a) ____ farm gate

b) ____market retailers

c) ____street hawkers

d)____supermarket

e)____other (specify)___________

16. Is/are there chemical residue(s) in organic fruits/vegetables? ___Yes ___No ____ don't know

17. If yes do you know of any? Kindly name one_______________________

18.Is/are there chemical residue(s) in conventional fruits/vegetables?

___Yes ___No ___ don't know

19. If yes, do you know of any? Kindly name one_______________________

20. Do you know of any health risk (disease) associated with organic fruits/vegetables?

___Yes ___No ____ don't know

21. If yes, do you know of any? Kindly name one_______________________

22. Do you know of any health risk (disease) associated with conventional fruits/vegetables?

___Yes ___No ____ don't know

23. If yes, do you know of any? Kindly name one_______________________

24. How often would you purchase/consume organic fruits/vegetables?

_____Always (every time)
_____Frequently (on many occasions)
_____Sometimes (on some occasions)
_____Very seldom (almost never)
_____Never

25. How often would you purchase/consume conventional fruits/vegetables?

_____Always (every time)
_____Frequently (on many occasions)
_____Sometimes (on some occasions)
_____Very seldom (almost never)
_____Never

26. Please indicate how you agree with the following statements;

(1) Strongly Disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly agree

Characteristics of organic fruits/vegetables	**1**	**2**	**3**	**4**	**5**
26a.Organic products are tastier					
26b. Organic products have superior quality					
26c.Organic products are safer					
26d. Organic products are less expensive					
26e. Production of organic products makes the environment safe.					

27. How would you like organic products be differentiated from conventional products?

a)_______Labelling

b)_______Selling in special markets/ stores

c)_______Other (specify)_________

B. Statistical Analysis Proximate, Minerals and Physicochemicals

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
MOISTURE	Between Groups	.042	1	.042	2.639	.246
	Within Groups	.032	2	.016		
	Total	.074	3			
ASH	Between Groups	.416	1	.416	32.952	.029
	Within Groups	.025	2	.013		
	Total	.441	3			
PROTEIN	Between Groups	.009	1	.009	12.448	.072
	Within Groups	.001	2	.001		
	Total	.010	3			
FAT	Between Groups	.001	1	.001	5.444	.145
	Within Groups	.000	2	.000		
	Total	.002	3			
FIBRE	Between Groups	.026	1	.026	1.848	.307

	Within Groups	.028	2	.014		
	Total	.053	3			
CARBOHYDRATE	Between Groups	1.051	1	1.051	1.704	.322
	Within Groups	1.233	2	.617		
	Total	2.284	3			

2. MINERALS

26-Jan-16 6:29:20 AM

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
POTASSIUM	Between Groups	53.290	1	53.290	3.773	.192
	Within Groups	28.250	2	14.125		
	Total	81.540	3			
SODIUM	Between Groups	5.290	1	5.290	264.500	.004
	Within Groups	.040	2	.020		
	Total	5.330	3			
CALCIUM	Between Groups	.593	1	.593	4.824	.159
	Within Groups	.246	2	.123		
	Total	.839	3			
MAGNESSIUM	Between Groups	.303	1	.303	9.308	.093
	Within Groups	.065	2	.033		
	Total	.368	3			

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Total Phenol Content	Between Groups	1.440	1	1.440	1.125	.400
	Within Groups	2.560	2	1.280		
	Total	4.000	3			
Titrable acidity	Between Groups	.000	1	.000	32.000	.030
	Within Groups	.000	2	.000		
	Total	.000	3			
pH	Between Groups	.016	1	.016	125.000	.008
	Within Groups	.000	2	.000		
	Total	.016	3			
TOTAL SOLUBLE SUGER	Between Groups	.062	1	.062	25.000	.038
	Within Groups	.005	2	.003		
	Total	.068	3			
REFRACTIVE INDEX	Between Groups	.001	1	.001	25.000	.038
	Within Groups	.000	2	.000		
	Total	.001	3			

