UNIVERSITY OF CAPE COAST

CONSUMER ACCEPTABILITY OF ORANGE FLESHED SWEET POTATO FORTIFIED GARI

NANCY AKYEA-MENSAH

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BY

NANCY AKYEA-MENSAH

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DECLARATION

Candidate's Declaration

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

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

Name: Nancy Akyea-Mensah

Supervisors' Declaration

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

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

Name: Prof. Mrs. Sarah Darkwa

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ABSTRACT

The purpose of the study was to explore the effect of different proportions of Cassava – Orange Fleshed Sweet Potato (OFSP) on the physical, chemical and sensory properties of gari produced from cassava roots and OFSP tubers. A factorial experimental design was employed to obtain seven samples of cassava and OFSP gari of different proportions of the traditional production method for gari. Convenient sampling technique was also employed to describe consumer acceptability of the developed products using a panel of 50 volunteers who were used for the evaluation phase of the study. The result from the chemical properties of Cassava – OFSP gari showed that, there was a significant difference ($p < 0.05$) among the Cassava – OFSP gari samples and an increase in the level of moisture content was observed as the level of OFSP addition increased was observed. The results showed a swelling index range of samples ranged from $340 - 400\%$, with 0% Cassava gari having the highest value and that of 100% OFSP the least. The results of the sensory evaluation showed that the OFSP fortified gari samples assessed in their dry particulate form differed significantly ($p < 0.05$) in all the sensory attributes (aroma, taste, texture, colour, soakability and overall acceptability) evaluated. The study showed that 30% OFSP can traditionally be added to cassava for quality gari production. A research needs to done on Cassava – OFSP gari to evaluate the nutritional composition for recommended dietary allowance and also to deduce its suitability for consumption by all groups. More so, a research into technologies of improving upon the traditional gari processing method in order to increase the quantities of gari produced is recommended.

KEY WORDS

Physical Properties

Chemical Properties

Sensory Properties

Cassava

Orange Fleshed Sweet Potato

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I wish to acknowledge all the people who participated to make this thesis a reality especially my supervisors.

DEDICATION

To my beloved mother,

Evelyn Baffoe

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

CBOs	Community Based Organizations
CNP	Cyanogenic Potential
DFCC	Dried cassava-fermented chips
FAO	Food and Agricultural and Organization
GDP	Gross Domestic Product
HCN	Liberate Hydrogen Cyanide
HQCF	High Quality Cassava Flour
IPC	International Potato Centre
ISSR	Molecular Markers Inter-Simple Sequence Repeat
MoFA	Ministry of Food and Agriculture
NGOs	Non-Governmental Organizations
OFSP	Orange Fleshed Sweet Potato
PQS	Plant Quarantine Station
RAPD	Randomly Amplified Polymorphic DNA
SAVACG	South African Vitamin A Consultative Group
SSR	Simple Sequence Repeats

CHAPTER ONE

INTRODUCTION

A staple is a food that is eaten routinely, and in such quantities that it constitutes an overwhelming portion of a standard diet in a given society, providing an extensive portion of the requirements for vital materials and generally a significant proportion of the intake of other nutrients as well (FAO, 2013). Cassava *(Manihot esculenta Crantz)* and Sweet Potato *(Ipomoea batatas Lam)* are examples of the most proliferative staple food crops grown and eaten in tropical Africa. These crops play major roles worldwide as a staple crop and is especially important in developing countries (Laurie, Faber, Adebola & Belete, 2015). This study explores the nutrition and consumer acceptability of Cassava and Orange fleshed sweet potato gari.

Background to the Study

Cassava and Orange Fleshed Sweet Potato (OFSP) are two major starchy crops in tropical countries (Laurie, Faber, Adebola & Belete, 2015). Albeit the growing evidence that starchy crops are vital components of the diet of over 1 billion people in tropical countries, are characterized as traditional or subsistence food. According to FAO report (2013), 94% of the world's food comes from developing countries. In Ghana, cassava and OFSP seem to be popular. However, the cultivation of these crops are done under small scattered plots. They are planted during intercropping and shifting cultivation, thus making it difficult to assess how much of these contribute to human food

(Aboagyewaa, 2011). This is not surprising since a very small proportion, about a third of the world are root crop consumers and little research has been done or funded on them (Aboagyewaa, 2011). The root and tuber crops are rich sources of starch besides other minerals and vitamins. They are often thought of as staples that provide high energy diet (Wheatley & Bofu, 2000). Cassava *(Manihot esculenta Crantz)* is a staple root crop, which originated from the Central America and is now cultivated in the tropics and consumed by millions of people. Cassava is an important staple food in Africa, providing a source of carbohydrates in most sub-Saharan Africa countries (Ukwuru & Egbonu, 2013; Nweke, Spencer & Lyanam, 2002). Cassava is used for the preparations of various foods and in many industrialized processes (Dufour, 2011). Although it was not initially well known outside the tropics, cassava now accounts for about 30% of the tropical staple food crops for over 200 million people in Africa (Dufuor, 2011).

Ghana is the sixth largest producer of cassava in the world with more than 14 million metric tonnes produced per year (FAO, 2010), making it one of the most important agricultural commodities in Ghana. According to the Ministry of Food and Agriculture (MoFA) (2007), it stands for 22 % of the Agricultural Gross Domestic Product (GDP) and is considered as a crop that can drive rural and industrial development to generate income for producers, processors, and traders. The crop has been viewed as a means of attaining food security for households and increasing availability of food in Africa (Lebot, 2009).

Cassava is rich in starch, and its flour has been widely examined as a local alternative to wheat flour (Taylor, Schober, & Bean, 2006). It is reportedly, consumed by those with celiac disease because it does not contain gluten (Carvalho, Cebola Lidon, Motrena, Belga, Guerreiro & Alvarenga, 2011). High value and shelf stable cassava products that may offer export opportunities and possibility to earn foreign exchange include cassava starch and High Quality Cassava Flour (HQCF) (Eriksson, 2013).

Starch extracted from cassava roots is used as an important raw material in the food industry and also in the non-food industries for textile, paint, cement, detergents, plywood, and paper (Eriksson, 2013). It has been reportedly used for pharmaceutical purposes as well (Balagopalan, 2002). Some characteristics of cassava starch include high freeze-thaw stability, high paste viscosity and high paste clarity, which are valuable for many industries (Odedina & Adebayo, 2012).

In Ghana, fresh cassava tubers (the raw produce) are firstly processed into primary products such as *ampesi,*, *gari* and starch to reduce the cyanic acid and moisture contents. Further processing of the primary products results into intermediates or finished forms. In some cases, processing of cassava is to improve quality and add value to the finished products creating opportunity to increase longevity of the products for storage, improve palatability, facilitate transportation and marketing (Oppong-Apane, 2013). Unfortunately, it is not a usual practice of the cassava processors to improve the nutritive value of the high carbohydrate content of the processed products (Sekle, 2017). The peels of the tubers and the fresh leaves are usually suitable as feed for livestock (Oppong-Apane, 2013).

Industrially, starch produced from cassava is used in the textile, pharmaceutical, cosmetics, adhesive and paper industries as well as the brewing and the bakery industries (Arko & Kelly, 2001). The tubers of cassava are extremely rich in starch and are considered the richest source of starch compared to any other food plant. (Duke, 2013).

Nearly 70% of cassava produced worldwide is used for human consumption and the remaining 30% is used as feed for animals and other industrial products like glucose and alcohol (Ernesto, Cardoso, Cliff, & Bradbury, 2000). According to FAO (2013), cassava is a potential livestock feed for poor farmers. It serves as feed for fattening of farm animals such as cattle, pig and poultry. The leaves serve as a good roughage source for cattle, goats, and sheep by either direct feeding or as protein source in the concentrate mixtures. Processing the raw cassava into pellets, chips and feed meal could directly boost the Ghanaian livestock sector by reducing the production costs.

Cassava leaves are used for checking bleeding while the starch mixed with rum (alcoholic beverage distilled from fermented cassava) has been used to treat skin problems especially for children. The leaves of the bitter varieties are used for treatment of hypertension, headache and pain (Anderson & Ingram, 1993). Cassava roots are prepared into *poultic*e and applied to the skin for treatment of sores (Wingertzahn, Teichberge & Wapnir, 1999). The starch obtained from the roots may be used as vitamin C supplements (Saidou, 2004).

OFSP (Ipomoea batatas Lam) is a dicotyledonous plant that belongs to the morning glory family, Convolvulaceae. It is a vegetable with roots that are sweet-tasting, starchy and tuberous. It is native to the tropical regions in America and requires warm days and nights for optimum growth and root development. It yields more and better quality roots on well drained, light, sandy loam or silt loam soils (Tewe, Ojeniyi & Abu, 2003; Loebenstein & Thottappilly, 2009).

OFSP is reckoned to be one of the world's most important food crops and the tuber has been reported to be high in food value, fibre and energy (Hair, Pickering & Mills, 2012). OFSP has also been reported to contain a high level of vitamins A, C, B6, potassium, phosphorus and niacin (Nedunchezhiyan, Byju & Naskar, 2008). Johnson and Pace (2010) reported that the leaves of OFSP contain high amounts of vitamins, minerals, antioxidants, dietary fibre and essential fatty acids which play a vital role in promoting health.

According to Philpott, Gould, Lim and Ferguson (2004), the commonly cultivated varieties of OFSP include orange/copper skin with orange flesh, white/cream skin with white/cream flesh and red/purple skin with cream/white flesh. Most of the OFSP cultivars are landraces that are white, cream or purple-fleshed with low beta-carotene content.

Orange-Fleshed Sweet Potato (OFSP) has a nutritional advantage over white- or cream-fleshed OFSP because of their beta-carotene and, therefore, vitamin A content is higher. This is evidenced by the deep-orange colour of the tuber flesh, which is related to the higher beta-carotene and vitamin A content. The highest beta - carotene and vitamin A contents are found in the deepest or brightest orange-fleshed accessions (Stathers, Benjamin, Katcher, Blakenship & Low, 2013).

In addition to providing high levels of vitamin A, the OFSP roots contain high levels of vitamins B, C, E and K, all of which help to protect the human body and enhance recovery from illness. OFSP tubers also have high carbohydrate content, which is responsible for the production of high edible energy per hectare per day compared to other common sources of carbohydrate such as rice and maize (Stathers, Benjamin, Katcher, Blakenship & Low, 2013).

OFSP has significant antioxidant activity, and can potentially improve vitamin A status in children (Laurie, Faber, Adebola & Belete, 2015; Li, Mu & Deng 2013; Burri, 2011). Emerging health benefits of the OFSP are substantial, making it an even more important food; especially for populations in danger of malnutrition (Aywa, Nawiri & Nyambaka, 2013; Kaspar, Park, Brown, Weller, Ross, Mathison & Chew, 2013).

Generally, Gari is a convenience food, with long shelf life and can be stored for more than a year in dry conditions (Tivana, Dejmek & Bergenståhl, 2013). Gari can be eaten dry, or reconstituted in warm or hot water. It is also common for gari to be milled to flour and used to make porridge (Ogundele, 2007). Its wide consumption is also attributed to the ease of preparation for eating. The popularity of gari in rural and urban communities is due to its ease and ready- to-eat-form (Ogundele, 2007).

A safety concern in the eating of cassava based products such as gari is due to the presence of cyanohydrins which breaks down to produce hydrogen cyanide (Ernesto, Cardoso, Cliff & Bradbury, 2002; Bokanga, 1994). Some cassava varieties contain large quantities of cyanide which is toxic to human health and gives the tuber a bitter taste. Cassava varieties are classified as sweet or bitter based on the cyanide level.

Bitter varieties have high starch content and are usually used for industrial purposes. The sweet varieties are normally consumed as food. Gari processing methods vary from locality to locality and from processor to processor. However, the two most common methods are the traditional and modern methods. Both methods of processing gari ensures a reduction in the cyanide content of the fresh cassava tubers. The traditional gari processing method reduces the cyanide content in gari through prolonged periods of fermentation. A period of seven days is a vital strategy for producing a safe product (Sanni, Ikuomola & Sanni, 2001).

According to Nweke, Spencer and Lynam (2002), gari processed by the traditional method contains varied amounts of cyanide because different processors tend to shorten the fermentation period in order to meet the increasing market demand. The traditional method of processing gari is tedious and is often used to produce gari in small quantities, as compared to the modern method which is used to produce gari in commercial quantities. It is therefore important that the use of modern methods should aim at reducing the period of fermentation and still eliminate cyanide so as to obtain quality gari and also produce quantities that would meet the ever increasing market demand for gari. Gari is produced from any available cassava variety. Since different cassava varieties differ in quality characteristics, the interactions between cassava variety and the method of processing may affect the physicochemical properties of the gari, and consequently the quality of the gari produced. Studies have shown that the major processes involved in gari processing (peeling, grating, fermentation, pressing and roasting) potently effect cyanide elimination, as well as other physicochemical properties of the product (gari) (Nweke, Spencer & Lynam, 2002; Sanni, Ikuomola & Sanni, 2011).

Statement of the Problem

Food fortification is a viable strategy to improving nutritional quality of foods and consequently enhance adequate nutritional intake among people. Fortification of gari with vitamin-rich plant foods such as OFSP has the potential of producing gari with improved nutrient quality (Oluwamukomi, 2015). It has been stated that OFSP contains high β - carotene content, which may potentially reduce vitamin A deficiency (WHO & Consultation, 2003). In addition to fortifying gari with OFSP, it can also replace cassava during the processing of gari.

Although it is technically possible to combine cassava and OFSP to produce a nutritious product (gari), the actual formulations to achieve this has not yet been developed. Additionally, gari in the past has been made of only cassava and hence introducing gari which is made up of different proportions of cassava and OFSP requires that, it is sensory tested to obtain consumer acceptability of the new gari. Also, the proximate analysis of the new Cassava – OFSP gari needs to be checked. It is against these that the researcher sought to explore the effect of different proportions of Cassava – OFSP on the physical, chemical and sensory properties of gari produced from cassava roots and OFSP tubers.

Purpose of the Study

The study sought to explore the effects of different proportions of Cassava and OFSP on the physical, chemical and sensory properties of gari produced from cassava roots and OFSP tubers.

Research Questions

The study sought to answer the following research questions:

1. What are chemical properties of Cassava – OFSP gari?
2. What are the physical properties of Cassava – OFSP gari?
3. Which of the OFSP fortified gari compositions was generally preferred through sensory evaluation?

Research Hypothesis

Hypotheses were tested to establish the significance of the variables used in the study.

1. $H_0 1$: There is no significant difference in the proximate compositions of Cassava – OFSP gari samples.
2. $H_0 2$: There is no significant difference in the dry particulate form of Cassava – OFSP gari samples in terms of sensory attribute.
3. $H_0 3$: There is no significant difference in *eba* form of Cassava – OFSP gari samples in terms of sensory attribute.
4. $H_0 4$: There is no significant difference in soaked gari samples in terms of sensory attribute.

Significance of the Study

The study is significant because it could provide insight for potential processors in selecting the most preferred proportions of Cassava – OFSP as well as adoption of appropriate processing technologies to ensure high quality and sustainable quantity of Cassava – OFSP by-products. More so, findings on more viable processing technologies can potentially spur rural and industrial development and raise the incomes for processors, traders and all stakeholders in the Cassava – OFSP chain. A valuable development of value-added Cassava – OFSP through processing would boost the economic position of Cape Coast as well as increasing the profit margin for the industrial firms. Finally, the empirical findings and suggestions based on the study will help policy makers on the proper allocation of resources and other interested research scholars for reference purposes.

Delimitations

The study was delimited to only cassava and OFSP and the outcome might be different if other crops were used. Furthermore, the study was delimited to only consumers of gari in the Cape Coast Metropolis in the Central Region, and again, the outcome might be different if consumers of gari from different districts or regions were included. Moreover, there were eight different samples of the gari and the outcome might be different if the samples were more.

Limitation

Self-reporting scales were used in examining the sensory properties of Cassava – OFSP gari. This might have affected the result of the study since some of the respondents may have over–estimated their responses. In addition, the study covers only one municipality in the Central Region of Ghana.

However, the literature review contextualizes the study and assist in grounding the findings and conclusions in the literature.

