KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY,

KUMASI

COLLEGE OF AGRICULTURE AND NATURAL RESOURCES
DEPARTMENT OF HORTICULTURE

EFFECT OF VARIETY AND PROCESSING METHODS ON THE PHYSICOCHEMICAL AND SENSORY PROPERTIES OF GARI IN THREE DISTRICTS OF THE BRONG AHAFO REGION

BY

LATAH EBENEZER KOFI

SEPTEMBER, 2016

EFFECT OF VARIETY AND PROCESSING METHODS ON THE PHYSICOCHEMICAL AND SENSORY PROPERTIES OF GARI IN THREE DISTRICTS OF THE BRONG AHAFO REGION

BY

LATAH EBENEZER KOFI

A THESIS IS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF PHILOSOPHY DEGREE (M. phil. POST HARVEST TECHNOLOGY).

SEPTEMBER, 2016

DECLARATION

I hereby declare that with the exception of references to other people's work which have been duly cited, this work submitted as thesis to the Department of Horticulture, Faculty of Agriculture, College of Agriculture and Natural Resources, Kwame Nkrumah University of Science and Technology, Kumasi, for the Degree of Master of Philosophy in Postharvest Technology, is the result my own investigation.

EBENEZER KOFI LATAH	………………………..	…………………
(Student, PG2589414)	Signature	Date

Certified by:

DR. B. K. MAALEKUU	………………………..	…………………
(Main Supervisor)	Signature	Date
DR. ELI GAVEH	…………………………	…………………
(Co-Supervisor)	Signature	Date
DR. B. K. MAALEKUU	…………………………	…………………
(Head of Department)	Signature	Date

DEDICATION

I dedicate this work to my loving father Mr. B. K Kumah, my dear wife Joyce Yaa Afriyie Latah and my daughters; Benedicta, Dorothy and Judith.

ACKNOWLEDGEMENT

I am most grateful to the Almighty God for seeing me throughout my period of study. I am very grateful to my main supervisor, Dr. B K Maalekuu, for his constructive criticism, guidance and immense contribution to this thesis. I would also like to express my profound gratitude to my co-supervisor, Dr. Eli Gaveh, for his encouragement and contribution to this work.

My sincere thanks go to Mr. Ben Tibo of the Ministry of Food and Agriculture, Wenchi, for his organisational and technical support during the field survey work with some farmers and gari processors in the Wenchi Municipality.

Words cannot express my appreciation to Mr. Bless Sangmor Donkor, Mr. Kyei - Dompreh and Mr. Tettey Dossey (TT), all staff members of SUTESCO, for their immense contribution in typing and arrangement of this work. God richly bless you.

I am thankful to my siblings; Solomon, Samuel and Emmanuel for their moral and financial support throughout my study. This study would not have been possible without the support of my dear wife, Joyce and my children Benedicta, Dorothy and Judith. I am most grateful to them.

ABSTRACT

The effect of variety and processing methods on the physicochemical and sensory properties of gari in three districts of the Brong Ahafo region was studied. The study aimed at investigating the effect of cassava varieties and processing methods on the proximate, functional, physicochemical and sensory properties of gari. Gari was processed from *Bankyehemaa*, *Ampong* and *Bensre* cassava varieties. Each of the varieties was processed using both traditional and modern processing methods to obtain six gari samples. Physicochemical, proximate and functional analyses were conducted on all the six samples, after which sensory evaluation was carried out using a thirty member panel based on ratings on bases of colour, taste, aroma, texture and overall acceptability. The results showed that carbohydrate, protein and moisture content of gari from all the varieties were significantly different ($p<0.01$).

Bankyehemaa had the highest carbohydrate (90.31%) and protein (3.41%) contents. Processing methods did not have any significant impact ($p>0.01$) in making variation among the functional properties of gari. The hydrocyanic acid level of the varieties was not significantly influenced ($p>0.01$). However, the interaction of variety and processing methods influenced significantly differences among pH and hydrocyanic acid of gari. Traditionally processed gari had the least cyanide content as compared to gari obtained from modern processing method. Overall acceptability from sensory evaluation showed that *Bankyehemaa* gari samples processed through both methods were the most preferred, and the traditionally processed *Bensre* gari was the least preferred. From the results, it was concluded that variations in physicochemical properties were due to both genetic variation and processing methods. Traditionally processed gari is safer for consumption due to low hydrocyanic acid content.