VEGETABLES

1. PROXIMATE

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
MOISTURE	Between Groups	.474	3	.158	72.621	.001
	Within Groups	.009	4	.002		
	Total	.483	7			
ASH	Between Groups	.235	3	.078	91.980	.000
	Within Groups	.003	4	.001		
	Total	.238	7			
PROTEIN	Between Groups	1.804	3	.601	2.291E3	.000
	Within Groups	.001	4	.000		
	Total	1.805	7			
FAT	Between Groups	10.575	3	3.525	3.133E4	.000
	Within Groups	.000	4	.000		
	Total	10.575	7			
FIBRE	Between Groups	4.857	3	1.619	97.752	.000
	Within Groups	.066	4	.017		
	Total	4.923	7			
CARBOHYDRATE	Between Groups	55.795	3	18.598	1.007E3	.000
	Within Groups	.074	4	.018		
	Total	55.869	7			

Multiple Comparisons

Dependent Variable		(I) SAMPLE CODE	(J) SAMPLE CODE	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
MOISTURE	LSD	PEPPER ORGANIC	PEPPER INORGANIC	-.23000*	.04664	.008	-.3595	-.1005
			OKRO ORGANIC	.44500*	.04664	.001	.3155	.5745
			OKRO ORGANIC	.11500	.04664	.069	-.0145	.2445
		PEPPER INORGANIC	PEPPER ORGANIC	.23000*	.04664	.008	.1005	.3595
			OKRO ORGANIC	.67500*	.04664	.000	.5455	.8045
			OKRO ORGANIC	.34500*	.04664	.002	.2155	.4745
		OKRO ORGANIC	PEPPER ORGANIC	-.44500*	.04664	.001	-.5745	-.3155
			PEPPER INORGANIC	-.67500*	.04664	.000	-.8045	-.5455
			OKRO ORGANIC	-.33000*	.04664	.002	-.4595	-.2005
		OKRO ORGANIC	PEPPER ORGANIC	-.11500	.04664	.069	-.2445	.0145
			PEPPER INORGANIC	-.34500*	.04664	.002	-.4745	-.2155
			OKRO ORGANIC	.33000*	.04664	.002	.2005	.4595
ASH	LSD	PEPPER ORGANIC	PEPPER INORGANIC	.38000*	.02915	.000	.2991	.4609
			OKRO ORGANIC	.28000*	.02915	.001	.1991	.3609
			OKRO ORGANIC	.45000*	.02915	.000	.3691	.5309
		PEPPER INORGANIC	PEPPER ORGANIC	-.38000*	.02915	.000	-.4609	-.2991
			OKRO ORGANIC	-.10000*	.02915	.027	-.1809	-.0191
			OKRO ORGANIC	.07000	.02915	.074	-.0109	.1509

		OKRO ORGANIC	PEPPER ORGANIC	-.28000*	.02915	.001	-.3609	-.1991
			PEPPER INORGANIC	.10000*	.02915	.027	.0191	.1809
			OKRO ORGANIC	.17000*	.02915	.004	.0891	.2509
		OKRO ORGANIC	PEPPER ORGANIC	-.45000*	.02915	.000	-.5309	-.3691
			PEPPER INORGANIC	-.07000	.02915	.074	-.1509	.0109
			OKRO ORGANIC	-.17000*	.02915	.004	-.2509	-.0891
PROTEIN	LSD	PEPPER ORGANIC	PEPPER INORGANIC	-.37000*	.01620	.000	-.4150	-.3250
			OKRO ORGANIC	.62000*	.01620	.000	.5750	.6650
			OKRO ORGANIC	.81500*	.01620	.000	.7700	.8600
		PEPPER INORGANIC	PEPPER ORGANIC	.37000*	.01620	.000	.3250	.4150
			OKRO ORGANIC	.99000*	.01620	.000	.9450	1.0350
			OKRO ORGANIC	1.18500*	.01620	.000	1.1400	1.2300
		OKRO ORGANIC	PEPPER ORGANIC	-.62000*	.01620	.000	-.6650	-.5750
			PEPPER INORGANIC	-.99000*	.01620	.000	-1.0350	-.9450
			OKRO ORGANIC	.19500*	.01620	.000	.1500	.2400
		OKRO ORGANIC	PEPPER ORGANIC	-.81500*	.01620	.000	-.8600	-.7700
			PEPPER INORGANIC	-1.18500*	.01620	.000	-1.2300	-1.1400
			OKRO ORGANIC	-.19500*	.01620	.000	-.2400	-.1500
FAT	LSD	PEPPER ORGANIC	PEPPER INORGANIC	-.58000*	.01061	.000	-.6094	-.5506
			OKRO ORGANIC	1.98500*	.01061	.000	1.9556	2.0144
			OKRO ORGANIC	1.96000*	.01061	.000	1.9306	1.9894
		PEPPER INORGANIC	PEPPER ORGANIC	.58000*	.01061	.000	.5506	.6094