Furthermore, consumers' acceptability of a product is dynamic, which means that there are new developments and announcements happening on a daily basis somewhere in the region. Therefore, the study needs to be seen as "snapshots" that were current at the time they were taken. It is expected that certain facts and figures presented in this study may become outdated very quickly due to rapid development.

Definition of Terms

Chemical Property: A chemical property is a characteristic or behavior of a substance that may be observed when it undergoes a chemical change or reaction. Chemical properties are seen either during or following a reaction since the arrangement of atoms within a sample must be disrupted for the property to be investigated.

Physical Property: A physical property is a characteristic of matter that can be observed and measured without changing the chemical identity of the sample. The measurement of a physical property can change the arrangement of matter in a sample but not the structure of its molecules.

Sensory Property: Sensory property is defined as the acceptance of the sensory attributes of a product by consumers who are the regular users of the product category (Galvez & Resurrection, 1992).

Cassava: Cassava is any of several American plants (genus *Manihot*, especially *M. esculenta*) of the spurge family grown in the tropics for their edible tuberous roots which yield a nutritious starch.

Orange Fleshed Sweet Potato: Orange-fleshed sweet potato (OFSP) is a staple crop that is high in beta-carotene, a provitamin A carotenoid.

Gari: Gari is a crisp and crunchy West African food made from grated fresh cassava with the excess liquid dried out. It can be eaten with Shito or mixed with sugar, smoked peanuts and milk to make soakings.

Fortification of Gari: The process of making gari more stronger nutritious for consumption.

Organization of the Study

The study was organized into five chapters. Chapter one is the introductory chapter which focuses on the background of the study, statement of the problem, purpose of the study, research questions, significance of the study, delimitations, limitations, and organization of the study. In the second chapter, the study reviews the existing literature.

The research design and methodology were described in Chapter three. Chapter four involves data analysis and discussion of the results from data analysis. The fifth and final chapter gives the summary, conclusion and the recommendations arising thereof from the study.

CHAPTER TWO

LITERATURE REVIEW

Introduction

For a proper understanding of this study, a review of relevant literature was discussed in this chapter to create a focus of the study. In this light, the researcher discussed origin and distribution, consumption and utilization, nutritional qualities, and consumer preference of Cassava and Orange Flashed Sweet Potato (OFSP).

Origin and Distribution of Cassava

Cassava (*Manihotesculenta Crantz*) is a shrubby, short-lived perennial plant which can grow to a height of 3m or more, with an erect stem marked by prominent knobby leaf scars and varied degrees of branching, (Tweneboah, 2000). Branching is variable: some cultivars branch near the base and spread, others are erect and branch near the apex. Stems vary in colour, being grey, green, greenish-yellow, reddish-brown, or streaked with purple (Gooding, 1987). The branches carry large alternate, spirally arranged palmate compound, deeply lobed leaves on long petioles subtended by small deciduous stipules. The leaves tend to be clustered towards the top of the stem as those below are shed, leaving the prominent leaf scars (Tweneboah, 2000). The tuberous roots are in a cluster of 2-10 at the base of the stem with secondary branches of adventitious root which become thickened with stored food. The genus Manihot is a member of the economically important family Euphorbiaceae to which rubber and castor belong (Tweneboah, 2000).

Even though the exact place in the Central to South Americas is a subject of dispute. Cassava was initially cultivated in Brazil, Colombia, Venezuela, Paraguay, Mexico and other South American countries before 1600 (Figure 1). In the fifteenth century, the Portuguese were already colonising Brazil and were actively engaged in the "slave trade" in Africa. Portuguese brought cassava from the Latin Americas to feed slaves in West Africa in the sixteenth century (Okogbenin, Porto, Egesi, Mba, Espinosa, Santos & Ekanayake, 2007). Later, cassava was taken to India in the seventeenth century and East Africa in the eighteenth. The movement of the Europeans from Brazil to São Tomé and Fernando Po continued the spread of cassava until it reached the central parts of the African continent. Also, the French who were colonising the Guianas and Réunion were mainly responsible for the transfer of cassava to the East African countries and Madagascar and later to Ceylon (Sri Lanka) in 1786. As a result, it was realised that the crop was tolerant to drought, low soil fertility and poor crop husbandry and served as a famine reserve crop (van Vark, 2013). As populations continued to increase, cassava was widely grown in West African countries including Ghana (Eke-okoro & Njoku, 2012) in the twentieth century to satisfy the increasing demand for food.

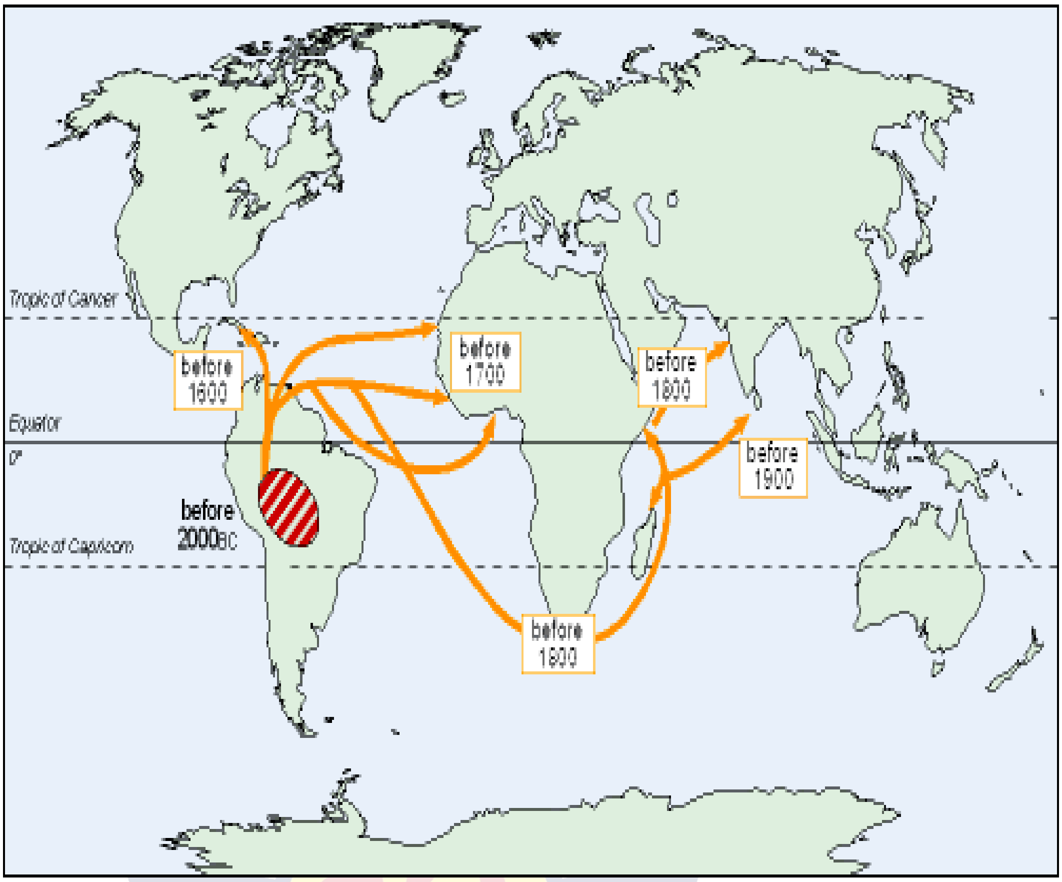

Figure 1: The Spread of Cassava to Ghana and Other Parts of the World

Source: London Natural History Museum (UK)

Cassava is grown in all parts of West Africa south of latitude 120N but the main areas of intensive cultivation are in the semi-deciduous forest or the transition to forest areas (Tweneboah, 2000). Cassava can be grown in most agro-ecological zones in Ghana because it can tolerate poor soils with low water content and nutrients. A site of sandy to deep loamy soils gives a better yield than heavy clayey soils as the crop requires loose soils for maximum rooting and root penetration into soils. Cassava plant is hardy able to tolerate drought and poor soil conditions than most food crops (Hillocks, Raya, Mtunda &

Kiozia, 2001), and recover when foliage/stem is damaged by crop pests (Dufour, 2011).

In Ghana, the varieties mainly known and grown by farmers are *Tuaka*, *Ankrah*, *Agege*, *Afram plains*, and many others (Doku, 1999; Tweneboah, 2000; CSD, 2013). Generally, the colour of petiole, stem, tuber, flesh of tuber and duration to maturity are used to distinguish among the varieties (RTIMP, 2006; CSD, 2013). Other properties such as stem branching, high yielding and height of the crop can be used to identify the variety (Gooding, 1987; Doku, 1999). However, it is impossible to predict the varietal origin of the processed products; similar products of different varieties normally look alike physically but may differ slightly in taste (Aboagyewaa, 2011). The general characteristics of the various varieties provide a guide to both cassava farmers and processors. Selection of the variety depends on high yields, marketability and suitability for the products (Hahn, 1992). Root tubers of some varieties have higher moisture content and are more perishable; fungal attack usually causes tuber rots or discoloration and is responsible for most post-harvest losses. Therefore, the crops are not left to over-mature before harvesting (Egyir, Sarpong & Obeng-Ofori, 2008; Chijindu & Boateng, 2008).

There is a wide range of cassava varieties which constitute the sweet and bitter cassava varieties. The designation of bitter and sweet varieties depends on taste that is associated with the levels of cyanogenic glucosides mainly linamarin. The bitter cassava (*Manihot utilissima*) has high level of hydrogen cyanide, evenly distributed through the root, which can amount up to 250mg/kg fresh root. It is easily recognized first by its green leaf-stalk and the whitish outer cortical layer of the root (Sirtunga, Aris & Sayre, 2004). It also has a vegetation period of 12-18 months. The sweet cassava (Manihot palmata) is known by a red leaf stalk and purplish outer cortical layer. In the sweet cassava, the hydrocyanic acid is confined to the skin and outer layer of the root. It's vegetation period is relatively short usually between 6-9 months (Nhassico, Muquingue, Cliff, Cumbana & Bradbury, 2008).

Nutritionally, cassava is one of the principal sources of calorie to human diet, and contributes a nominal quantity of protein and fat. Among the minerals in the tuber, phosphorous and iron predominate with nutritionally significant amount of calcium (33mg per 100g fresh weight). The tuber is relatively rich in vitamin C (35mg per 100g fresh weight), and contain traces of niacin, thiamine, riboflavin and vitamin A. The protein of the cassava tuber is rich in arginine, but low in methionine, lysine, tryptophan, phenylalanine and tyrosine. As such, protein in cassava is not only low in quantity, but also poor in quality (Delange, Ekpechi & Rosling, 1994). In fact an unbalanced diet containing only cassava can lead to nutritional deficiency.

Cassava contain cyanogenic glucosides, mainly linamarin, and in a small proportion, lotaustralin which may be hydrolysed by the endogenous enzyme linamarse to Liberate Hydrogen Cyanide (HCN) (Ernesto et al., 2002). According to Bokanga (1994) valine and isoleucine are the precursor in the synthesis of linamarin and lotaustralin respectively. All tissues of cassava contain cyanogenic glucosides. The Cyanogenic Potential (CNP) of leaves including the petioles is usually the highest in the plant and may be 5 to 20 times of that of the root cortex.

Cassava tubers vary widely in their cyanide content, although most varieties contain 150 – 400mg HCN per kg fresh weight (Padmaja & Steinkraus, 1995). Cyanide doses of 50-100mg are reported to be lethal to adults whereas, acute poisoning occurs scarcely. Several diseases are associated with the consumption of cassava products if inadequately processed, such as tropical ataxic neuropathy, endemic goiter, spastic paralysis and konzo (Nassar, 2004).

As such, lethal dose of cyanide is usually detoxified by the body to the low toxic metabolite thiocyanate, which is excreted in the urine. A chronic overload of thiocyanate in conjunction with low iodine intake however, results in goiter and, in extreme cases, cretinism in children (Padmaja & Steinkraus, 1995). The different techniques of processing cassava have one common goal, to obtain a safe food. The traditional methods usually include; chipping, soaking, fermentation, cooking, steaming, drying, and roasting. They all permit the enzyme linamarase to interact with the cyanogenic glycoside, thereby bringing about the hydrolysis of linamarin.

In the intact cassava tissue, endogenous linamarin is segregated from the endogenous enzyme linamarase. However, when the root is bruised, cut, grated or otherwise disintegrated, linamarin and endogenous linamarase come in contact resulting in the hydrolysis of linamarin to yield hydrogen cyanide (Okaka, 2005). Bound and free cyanide levels in cassava products must be monitored as a positive tool for predicting product wholesomeness. Any deviation in conduct and timing of the process steps may adversely affect the detoxification value of the process. For example, the process whereby little or no fermentation time is allowed prior to dewatering during garri production results in the product having higher than normal level of bound cyanide and so must be discouraged (Okaka, 2005).

Origin and Distribution of Sweet Potato

The Sweet potato (*Ipomoea batatas (L.) Lam.*) (Batatas an Arawak name) was originally domesticated at least 5000 years ago in tropical America (Austin, 1988; Yen, 1982). Based on the analysis of key morphological characters of sweet potato and the wild Ipomoea species, Austin (1988) postulated that sweet potato originated in the region between the Yucatan Peninsula of Mexico and the Orinoco River in Venezuela. Using molecular markers the highest diversity was found in Central America, supporting the hypothesis that Central America is the primary center of diversity and most likely the center of origin of sweet potato (Huang & Sun, 2000; Zhang, Carbajulca, Ojeda, Rossel, Milla, Herrera & Ghislain, 2000). Columbus in 1492 brought it to Europe and Portuguese explorers of the sixteenth century took it to Africa, India, Southeast Asia and the East Indies. Spanish ships brought sweet potatoes from Mexico to the Philippines in the 16th century. Introduction of the sweet potato to the Pacific islands apparently occurred in prehistoric times (Yen, 1982). Fossil carbonized storage roots of sweet potato found in northern New Zealand have been dated back some 1000 years (Yen, 1982), which strongly supports the theory of prehistoric transfer, probably (though with some controversy) by Peruvian or Polynesian voyagers (Yen, 1982). The linguistic links between the Quechua and Polynesian names for sweet potato, support the Peruvian origin and human transfer of the Polynesian sweet potato. However, studies based on molecular markers showed that Peruvian sweet potatoes are not closely related to those from Papua New Guinea (Zhang *et al.*, 2000) and are also different from those of Mesoamerica (Zhang *et al.*, 2000). It was suggested that the Oceania sweetpotato probably came from Central America, through non-human dispersal (Zhang *et al.*, 2009).

To China the crop was apparently introduced in the late 16th century by ship from Luzon in the Philippines to Fujian of China (O'Brien, 1972). The year 1594 was a famine year, and a huge area of crops was destroyed. The governor of Fujian ordered farmers to grow sweet potatoes extensively, in order to stave off famine (Zhang *et al.*, 2009). Other data give information that sweet potato was introduced to China from Vietnam, India and Burma. Extension of sweet potato inside China was apparently from south to east along the coast, and from south to north through the Yangtze River and the Yellow River valleys (Zhang et al. 2009).