TABLE OF CONTENTS

Title Page

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

NGOs	Non-Governmental Organizations
MoFA	Ministry of Food and Agriculture
IFAD	International Fund for Agricultural Development
IITA	International Institute of Tropical Agriculture
HCN-A	Hydrocyanic Acid
NaOH	Sodium Hydroxide
CSIR	Council of Scientific and Industrial Research
CIR	Crop Research Institute
CMD	Cassava Mosaic Disease
SPSS	Statistical Package for Social Scientists
CRD	Completely Randomized Design
AEA's	Agricultural Extension Agents
AGDP	Agricultural Gross Domestic Product
AOAC	Association of Official Analytical Chemists
%MC	Percentage Moisture Content
WAC	Water Absorption Capacity
TTA	Total Titratable Acidity
TSS	Total Soluble Solids
CHO	Carbohydrate
LSD	Least Significant Difference
CV	Coefficient of Variation
ANOVA	Analysis of Variance

CHAPTER ONE

1.0 INTRODUCTION

Cassava is a popular root crop widely cultivated in the tropical areas. It is scientifically known as *Manihot esculenta* which belongs to ***Euphobiaceae*** family. The plant is a woody shrub usually cultivated as perennial. The enlarged tuberous roots are highly perishable and can be stored only for a few days after harvest. The root provides a lot of carbohydrates to consumers. The crop is highly resistant to drought and has the ability to survive on poor soils. Variation in yield depends on cultivar, planting season, soil type and fertility of soil. Yields of improved varieties can reach 20-25 tonnes per hectare when cultivated under proper management practices. It is mainly cultivated for the roots but its leaves are also used as vegetables. The tuber contains 25 to 30% starch but poor in minerals, protein, vitamins (Ayankumbi *et., al* 1991). Both the leaves and roots are for human consumption and for feeding animals which are important source of carbohydrates, protein and minerals in the diet.

Cassava provides food security in Africa. More than two billion people living in Africa, Asia and Latin America will depend on roots and tubers such as cassava, yam and sweet potato for their nutrition and tax income by 2020 (Scott *et al*., 2000). Also,
Food and Agriculture Organization Corporate Document Repository entitled "The World Cassava Economy" produced by Agriculture and Consumer Protection indicated that almost 70 % of the world cassava production is produced in Nigerian, Democratic Republic of Congo, Brazil, Thailand and Indonesia .The report added that more than 50 % of the present global production of cassava is cultivated in Africa of and about 70% of the region's production is harvested in Nigeria, Democratic Republic of Congo and Tanzania.

According to Egesi *et. al.* (2006) Nigeria is the leading cassava producer worldwide which produces about 45 million metric tonnes and cassava transformation in Nigeria is the most advanced in Africa. Globally, Ghana is and the sixth highest cassava producer and the third in Africa, with about 70 percent of local farmers producing over 14 million metric tonnes every year. Production of cassava in Ghana increased from 14,270,000 metric tonnes in 2011 to 14,547,000 metric tonnes in 2012 and went up to 14, 990,000 metric tonnes in 2013(www.theafricareport.com/West-africa/ Ghana).

Recently there is an increasing demand for quality products processed from fresh cassava such as gari, flour, dough, starch and alcohol. This has enhanced the production of cassava because farmers have ready market for their produce. Generally, roots of cassava mature 6 -18 months depending on the cultivar. The crop is popular because of its use in producing food such as *gari, fufu and kokonte*. The root deteriorates quickly after harvesting and has to be processed within 24 hours after harvest (Hahn, 1998). Gari is a fermented product of fresh cassava tubers which is an important source of energy for consumers in Tropical Africa (Ihekoronye and Ngoddy, 1985). Gari is also widely consumed because it has a longer shelf life as compared to other products produced from fresh cassava. 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 (Flach, 1990).

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 *et al.*, 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 bring about reduction in the cyanide content of the fresh cassava tubers. The traditional gari processing method reduces the cyanide content in gari through prolonged period of fermentation up to seven days which is a vital strategy for producing a safe product (Sanni, 2001).