			OKRO ORGANIC	2.56500*	.01061	.000	2.5356	2.5944
			OKRO ORGANIC	2.54000*	.01061	.000	2.5106	2.5694
		OKRO ORGANIC	PEPPER ORGANIC	-1.98500*	.01061	.000	-2.0144	-1.9556
			PEPPER INORGANIC	-2.56500*	.01061	.000	-2.5944	-2.5356
			OKRO ORGANIC	-.02500	.01061	.078	-.0544	.0044
		OKRO ORGANIC	PEPPER ORGANIC	-1.96000*	.01061	.000	-1.9894	-1.9306
			PEPPER INORGANIC	-2.54000*	.01061	.000	-2.5694	-2.5106
			OKRO ORGANIC	.02500	.01061	.078	-.0044	.0544
FIBRE	LSD	PEPPER ORGANIC	PEPPER INORGANIC	-.81500*	.12870	.003	-1.1723	-.4577
			OKRO ORGANIC	1.23000*	.12870	.001	.8727	1.5873
			OKRO ORGANIC	.78000*	.12870	.004	.4227	1.1373
		PEPPER INORGANIC	PEPPER ORGANIC	.81500*	.12870	.003	.4577	1.1723
			OKRO ORGANIC	2.04500*	.12870	.000	1.6877	2.4023
			OKRO ORGANIC	1.59500*	.12870	.000	1.2377	1.9523
		OKRO ORGANIC	PEPPER ORGANIC	-1.23000*	.12870	.001	-1.5873	-.8727
			PEPPER INORGANIC	-2.04500*	.12870	.000	-2.4023	-1.6877
			OKRO ORGANIC	-.45000*	.12870	.025	-.8073	-.0927
		OKRO ORGANIC	PEPPER ORGANIC	-.78000*	.12870	.004	-1.1373	-.4227
			PEPPER INORGANIC	-1.59500*	.12870	.000	-1.9523	-1.2377
			OKRO ORGANIC	.45000*	.12870	.025	.0927	.8073
CARBOHYDRATE	LSD	PEPPER ORGANIC	PEPPER INORGANIC	1.61500*	.13588	.000	1.2377	1.9923
			OKRO ORGANIC	-4.56000*	.13588	.000	-4.9373	-4.1827

		OKRO ORGANIC	-4.12000*	.13588	.000	-4.4973	-3.7427
	PEPPER INORGANIC	PEPPER ORGANIC	-1.61500*	.13588	.000	-1.9923	-1.2377
		OKRO ORGANIC	-6.17500*	.13588	.000	-6.5523	-5.7977
		OKRO ORGANIC	-5.73500*	.13588	.000	-6.1123	-5.3577
	OKRO ORGANIC	PEPPER ORGANIC	4.56000*	.13588	.000	4.1827	4.9373
		PEPPER INORGANIC	6.17500*	.13588	.000	5.7977	6.5523
		OKRO ORGANIC	.44000*	.13588	.032	.0627	.8173
	OKRO ORGANIC	PEPPER ORGANIC	4.12000*	.13588	.000	3.7427	4.4973
		PEPPER INORGANIC	5.73500*	.13588	.000	5.3577	6.1123
		OKRO ORGANIC	-.44000*	.13588	.032	-.8173	-.0627

*. The mean difference is significant at the 0.05 level.