Sweet potato is the seventh most important food crop in the world in terms of production. They are grown on about 9 million hectares, yielding c-140 million tons, with an average yield of about 14 ton/ha (FAO, 2010). They are mainly grown in developing countries, which account for over 95% of world output. Roughly 80% of the world's sweet potatoes are grown in Asia, about 15% in Africa, and only 5% in the rest of the world. The cultivated area of sweet potato in China, about 6.6 million ha, accounted for 70% of the total area of sweet potato cultivation in the world. China produces about 100 million tons, circa 80% of the total world production. Vietnam is the second largest producer. In China 65% of sweet potato output goes to animal feed, principally to pigs. In Vietnam also sweet potato production is substantially linked to pig production

(Bottema, 1992). In addition to China and Vietnam, sweet potato-pig systems play an important role in the rural economy of many parts of Asia: the Philippines, India, Korea, Taiwan, some eastern islands of Indonesia (Bali and Irian Jaya), and Papua New Guinea, while these systems are also practiced, to a lesser extent, in Latin America and Africa (Scott & Ewell, 1992). In Brazil, it is the fourth most consumed vegetable, a food of high-energy value, rich in carbohydrates. It also supplies reasonable quantities of vitamins A, C and some of the B complex (Scott & Ewell, 1992). In the US about 37 000 hectares are grown, producing ~ 720 000 tons per year. In Africa sweet potato is a 'poor man's crop', (and traditionally considered as “women’s work”) with most of the production done on a small or subsistence level. Sweetpotato produces more biomass and nutrients per hectare than any other food crop in the world. It is well suited to survive in fertile tropical soils and to produce tubers without fertilizers and irrigation and is one of the crops with a unique role in relief famine. Thus, for example, across East Africa’s semiarid, densely populated plains, thousands of villages depend on sweetpotato for food security and the Japanese used it when typhoons demolished their rice fields. Sweetpotato is grown for both the leaves, which are used as greens, and the tubers, for a high carbohydrate and beta-carotene source. Yields differ greatly in different areas or even fields in the same location. Thus, the average yield in African countries is about 4.7 tons/ha, with yields of 8.9, 4.3, 2.6 and 6.5 ton/ha in Kenya, Uganda, Sierra Leone and Nigeria, respectively. The yields in Asia are significantly higher, averaging 18.5 tons/ha. China, Japan, Korea, Thailand and Israel have the highest yields with about 20, 24.7, 20.9, 12 and 33.3 tons/ha, respectively.

In South America the average yield is 12.2 tons/ha, with Argentina, Peru and Uruguay in the lead with 18, 11 and 10 tons/ha, respectively. For comparison, the average yield in the US is 16.3 tons/ha (FAO, 2010).

These differences in yields are mainly due to variation in quality of the propagation material. Sweet potatoes are vegetatively propagated from vines, root slips (sprouts) or tubers, and farmers in African and other countries often take vines for propagation from their own fields year after year. Thus, if virus diseases are present in the field they will be inevitable transmitted with the propagation material to the newly planted field, resulting in a decreased yield.

In the US consumption of the crop has increased slightly in recent years. The increased consumption is largely due to national advertising campaigns focused on the nutritional aspects of sweetpotatoes aimed at health conscious consumers. The sweetpotato is very high in nutritive value, and merits wider use on this account alone. Sweetpotatoes rank as one of the healthiest vegetables, because of high levels of vitamins A and C, iron, potassium, and fiber. They are also an excellent source of the vitamin A precursor, beta-carotene. One cup of the orange flesh types contains four times the recommended daily allowance of this important nutrient. It is expected that with improved curing and storage procedures and development of fresh shipping methods (wrapping of individual tubers in plastic ready for microwaving) and processed products such as sweet potato chips, fries, and canned sweet potatoes will enlarge the market.

Origin and Distribution of Orange Fleshed Sweet Potato

OFSP (*Ipomoea batatas*) plays a major role worldwide as a staple crop and is especially important in developing countries (Laurie, Faber, Adebola & Belete, 2015). OFSP is thought to have originated in Latin America (Davidson, From the Americas, the Spanish brought the OFSP to Europe, where it spread to Africa, India, China and Japan (Katayama, Kobayashi, Sakai, Kuranouchi & Kai, 2017). It is hardy, has low input requirements and is a versatile crop (Laurie, Faber, Adebola & Belete, 2015).

OFSP is the world's seventh most important staple crop, grown in over 100 countries of the world, covering an estimated total area of 9.2 million hectors, with an annual global production of around 125 million tones (CIP, 2000). In Africa, the area grown to OFSP is about 1.7 million hectors and the production is about 5.5 metric tones per annum contributing to approximately 4% of the world production (FAO, 2010). Almost 95% of the total production is in developing countries. Past and current production trends suggest that OFSP output in developing countries is increasing, for example, in Africa it is estimated that it is presently growing at about five percent per year (CIP, 2000; Scott, Best, Rosegrant, & Bokanga, 2000). It is one of the most important non-grain staple food crops providing essential minerals, vitamins and carbohydrates in the diets of majority of the people living in the tropics (Laurie, Faber, Adebola & Belete, 2015). Root and tuber crops have big complex roles to play in feeding the developing world in the coming decades. By 2020, more than two billion people in Asia, Africa, and Latin America will depend on these crops for food, feed, and income. The roots and tubers will be integrated into emerging markets through the efficient and environmentally sound production of diversified range of high-quality, competitive products for food, feed, and industry. The crops' adaptation to marginal environments, their contribution to household food security, and their great flexibility in the mixed farming systems make them an important component of a targeted strategy that seeks to improve the welfare of the rural poor and to link smallholder farmers with these emerging growing markets (Adipala, Namanda, Mukalazi, Abalo, Kimoone, & Hakiza, 2000; Scott, Best, Rosegrant, & Bokanga, 2000).

OFSP is one of the under-exploited crops in developing countries (Walker & Crissman, 1996). Since the OFSP is considered to be the 'poor person's food, it can lead to the sensory and preference criteria of OFSP to be under represented and neglected (Tomlins, Manful, Larwer & Hammond, 2005). The breeding initiatives for OFSP are at a relatively early stage compared to other staple crops. Varieties grown in many regions are of low yielding, and the potential for improvements through breeding are high. While the main objectives of breeding programmes have traditionally been an increase in yield and improvement of other characteristics, the importance of post-harvest characteristics for acceptance of new varieties is being increasingly recognized (Kihinga, 2009).

In Africa the research institutes are maintaining OFSP collections using modern conservation methods for producing healthy planting materials. The International Potato Centre (IPC) research is assessing the new methods for the conservation of OFSP genetic resources, characterizing the cultivated collection to select a core collection in order to eradicate viruses from core accessions and evaluating them to identify sources of desired traits and this work has been done in collaboration with the research institutes in their respective country (Scott, Best, Rosegrant & Bokanga, 2000). Participatory rural appraisals and baseline studies have been conducted in Tanzania and Kenya. Low crop yield, lack of high-yielding, early-maturing varieties, pests' diseases and poor management were cited as the major constraints to production. Promotion of drought-resistant crops, kitchen-gardens and post-harvest processing training were suggested as potential interventions to address rural poverty (Gichuki, La Bonte, Burg, Kapinga, & Jeremiah, 2004).

Hundreds of accessions have been morphologically characterized. Cluster analysis suggests a close relationship among the East African OFSP. Molecular markers Inter-Simple Sequence Repeat (ISSR), Randomly Amplified Polymorphic DNA (RAPD) and Simple Sequence Repeats (SSR) are being used for diversity analysis and development of fingerprints for key varieties. A total of 58 new SSR markers from East Africa have been developed. Agronomic evaluation of the germplasm has been done in Kakamega, Kabete, Katumani and Kisii in Kenya as well as Ukiriguru and Kibaha in Tanzania. The International Centre for Potato (ICP) continued to coordinate development of varieties with high β-carotene and other agronomic traits. Research centers are multiplying clean planting materials for secondary multiplication and distribution by local Non-Governmental Organizations (NGOs) and Community Based Organizations (CBOs) (Gichuki, La Bonte, Burg, Kapinga, & Jeremiah, 2004).

In early 2003, a total of 20 clones of high dry matter and high β-carotene were received in vitro from CIP-Lima. These have been multiplied in the screen house at Plant Quarantine Station (PQS) Muguga and distributed to Uganda, Tanzania and Kenya. In particular, the materials were sent to National Agricultural Research Institute (NARI) in Uganda, Kenya Agricultural Research Institute (KARI) - Kakamega and KARI Katumani in Kenya and Agricultural Research Institute (ARI) Maruku in Tanzania. Additional regions for distributions in Tanzania were Ukiriguru and Zanzibar (Kihinga, 2009). These are currently being evaluated for adaptability in different agro-ecologies and for farmer preference culinary qualities.

A number of orange-fleshed varieties have been evaluated at different agro-ecological zones in Kenya, Tanzania and Uganda. In Tanzania, most of the clones were susceptible to OFSP virus disease (Gichuki, La Bonte, Burg, Kapinga, & Jeremiah, 2004; Kihinga, 2009). In Tanzania 35 accessions of OFSP germplasm were collected in the Western and Lake Zone. The selection criteria included storage tuber yield, uniformity of tuber size, and tuber shape. Dry matter content and herbage yield were also considered. These collections were identified and distinguished by their local names, which show polymorphisms. During characterization of the collected germplasm the estimate of genetic diversity was established (Jeremiah, Luambano, Muhana, Kulembeka & Sonda, 2004).

Cassava Consumption and Utilization

Cassava root can be consumed in a number of forms. It can be boiled and pounded into *fufu* or eaten as *ampesi* served with sauce and protein from either meat or fish source (Dorosh, 1988). It can also be processed into *agbelima*, *akple*, *banku* and *yakayeke* or roasted and eaten as well as processed into dried fermented chip (*kokonte*) and *gari*. Cassava root can also be processed into tapioca, flour, cookies, biscuits, buns, doughnuts, bread and cakes.

Industrially, starch produced from cassava is used in the textile, pharmaceutical, cosmetics, adhesive and paper industries as well as the brewing and the bakery industries (Arko & Kelly, 2001). The tubers of cassava are extremely rich in starch and are considered the richest source of starch than any other food plant (Duke, 2013).

Nearly 70% of cassava produced worldwide is used for human consumption and the remaining 30% is used as feed for animals and other industrial products like glucose and alcohol (El- Sharkawy, 2004). According to FAO (2013), cassava is a potential livestock feed for poor farmers. It serves as feed for fattening of farm animals such as cattle, pig and poultry. The leaves serve as good roughage source for cattle, goats, and sheep by either direct feeding or as a protein source in the concentrate mixtures. Processing the raw cassava into pellets, chips and feed meal could directly boost the Ghanaian livestock sector by reducing the production costs.

Cassava leaves are used for checking bleeding while the starch mixed with rum (alcoholic beverage distilled from fermented cassava) has been used to treat skin problems especially for children. The leaves of the bitter varieties are used for treatment of hypertension, headache and pain (Anderson & Ingram, 1993). Cassava roots are prepared into *poultice* and applied to the skin for treatment of sores (Wingertzahn, Teichberge & Wapnir, 1999). The starch obtained from the roots may be used as vitamin C supplements (Saidou, 2004).

According to Al-Hassan (2009), cassava has numerous uses and by-products. Each component is valuable; the leaves are used for stews and the roots for various food kinds (Oppong-Apane, 2013). In pharmaceuticals, starch is a major source of glucose for medicinal drugs such as tablets, capsules and others. It is also used for in manufacture of mosquito coils. Cassava is also used in the textile, soap and detergent industries. The starchy pastes are used in the manufacture of dry cells. The leaves of cassava are used usually as feed supplements for livestock (Al-Hassan, 2009; Oppong-Apane, 2013).

The crop “cassava” is literally termed by many coastal West Africans in Ewe language as *agbeli* meaning "by it life exists" (FAO, 2013). Cassava is an important crop in the Ghanaian economy and accounts for 22% of the national GDP (Sagoe, 2006). Cassava serves as a daily caloric intake of 60% of the Ghanaian population making it produced by nearly every household (Sanni, Onadipe, Ilona, Mussagy, Abass & Dixon, 2009).

Orange Fleshed Sweet Potato Consumption and Utilization

OFSP can be consumed and utilized in different forms as fresh tubers and dried chips. Fresh tubers and dried chips are used in industries in making starch, wine, alcohol and animal feeds (Scott, Best, Rosegrant, & Bokanga, 2000). OFSP has been consumed as food for a long time in Ghana. Previously, farmers grew OFSP for their families’ consumption and to earn some extra income, but nowadays commercial production is available for the urban markets. For human consumption, OFSP in Ghana has been boiled, roasted, fried or used in salads. Most of the high quality OFSP are consumed as boiled snack and main dishes. In urban areas, OFSP are roasted or deep-fried for consumption as snack food (Ndunguru, Thomson, Waida, Rwiza, & Westby, 1998). Consumption rises during peak harvesting season, mid-March to mid-August when over 70 percent of the annual crop is harvested and prices are low (Scott, Best, Rosegrant, & Bokanga, 2000; Kihinga, 2009; Oppong-Apane, 2013).

OFSP provides a wide variety of benefits including food, employment and income (IPC, 2000). In recent years, OFSP processing into starch (to make noodles) has emerged as a major use of OFSP in China (Fuglie, Zhang, Salazar & Walker Fuglie, 1999). OFSP flour shows more limited commercial promise. It has been tested in East Africa as substitute for cassava in composite flour (Hagenimana, Carey, Gichuki, Oyunga & Imungi, 2001). OFSP traditionally has been produced in the subsistence sector in Ghana, but they are moving into market economy.

Nutritional Qualities of Cassava

Cassava is grown primarily for its starchy roots which serve as major source of dietary energy (Lynam, 1994; Nassar, 2007). It accounts for nearly one-third of the total number of staple foods produced in Sub-Saharan Africa. The leaves are important source of vegetables, protein, mineral and vitamins (Nassar, 2007). Cassava is an efficient source of carbohydrate, producing about 250,000 calories/hectare/day (Nassar, 2007). The sweet cassava variety is made up of about 17% of sucrose and small quantities of fructose and dextrose

(Charles, Huang, Lai, Chen, Lee, & Chang, 2007). The roots contain nutrients such as magnesium, manganese, calcium, iron, copper, zinc, and potassium.

Cassava roots are rich in carbohydrate (30–35 %), and low in protein (1–2%), fat (< 1%), and some of the minerals and vitamins (Dufuor, 2011). Consequently, cassava roots have lower nutritional value than cereals, legumes and other root and tuber crops. The starch contents of the carbohydrate are 64 to 72% in the form of amylose and amylopectin. The lipid content of cassava is about 0.5% and the essential amino acids particularly lysine, methionine and tryptophan are very low but the peels of roots contain slightly more protein (Smith, 1992) and significant amounts of calcium (50 mg/100g), phosphorous (40 mg/ 100g) and vitamin C (25 mg/100g) and ascorbic acid. The starch is generally digestible. The leaves are richer in protein (23 percent), vitamins and minerals (Dufour, 2011).

Apart from cassava serving as the major food security in the world, arbuscular mychorrizal fungi (Glomus spp.) are the commonest organisms in symbiotic association with cassava roots. Ecologically, the symbionts supply plant nutrients to the roots in exchange of organic exudates from the cassava root. Usually, the symbionts serve as extension of the cassava root system to plant nutrients beyond the reach of the roots and as a result, provide inorganic soil (Ceballos, Morante, Sánchez, Ortiz, Aragon, Chávez & Dufour, 2013) and increase cassava yields. The complex network of the mychorriza hyphae in the rhizosphere of crops reduces soil loss by minimizing leaching (Vandegeer, Miller, Bain, Gleadow & Cavagnaro, 2013). It has also been found that mychorriza promotes uptake of K, Ca and Mg by crop plants (Liu, Zheng, Ma, Gadidasu, & Zhang, 2011). Perhaps, mychorriza increase soil moisture contents in the rhizosphere and act as entophytic symbionts to crop roots. In Ghana, farmers hardly apply mineral fertilizers to cassava and/or bother to control soil borne pests because the crop can grow in poor soils and forms a symbiotic association with soil mychorrizal fungi, which can suppress population of plant root feeding nematodes (Álvarez-Venegas, & De-la-Peña, 2016) and increase soil organic carbon. Normally, increased soil fertility status of cassava fields increases yields of subsequent seasonal crops in crop rotation system (Salami & Sangoyomi, 2013).

The root of cassava elongates as it matures and creates a mechanical pressure on the soil structure; loosening of hard soil pans and soil aeration are then promoted especially by cassava with longer root system penetrating deeper into soils. Dakora and Phillips (2002) reported that the organic exudates from roots of plants are mediators that facilitate an increase in plant nutrients in poor soils. The root exudates are responsible for the symbiotic association between the mychorrizal fungi and the root system of cassava (Selvaraj & Chellappa, 2006). The exudates may signal for an increased microbial population in the root zone. Grating cassava is generally carried out by a motorized cassava grater that disintegrates cassava tissue, which facilitates later steps such as pressing and drying due to an increased surface area (Kaur & Ahluwalia, 2017).