According to Nweke *et. al*. (2002), gari processed by the traditional method contain varied amounts of cyanide because different processors tend to shorten fermentation period in order to meet the increasing market demand. The traditional method of processing gari is tedious and usually 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 method should aim at reducing the period of fermentation and still eliminate cyanide so as to obtain gari quality 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) vigorously effect cyanide elimination, as well as other physicochemical properties of the product (gari).

Not much research have been done on the effect of cassava variety and gari processing methods on the physicochemical properties of gari. Therefore understanding the effect a particular cassava variety and processing methods have on the proximate functional and physicochemical properties of gari will greatly aid the production process of gari. In recent times, improved cassava varieties such as *Ampong, Bankyehemaa, Sika bankye and Esam bankye* have been introduced to farmers for cultivation within the Wenchi Municipality, Techiman Municipality and Techiman North District, all in the Brong Ahafo Region.

Most gari processors now use these new varieties alongside popular local varieties like *Kentema, Bensre, Asuma, Ahenemma, Buoy*am and others .The gari processors in the study area complain that even though the improved varieties are high yielding, they do not produce the best quality gari as compared to some of the local varieties. Some cassava growers have therefore threatened to stop the cultivation of these new varieties. This can be a threat to food security because the demand for cassava, and for that matter gari, would be high as a result of low production of cassava.

More often than not, most gari processors use a mix of both the local and improved varieties in processing gari. Since each variety has different physicochemical properties, there is the need to conduct a study into the physicochemical properties of selected local and improved cassava varieties commonly cultivated and used for gari processing in the study area so as to ascertain the claim by the processors. In addition, research on the methods of processing gari, and making appropriate recommendations with reference to a particular variety would be of great benefits especially to the people within the study area and the nation as a whole.

The study would provide a solution to the inability of gari processors to identify varieties which would produce gari of the best quality so that farmers would know which varieties to cultivate based on demand of the gari processors. It may also provide information for government, financial institutions and Non-Governmental

Organizations (NGOs) who would be interested to support cassava farmers and gari processors in the study area.

1.1 OBJECTIVE

The main objective of this research was to determine the proximate, functional and physicochemical properties of selected local and improved cassava varieties using two different gari processing methods.

1.1.1 Specific Objectives

The specific objectives were to:

1. To investigate the effect of cassava varieties on the proximate composition and of gari.
2. To investigate the effects of cassava varieties on the functional properties of gari.
3. To investigate the effect of processing methods on the physicochemical properties of gari.
4. To determine the interactive effect between cassava varieties and processing methods on the physicochemical properties of gari.
5. To determine the relationship among physicochemical properties and sensory attributes of gari.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 TAXONOMY OF CASSAVA

Cassava (*Manihot esculenta* Crantz) is in the family *Euphobiaceae* and consists of 7,200 species. Early literature classified the genus into two main edible species; sweet cassava (*Manihot utilissima* Phol) and bitter cassava (*Manihot aipi* Phol). In recent times, cassava has been classified according to morphology such as size and shape of leaf, height of plant, colour of stem, petiole, inflorescence and flower, root shape and level of cyanogenic glucoside present in the root (Onwueme, 1978).

2.1.1 Origin and domestication of cassava

Cassava originated from Brazil to the tropics during the 17^{th} century .The Portuguese cultivated the crop as a staple food in the Gold Coast near their forts, trading ports and castles. Cassava is now a popular crop in Ghana and the tubers prepared into gari, fufu and kokonte and are consumed by a majority of Ghanaians.

2.1.2 General morphology of cassava

Cassava is a perennial crop which is cultivated as an annual and can reach about 1-3 metres high. The tuber matures from 8 to 24 months after planting based on cultivar. The mature root may be 15 to 100 cm long. Mature tuber is about 0.5 to 2.0 kg in weight, depending on variety and growing conditions. A transverse cut through the tuber shows three layers namely the periderm, cortex and starchy flesh.

The periderm is the outermost layer of the root and made up of dead cork cells. The cortex is the second layer which is about 1-2 mm thick and situated just beneath the periderm. The flesh is the central part of the tuber and consists of parenchyma cells.