HOMOGENOUS

MOISTURE

	SAMPLE CODE	N	Subset for alpha = 0.05		
			1	2	3
Duncan[a]	OKRO ORGANIC	2	84.4600		
	OKRO ORGANIC	2		84.7900	
	PEPPER ORGANIC	2		84.9050	
	PEPPER INORGANIC	2			85.1350
	Sig.		1.000	.069	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 2.000.

ASH

	SAMPLE CODE	N	Subset for alpha = 0.05		
			1	2	3
Duncan[a]	OKRO ORGANIC	2	1.1850		
	PEPPER INORGANIC	2	1.2550		
	OKRO ORGANIC	2		1.3550	
	PEPPER ORGANIC	2			1.6350
	Sig.		.074	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 2.000.

PROTEIN

	SAMPLE CODE	N	Subset for alpha = 0.05			
			1	2	3	4
Duncan[a]	OKRO ORGANIC	2	2.3750			
	OKRO ORGANIC	2		2.5700		
	PEPPER ORGANIC	2			3.1900	
	PEPPER INORGANIC	2				3.5600
	Sig.		1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 2.000.

FAT

	SAMPLE CODE	N	Subset for alpha = 0.05		
			1	2	3
Duncan[a]	OKRO ORGANIC	2	.2950		
	OKRO ORGANIC	2	.3200		
	PEPPER ORGANIC	2		2.2800	
	PEPPER INORGANIC	2			2.8600
	Sig.		.078	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 2.000.

FIBRE

	SAMPLE CODE	N	Subset for alpha = 0.05			
			1	2	3	4
Duncan[a]	OKRO ORGANIC	2	2.6500			
	OKRO ORGANIC	2		3.1000		
	PEPPER ORGANIC	2			3.8800	
	PEPPER INORGANIC	2				4.6950
	Sig.		1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 2.000.

CARBOHYDRATE

	SAMPLE CODE	N	Subset for alpha = 0.05			
			1	2	3	4
Duncan[a]	PEPPER INORGANIC	2	2.4950			
	PEPPER ORGANIC	2		4.1100		
	OKRO ORGANIC	2			8.2300	
	OKRO ORGANIC	2				8.6700
	Sig.		1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 2.000.

2. MINERALS

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
POTASSIUM	Between Groups	9347533.824	3	3115844.608	2.486E5	.000
	Within Groups	50.126	4	12.532		
	Total	9347583.950	7			
SODIUM	Between Groups	5946.921	3	1982.307	3.154E3	.000
	Within Groups	2.514	4	.628		
	Total	5949.435	7			
CALCIUM	Between Groups	581166.917	3	193722.306	1.069E4	.000
	Within Groups	72.510	4	18.128		
	Total	581239.428	7			
MAGNESSIUM	Between Groups	244482.531	3	81494.177	1.916E4	.000
	Within Groups	17.011	4	4.253		
	Total	244499.542	7			