Nutritional Qualities of OFSP

In a study on physical, chemical and sensory properties of cassava (Manihot esculenta) – sweet potato (Ipomoea batatas) gari by Karim, Adebanke, Akintayo and Awoyale (2016), the results revealed that the inclusion of sweet potato significantly ($p<0.05$) influenced the proximate composition of the cassava-sweet potato gari and the values are also within the recommended levels for quality gari. The result further showed that the moisture content ranged from 10.10 to 12.30%, crude fibre 1.93 to 1.98%, ash content 1.13 to 1.31%, protein content 1.43 to 4.29%, and carbohydrate content 78.11 – 83.59% (Karim *et al.*, 2016). Also, the cyanide contents ranged from 0.58 to 2.16 mg/100 g, with 100% cassava gari having the highest while 100% sweet potato gari recorded the lowest (Karim *et al.*, 2016). A decrease in porosity from 40 ± 2 % for the 100% cassava gari to 27.33 ± 2 % for sweet-potato gari was observed. The particle size of the sweet potato gari had the highest angle of repose of 38° while 100% cassava gari recorded the lowest angle of repose at 29° (Karim *et al.*, 2016). The swelling index of the samples ranged from 330 to 450% and100% sweet potato gari had the highest loose and packed densities (Karim *et al.*, 2016). The sensory evaluation results showed that the cassava sweet potato (10%) gari was rated the best for colour (8.07), texture (7.67), and aroma (6.87), while 100% cassava gari had highest value for taste (7.47), and both shared the highest value (7.60) in overall acceptability (Karim *et al.*, 2016).

In a study to find the effect of sweet potato inclusion in cassava to prepare gari had indicated that the level of crude fibre contents of the cassava-sweet potato increases the level of sweet potato incorporation which ranged from 1.24–1.64% (Kure, Nwankwo & Nyasu, 2012). The main nutritional value of roots and tubers lies in their potential ability to provide one of the cheapest sources of dietary energy, in form of carbohydrates.

In a similar study, crude fibre in cassava was found to aid digestion through its water absorption capacity has been found to aid bowel movement and therefore significant in diet (Abu, Badifu & Akpapunam, 2006). A study in Yaoundé, Cameroon between October 2011 and August 2014 on the assessment of cassava (Manihot esculenta Crantz) fermentation and detoxification had indicated that dried cassava-fermented chips (DFCC) samples collected have high retting performances variability correlated to their fermentation time and microbial concentration (Ze, Kamdem, Agnia, Mengo & Ngang, 2016).

The best DFCC used as cassava retting accelerator (CRA) was obtained after 96h of fermentation (CRA-96). It permitted to reduce the retting time from 71.3±8.5 hours to 35.8±1.4 hours compared to the spontaneous fermentation; and final cyanides contain of 7.86±0.00 ppm corresponding to 98.8% reduction. OFSP is high in carbohydrates (Abu, Tewe, Losel & Onifade, 2000) and can produce more edible energy per hectare per day than wheat and rice (Table 1). The energy content of OFSP is about one-third of the weight of cereal grains, such as rice or wheat, since tubers have a high water content (FAO, 2013). As with all crops, the nutrient composition of roots and tubers varies from place to place depending on climate, the soil, the crop variety and other factors.

Table 1: Nutritional Qualities OFSP

Nutritional Qualities	OFSP
Energy KJ	481.0
Moisture %	70.0
Protein (g)	1.0
Fat (g)	0.3
Carbohydrate	27.1
Fibre (g)	0.8
Ash (g)	0.7
Calcium Ca (g)	36.0
Phosphorous P (g)	56.0
Iron Fe (g)	0.9
Potassium K (g)	304.0
Sodium Na (g)	36.0
Carotene equivalent (µg)	1680.0

Source: USDA, 2016

The dry matter of tuber crop is made up mainly of carbohydrate, usually 60 to 90% and the fresh roots have 20-40/100 g dry matter. Plant carbohydrates include celluloses, gums and starches, but starches are the main source of nutritive energy as celluloses are not digested (FAO, 2013). The principal constituent of edible carbohydrate is starch together with some sugars, the proportion depending on the tuber crop. The physical properties of starch grain influence the digestibility and processing qualities of the tuber crops. The starch granules of some varieties of root and tubers are very small, which improves the starch digestibility. In addition to starch and sugar, root crops also contain some non-starch polysaccharides, including cellulose, pectins and hemicelluloses, as well as other associated structural proteins and lignins which are collectively referred to as dietary fibre (FAO, 2013). OFSP is a significant source of dietary fibre as its pectin content can be as high as 5% of the fresh weight or 20% of the dry matter at harvest. The role of dietary fibre in nutrition has aroused a lot of interest in recent years. Some epidemiological evidence suggests that increased fibre consumption may contribute to a reduction in the incidence of certain chronic diseases, including diabetes, coronary heart disease, colon cancer and various digestive disorders. The fibre appears to act as a molecular sieve, trapping carcinogens which would otherwise have been recirculated into the body; it also absorbs water thus producing soft and bulky (FAO, 2013).

Starch is considered to be the main component of the sweet potato root, followed by simple sugars such as sucrose, glucose, fructose, and maltose which make up about 32% of its carbohydrate content (Mohanraj & Sivasankar, 2014).

The limiting nutritional qualities of OFSP are the low protein content which constitutes about 1-3% of the fresh weight in OFSP, but this includes 10–15% nonprotein nitrogenous components (Abu, Tewe, Losel & Onifade, 2000; Shewryl, 2003). The amino-acid content of root and tubers, unlike most cereals is not complemented by that of legumes as both are limiting in respect of the sulphur amino acids. In order to maximize their protein contribution to the diet, roots and tubers should be supplemented with a wide variety of other foods, including cereals (FAO, 2013). To some extent the protein content of tuber crops is influenced by variety, cultivation practice, climate, growing season and location. In tuber crops the quality of the protein, in terms of the balance of essential amino-acids present, may be compared to that of standard animal proteins in beef, egg or milk. Most of the tuber crops contain a reasonable amount of lysine, though less than legumes, but the sulphur amino-acids are limiting. The quality of proteins will depend on the severity of heat treatment during the processing of OFSP products (Abu, Tewe, Losel & Onifade, 2000; Shewryl, 2003; FAO, 2013).

All the root and tuber crops exhibit very low lipid content (Abu, Tewe, Losel & Onifade, 2000). These are mainly structural lipids of the cell membrane which enhance cellular integrity, offer resistance to bruising and help to reduce enzymic browning (Owori and Agona, 2003; Rees, 2003) and are of limited nutritional importance. The content ranges from 0.12% in banana to about 1.7% in OFSP. The lipid may probably contribute to the palatability of the root crops. Most of the lipid consists of equal amounts of unsaturated fatty acids, linoleic and linolenic acids and the saturated fatty acids, stearic acid and palmitic acid. In dehydrated products such as dehydrated potato or instant potato, the high percentage of unsaturated fatty acids in the lipid fraction may accelerate rancidity and auto-oxidation, thereby producing off-flavours and odour (FAO, 2013).

The dietary sources of vitamin A are of two categories: vitamin A or retinol, also known as preformed vitamin A; and provitamin A carotenoids, which are the carotenoids that are biologically active as retinol. Of approximately many carotenoids found in nature, only three are important precursors of vitamin A in humans: β-carotene, α-carotene and β-cryptoxanthin. Of these, β-carotene is the major provitamin A component of most foods containing carotenoid and has the highest vitamin A activity (Mulokozi, 2003; Rodriquez- Amaya & Kimura, 2004). Since roots and tubers are very low in lipid they are not themselves rich in sources of fat-soluble vitamins. However, provitamin A is present as the pigment β-carotene in the leaves of root crops, some of which are edible. Most roots and tubers contain only negligible amounts of β-carotenes with exception of selected varieties of OFSP. Deep coloured varieties are richer in carotenes than white cultivars especially the orange-fleshed roots (300 µg/100 g, fresh weight) (FAO, 2013; Mulokozi & Svanberg, 2003; Mulokozi, 2003; Rodriguez-Amaya, 1999). This is one of the nutritional advantages of OFSP because sufficient and regular ingestion of OFSP leaves, together with the tubers of high β-carotene varieties can meet the consumer’s daily requirements of vitamin A, hence prevent the dreadful disease of xerophthalamia (FAO, 2012; WHO, 2003; Mulokozi, 2013; Rodriquez-Amaya and Kimura, 2004).

Retinol is readily absorbed (70 to 90%) by the cells of the intestinal mucosa by facilitated diffusion (Mulokozi, 2013). FAO/WHO (2013) estimated, recommended and confirmed the traditional conversion factors of the vitamin A value of provitamin A carotenoids as 6 µg of all-trans-β-carotene in food to be equivalent to 1 µg all trans-retinol, i.e. a ratio of 6:1. However, more recently, higher ratios for conversion of β-carotene to vitamin A have been suggested due to poor bioavailability (Mulokozi, 2003).

Vitamin A is necessary for strong tissues and is required to maintain healthy immune system function and develop resistance to infection. It also protects the body from cardiovascular diseases and lowers the risk of stroke (WHO, 2003). The OFSP have large quantities of β-carotene, which is an essential component for vision, promote bone growth and tooth development, and helps maintain healthy hair, and mucous membrane. β-carotene protects the heart and cardiovascular system, boost immune functions, speeds recovery from respiratory infections such as colds and flu, and promotes wound healing (Tang, Graham & Kirby, 1993).

As an antioxidant, β-carotene can inhibit oxidative damage to cholesterol and protect against atherosclerotic plaque formation. Also higher vitamin C and β-carotene levels were associated with scores on free recall, recognition and vocabulary tests (Rodriquez-Amaya and Kimura, 2004).

Vitamin A is potentially teratogenic, high-dose vitamin A supplements can be given safely to women of child bearing age only within the first 6 weeks postpartum, when the likelihood of becoming pregnant is very low. The provision of small daily doses of vitamin A from food may be an alternative strategy for improving vitamin A status in populations at risk of deficiency (Tang, Graham & Kirby, 1993; WHO, 2003; Mulokozi and Svanberg, 2003; Mulokozi, 2003).

Appropriate foods provide safe amounts of vitamin A and can be given to all population groups at risk of deficiency, including women of childbearing age. Animal source foods, such as dairy foods, eggs, and liver, contain preformed retinol, which is readily absorbed in the human intestine; however, these foods are generally not affordable by population at risk of deficiency. In less-industrialized countries, 65–85% of vitamin A in the diet is estimated to be supplied by provitamin A carotenoids in vegetables and fruits (Haskell, Jamil, Hassan, Peerson, Hossain, Fuchs & Brown, 2004).

Potassium is the major mineral in most root crops while sodium tends to be low (Table 2). This makes some root crops particularly valuable in the diet of patients with high blood pressure, who have to restrict their sodium intake. An important, often unrecognized, mineral contribution that potato can make is in its appreciable amount of iodine it contains. This could be significant in goitrous areas where iodine intake is low. Potassium in OFSP help to maintain fluid and electrolyte balance in the body cells, as well as normal nerve and heart function and blood pressure (FAO, 2003).

Zinc is a component of more than 200 mammalian metallo-enzymes (McQuade, Tomasselli, Liu, Karacostas, Moss, Sawyer & Tarpley, 1990). In humans, zinc deficiency can manifest as T-cell lymphopenia, decreased lymphocyte response to mitogens, depressed thymic hormone activity, a specific CD4+ Tcell population depression, decreased natural killer cell activity, (Prasad, 1993) and depressed serum concentrations of albumin, prealbumin, and transferrin. Zinc has a modulating role in blood sugar regulation, thyroid and gonadal function, adrenal hormone and prolactin production, and calcium/phosphorus metabolism, all of which are disturbed in a state of zinc deficiency (Neve, 1992). Zinc salts have been shown to have anti-viral activity, either directly or through immune-modulation, against more than 40 viruses including the HIV (Sergio, 1998).

In HIV infection, zinc plays specific roles as an anti-oxidant, immune-modulator (Tanaka, Shiozawa & Morimoto, 1990) and a possible direct anti-viral agent (Favier, Sappey & Leclerc 1994, Sprietsma, 1999). Zinc, in vitro, has been found to inhibit cell death mediated by tumor necrosis factor, a cytokine linked to cellular apoptosis and wasting syndrome in HIV. The HIV protease enzyme, currently the topic of much research and one of the central focuses of pharmaceutical HIV suppression, is necessary to potentiate the production of new HIV-1 viruses (McQuade, Tomasselli, Liu, Karacostas, Moss, Sawyer & Tarpley, 1990).

The HIV virus binds to zinc ions in T-cells in order to produce pro-viral peptides which form the basis of new infectious viral particles. The HIV- 1 protease enzyme then cuts the viral chains to form new infectious viral particles, which are released into circulation and infect new immune cells. As with other proteases, including collagenase, angiotensin-converting enzyme, carboxypeptidase A, and neutral endopeptidases, zinc has both an enhancing and inhibiting activity, depending on the concentration of zinc in the surrounding tissues (Larsen & Auld, 1991). Multiple studies have shown if sufficient zinc ions are bound to the protease it will remain inactive (Zhang *et al*., 2001).

In HIV replication, viral Ribonucleic Acid (RNA) is transformed into viral Deoxyribonucleic Acid (DNA) via the enzyme reverse transcriptase. Then the enzyme integrase allows for the integration of viral DNA with host DNA. Zinc binds to the integrase enzyme via "zinc finger protein" structures and allows for optimal activity of the integrase enzyme. Inhibitors of zinc finger proteins is currently the subject of research in HIV pharmacology (South, Bo, Hare, & Summers, 1990; Rice, Supko & Malspeis, 1995).

Nutritional Importance of Orange-Fleshed Sweet Potato

The nutritional content of food is recognised as being related to food choice in that it influences diet, health and disease (Shepherd, Sparks, MacFie, & Thomson, 1994). The South African Vitamin A Consultative Group [SAVACG] (1995), which was formed in 1993 to assess the vitamin A and iron status of South African children, established that one in three children suffered from vitamin A deficiency. Its main findings identified the prevalence of vitamin A deficiency in South Africa as a cause of concern.

The SAVACG study (1995) identified iron status as deficient, where one in five children was anaemic. In 1999, the National Food Consumption Survey (NFCS), that was conducted among children between the ages of 1-9 years, observed that one out of two children had an intake of less than half of the recommended level for energy, vitamin A. vitamin C, riboflavin, niacin, vitamin 86, folate, calcium, iron and zinc. The nutrient intake of children living in rural areas was considerably lower than that of children living in urban areas (Labadarios, Steyn, Maunder, Macintyre, Swart, Gericke, Dannhauser, Voster & Nesamvuni, 2000).

SAVACG recommended vitamin A supplementation for children between the ages of 6 month and 6 years, as well as for lactating mothers to be introduced in high risk areas. The vitamin A status of the people living in rural and urban areas in South Africa requires strategies that are aimed at increasing production, availability, access and subsequently, the consumption of foods rich in vitamin A and provitamin A carotenoids in order to limit the prevalence of vitamin A deficiency.

Generally there are three approaches that assist in combating vitamin A deficiencies. These include:

1. the fortification of food products such as maize meal and bread (flour) that are consumed in large quantities. Fortification of maize meal with vitamin A, thiamine, riboflavin, niacin, folic acid, pyridoxine, iron and zinc, became mandatory in October 2004 in West Africa. A logo, identifying fortified maize and wheat has been introduced and appears on all maize-meal packaging as well as on packaging of breads that are fortified,
2. Supplementation through the use of vitamin A capsules or drops for children, which is an effective approach. However, not all people in need of vitamin A supplementation are able to visit mobile clinics in order to get the required dose,
3. dietary diversification which aims at increasing the consumption of vitamin A rich foods, especially through planting vitamin A rich vegetables such as OFSP, carrots, butternut, pumpkin and spinach in home gardens. Products that could increase the vitamin A intake of South Africans that are cost effective and, simple to grow on small pieces of land, should be actively promoted. Therefore the cultivation of sweet potatoes that have a high nutritional content (especially that of vitamin A), such as OFSP, could be beneficial to South Africans in terms of reducing vitamin A deficiencies

(Labadarios, Maunder, Swart, Bagriansky, J., Steyn, MacIntyre & Nesamvuni, 2000).

Products that are rich in vitamin A should be readily available in all markets to make it more accessible to all Ghanaians and for improved dietary diversity. Vitamin A-rich home gardens can increase the availability of fruits and vegetables that are rich in betacarotene for home consumption.