2.1.3 Climatic and soil requirement

Cassava does well in the tropics between latitude 30˚ N and S of the equator under varied agronomic and ecological conditions (Lazano *et. al.,* 1980; Nassar, 2005). It requires a warm climate with temperature ranging between 24˚ C – 30˚ C. Cassava prefers light sandy loam soil with average fertility. Cassava is drought tolerant and capable of growing on marginal soils where cereals and other crops do not perform well. However, it does not stand soils with pH greater than 8 and excess soil moisture and temperature above 10˚ C (Onwueme 1978; Lazano *et. al.,* 1980; IITA, 2001; Benesi; 2002; Mkumbira, 2002; Nassar, 2005).

2.2 ECONOMIC IMPORTANCE OF CASSAVA

Ghana is ranked the 6th largest cassava producer worldwide in terms of value. It constitutes 22 percent of Ghana's Agricultural Gross Domestic Product (AGDP). More than 10 million metric tonnes of cassava was produced in Ghana over the last decade. Cassava is a staple crop in Ghana with great economic importance throughout the world (El-Sharkawy, 2003). It constitutes one of the most important tropical plants and ranked fourth to rice, sugar and maize in terms of carbohydrates source in the tropics. It serves as an industrial crop for gari production, flour, alcohol, starch and feed for animal.

The crop is of great importance to peasant farmers due to its role in food security and income generation. Products of cassava, especially gari, are a reliable source of food for rural and urban dwellers in Ghana. Cassava has become an important crop in Ghana and the world over. According to Amaner (2011), the world annual production of cassava is over 158 billion tons. Yan *et.al;* (2001) also confirmed that the quantity produced is for various uses including human consumption (58%), animal feed (22%), and other uses (20%).

2.3 UTILIZATION OF CASSAVA IN GHANA

2.3.1 Food

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.

2.3.2 Industrial use

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 and 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).

2.3.3 Animal feed

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.

2.3.4 Medicinal uses

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 and Ingram, 1993 b). Cassava roots are prepared into *poultice* and applied to the skin for treatment of sores (Wingertzahn *et. al*; 1999). The starch obtained from the roots may be used as vitamin C supplements (Saidou, 2004).

2.4 GLOBAL SITUATION OF CASSAVA

Currently, Nigeria is highest producer of cassava in the world which produces about 54 million metric tonnes each year (FAO, 2013). Ghana is the sixth highest producer of cassava globally and the third in Africa while an estimated 70 percent of local farmers are engaged in cassava production, turning out more than 14 million metric tonnes every year. Ghana’s cassava production rose from 14,270,000 metric tonnes in 2011 to 14,547,000 metric tonnes in 2012 and went up to 14, 990,000 metric tonnes in 2013 (www.theafriareoprt.com/West-africa/ghana).

2.5 NUTRITIONAL VALUE OF CASSAVA

Cassava is grown primarily for its starchy roots which serve as major source of dietary energy (Onwueme, 1978; Lynam, 1993; Nassar, 2005). It accounts for nearly one-third of the total staple food production in Sub-Saharan Africa. The leaves are important source of vegetables, protein, mineral and vitamins (Jones, 1957; Hahn, 1988). Cassava is an efficient source of carbohydrate, producing about 250,000 calories/hectare/day (Julie *et. al.*, 2009). The sweet cassava variety is made up of about 17% of sucrose and small quantities of fructose and dextrose (Charles *et. al.*, 2005). The roots contain nutrients such as magnesium, manganese, calcium, iron, copper, zinc, and potassium.

2.6 DETERIORATION OF CASSAVA

Cassava roots are more perishable than other root crops once it is out of the soil because it is mainly a storage organ and has no dormancy. Usually, the root begins to show signs of discoloration 48 hours after harvesting. The root is a living organ and continues to metabolize and respire after harvest. Cassava deterioration occurs in two separate phases:

2.6.1 Physiological deterioration

It usually occurs within 24 hours after harvesting and characterized by brown or blue discoloration of the tuber. Physiological deterioration is due to wounds inflicted on the tuber during harvesting.

2.6.2 Microbial deterioration

This usually occurs within 5-7 days after harvesting and involves a variety of fungi which causes both wet and dry rots of the tuber leading to rapid post-harvest deterioration.