Multiple Comparisons

Dependent Variable		(I) SAMPLE CODE	(J) SAMPLE CODE	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
POTASSIUM	LSD	PEPPER ORGANIC	PEPPER INORGANIC	26.65500*	3.53999	.002	16.8264	36.4836
			OKRO ORGANIC	-1996.00000*	3.53999	.000	-2005.8286	-1986.1714
			OKRO ORGANIC	-2282.00000*	3.53999	.000	-2291.8286	-2272.1714
		PEPPER INORGANIC	PEPPER ORGANIC	-26.65500*	3.53999	.002	-36.4836	-16.8264
			OKRO ORGANIC	-2022.65500*	3.53999	.000	-2032.4836	-2012.8264
			OKRO ORGANIC	-2308.65500*	3.53999	.000	-2318.4836	-2298.8264
		OKRO ORGANIC	PEPPER ORGANIC	1996.00000*	3.53999	.000	1986.1714	2005.8286
			PEPPER INORGANIC	2022.65500*	3.53999	.000	2012.8264	2032.4836
			OKRO ORGANIC	-286.00000*	3.53999	.000	-295.8286	-276.1714
		OKRO ORGANIC	PEPPER ORGANIC	2282.00000*	3.53999	.000	2272.1714	2291.8286
			PEPPER INORGANIC	2308.65500*	3.53999	.000	2298.8264	2318.4836
			OKRO ORGANIC	286.00000*	3.53999	.000	276.1714	295.8286
SODIUM	LSD	PEPPER ORGANIC	PEPPER INORGANIC	7.90000*	.79273	.001	5.6990	10.1010
			OKRO ORGANIC	53.02500*	.79273	.000	50.8240	55.2260
			OKRO ORGANIC	62.52500*	.79273	.000	60.3240	64.7260
		PEPPER INORGANIC	PEPPER ORGANIC	-7.90000*	.79273	.001	-10.1010	-5.6990

			OKRO ORGANIC	45.12500*	.79273	.000	42.9240	47.3260
			OKRO ORGANIC	54.62500*	.79273	.000	52.4240	56.8260
		OKRO ORGANIC	PEPPER ORGANIC	-53.02500*	.79273	.000	-55.2260	-50.8240
			PEPPER INORGANIC	-45.12500*	.79273	.000	-47.3260	-42.9240
			OKRO ORGANIC	9.50000*	.79273	.000	7.2990	11.7010
		OKRO ORGANIC	PEPPER ORGANIC	-62.52500*	.79273	.000	-64.7260	-60.3240
			PEPPER INORGANIC	-54.62500*	.79273	.000	-56.8260	-52.4240
			OKRO ORGANIC	-9.50000*	.79273	.000	-11.7010	-7.2990
CALCIUM	LSD	PEPPER ORGANIC	PEPPER INORGANIC	-1.96000	4.25765	.669	-13.7811	9.8611
			OKRO ORGANIC	-481.50000*	4.25765	.000	-493.3211	-469.6789
			OKRO ORGANIC	-588.00000*	4.25765	.000	-599.8211	-576.1789
		PEPPER INORGANIC	PEPPER ORGANIC	1.96000	4.25765	.669	-9.8611	13.7811
			OKRO ORGANIC	-479.54000*	4.25765	.000	-491.3611	-467.7189
			OKRO ORGANIC	-586.04000*	4.25765	.000	-597.8611	-574.2189
		OKRO ORGANIC	PEPPER ORGANIC	481.50000*	4.25765	.000	469.6789	493.3211
			PEPPER INORGANIC	479.54000*	4.25765	.000	467.7189	491.3611
			OKRO ORGANIC	-106.50000*	4.25765	.000	-118.3211	-94.6789
		OKRO ORGANIC	PEPPER ORGANIC	588.00000*	4.25765	.000	576.1789	599.8211
			PEPPER INORGANIC	586.04000*	4.25765	.000	574.2189	597.8611
			OKRO ORGANIC	106.50000*	4.25765	.000	94.6789	118.3211
MAGNESSIUM	LSD	PEPPER ORGANIC	PEPPER INORGANIC	7.57000*	2.06220	.021	1.8444	13.2956
			OKRO ORGANIC	-360.16000*	2.06220	.000	-365.8856	-354.4344

			OKRO ORGANIC	-330.16000*	2.06220	.000	-335.8856	-324.4344
		PEPPER INORGANIC	PEPPER ORGANIC	-7.57000*	2.06220	.021	-13.2956	-1.8444
			OKRO ORGANIC	-367.73000*	2.06220	.000	-373.4556	-362.0044
			OKRO ORGANIC	-337.73000*	2.06220	.000	-343.4556	-332.0044
		OKRO ORGANIC	PEPPER ORGANIC	360.16000*	2.06220	.000	354.4344	365.8856
			PEPPER INORGANIC	367.73000*	2.06220	.000	362.0044	373.4556
			OKRO ORGANIC	30.00000*	2.06220	.000	24.2744	35.7256
		OKRO ORGANIC	PEPPER ORGANIC	330.16000*	2.06220	.000	324.4344	335.8856
			PEPPER INORGANIC	337.73000*	2.06220	.000	332.0044	343.4556
			OKRO ORGANIC	-30.00000*	2.06220	.000	-35.7256	-24.2744

*. The mean difference is significant at the 0.05 level.