Small quantities of the high beta-carotene sweet potato added to a family's diet can substantially reduce vitamin A deficiencies in both children and adults (King, Burgess, Quinn & Osei, 2015). In a study done by the Medical Research Council (MRC), OFSP was successfully incorporated during a trial period, into the school feeding programme. The children's vitamin A status improved after they consumed a half a cup of OFSP for 53 days as part of the school meal (Van Jaarsveld, Faber, Tanumihardjo, Nestel, Lombard & Benade, 2005).

In rural areas, the high beta-carotene sweet potatoes confirmed in a study by Hagenimana, Low, Anyango, Kurz, Gichuki & Kabira (2001) where it was found that nutritional education and counselling activities significantly increase the consumption of vitamin A rich foods. can be produced on small pieces of land in order to produce vegetables that are rich in beta-carotene and readily available. African mothers have been found to be more open to accepting the new varieties of sweet potato once they understood their nutritional value and contribution to alleviating vitamin A deficiency (Leighton, 2008). The result of Leighton (2008) was similar a study by Hagenimana, Low, Anyango, Kurz, Gichuki and Kabira (2001) where it was found that nutritional education and counselling activities significantly increase the consumption of vitamin A rich foods.

The Resisto cultivar OFSP is rich in beta-carotene. WFSP has a high energy value but is devoid of beta-carotene and is widely produced and consumed by rural and urban consumers in South Africa (Van Jaarsveld, Faber, Tanumihardjo, Nestel, Lombard & Benadé, 2005). Although the absorption and conversion of beta-carotene are less efficient than those of retinoids (derived from animal foods), it still plays an essential role in the diet in that it contributes to the daily requirement of vitamin A (Parker & Howard, 2001).

The biology and management of wireworms (Agriotes spp.) on potato with particular reference to the UK. Sweet potato is a hardy crop and produces a high yield in terms of kilo Joules per unit area per unit time, with low demands on soil nutrients and cultivation input (Appiah-Danquah, 2015; Woolfe, 1992). Research has been conducted on OFSP in West Africa for more than ten years in order to select cultivars that would be accepted for their flavour attributes by African consumers, while, at the same time, preserving the beta-carotene content (Leighton, 2008). However, the sensory properties of new crop cultivars have generally been ignored in traditional breeding programmes (Van Oirschot, Rees & Aked, 2003). In view of the role that OFSP could play in reducing vitamin A deficiency, it is important to identify its sensory properties, as well as determine the consumer acceptability of OFSP by targeted consumers.

Physical Properties of Cassava

A study conducted to investigate the effects of drying temperature of chips, time of soaking and pressing on the quality of gari processed from dried cassava chips. The pH (4.00 – 6.80) of the gari samples decreased with fermentation time. The samples gelled completely at 9% (w/v). The result thus showed that the pasting temperature (61.53-62.28°C) of the gari samples were not significantly ($p < 0.05$) different from each other (Udoro, Kehinde, Olasunkanmi & Charles, 2014). Solubility (3.03 – 38.10%), swelling capacity (3.13 – 8.19) and water absorption capacity (209.06 – 459.31%) were significantly ($p > 0.05$) influenced by the drying temperatures of the chips with gari from chips dried at 50°C having the highest values (Udoro, Kehinde, Olasunkanmi & Charles, 2014).

Packaging of gari guarantees the quality of the root by protecting it from bruises and injuries and also prevents excessive moisture loss. Also the stored root influences the quality of the product formed as well as its yield (Akingbala, Oyewole, Uzo-Peters, Karim & Baccus-Taylor, 2005). Earlier studies by Irtwange and Achimba (2009) on the effect of the duration of fermentation on the quality of gari indicated that there was a highly significant effect of the duration of fermentation on the moisture content, ash, crude fibre, fat, crude protein and HCN. The result of their study further expressed that the moisture content, ash, crude fibre and crude protein increased with increase in the duration of ferentation. Similarly, Owuamanam, et al. (2011) found that duration of fermentation significantly affected the physicochemical and sensory quality of gari, and that the duration of fermentation improved the appearance, taste and general acceptability of the resultant gari.

Owuamanam *et al*. (2011) in their study on the effect of temperature of fermentation on gari quality revealed that maintaining the temperature above the ambient, contributed to volatilization of residual cyanide, and also gave better performance in the physicochemical and sensory properties. Furthermore, the result suggested that the optimum temperature for fermentation in gari processing is between 35-40oC. This is due to the fact that the optimum fermentation temperature enhances the cyanide reduction and the activities of microbes for the production of useful metabolites (Owuamanam *et al*., 2011).

Fresh (1-2 days old) and healthy cassava roots are have been described to be the best raw material for producing gari. They carry a large amount of soil (especially during the rainy season), which is the source of microbial inoculation and therefore two washing stages are desirable. Double washing before and after peeling reduces the microbial count in gari product (Awan & Okaka, 1983).

The optimum period for the fermentation should be at least 3days after an experiment which was carried out on the effect of process time and control of gari quality by Irtwange and Achimba (2009). It is important to note that the small daily change in pH accounted for the desirable changes in aroma and taste of gari (Irtwange & Achimba, 2009). The mash must be toasted immediately after dewatering process or drastic change in pH will occur (Awan & Okaka, 1983). Adequate roasting is important to reduce cyanide content. It is not advisable to mill gari after cooling. Sieving it after roasting is sufficient to produce even granules since granules rather than powdery consistency is desired by consumers. The maintenance of equipment is easier if non-rusting metal is used to construct the grater and sieves. Cleaning schedules should be adhered to. Also during stages of processing, personal hygiene must be monitored.

Gari like the raw material from which it is made from is a nutritionally poor diet (Owuamanam, Hart, Barimalaa, Barber & Achinewhu, 2010). It is low in protein, fats, ash, and fibre, but it is a valuable source of carbohydrate and energy. Gari is low in methionine, lysine and tyrosine but high in arginine (Onyenuga, 1985). In diet however, gari is always combined with other nutritious food stuffs which enhance their nutritional value. For example, traditionally, gari is eaten with vegetable soup with meat or fish. As a snack, is taken with groundnut, coconut, fish or meat.

A well processed and packaged gari with moisture content of about 8-10% can be stored for about one year, with little or minimal alteration in its organoleptic properties (Carcea Bencini & Walston, 1991). Gari for use within the shortest possible time may be dried up to about 12-14% moisture content (Okaka & Okaka 2001). Upgraded packaging materials for gari consists of jute sacks, which are sometimes lined with polyethylene pouches. The pouches may either be heat sealed or by twisting and tying it with twine.

The effect of different garification duration on the chemical, pasting, functional and sensory properties of cassava gari was studied. Sieved fermented cassava mash of equal quantity was roasted for 15minutes, 20 minutes, 25 minutes, 30 minutes and 35 minutes at constant roasting temperature of 95^{o}C, the resulting cassava gari samples were subjected to chemical, pasting, functional and sensory analysis using standard methods. Increase in garification duration resulted in reduction in the moisture and hydrogen cyanide contents, and caused an increase in sugar content and pH. The moisture, protein, ash, fibre, sugar and hydrogen cyanide contents were in the range 7.96%-17.89%;

1.89%-2.23%; 1.03%-1.64%; 1.16%-1.97%; 2.21%-5.05% and 14.08 mg/kg-23.43 mg/kg respectively.

According to Arinola (2016), the samples were roasted for 25 minutes and 30 minutes and they have higher peak and final viscosities with lower breakdown viscosity, peak time and pasting temperature. The author noted that even though the percentage yield reduced with increase in garification duration, the swelling index and water absorption capacity of samples roasted for higher duration were however better (Arinola 2016). The ranges of the percentage yield, swelling index and water absorption capacity were: 53.57%-75.00%; 1.20-3.10 and 4.00 ml/g-7.60 ml/g respectively.

Gari

Gari is a fermented, pre-gelled grit made from cassava, and is the most popular form in which cassava is consumed in West Africa (Okaka, 2005). It is a stable, ready-to eat food, well suited to urban and rural markets. Gari is principally consumed in the main meal with soup or stew. It can also be eaten as snack when soaked in cold water or milk, with sugar, roasted groundnut or coconut. Gari contributes up to 60% of the total caloric intake in West Africa, where an average of 150g per person, per day is consumed (Okaka, 2005).

In Ghana gari is mainly produced on a small scale and marketed by women. It is an important source of income in the rural areas. Gari variability exists in consumer perception of gari quality and it is difficult to establish optimum values for the different quality parameters. However, in general, consumers prefer crisp, fine grained, slightly soured product with good swelling power in water, and a lightly toasted colour (Flach, 1990).

The production of gari involves some processing steps in which all are important in determining the end product quality. Some of them are mechanical (peeling, grating, sieving, and dewatering) while others like fermentation and garification involve some physical and chemical modification, which improve detoxification and digestibility. The traditional processing of gari described by Okaka (2005) is as follows: Cassava is peeled, washed, grated and packed in cloth bags, which are then subjected to heavy pressing for 2-4 days by weights placed on the product contained in the bags. A simultaneous dewatering and fermentation occur during this period, yielding a pulp cake which when rasped gives a grain mass. This mass is toasted in a hot pan over a wood fire until the starch gelatinized and the moisture content reduced to 10-15%. The mash must be stirred constantly to avoid sticking or burning. Palm oil may be added to facilitate this operation and impart a yellow colour to the final product.

Tissue disintegration in the presence of excess moisture during grating permits the rapid hydrolysis of glucosides, effectively reducing both free and residual cyanide in the gari product. The observations of Westby and Twiddy (1992) and Vasconcelos, Twiddy, Westby and Reilly (1990) indicate that the release of endogenous linamarase during grating was one of the important steps in detoxification.

Fermentation is crucial to the detoxification of cassava mash and the development of the characteristic aroma and sour flavor of gari, imparted mainly by lactic acid bacteria, which produce lactic acid and volatiles such as; aldehydes, diacetyl, esters and ethanol (Owuamanam, Hart, Barimalaa, Barber & Achinewhu, 2010). The fermentation of the grated mash occurs in two stages;

Corynebacterium manihot breaks down the starch to produce organic acids which decrease the pH and this lead to the hydrolysis of linamarin during which gaseous hydrogen cyanide is evolved. This stage is completed within 24hrs. The production of organic acids stimulates the growth of a fungus Geotricum candida, which produces the aldehydes and esters responsible for the characteristic flavor of gari (Ihekoronye & Ngoddy, 1985).

Early studies (Collard & Levi, 1959) of the microbiology of the gari fermentation reported that a Corynebacterium sp and Geotricum candida were responsible for acid and flavor production Owuamanam, *et al*. (2011) found however, that of the microorganisms isolated from gari, Lactobacillus plantarrium produced the most typical gari flavor. Okafor and Ejiofor (1990) isolated organisms of five genera from the gari fermentation; Leuconostoc, Alcaligenes, Corynebacterium Lactobacillus and Candida. In a similar type of study on gari, Westby and Twiddy (1992) observed that during gari production (fermentation) lactic acid bacterium was found to be dominant. Overall equal number of homo and hetero- fermentative lactic acid bacteria was isolated however, homo-fermentative organisms dominated in the early stages of the process and hetero-fermenters in the later stage.

The time allowed for fermentation has been found to be critical. Short fermentation period results to incomplete detoxification process thereby producing a toxic gari product, while too long fermentation period produces a product with a strong sour taste and a poor textural quality (Azam, Judge, Fellows & Battcock, 2003).

Consumer Acceptability

Traditionally, sweet potato cultivars consumed in Africa had a white and cream coloured flesh. OFSP cultivars have been introduced due to their high β-carotene. The success of any newly introduced cultivars will depend not only on production characteristics, but also on its acceptability in terms of both sensory and utilization characteristics. Van Oirschot, O'Brien, Dufour, El-Sharkawy and Mesa (2000) reported that sensory differences between sweet potato cultivars are mainly determined by textural components.

Consumer acceptability and sensory evaluation in Africa has been investigated for the white fleshed cultivars of sweet potato Van Oirschot *et al.* (2003); Tomlins, Manful, Larwer and Hammond (2005) reported that the appropriate consumer preference and sensory evaluation approaches can have an impact on sweet potato research, production and marketing for low-income consumers in developing countries; and for OFSP. Tomlins, Manful, Larwer and Hammond (2005) found that increased consumption of OFSP is thought to benefit children and mothers in locations where it is commonly grown and consumed. Hedonic scale was used to assess the acceptability of gari which have been substituted with sweet potato, the highest mean score in overall acceptability of “like very much” was the general response of preference (Iwe, 2003).

Consumer Evaluation of Food Products

Consumer sensory evaluation is conducted with coded, unbranded samples, whereas in marketing research, branded products are used. In consumer sensory testing, the researcher is interested in finding out whether the consumer likes the product and prefers it above another product in order to determine the acceptability of the product, based on its sensory characteristics (Lawless & Heymann, 1998).

An important function of the introduction of new products into the market place, such as OFSP FORTIFIED, is the ability to understand the needs of the present and future consumer in order to identify products with attributes that are desired by the target consumers. Specific cultivars OFSP FORTIFIED have been selected to potentially meet nutrient and energy requirements of sub-Saharan African people as part of a food-based approach (Faber, Laurie & Venter, 2006). In most sub-Saharan African countries, only WFSP is available, which contains very little or no beta-carotene.

According to McBride and MacFie (1990) a better understanding of the factors that influence food choice is required to improve the diet of people in general. Food choice and food consumption is also closely related as both refer to the behavioural act involving the acquisition of food. Food acceptance, on the other hand, denotes the pleasure derived from the consumption of food and comprises both a behavioural and attitudinal component (Van den Heuvel, van Trijp, van Woerkum, Renes, & Gremmen, 2007), including the palatability or taste of food. Sensory perception is one of the most important determinants of consumer food choice behaviour (Van den Heuvel *et al*., 2007).

In order to understand the determinants of food choice as a human behaviour, one has to look at research done on the psychological process and individual attitudes for making food choices. Attitudes have been defined as learned dispositions or mannerisms of an individual to act in a consistently favourable or unfavourable way towards some objects and consist of three distinguishable components:

1. first it is either our emotional or affective reactions to objects - a natural preference (like or dislike) for a particular food;
2. second our behaviour tendencies (cognitive) towards objects - therefore our need or wish to consume or avoid certain foods;
3. and third our thoughts or cognitive ability - the information we have about the food, including what we believe the benefits or consequences are of a particular food (Conner, 1993).

This approach was developed by Fishbein and Ajzen (1976) and offers a coherent framework within which these three components of attitude could be related. Preferences are also based on the belief that, by consuming a particular food, the outcome will be positive (Conner, 1993). The positive outcomes include beliefs about foods that are healthy or unhealthy; foods that are appropriate for certain occasions or people and those that are not (Conner, 1993). This relationship between attitudes and beliefs has been widely studied, although the relationship has remained somewhat unclear (example, Conner, 1993). However. Within this framework, attempts have been made to relate attitudes to food consumption. Which have led to the development of the framework of knowledge-attitude-practice (behaviour), which means that changes in behaviour can be brought about by increasing knowledge about a particular food (Frewer, Shepherd & Sparks, 1994).

Thus, a closer look at the theory of planned behaviour (Ajzen, 2011). shows that an individual's attitude towards the behaviour is based on his or her belief of salient outcomes of the behaviour. These outcomes include behavioural outcomes (e.g. price of a food item), emotional outcomes (pleasantness of taste) and potential risks (will the food increase the chances of heart disease) (Conner, 1993). According to this theory, individuals are likely to choose and consume a particular food if they believe that the consumption will lead to specific positive outcomes and therefore, by changing the beliefs about the outcomes, changes in food choices can be influenced (Conner, 1993).

When considering the food itself, food choice consists of three aspects i.e. the food, the consumer and the context or situation in which it is consumed or the interaction with the food (Shepherd, Raats, Meiselman, & Macfie, 1996). Conner (1993) states that, when comparing diverse influences on food choices with the reasons people provide for consumption, the flavour or 'taste' of the food is a strong predictive positive factor, followed by satiety as a physiological factor and lastly benefits such as price and convenience have little or no effect. Men (husbands) have been found to value the taste of food as the most important determinant of food choice, while the nutritional contribution and the safety (safe for consumption) of the food are more important determinants of food choice by mothers of a household (Shepherd *et al.*, 1996).