2.7 CYANOGENIC GLYCOSIDES CONTENT IN CASSAVA

The two main forms of cyanide in cassava are the glycosides and the non-glycosides (hydrogen cyanide). Cyanide can be toxic to human and therefore cassava used for food must to be processed to minimize the cyanide content. The "sweet" cultivars contain low cyanogenic glycosides content and "bitter" cultivars contain high cyanogenic glycoside content. Variation in toxicity level exist between cultivars. The bitter ones are considered poisonous while the sweet cultivars are considered nontoxic. Peeling of cassava tubers which removes the outer periderm layer reduce the cyanide level in the tuber. Methods used in processing cassava also reduce the HCN content of cassava tuber.

2.8 CASSAVA VARIETIES

Some common local varieties of cassava cultivated in Ghana include Bankye brode, Bensre, Tweneboah, Akosuatuntum, Ampenkene, Ahenema, Tomo, Buoyam, Asuma, Afosa, Kentema, Bankyefitaa, Bankyekokoo, Tuobodom and Akosombo. In November 2015, six new improved cassava varieties were launched by the CSIR-Crop Research Institute. They include CRI -Abrabopa, CRI -Amansan bankye, CRIDuade Kpakpa, CRI -AGRA bankye, CRI -Dudzi and CRI -Lamesese. These varieties are said to be tolerant to Cassava Mosaic Disease (CMD), high yielding and are also poundable. The table below shows some commonly cultivated improved cassava varieties in Ghana , year of release, period of maturity, mean root yield, total dry matter, resistance to cassava mosaic disease, suitability to particular ecology and the uses of the varieties.

Source: CSIR-CRI, GHANA

Table 2.1 Characteristics of some commonly cultivated improved cassava varieties

VARIETY	YEAR RELEASED	MATURITY PERIODS (MONTH)	MEAN ROOT YIELD(T/HA)	TOTAL DRY MATTER (%)	USES	CMD RESISTANCE	SUITABLE ECOLOGY
Afitiafi	1993	12-15	28-35	32	Starch, flour, gari	Tolerant	Forest/Forest Savannah/Coastal Savannah
Abasafitaa	1993	12-15	29-35	35	Starch, flour, gari	Tolerant	Forest/Forest Savannah/Coastal Savannah
Tekbankye	1997	12-15	30-40	30	Fufu, gari, ampesi	Susceptibe	Forest/Forest Savannah
Dokuduade	2005	12	35-40	30	Starch, gari	Resistant	Forest/Forest Savannah/Coastal Savannah
Agbelifia	2005	12	40-45	33	Starch, gari	Resistant	Forest/Forest Savannah/Coastal Savannah
Essambankye	2005	12	40-50	35	Flour, gari	Resistant	Forest/Forest Savannah/Coastal Savannah
Bankyehemaa	2005	12	40-50	32	Flour, gari, pounda-ble	Resistant	Forest/Forest Savannah/Coastal Savannah
Cape Coast Univ.bankye	2005	12-15	25-30	29	Fufu, gari, ampesi	Tolerant	Forest/Coastal Savannah
Bankyebotan	2005	12-15	25-30	28	Fufu, gari, ampesi,	Tolerant	Forest/Coastal Savannah
Eskamaye	2005	15-18	16-23	25	Tuo, kokonte	Tolerant	Guinea Savannah
Filindiakong	2005	15-18	16-23	28	Tuo, kokonte,	Tolerant	Guinea Savannah
Nyerikobga	2005	15-18	17-29	30	Tuo, kokonte	Tolerant	Guinea Savannah
Nkabom	2005	12-15	28-32	32	Starch, fufu	Tolerant	Forest/Forest Savannah
IFAD	2005	12-15	30-35	30	Starch, fufu	Tolerant	Forest/Forest Savannah
Ampong	2010	12	40-50	36	Flour, starch, Poudable	Resistant	Forest/Forest Savannah/Coastal Savanna
Bronibankye	2010	12	40-45	33	Flour and bakery product	Resistant	Forest/Forest Savannah/Coastal Savannah
Sika bankye	2010	12	40-45	36	Starch, flour	Tolerant	Forest/Forest Savannah/Coastal Savannah
Otuhia	2010	12	35-40	39	Starch and flour	Tolerant	Forest/Forest Savannah/Coastal Savannah

2.9 PROCESSING FRESH CASSAVA INTO GARI

According to James *et. al.*, 2012, in "An illustrated guide for small holder cassava processors," five major steps to follow in processing fresh cassava into gari were outlined. They include peeling and washing, grating, de-watering and fermentation, sieving wet cake into grits and roasting grits into gari. Peeling is done to remove the outer brown layer which is followed by washing to avoid contamination. Grating roots by the traditional method require the use of manual graters and the modern method make use of mechanized graters which produce enough quantities of gari. The Guide further explains that de-watering is done traditionally by the use stones or logs used as weight to press the bags of mash and remove excess water. The wet cakes are sieved into grits and roasted, bagged and stored.