HOMOGENEOUS SUBSETS

POTASSIUM

	SAMPLE CODE	N	Subset for alpha = 0.05			
			1	2	3	4
Duncan[a]	PEPPER INORGANIC	2	62.3450			
	PEPPER ORGANIC	2		89.0000		
	OKRO ORGANIC	2			2.0850E3	
	OKRO ORGANIC	2				2.3710E3
	Sig.		1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 2.000.

SODIUM

	SAMPLE CODE	N	Subset for alpha = 0.05			
			1	2	3	4
Duncan[a]	OKRO ORGANIC	2	20.0000			
	OKRO ORGANIC	2		29.5000		
	PEPPER INORGANIC	2			74.6250	
	PEPPER ORGANIC	2				82.5250
	Sig.		1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 2.000.

CALCIUM

	SAMPLE CODE	N	Subset for alpha = 0.05		
			1	2	3
Duncan[a]	PEPPER ORGANIC	2	78.5000		
	PEPPER INORGANIC	2	80.4600		
	OKRO ORGANIC	2		5.6000E2	
	OKRO ORGANIC	2			6.6650E2
	Sig.		.669	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 2.000.

MAGNESSIUM

	SAMPLE CODE	N	Subset for alpha = 0.05			
			1	2	3	4
Duncan[a]	PEPPER INORGANIC	2	63.7700			
	PEPPER ORGANIC	2		71.3400		
	OKRO ORGANIC	2			4.0150E2	
	OKRO ORGANIC	2				4.3150E2
	Sig.		1.000	1.000	1.000	1.000

POTASSIUM

	SAMPLE CODE	N	Subset for alpha = 0.05			
			1	2	3	4
Duncan[a]	PEPPER INORGANIC	2	62.3450			
	PEPPER ORGANIC	2		89.0000		
	OKRO ORGANIC	2			2.0850E3	
	OKRO ORGANIC	2				2.3710E3
	Sig.		1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 2.000.

3. OTHER CHEMICAL COMPOSITION

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
TOTAL PHENOL CONTENT	Between Groups	3800.783	3	1266.928	5.876E4	.000
	Within Groups	.086	4	.022		
	Total	3800.869	7			
TITRABLE ACIDITY	Between Groups	20.604	3	6.868	683.376	.000
	Within Groups	.040	4	.010		
	Total	20.644	7			
pH	Between Groups	3.314	3	1.105	294.556	.000
	Within Groups	.015	4	.004		
	Total	3.329	7			

Multiple Comparisons

Dependent Variable		(I) SAMPLE CODE	(J) SAMPLE CODE	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
TOTAL PHENOL CONTENT	LSD	PEPPER ORGANIC	PEPPER INORGANIC	13.55000*	.14684	.000	13.1423	13.9577
			OKRO ORGANIC	43.90500*	.14684	.000	43.4973	44.3127
			OKRO ORGANIC	53.59000*	.14684	.000	53.1823	53.9977
		PEPPER INORGANIC	PEPPER ORGANIC	-13.55000*	.14684	.000	-13.9577	-13.1423
			OKRO ORGANIC	30.35500*	.14684	.000	29.9473	30.7627
			OKRO ORGANIC	40.04000*	.14684	.000	39.6323	40.4477
		OKRO ORGANIC	PEPPER ORGANIC	-43.90500*	.14684	.000	-44.3127	-43.4973
			PEPPER INORGANIC	-30.35500*	.14684	.000	-30.7627	-29.9473
			OKRO ORGANIC	9.68500*	.14684	.000	9.2773	10.0927
		OKRO ORGANIC	PEPPER ORGANIC	-53.59000*	.14684	.000	-53.9977	-53.1823
			PEPPER INORGANIC	-40.04000*	.14684	.000	-40.4477	-39.6323
			OKRO ORGANIC	-9.68500*	.14684	.000	-10.0927	-9.2773
TITRABLE ACIDITY	LSD	PEPPER ORGANIC	PEPPER INORGANIC	-.04000	.10025	.710	-.3183	.2383
			OKRO ORGANIC	-2.96000*	.10025	.000	-3.2383	-2.6817
			OKRO ORGANIC	-3.46000*	.10025	.000	-3.7383	-3.1817
		PEPPER INORGANIC	PEPPER ORGANIC	.04000	.10025	.710	-.2383	.3183
			OKRO ORGANIC	-2.92000*	.10025	.000	-3.1983	-2.6417
			OKRO ORGANIC	-3.42000*	.10025	.000	-3.6983	-3.1417