All these theories relate to the purpose of this study which is to establish consumer taste preference for OFSP fortified in order to meet the nutritional requirements of the consumers that are most in need of vitamin A in their diet (therefore a health benefit). It can, therefore, be predicted that, if the taste of OFSP fortified surpasses that of White Fleshed Sweet Potato (WFSP), it could successfully be introduced into any community, in particular low income.

Measuring the sensory properties of OFSP fortified and determining the importance of these properties as a basis for predicting consumer acceptance is an essential component in the promotion of OFSP fortified to Ghanaian consumers.

Food acceptance refers to the palatability, hedonic tone, liking or disliking, food taste preference and pleasantness accompanied by the consumption of the foods (Meiselmann, 2006). Food acceptance comprises a behavioural and attitudinal component (Randall & Sanjur, 1981). Taste preferences in food often reflect a consumer's social and cultural origins, social ambitions as well as cultural capital acquired (Wright, Nancarrow & Kwok, 2001). From ancient days to the modern world of today, food and taste preferences have been closely linked to cultural development. Often, with affluence, consumers move from satisfying basic physiological needs to fulfilling social and psychological needs, shaped by the structures to which they belong (Wright *et al.*, 2001). Meiselmann (2006) show a schematic model of the sensory basis of food acceptance, the stages, interactions and levels involved in the processing of sensory and perceptual information about food.

CHAPTER THREE

RESEARCH METHODS

Introduction

This chapter provides detailed description of the research methodology that was employed in the study which includes research design, study area, population, sampling procedure, data collection instruments, data collection procedures and data processing and analysis that was used to find the effect of different proportions of Cassava - OFSP gari on the physical, chemical and sensory properties of gari produced from cassava roots and sweet potato tubers.

Research Design

The study employed a factorial experimental design involving cassava and OFSP gari from three modifications of the traditional production method for gari. The statistical optimization technique using full factorial design of experiments is generally applied to determine the boundary conditions, which allows the maximum output of the desired products. Using a proper design matrix, one can obtain a regression equation, which highlights the effect of individual parameters and their relative importance in a given operation/process. The interactional effects of two or more variables can also be known, this is not possible in a classical experiment (Sing, Stefanescu, & Pen, 2002).

The principal steps of statistically designed experiments are: determination of response variables, factors and factor levels; choice of the experimental design; and statistical analysis of the data. Today, the most widely used experimental design to estimate main effects, as well as interaction effects, is the 2" factorial design, where each variable is investigated at two levels. Research can be designed for multiple factors and treatments, but data analysis and treatment establishment becomes more complex and time consuming as the number of factors and treatments increase (Montgomery, 2001). So, 2^3 factorial design was selected in this study. In this study for the effects of three modifications of the traditional production method for gari on the physical, chemical and sensory properties of the gari, a two level factorial design of experiments was adopted. The modifications of the traditional production method for gari were done before grating, before roasting and after separate production. The number of experiments required for understanding all the effects is given by $a^k = 2^3 = 8$, where a is the number of levels and k is the number of factors. Factorial designs allow the effects of a factor to be estimated at several levels of the other factors, yielding conclusions which are valid over a range of experimental conditions (Montgomery, 2001).

Study Area

The study was conducted in the Cape Coast Metropolis of the Central Region of Ghana. The traditional name of Cape Coast 'Oguaa' originates from the Fante word 'gua' meaning market. It was named Cabo Corso by the Portuguese meaning Short Cape and later on changed to Cape Coast by the British. The Cape Coast Metropolitan Area is one of the oldest districts in Ghana. It was raised to the status of municipality in 1987 by LI 1373 and upgrade to metropolitan status in 2007 by LI 1927.

The Cape Coast Metropolitan Assembly is one of 17 districts of the Central Region of south Ghana. The Metropolis is bounded to the South by the Gulf of Guinea, to the West by the Komenda Edina Eguafo Abrem Municipality (at Iture bridge), to the East by the Abura Asebu Kwamankese District, and to the North by the Twifu Heman Lower Denkyira District. It is located on longitude 1° 15'W and latitude 5° 06'N. It occupies an Area of approximately 122 square kilometres, with the farthest point at Brabedze located about 17 kilometres from Cape Coast, the Central Regional capital. The figure below shows the study area.

Figure 2: Map Central Region

Population

The population of the Cape Coast Metropolis, according to the 2010 Population and Housing Census, is 169,894 representing 7.7 % of the region's total population. Males constitute 48.7 percent and females represent 51.3 %. Twenty three percent of the population lives in rsural localities. The metropolis has a sex ratio (number of males per 100 females) of 95. The proportion of the metropolis youth (less than 15 years) is 28.4 % depicting not too broad base a population pyramid which tapers off with a small number of elderly (60 years and older) persons (4.5%). The total age dependency ratio for the metropolis is 49.1, the age dependency ratio for males is lower (48.2) than that of females (49.9).

Sampling Procedure

The study used convenient sampling technique as it sought to use naturally occurring consumers of gari. Creswell (2009) argued that in many experiments only a convenient sample is possible because the researcher must use naturally formed groups such as classrooms, organizations, family units, or volunteers. Panelist were selected using simple convenient sampling technique so as to minimize biasness. Sensory evaluation questionnaire was administered to selected gari consumers in the Cape Coast Metropolis in the Central Region. The panel consisted of 50 volunteers within the study area. Data was collected between 23rd July 2019 to 16th August, 2019.

Data Collection Instrument and Procedures

OFSP *(Ipomoea batatas Lam)* and Cassava *(Manihot esculenta Crantz)* tubers were obtained from the Teaching and Research Farm, Faculty of

Agriculture, University of Cape Coast. They were processed few hours after harvesting.

Production of OFSP fortified Gari

The method described by (Ojo & Akande, 2013) was used with few modifications. The modifications included pretreatment of OFSP to prevent enzymatic browning with concentrated salt solution and OFSP fortified mixing at different proportions in the course of production, as this forms the basis of the difference in the production methods to be studied. The cassava roots and OFSP tubers were washed with clean water to remove soil and adhering dirt, and then peeled separately with sharp knives into separate bowls. The peeled sweet potato tubers were immersed in salt solution for 20 minutes to prevent enzymatic browning.

After washing and peeling, the OFSP and Cassava were grated separately. The grated Cassava- OFSP mash of each ratio was then bagged in a porous jute bag. The mashes of pure cassava and OFSP was also bagged in separate jute bags. The bags were tied and the mashes were left for three days to ferment. After three days, the mashes were put under hydraulic press and dewatered for two days. The resulting grits were then broken and sieved using a local sieve with an aperture (square holes) of about 2 mm^2. Some of the grated Cassava roots and OFSP tuber paste were taken and mixed during the frying stage of gari according to the following proportions: 50% Cassava and 50% OFSP; 60% Cassava and 40% OFSP; 40% Cassava and 60% OFSP; 70% Cassava and 30% OFSP; 30% Cassava and 70% OFSP; and 100% Cassava; and 100% OFSP,

Determination of Chemical Properties of Cassava-Sweet Potato Gari

Moisture Content

Porclain crucibles were washed dried and weighed. About 10-12g of the fresh samples were put into clean oven-dried crucibles and weighed. The crucibles containing the sample were spread over the base of the oven to ensure equal distribution of heat. They were then kept in a thermostatically controlled oven at 105˚C for 48 hours. At the end of the period the samples were removed, cooled in a desiccator and weighed. Each sample was done thrice. The moisture content was then calculated as the percentage water loss by the sample

Crude Fibre Content

The crude fibre content of the various gari samples was determined by defatting (with petroleum ether) and boiling (with H_2SO_4 and NaOH) 2 g of the gari samples followed by incineration in a murfle furnace. The incinerated sample was thereafter cooled in a desiccator.

Ash Content

The dried samples were then heated gently in an oven at 105˚C for about an hour and then transferred to the furnace. The sample was left in the furnace overnight a temperature of 550˚C and continued the next morning till al carbon particles burnt away. The ash in the dish was removed from the furnace cooled in a dessicator and weighed. The ash content was then calculated as a percentage of the original sample.

Crude Protein

The protein content of the gari samples was determined by digestion of 2 g of the sample followed by distillation and titration.

Carbohydrate Content

This was calculated by subtracting the sum of the percentage contents of moisture, crude fibre, ash, crude protein and crude fat from 100%.

Crude Fat Content

This involved the extraction of 2 g of each of the gari samples in a soxhlet apparatus with a petroleum ether, after which the samples were dried in an oven and cooled in a desiccator. The weight lost during extraction was the fat content of the gari samples.

pH Determination

10g of each of the gari samples was put into a 100 ml beaker and 100 ml of distilled water was added to it. This was allowed to stay for a few minutes after which it was filtered with a whatmann filter paper. The filtrate was then taken and tested using a standardized pH meter. Triplicate values were obtained, the mean of which was then calculated.

Determination of Total Titratable Acidity

Five grams of each of the samples was dissolved in a beaker and made up to 100 ml with distilled water, then allowed to stand for about 30 mins. The resulting suspension was filtered with a filter paper, and 25 ml of the filtrate was taken and titrated against 0.1 M NaOH, using phenolphthalein as indicator. The end point was obtained when the colour became pink. The mean (TTA) was then calculated from triplicate values. TTA (%)= $0.005X \times 100 = 0.01X$, where X is the mean titre value.

Determination of Hydrogen Cyanide Content

Using this method, thirty grams (30 g) of Cassava – OFSP gari was milled and homogenized with 250 ml of 0.1 M orthophosphoric acid. The homogenate was centrifuged. The supernatant was taken as the extract; 0.1 ml of the enzyme (linamarase prepared from the freshly harvested cassava roots) was added into 0.6 ml of the extract. The 3.4 ml of the acetate buffer (pH 4.5) was added and stirred to mix. After which 0.2 ml of 0.5% chloramin-T and 0.6 ml of colour reagent were added and allowed to stand for 15 min.utes for colour development. The absorbance value was obtained at 605 nm against a blank similarly prepared containing all reagents and 0.1 ml phosphate buffer added instead of KCN.

Calculation

The data from the standard were used to obtain a standard curve and its slope (b) by plotting absorbance values (Y-axis) against standard concentrations (X-axis). The unknown mean absorbance (A) and the weight of the sample (w) were used to calculate the residual hydrogen cyanide, using the formula: Residual cyanide $= A \times 250 \times 0..4151\ b \times W$ and the unit in mg HCN equivalent kg^{-1} sample. Where A is absorbance, b is the slope, and W is weight of sample.

Determination of Physical and Technological Properties

Swelling Index

Ten grams of the garisample was transferred into a clean, dried, calibrated measuring cylinder. The gari was gently leveled by tapping the cylinder and the initial volume recorded. Fifty milliliter of distilled water was poured into the cylinder and allowed to stand for 4 h. The value for SI was taken as the multiples of the original volume.

Water Absorption Capacity

One gram of Cassava – OFSP gari was weighed into an already weighed clean dried centrifuge tube. Twenty milliliter of distilled water was poured into the centrifuge tube and stirred thoroughly; centrifuge at a speed of 3500 rpm for 45 min. The supernatant was discarded and the tube and its content reweighed. The gain in mass was taken as the water absorption capacity.

Bulk Density

Ten grams of the Cassava – OFSP gari was transferred into 50 ml measuring cylinder. The cylinder was tapped repeatedly for 5 min. The BD of the Cassava – OFSP gari sample was calculated as the mass of Cassava – OFSP gari over the volume at the end of tapping. The mean value was recorded from triplicate determinations.

Sensory Evaluation

A multiple – paired comparison test was used. Panelists were selected from among gari consumers. Fifty panelists were made to assess the Cassava – OFSP gari samples in the dry particulate form for taste, colour, aroma, sourness, texture, and overall acceptability. The Cassava – OFSP gari samples were made into "*eba*" and were assessed by the 50 panelists for aroma, taste, texture, colour, mouldability, and overall acceptability. The gari samples were also assessed in soaked form for aroma, taste, texture, colour, soakability and overall acceptability. In each case, the samples were rated according to a 9-point hedonic scale of preference with ratings ranging from 1 (dislike extremely) and

9 (like extremely). The results of the evaluation were then subjected to statistical analysis.

Data Collection Procedures

The researcher collected an introductory letter from the Department of Vocational and Technical Education of UCC. The Introductory letter was then given to the panel members of the participating sensory evaluation phase of the study and also to the laboratory technician after taking samples. With consent from the panel members, the sensory evaluation was done using questionnaire. The questionnaire was administered personally to help improve the collection and response rate of the questionnaire. The questionnaire was collected as soon as it was completed by the respondents. This enabled the researcher to obtain 100% response rate.

Data Processing and Analysis

The responses from the questionnaire items on the sensory evaluation were and laboratory test coded and analyzed through the use of Statistical Package for Social Science (SPSS) software version 20.0. The SPSS software was used for the data analysis because it is user friendly and does most of the analysis of the quantitative data for the researcher. The data entries were done by the researcher in order to check the accuracy of the data. Data was cleaned before running any analysis. Cleaning the data helped the researcher to get rid of errors that could result from coding, recording, missing information, influential cases or outliers. Descriptive such as percentages, means and standard deviations were used to answer the research questions. The data were further subjected to analysis of variance (ANOVA) to determine significant differences among the samples, and the means were separated with a Tukey test.

Chapter Summary

This chapter discussed the research methodology used to accomplish the objectives of the study. The chapter included the discussion about: research design, study area, population, sampling procedure, data collection instruments, data collection procedures and data processing and analysis.

The researcher employed a factorial experimental design involving Cassava and OFSP from different proportions in making gari. The study was conducted in the Cape Coast Metropolis. A convenient sampling was used to select 50 volunteers for the sensory evaluation.

CHAPTER FOUR

RESULTS AND DISCUSSION

Introduction

The study sought to explore the effect of different proportions of Cassava – OFSP on the physical, chemical and sensory properties of gari produced from cassava roots and OFSP tubers. The study employed a factorial experimental design involving cassava and OFSP gari from three modifications of the traditional production method for gari. The method described by (Ojo & Akande, 2013) was used with few modifications. The data was organized and presented using both descriptive and inferential statistics. The results are presented under the following themes: (1) chemical properties of Cassava – OFSP gari (2) physical properties of Cassava – OFSP gari and (3) sensory evaluation.

Chemical Properties of Cassava – OFSP Gari

In assessing chemical properties of the various Cassava – OFSP gari research question one was addressed. The chemical properties of the various Cassava – OFSP gari is presented in Table 2. The moisture contents ranged from $10.02 - 12.53\%$. The 100% OFSP gari had the highest level of moisture content (12.53%) while the lowest was 100% Cassava gari. There was a significant difference ($p < 0.05$) among the Cassava – OFSP gari samples and an increase in the level of moisture content as the level of OFSP addition increased was observed in Table 2. This variation can be attributed to the difference in the proportions of Cassava – OFSP used. The highest moisture content recorded for 100% OFSP gari could be attributed to the fibrous nature of OFSP which would make moisture removal during roasting more difficult hence, longer roasting time requirement to obtain the same level of dryness. The values obtained were above the standard specifications set for gari by the Ghana Standards Board. The crude fibre contents of the Cassava – OFSP gari samples ranged from $1.91 - 1.98\%$. Cassava – OFSP gari with 30% level of OFSP had the highest crude fibre content while that with 40% OFSP incorporation had the lowest value. The samples however did not differ significantly ($p > 0.05$). Though the expected increase in the level of crude fibre contents of the Cassava – OFSP gari samples with increase in the level of OFSP incorporation was not obtained, the values are close to those $(1.24 - 1.64\%)$ recorded by Kure, Nwankwo and Nyasu (2012). The deviation from the expected trend might be as a result of the difference in the proportions use of Cassava – OFSP gari. Crude fibre through its water absorption capacity has been found to aid bowel movement and aid digestion (Abu, Badifu & Akpapunam, 2006) and therefore significant in diet.

The protein contents of the Cassava – OFSP gari samples differed significantly ($p < 0.05$) and ranged from $(1.81 - 4.56\%)$. Cassava – OFSP gari proportions with 0% OFSP had the lowest crude protein content while that of 100% OFSP had the highest amount. It was expected that the protein content would increase invariably with increased level of OFSP incorporation which was just as expected. The results of the study confirms those of (Karim, Adebanke, Akintayo, & Awoyale, 2016; Ojo & Akande, 2013).