2.10 PESTS OF CASSAVA

2.10.1 Mites

The cassava green spider mite (*Mononychellus tanajoa*) is a green insect which turns yellow at the adult stage. They are usually found on lower surfaces of young leaves, on green stems and in auxiliary buds. Damages usually appear as yellowish "pinpricks" on the surface of leaves. Heavy attack may cause stunted, deformed leaves and complete chlorosis

2.10.2 Mealy Bugs

The cassava mealy bug (*Phenococcus manihoti*) is pinkish in colour and reproduces all year round, reaching the highest point in the dry season. It sucks sap from the shoot tips, stems and surfaces of leaves during which they inject toxins into the plant and cause the terminal shoots to be deformed and stunted. Internodes lengths reduce and stems are distorted. Mealy bugs attack causes leaf loss and the plant produce poor quality planting material. Tuber loss has been estimated up to 80%.

2.10.3 White flies

This is the vector of the African mosaic disease. Yield losses up to 76% due to serious attack have been recorded. The insect sucks sap from the leaves during which it releases large quantities of honeydew which promote the growth of black sooty mould on the plant and cause premature drop of older leaves.

2.10.4 Grasshoppers

Grasshoppers chew cassava leaves and barks of stems and may cause a total defoliation in severe cases. The females lay their eggs under the shade of the cassava plant which hatch at the beginning of the dry season.

2.10.5 Termites

Termites eat stems and roots of cassava mostly in the dry season. They chew up the stems which eventually become weak and break.

2.11 DISEASES OF CASSAVA

Some common diseases of cassava include Cassava Anthracnose, Cassava tuber/root rot and African Cassava Mosaic Virus Disease.

2.11.1 Cassava tuber/ root rot disease

The disease is mostly caused by fungi and bacteria. The microorganism is able to cause 100% yield loss in cultivars that are susceptible. The fungus is transmitted mostly through infested farm tools and contaminated plant debris left on the field.

Leaves of affected plants turn brown and wilt. Tubers of affected plants become coloured when cut opened. The figure below is an illustration of cassava tuber affected by cassava root rot.

Figure 2.1 Cassava tuber showing root rot.

2.11.2 Control of root rots disease of cassava

Do not plant cassava on soils that are prone to flooding or on waterlogged soil. Use healthy planting materials and disease resistant or tolerant varieties. Adopt proper farm sanitation by collecting and burning plant debris together with spores of fungi. Early harvesting also reduces the incidence of root rot. Rotating cassava with cereals reduce the spread of inoculums (spores). The use of infested t ools and equipment also minimizes the spread of the fungi.

2.12 CASSAVA ANTHRACNOSE (Colletotrichum spp or Glomerella spp.)

Cassava Anthracnose disease is one of the important diseases affecting cassava in the tropics. The fungus attacks tissues which develop dark-brown lesions. There is the appearance of several circular spots on the leaf surface. In severe cases, dramatic wilting and defoliation may occur. Young stems develop oval pale-brown shallow depressions. On older stems, infections occur as round lesions which later develop to form large canker.

2.12.1 Control of Cassava Anthracnose disease

2.12.1.1 Cultural control

Cultural control measures such as deep burial or burning of infected plant debris, crop rotation, and fallow has been shown to minimize inoculum build up, as reported by (Onyeagba *et. al*., 1978; Lazano *et. al.*, 1981). The use of clean planting materials is effective in producing disease-free cuttings for propagation.

2.12.1.2 Chemical control

Even though chemical control for cassava Anthracnose is not well established, alternative control measures such as spraying anti-microbial plant products like neem extract has been identified as a promising preventive measure as indicated by Fokunang *et. al.*, (1999 b).