		OKRO ORGANIC	PEPPER ORGANIC	2.96000*	.10025	.000	2.6817	3.2383
			PEPPER INORGANIC	2.92000*	.10025	.000	2.6417	3.1983
			OKRO ORGANIC	-.50000*	.10025	.008	-.7783	-.2217
		OKRO ORGANIC	PEPPER ORGANIC	3.46000*	.10025	.000	3.1817	3.7383
			PEPPER INORGANIC	3.42000*	.10025	.000	3.1417	3.6983
			OKRO ORGANIC	.50000*	.10025	.008	.2217	.7783
pH	LSD	PEPPER ORGANIC	PEPPER INORGANIC	-.15000	.06124	.070	-.3200	.0200
			OKRO ORGANIC	-1.25000*	.06124	.000	-1.4200	-1.0800
			OKRO ORGANIC	-1.45000*	.06124	.000	-1.6200	-1.2800
		PEPPER INORGANIC	PEPPER ORGANIC	.15000	.06124	.070	-.0200	.3200
			OKRO ORGANIC	-1.10000*	.06124	.000	-1.2700	-.9300
			OKRO ORGANIC	-1.30000*	.06124	.000	-1.4700	-1.1300
		OKRO ORGANIC	PEPPER ORGANIC	1.25000*	.06124	.000	1.0800	1.4200
			PEPPER INORGANIC	1.10000*	.06124	.000	.9300	1.2700
			OKRO ORGANIC	-.20000*	.06124	.031	-.3700	-.0300
		OKRO ORGANIC	PEPPER ORGANIC	1.45000*	.06124	.000	1.2800	1.6200
			PEPPER INORGANIC	1.30000*	.06124	.000	1.1300	1.4700
			OKRO ORGANIC	.20000*	.06124	.031	.0300	.3700

*. The mean difference is significant at the 0.05 level.

Homogeneous Subsets

TOTAL PHENOL CONTENT

	SAMPLE CODE	N	Subset for alpha = 0.05			
			1	2	3	4
Duncan[a]	OKRO ORGANIC	2	50.8100			
	OKRO ORGANIC	2		60.4950		
	PEPPER INORGANIC	2			90.8500	
	PEPPER ORGANIC	2				1.0440E2
	Sig.		1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 2.000.

TITRABLE ACIDITY

	SAMPLE CODE	N	Subset for alpha = 0.05		
			1	2	3
Duncan[a]	PEPPER ORGANIC	2	.1400		
	PEPPER INORGANIC	2	.1800		
	OKRO ORGANIC	2		3.1000	
	OKRO ORGANIC	2			3.6000
	Sig.		.710	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 2.000.

pH

	SAMPLE CODE	N	Subset for alpha = 0.05		
			1	2	3
Duncan[a]	PEPPER ORGANIC	2	5.1000		
	PEPPER INORGANIC	2	5.2500		
	OKRO ORGANIC	2		6.3500	
	OKRO ORGANIC	2			6.5500
	Sig.		.070	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 2.000.