The fat contents of the various OFSP fortified gari samples ranged from $1.36 - 1.78\%$ and differed significantly among the samples $(P < 0.05)$. Gari from 0% cassava and 100% OFSP and 100% cassava and 0% sweet potato from the different proportions had the highest and lowest fat contents respectively. These values agree with the $1.08 - 2.11\%$ as reported by Ojo & Akande (2013). The variation in the level of fat content could be attributed to the effect of the different proportions on the Cassava – OFSP gari samples.

The ash content of the Cassava – OFSP gari samples ranged from $1.14 - 1.56\%$ and differed significantly $(p < 0.05)$. Cassava – OFSP gari with 40% OFSP incorporation had the highest level of ash content while 100% cassava gari had the lowest. These values fall within the range of values $(0.12 - 0.48\%)$ and $1.40 - 1.82\%$ reported by Ojo & Akande (2013) and Kure, Nwankwo, & Nyasu (2012) respectively. The Cassava – OFSP gari of with 60% cassava and 40% OFSP recorded the highest value probably due to the level of OFSP in it. Ash content is a representation of mineral content in food. Therefore the Cassava – OFSP gari will be a good source of minerals which are essential in many biochemical reactions of the body.

There was a significant difference $(p < 0.05)$ in the carbohydrate contents of the Cassava – OFSP gari samples. Gari from 0% OFSP had the highest carbohydrate content while 100% OFSP gari of had the lowest. The carbohydrate content of the Cassava – OFSP gari $(81.04 - 83.59\%)$ are close to the $(82.53 - 87.10\%)$ reported by Ojo & Akande (2013). There was a decrease in the carbohydrate content of the Cassava – OFSP gari with increased level of OFSP incorporation which suggests that the cassava roots used had more carbohydrate content than the OFSP used, or OFSP incorporation increased level of fermentation which consequently resulted to higher level of carbohydrate break down. This might be as a result of higher sugar content in OFSP which is the main substrate for fermentation. OFSP contain simple sugars such as glucose, fructose, sucrose and maltose which make up about 32% of its carbohydrate content (Mohanraj, & Sivasankar, 2014). Table 2 presents the Chemical Properties of Cassava - OFSP gari.

Table 2: Chemical Properties of Cassava – OFSP Gari

Samples	Moisture (%)	Crude Fibre (%)	Ash (%)	Protein (%)	Fat (%)	CHO (%)
$C_{50}OFSP_{50}$	$10.74^{a} \pm 0.01$	$1.94^{a} \pm 0.01$	$1.38^{a} \pm 0.01$	$2.98^{a} \pm 0.02$	$1.54^{a} \pm 0.03$	$82.56^{e} \pm 0.03$
$C_{60}OFSP_{40}$	$10.59^{e} \pm 0.01$	$1.91^{a} \pm 0.01$	$1.56^{a} \pm 0.02$	$2.73^{a} \pm 0.02$	$1.46^{a} \pm 0.02$	$82.91^{c} \pm 0.03$
$C_{40}OFSP_{60}$	$10.92^{c} \pm 0.01$	$1.93^{a} \pm 0.01$	$1.31^{abc} \pm 0.01$	$3.01^{a} \pm 0.03$	$1.58^{ab} \pm 0.02$	$82.32^{d} \pm 0.03$
$C_{70}OFSP_{30}$	$10.38^{d} \pm 0.02$	$1.98^{a} \pm 0.01$	$1.23^{abc} \pm 0.01$	$2.09^{a} \pm 0.02$	$1.44^{bc} \pm 0.01$	$83.42^{b} \pm 0.03$
$C_{30}OFSP_{70}$	$11.27^{ab} \pm 0.01$	$1.92^{a} \pm 0.02$	$1.24^{bc} \pm 0.02$	$3.14^{a} \pm 0.03$	$1.62^{c} \pm 0.02$	$81.84^{a} \pm 0.03$
$C_{100}OFSP_{0}$	$10.02^{d} \pm 0.01$	$1.97^{a} \pm 0.01$	$1.14^{c} \pm 0.01$	$1.81^{b} \pm 0.02$	$1.36^{c} \pm 0.03$	$83.59^{e} \pm 0.03$
$C_{0}OFSP_{100}$	$12.53^{e} \pm 0.01$	$1.95^{a} \pm 0.01$	$1.47^{d} \pm 0.01$	$4.56^{c} \pm 0.02$	$1.78^{d} \pm 0.05$	$81.04^{bc} \pm 0.03$

In each of the columns, any means not followed by the same superscripts are significantly different ($p < 0.05$)

Source: Field survey, Akyea-Mensah (2019)

KEY:

$C_{50}OFSP_{50}$; 50% Cassava and 50% OFSP

$C_{60}OFSP_{40}$; 60% Cassava and 40% OFSP

$C_{40}OFSP_{60}$; 40% Cassava and 60% OFSP

$C_{70}OFSP_{30}$; 70% Cassava and 30% OFSP

$C_{30}OFSP_{70}$; 30% Cassava and 70% OFSP

$C_{100}OFSP_{0}$; 100% Cassava and 0% OFSP

$C_{0}OFSP_{100}$; 0% Cassava and 100% OFSP

The values obtained for the total titratible acidity (TTA) and pH are shown in Table 3. There was a significant ($p < 0.05$) difference among the samples in terms of TTA. The values ranged from $1.24 - 1.72\%$. Cassava – OFSP gari with 100% OFSP had the highest TTA while Cassava – OFSP gari with 0% OFSP had the lowest. This could be attributed to the high level of free sugar in OFSP which increased its tendency to readily undergo lactic acid fermentation.

There was a significant ($p < 0.05$) difference in the pH values obtained for the Cassava – OFSP gari samples. The values ranged from $4.65 - 4.90$. These were within the range of values($4.42 - 5.98$) reported by Sanni et al. (2005) for gari samples. The pH of gari is also a function of the extent of fermentation. The lower the pH, the better will be the keeping quality of gari.

There was a significant ($p < 0.05$) difference among the Cassava – OFSP gari samples in terms of hydrogen cyanide (HCN) content (see Table 3). Cassava gari (100%) had the highest HCN content while that of 100% OFSP had the lowest. Table 3 shows the HCN contents of the various Cassava – OFSP gari samples. The highest level of HCN obtained for 100% cassava gari could be attributed to the high content in the raw cassava root. Sweet cultivars of cassava can produce as little as 20 mg of HCN per kg of fresh roots, while bitter ones may produce more than 50 times as much (Ihekoronye & Ngoddy, 1985). The value obtained would be far less than what was in the raw cassava root as a result of the detoxification brought about by fermentation (Ze, Kamdem, Agnia, Mengo & Ngang, 016), tissue disintegration (Kaur & Ahluwalia, 2017), dewatering, roasting, etc., in the course of production.

Table 3: Other Chemical Properties of Cassava – OFSP Gari

Samples	TTA (%)	pH	HCN (mg/100g)
$C_{50}OFSP_{50}$	$1.52^{e} \pm 0.01$	$4.75^{ab} \pm 0.05$	$1.64^{e} \pm 0.01$
$C_{60}OFSP_{40}$	$1.41^{e} \pm 0.02$	$4.75^{b} \pm 0.01$	$1.98^{b} \pm 0.01$
$C_{40}OFSP_{60}$	$1.58^{abc} \pm 0.04$	$4.80^{a} \pm 0.0$	$1.22^{e} \pm 0.02$
$C_{70}OFSP_{30}$	$1.37^{ab} \pm 0.01$	$4.70^{a} \pm 0.02$	$2.01^{e} \pm 0.01$
$C_{30}OFSP_{70}$	$1.63^{cd} \pm 0.01$	$4.85^{a} \pm 0.01$	$0.98^{c} \pm 0.01$
$C_{100}OFSP_{0}$	$1.24^{e} \pm 0.01$	$4.65^{a} \pm 0.00$	$1.23^{d} \pm 0.05$
$C_{0}OFSP_{100}$	$1.72^{a} \pm 0.05$	$4.90^{a} \pm 0.00$	$0.56^{b} \pm 0.03$

In each of the columns, any means not followed by the same superscripts are significantly different ($p < 0.05$)

Source: Field survey, Akyea-Mensah (2019)

Physical Properties of Cassava – OFSP Gari

In assessing physical properties of the various Cassava – OFSP gari research question two was addressed. The physical and technological properties of Cassava – OFSP gari samples are shown in Table 4. The swelling index of the samples ranged from $340 - 400\%$, with 0% Cassava gari having the highest value and that of 100% OFSP had the least. These values agreed with those $(301 - 430\%)$ reported by Ojo & Akande (2013). The high values can be attributed to the dryness of the gari samples as indicated by the low moisture content. Swelling index indicates the ability of the gari to swell and this is influenced by the quantity and starch components (amylose and amylopectin) present in the gari. Swelling index has been shown to give a greater volume and more feeling of satiety per unit weight of gari to a consumer and a swelling index of at least $3.0\ (300\%)$ was recommended to be preferred by consumers (Akingbala *et al.*, 2005; Arinola, 2016).

The loose and packed densities of the gari samples fell within $0.54 - 0.73\ g/ml$ and $0.57 - 0.77 g/ml$, respectively. The highest bulk density was obtained for 100% OFSP gari sample while the lowest was recorded for 0% OFSP gari. These can be compared with the values $(0.50 - 0.58\ g/ml)$ reported by Kure, Nwankwo and Nyasu (2012). OFSP gari (100%) had the highest loose and packed densities. This can be attributed to its finer particle size, as was observed from the hand feels of the various gari samples. This resulted to lesser space between the particles and more compactness, thereby reducing the volume; and the lesser the volume, the more the density. There was increase in the level of bulk density with increased level of sweet potato incorporation, which once again suggests the effect of the different proportions on the Cassava – OFSP gari. Higher packed bulk and loose bulk densities mean that more quantity of gari can be packed than for the same specific volume of lower densities (Udoro, Kehinde, Olasunkanmi & Charles, 2014).

Cassava – OFSP gari proportions with 0% OFSP had the highest water absorption capacity of $7.9\ ml/g$ while that with 100% OFSP had the lowest $(5.3 ml/g)$. The values are close to the values $(7.70 - 8.16\ ml/g)$ reported by Kure, Nwankwo & Nyasu (2012). The 100% cassava and 0% OFSP gari proportions had the highest water absorption capacity as well recorded the highest swelling index.

Table 4: Physical Properties of Cassava – OFSP Gari

Samples	Swelling index (%)	Loose Bulk Density (g/cm^3)	Packed Bulk Density (g/cm^3)	Water Holding Capacity (ml/g)
$C_{50}OFSP_{50}$	375	0.60	0.63	6.4
$C_{60}OFSP_{40}$	380	0.58	0.61	6.8
$C_{40}OFSP_{60}$	365	0.61	0.64	6.1
$C_{70}OFSP_{30}$	390	0.56	0.59	7.1
$C_{30}OFSP_{70}$	350	0.62	0.65	5.9
$C_{100}OFSP_{0}$	400	0.54	0.57	7.9
$C_{0}OFSP_{100}$	340	0.73	0.77	5.3

Source: Field survey, Akyea-Mensah (2019)

Sensory Evaluation

The results of the sensory evaluation are presented in Tables 5, 6 and 7. The OFSP fortified gari samples when assessed in their dry particulate form differed significantly $(p < 0.05)$ in all the sensory attributes evaluated. Least rated in all attributes was 100% OFSP gari, with mean scores of 3.96 (dislike slightly) in aroma, 4.11 (dislike slightly) in sourness, 5.42 (neither like, nor dislike) in texture, 3.70 (dislike moderately) in colour, and 4.00 (dislike slightly) in overall acceptability. Most preferred in aroma, sourness, texture and colour was 70% Cassava - 30% OFSP gari sample, with preference ratings falling within the range of “like moderately” and “like very much”. Both 70% Cassava - 30% OFSP gari sample and 100% Cassava gari shared the highest mean score in overall acceptability and this corresponds to “like very much” on the hedonic scale of preference (Iwe, 2003).

Table 5: Results of Sensory Evaluation of Cassava – OFSP Gari in Dry Particulate Form

Samples	Aroma	Taste	Texture	Colour	Mouldability	Overall Acceptability
$C_{50}OFSP_{50}$	6.00^{b}	6.10^{b}	6.40^{abc}	6.80^{b}	6.00^{ab}	6.20^{b}
$C_{60}OFSP_{40}$	6.30^{b}	6.45^{b}	6.55^{c}	7.10^{c}	6.20^{b}	6.45^{c}
$C_{40}OFSP_{60}$	5.85^{b}	5.70^{ab}	6.10^{abc}	6.45^{bc}	5.95^{ab}	5.80^{b}
$C_{70}OFSP_{30}$	6.95^{a}	7.10^{a}	7.35^{a}	8.20^{a}	7.45^{a}	7.95^{a}
$C_{30}OFSP_{70}$	5.40^{b}	5.45^{b}	5.80^{ab}	5.30^{b}	5.60^{ab}	5.40^{b}
$C_{100}OFSP_{0}$	6.85^{b}	6.95^{b}	6.90^{bc}	6.95^{bc}	6.70^{ab}	7.10^{bc}
$C_{0}OFSP_{100}$	4.20^{b}	4.65^{b}	5.50^{abc}	3.25^{b}	5.55^{a}	4.30^{bc}

In each of the columns, any means not followed by the same superscripts are significantly different ($p < 0.05$)

Source: Field survey, Akyea-Mensah (2019)

Table 6: Results of Sensory Evaluation of Cassava – OFSP Gari in Eba Form

Samples	Aroma	Sourness	Taste	Texture	Colour	Overall Acceptability
$C_{50}OFSP_{50}$	5.95^{b}	5.14^{ab}	6.12^{b}	6.10^{abc}	6.01^{bcd}	6.33^{b}
$C_{60}OFSP_{40}$	6.00^{b}	5.78^{b}	6.33^{b}	6.42^{c}	6.12^{cde}	6.72^{b}
$C_{40}OFSP_{60}$	5.21^{b}	4.73^{b}	5.84^{b}	5.91^{abc}	5.81^{bc}	6.02^{b}
$C_{70}OFSP_{30}$	6.89^{a}	6.84^{a}	7.21^{a}	7.73^{a}	8.42^{a}	7.80^{a}
$C_{30}OFSP_{70}$	4.82^{b}	4.33^{b}	5.08^{b}	5.56^{abc}	5.12^{bcde}	5.74^{b}
$C_{100}OFSP_{0}$	6.70^{b}	6.77^{b}	7.58^{b}	7.30^{bc}	7.40^{e}	7.70^{b}
$C_{0}OFSP_{100}$	3.96^{b}	4.11^{ab}	4.43^{b}	5.42^{ab}	3.70^{abc}	4.00^{b}

In each of the columns, any means not followed by the same superscripts are significantly different ($p < 0.05$)

Source: Field survey, Akyea-Mensah (2019)

Table 7: Results of Sensory Evaluation of Cassava – OFSP Gari in Soaked Form

Samples	Aroma	Taste	Soakability	Texture	Colour	Overall Acceptability
$C_{50}OFSP_{50}$	5.85^{b}	6.00^{ab}	6.10^{abc}	6.30^{ab}	6.50^{bc}	6.40^{b}
$C_{60}OFSP_{40}$	5.90^{ab}	6.30^{b}	6.30^{c}	6.50^{ab}	6.80^{c}	6.80^{b}
$C_{40}OFSP_{60}$	5.60^{b}	5.80^{a}	5.90^{bc}	6.00^{ab}	6.10^{b}	6.00^{ab}
$C_{70}OFSP_{30}$	6.10^{a}	6.80^{a}	7.50^{a}	6.80^{a}	7.90^{b}	7.40^{b}
$C_{30}OFSP_{70}$	5.45^{ab}	5.10^{b}	5.55^{bc}	5.85^{b}	5.80^{bc}	5.45^{b}
$C_{100}OFSP_{0}$	7.10^{b}	6.90^{b}	7.10^{b}	6.90^{b}	6.70^{ab}	7.10^{a}
$C_{0}OFSP_{100}$	5.10^{b}	4.80^{b}	4.80^{bc}	5.10^{ab}	3.60^{bc}	4.90^{ab}

In each of the columns, any means not followed by the same superscripts are significantly different ($p < 0.05$)

Source: Field survey, Akyea-Mensah (2019)

When the gari samples were made into *eba* and evaluated, there were also significant $(p < 0.05)$ differences in all the sensory attributes. In terms of mouldability and overall acceptability, 70% Cassava - 30% OFSP gari sample was liked moderately and very much, respectively. In soaked forms, the Cassava OFSP gari samples differed $(p < 0.05)$ significantly in all the sensory attributes, with 70% Cassava - 30% OFSP gari sample having the highest rating (corresponding to "like very much") in soakability.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Overview

The study sought to explore the effect of different proportions of Cassava – OFSP on the physical, chemical and sensory properties of gari produced from cassava roots and OFSP tubers. Two research questions guided the study which were; 1) What are chemical properties of Cassava – OFSP gari? and 2) What are the physical properties of Cassava – OFSP gari? The study also tested four hypothesis which were; 1) $H_0 1$: There is no significant difference in the proximate compositions of Cassava – OFSP gari samples; 2) $H_0 2$: There is no significant difference in the dry particulate form of Cassava – OFSP gari samples and sensory attribute; 3) $H_0 3$: There is no significant difference in *eba* form of Cassava – OFSP gari samples and sensory attribute; and 4) $H_0 4$: There is no significant difference in soaked form of Cassava – OFSP gari samples and sensory attribute. The study employed a factorial experimental design involving cassava and OFSP gari from modifications of the traditional production method for gari. The study used convenient sampling technique as it sought to use naturally occurring consumers of gari. Sensory evaluation questionnaire was administered to selected gari consumers in the Cape Coast Metropolis in the Central Region. The panel consisted of 50 volunteers within the study area. The quantitative data was analysed using Statistical Package for Social Science (SPSS) software version 20.0.