2.13 CASSAVA MOSAIC DISEASE (CMD)

It is the most significant virus disease which attack cassava and cause severe loss in yields in several cultivars as have been reported by Seif, (1982). Losses are substantial depending on variety and stage of crop growth at infection. Symptoms of the disease include leaf chlororis, with the leaves developing pale yellow colour. The disease is also characterized by distortion and reduction in leaflets size.

2.13.1 Control and prevention of CMD

The disease can be controlled by removing and destroying infested plants from the farm. Virus free stem cuttings should be used for planting. The use of resistant varieties is also an important preventive measure. The cultivation of different varieties on the same field has been found to reduce the spread of the virus, as reported by Leg *et al.*, (2005).

The figure below shows cassava leaves attacked by cassava mosaic disease.

Figure 2.2 Cassava leaves showing African Cassava Mosaic disease

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 FIELD SURVEY

3.1.1 Profile of study area

The survey was carried out in three districts of the Brong Ahafo Region namely Techiman North District, Wenchi and Techiman Municipalities. Wenchi Municipality is situated in the western part of the Brong Ahafo Region. It is bordered to the north and south by the Kintampo South District and Sunyani Municipality respectively. It also shares common boundaries with Techiman Municipality and Tain District to the east and west respectively. Techiman Municipality shares common boundary with Wenchi Municipal District and Techiman North District to the north, Sunyani Municipality and Offinso North District to the south, Nkoranza South District to the east and Tain District to the west.

3.1.2 Questionnaire Design

Stakeholders involved in the survey were cassava growers, gari processors and gari traders. Both open-ended and closed-ended questions were used to interview respondents. The study focused on cassava varieties commonly cultivated and the methods used for processing gari in the study area. Questionnaire for farmers covered demographic information, cassava varieties commonly cultivated, source of planting materials, source of finance, technical assistance received by farmers, methods of weed control and mode of land acquisition.

For gari processors, questionnaire covered demographic information, cassava varieties commonly used for gari processing methods used in processing gari and how some factors affect the quality of gari. Questionnaire for gari traders covered demographic information, processing method used by processors of traders and opinion of traders about quality of gari.

3.1.3 Sampling Technique and Administration of Questionnaire

Respondents interviewed were selected using simple random sampling technique so as to minimize biasness. Questionnaire was administered to selected farmers, gari processors and gari sellers within the Wenchi Municipal District, Techiman Municipal District and the Techiman North District, all in the Brong Ahafo Region. Each of the three stakeholders answered different set of questions. A total of 130 respondents made up of sixty (60) cassava farmers, thirty five (35) gari processors and thirty five (35) gari sellers were selected from fourteen (14) communities within the study area and interviewed.

3.2 DATA ANALYSES

Data obtained from the field survey was analyzed and interpreted as tables, pie charts and bar charts using Statistical Package for Social Scientists (SPSS).

3.3 SOURCE OF RAW MATERIALS.

Three cassava varieties were used for the study. They comprised two improved varieties (*Bankyehemaa* and *Ampong*) and one local variety (*Bensre*). Fresh tubers of *Ampong* and *Bankyehemaa* were harvested from the experimental farm of the Ministry of Food and Agriculture (MoFA) at Wenchi in the Brong Ahafo Region, whilst tubers of the local cassava variety (*Bensre)* were obtained from a farmer at Ayigbe in the Techiman Municipality. Two processing methods namely the Traditional and Modern methods were used to process the fresh cassava roots into gari. Each of the three varieties (*Ampong*, *Bankyehemaa* and *Bensre*) was processed using both method to obtain six different samples of gari. The stages involved in both methods of processing are:

- Peeling
- Washing

- Grating / grinding into mash
- Loading grated mash into sacks
- Pressing and fermentation
- Sifting
- Roasting
- Sieving roasted gari

3.4 PROCESSING CASSAVA ROOTS INTO GARI

3.4.1 Modern method of gari processing.

Fresh cassava roots of each of the three varieties were harvested into different jute sacks and clearly labeled. Each sample of cassava was peeled the same day, washed with tap water and grinded using commercial mechanical grater. The mash was allowed overnight to ferment. The grated mash obtained from each sample was then loaded into a different sacks and again labeled. The three sacks were then arranged horizontally on a wooden platform of a manual screw press and pressed to remove water in the mash. After one day (24 hours), the mashes in the three sacks were sifted separately to remove large chunks. Each of the samples was then roasted in different open air pans, while stirring continuously with a broken piece of calabash.