Summary of the Study

The result from the chemical properties of Cassava – OFSP gari showed that, there was a significant difference ($p < 0.05$) among the Cassava – OFSP gari samples and an increase in the level of moisture content as the level of OFSP addition increased was observed. The samples however did not differ significantly ($p > 0.05$) in terms of crude fibre contents. The protein contents of the Cassava – OFSP gari samples differed significantly ($p < 0.05$) and ranged from $(1.81 - 4.56\%)$. The fat contents of the various OFSP fortified gari samples ranged from $1.36 - 1.78\%$ and differed significantly among the samples ($P < 0.05$). The ash content of the Cassava – OFSP gari samples ranged from $1.14 - 1.56\%$ and differed significantly ($p < 0.05$). There was a significant difference ($p < 0.05$) in the carbohydrate contents of the Cassava – OFSP gari samples. There was a significant ($p < 0.05$) difference among the samples in terms of TTA with values ranging from $1.24 - 1.72\%$. There was also a significant ($p < 0.05$) difference in the pH values obtained for the Cassava – OFSP gari samples with values ranging from $4.65 - 4.90$. Future more, there was a significant ($p < 0.05$) difference among the Cassava – OFSP gari samples in terms of hydrogen cyanide (HCN) content.

In line with research question two which sought to investigate the physical properties of the various Cassava – OFSP gari, the results showed that the swelling index of the samples ranged from $340 - 400\%$, with 0% Cassava gari having the highest value and that of 100% OFSP had the least. The loose and packed densities of the gari samples fell within $0.54 - 0.73\ g/ml$ and

$0.57 - 0.77 g/ml$, respectively. Cassava – OFSP gari proportions with 0% OFSP had the highest water absorption capacity of 7.9 ml/g while that with 100% OFSP had the lowest ($5.3 ml/g$).

The results of the sensory evaluation showed that the OFSP fortified gari samples assessed in their dry particulate form differed significantly ($p < 0.05$) in all the sensory attributes evaluated. When the gari samples were made into *eba* and evaluated, there were also significant ($p < 0.05$) differences in all the sensory attributes. In soaked forms, the Cassava OFSP gari samples differed ($p < 0.05$) significantly in all the sensory attributes, with 70% Cassava - 30% OFSP gari sample having the highest rating (corresponding to "like very much") in soakability.

Conclusions

The study revealed that the different proportions of OFSP fortified gari have significant effects on the physical, chemical and sensory qualities of OFSP fortified gari. It can be concluded that the inclusion of OFSP in the production of gari by 30% is acceptable as attested to by the responses of the panelists selected for the sensory evaluation of the products. The method involving mixing of 70% cassava and 30% OFSP gave a gari product of the highest overall acceptability.

Gari produced from the different proportions had good proximate compositions; the various Cassava – OFSP gari products had protein, fat, carbohydrate and ash contents that compared favourably well with those of 100% cassava gari. The study has also shown that through modifications of traditional method, the physical and technological properties of gari, such as swelling index, bulk density and water absorption capacity, could be well improved.

Recommendations

A number of recommendations were made in this study. Some of the recommendations are for action by stakeholders in education while others are for further research.

Recommendations for Practice

1. The Ministry of Agriculture should give priority on more diversification of utilization methods, and marketing of OFSP in the country in order to reduce losses and increase the value of the crop.
2. There should be education on the merits of OFSP which will result in acceptance and consequently increase in demand.

Recommendations for Further Research

1. Further research needs to be done to on Cassava – OFSP gari to evaluate the nutritional composition for recommended dietary allowance and also to deduce its suitability for consumption by all groups.
2. Further research on the topic should be carried out in a different location using different proportions of OFSP fortified so as to compare the result of the physicochemical properties analyzed in this study.
3. A research into technologies of improving upon the traditional gari processing method in order to increase the quantities of gari produced to meet the market demand is recommended.

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APPENDICES

APPENDIX A

CONSUMERS OF GARI QUESTIONNAIRE

Dear Participant,

The purpose of this questionnaire is to gather data on Cassava –Orange Fleshed Sweet Potato (OFSP) gari samples in the dry particulate, eba and soaked form for taste, colour, aroma, sourness, texture, and overall acceptability.

Your thoughtful and truthful responses will be greatly appreciated. Please answer each question to the best of your sensory. Your name is not required. Your responses will be kept completely confidential. Thank you for taking time to complete this questionnaire.

Instructions

1. As a representative of the consuming population of gari, quantify the degree of liking or disliking of the Cassava – Orange Fleshed Sweet Potato (OFSP) gari samples one by one separately.
2. Please try them from left to right, in the order presented.
3. Please put a tick [√] in the space that best describes your overall opinion of each of the samples.
4. Don't forget to rinse your mouth with water in between the samples.

Form	Sensory Evaluation	Sample	Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like or dislike	Like slightly	Like moderately	Like very much	Like extremely
Cassava – OFSP Gari in Dry Particulate Form	Aroma	$C_{50}OFSP_{50}$									
		$C_{60}OFSP_{40}$									
		$C_{40}OFSP_{60}$									
		$C_{70}OFSP_{30}$									
		$C_{30}OFSP_{70}$									
		$C_{100}OFSP_{0}$									
		$C_{0}OFSP_{100}$									

Form	**Sensory Evaluation**	**Sample**	**Dislike extremely**	**Dislike very much**	**Dislike moderately**	**Dislike slightly**	**Neither like or dislike**	**Like slightly**	**Like moderately**	**Like very much**	**Like extremely**
Cassava – OFSP Gari in Dry Particulate Form	Taste	$C_{50}OFSP_{50}$									
		$C_{60}OFSP_{40}$									
		$C_{40}OFSP_{60}$									
		$C_{70}OFSP_{30}$									
		$C_{30}OFSP_{70}$									
		$C_{100}OFSP_{0}$									
		$C_{0}OFSP_{100}$									

Form	**Sensory Evaluation**	**Sample**	**Dislike extremely**	**Dislike very much**	**Dislike moderately**	**Dislike slightly**	**Neither like or dislike**	**Like slightly**	**Like moderately**	**Like very much**	**Like extremely**
Cassava – OFSP Gari in Dry Particulate Form	Texture	$C_{50}OFSP_{50}$									
		$C_{60}OFSP_{40}$									
		$C_{40}OFSP_{60}$									
		$C_{70}OFSP_{30}$									
		$C_{30}OFSP_{70}$									
		$C_{100}OFSP_{0}$									
		$C_{0}OFSP_{100}$									

Form	Sensory Evaluation	Sample	Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like or dislike	Like slightly	Like moderately	Like very much	Like extremely
Cassava – OFSP Gari in Dry Particulate Form	Colour	$C_{50}OFSP_{50}$									
		$C_{60}OFSP_{40}$									
		$C_{40}OFSP_{60}$									
		$C_{70}OFSP_{30}$									
		$C_{30}OFSP_{70}$									
		$C_{100}OFSP_{0}$									
		$C_{0}OFSP_{100}$									

Form	Sensory Evaluation	Sample	Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like or dislike	Like slightly	Like moderately	Like very much	Like extremely
Cassava – OFSP Gari in Dry Particulate Form	Mouldability	$C_{50}OFSP_{50}$									
		$C_{60}OFSP_{40}$									
		$C_{40}OFSP_{60}$									
		$C_{70}OFSP_{30}$									
		$C_{30}OFSP_{70}$									
		$C_{100}OFSP_{0}$									
		$C_{0}OFSP_{100}$									

Form	Sensory Evaluation	Sample	Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like or dislike	Like slightly	Like moderately	Like very much	Like extremely
Cassava – OFSP Gari in Dry Particulate Form	Overall Acceptability	$C_{50}OFSP_{50}$									
		$C_{60}OFSP_{40}$									
		$C_{40}OFSP_{60}$									
		$C_{70}OFSP_{30}$									
		$C_{30}OFSP_{70}$									
		$C_{100}OFSP_{0}$									
		$C_{0}OFSP_{100}$									

Form	**Sensory Evaluation**	**Sample**	**Dislike extremely**	**Dislike very much**	**Dislike moderately**	**Dislike slightly**	**Neither like or dislike**	**Like slightly**	**Like moderately**	**Like very much**	**Like extremely**
Cassava – OFSP Gari in Eba Form	Aroma	$C_{50}OFSP_{50}$									
		$C_{60}OFSP_{40}$									
		$C_{40}OFSP_{60}$									
		$C_{70}OFSP_{30}$									
		$C_{30}OFSP_{70}$									
		$C_{100}OFSP_{0}$									
		$C_{0}OFSP_{100}$									

Form	Sensory Evaluation	Sample	Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like or dislike	Like slightly	Like moderately	Like very much	Like extremely
Cassava – OFSP Gari in Eba Form	Sourness	$C_{50}OFSP_{50}$									
		$C_{60}OFSP_{40}$									
		$C_{40}OFSP_{60}$									
		$C_{70}OFSP_{30}$									
		$C_{30}OFSP_{70}$									
		$C_{100}OFSP_{0}$									
		$C_{0}OFSP_{100}$									

Form	**Sensory Evaluation**	**Sample**	**Dislike extremely**	**Dislike very much**	**Dislike moderately**	**Dislike slightly**	**Neither like or dislike**	**Like slightly**	**Like moderately**	**Like very much**	**Like extremely**
Cassava – OFSP Gari in Eba Form	Taste	$C_{50}OFSP_{50}$									
		$C_{60}OFSP_{40}$									
		$C_{40}OFSP_{60}$									
		$C_{70}OFSP_{30}$									
		$C_{30}OFSP_{70}$									
		$C_{100}OFSP_{0}$									
		$C_{0}OFSP_{100}$									

Form	Sensory Evaluation	Sample	Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like or dislike	Like slightly	Like moderately	Like very much	Like extremely
Cassava – OFSP Gari in Eba Form	Texture	$C_{50}OFSP_{50}$									
		$C_{60}OFSP_{40}$									
		$C_{40}OFSP_{60}$									
		$C_{70}OFSP_{30}$									
		$C_{30}OFSP_{70}$									
		$C_{100}OFSP_{0}$									
		$C_{0}OFSP_{100}$									

Form	**Sensory Evaluation**	**Sample**	**Dislike extremely**	**Dislike very much**	**Dislike moderately**	**Dislike slightly**	**Neither like or dislike**	**Like slightly**	**Like moderately**	**Like very much**	**Like extremely**
Cassava – OFSP Gari in Eba Form	Colour	$C_{50}OFSP_{50}$									
		$C_{60}OFSP_{40}$									
		$C_{40}OFSP_{60}$									
		$C_{70}OFSP_{30}$									
		$C_{30}OFSP_{70}$									
		$C_{100}OFSP_{0}$									
		$C_{0}OFSP_{100}$									

Form	Sensory Evaluation	Sample	Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like or dislike	Like slightly	Like moderately	Like very much	Like extremely
Cassava – OFSP Gari in Eba Form	Overall Acceptability	$C_{50}OFSP_{50}$									
		$C_{60}OFSP_{40}$									
		$C_{40}OFSP_{60}$									
		$C_{70}OFSP_{30}$									
		$C_{30}OFSP_{70}$									
		$C_{100}OFSP_{0}$									
		$C_{0}OFSP_{100}$									

Form	Sensory Evaluation	Sample	Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like or dislike	Like slightly	Like moderately	Like very much	Like extremely
Cassava – OFSP Gari in Soaked Form	Aroma	$C_{50}OFSP_{50}$									
		$C_{60}OFSP_{40}$									
		$C_{40}OFSP_{60}$									
		$C_{70}OFSP_{30}$									
		$C_{30}OFSP_{70}$									
		$C_{100}OFSP_{0}$									
		$C_{0}OFSP_{100}$									

Form	**Sensory Evaluation**	**Sample**	**Dislike extremely**	**Dislike very much**	**Dislike moderately**	**Dislike slightly**	**Neither like or dislike**	**Like slightly**	**Like moderately**	**Like very much**	**Like extremely**
Cassava – OFSP Gari in Soaked Form	Taste	$C_{50}OFSP_{50}$									
		$C_{60}OFSP_{40}$									
		$C_{40}OFSP_{60}$									
		$C_{70}OFSP_{30}$									
		$C_{30}OFSP_{70}$									
		$C_{100}OFSP_{0}$									
		$C_{0}OFSP_{100}$									

Form	Sensory Evaluation	Sample	Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like or dislike	Like slightly	Like moderately	Like very much	Like extremely
Cassava – OFSP Gari in Soaked Form	Soakability	$C_{50}OFSP_{50}$									
		$C_{60}OFSP_{40}$									
		$C_{40}OFSP_{60}$									
		$C_{70}OFSP_{30}$									
		$C_{30}OFSP_{70}$									
		$C_{100}OFSP_{0}$									
		$C_{0}OFSP_{100}$									

Form	**Sensory Evaluation**	**Sample**	**Dislike extremely**	**Dislike very much**	**Dislike moderately**	**Dislike slightly**	**Neither like or dislike**	**Like slightly**	**Like moderately**	**Like very much**	**Like extremely**
Cassava – OFSP Gari in Soaked Form	Texture	$C_{50}OFSP_{50}$									
		$C_{60}OFSP_{40}$									
		$C_{40}OFSP_{60}$									
		$C_{70}OFSP_{30}$									
		$C_{30}OFSP_{70}$									
		$C_{100}OFSP_{0}$									
		$C_{0}OFSP_{100}$									

Form	Sensory Evaluation	Sample	Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like or dislike	Like slightly	Like moderately	Like very much	Like extremely
Cassava – OFSP Gari in Soaked Form	Colour	$C_{50}OFSP_{50}$									
		$C_{60}OFSP_{40}$									
		$C_{40}OFSP_{60}$									
		$C_{70}OFSP_{30}$									
		$C_{30}OFSP_{70}$									
		$C_{100}OFSP_{0}$									
		$C_{0}OFSP_{100}$									

Form	Sensory Evaluation	Sample	Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like or dislike	Like slightly	Like moderately	Like very much	Like extremely
Cassava – OFSP Gari in Soaked Form	Overall Acceptability	$C_{50}OFSP_{50}$									
		$C_{60}OFSP_{40}$									
		$C_{40}OFSP_{60}$									
		$C_{70}OFSP_{30}$									
		$C_{30}OFSP_{70}$									
		$C_{100}OFSP_{0}$									
		$C_{0}OFSP_{100}$									