The roasted gari were then sieved into separate containers using a cane mesh and allowed to cool for 30 minutes. The gari samples obtained were transferred into separate plastic bottles and well covered with lids to prevent the entry of air.

3.4.2 Traditional method of gari processing

Harvested tubers of each of varieties were peeled with knife and washed. Grating was done manually by using a locally manufactured manual grater made by using nail to pierce multiple holes on a metallic sheet. The grated mashes obtained from each of the three cassava varieties were left overnight to ferment, after which they were loaded into different sacks and clearly labeled. Each sack was pressed with heavy stones to squeeze out the liquid content to allow the mash to dehydrate. The mashes in the sacks were sifted separately after two day (48 hours) to remove large chunks.

Each sample was then roasted in different open air pans, while continuously stirring with a broken piece of calabash. The roasted gari were then sieved into different containers using a cane mesh after which they were allowed to cool for 30 minutes.

Each gari sample was subsequently transferred into separate plastic bottles and tightly covered with lids to prevent the entry of air.

3.5 EXPERIMENTAL DESIGN.

A 3×2 factorial experiment in Completely Randomized Design (CRD) involving three cassava varieties and two processing methods were used in the study to establish the effect of variety and processing methods on the physicochemical properties of gari.
All determinations were carried out in three replications.

3.6 PROXIMATE ANALYSIS

3.6.1 Moisture content Determination (% MC)

The moisture content in gari samples was determined using AOAC (1995), official method 943.01. Exactly two grams (2 g) of gari was weighed and transferred into a dried glass crucible which weight was already taken. The sample was allowed to dry overnight in an air oven at 110˚ C for one day, after which it was removed and transferred into desiccators for cooling. The weight was again taken. The moisture content was then calculated by the weight difference which was expressed as a percentage.

Calculation

(A + B) – A=B

(A + B)- (A + C) = B – C=D

% moisture content = D/B x 100

Where A = crucible weight, B= sample weight, C =dry sample weight, D = moisture weight.

(A + B) = crucible +fresh sample

(A +C) = crucible + dry sample

3.6.2 Ether (Fat) Content Determination

Two (2) grams of gari sample was weighed and placed on a filter paper which was folded to hold the sample. Another filter paper was wrapped around and the top was left opened to look like a thimble. Cotton wool was placed at the top which distributed the solvent evenly so that it dropped on the sample during the extraction. The packet containing the sample was put in the butt tubes of the Soxhlet extraction apparatus. The extraction flask then was put in an oven for 5 minutes at 110˚C after which it was allowed to cool and weighed. The extraction of fat was done uninterruptedly for 2 hours by gentle heating. It was allowed to cool and the extraction flask dismantled.

Water bath was used to evaporate the ether until there was no odour of ether, after which it was cooled at room temperature. The extraction flask and its extracts were re-weighed and the weight recorded.

Calculations:

(A + B) – A =B

% ether extract = B/C x 100

Where A= flask weight, B= ether extract weight, C = sample weight.

3.6.3 Fibre content Determination

The residues of 2.0 g of sample was obtained from ether extract and transferred into a digestion flask. (Ether extract is a fatty acid ester of glycerol which is determined by extracting the dry gari sample with ether). Exactly 100 ml of boiling 1.2% H_2SO_4 solution was added to the residue of ether in the digestion flask, after which an antifoaming agent (N-trybutyl citrate) was also added.

The flask was straight away connected to a condenser and heated for 30 minutes. The digestion flask was removed and the content was filtered immediately using a filtering cloth. It was again washed using boiling water till the washing was no longer acid, after it tested negative for acid using litmus paper. The residue was washed back into a flat bottomed flask with 100 ml of boiling 1.25% sodium hydroxide solution. The flask was then connected to a reflux condenser and the content boiled again for 30 min. Afterwards, it was removed and the content filtered through a Gooch crucible. It was thoroughly washed with boiling water until no traces of NaOH was left.

The crucible and contents were dried at 110 ˚C until a constant weight was reached. It was cooled in desiccators and weight taken again. The content of the crucible was then incinerated in muffle furnace at a temperature of 550 ˚C for 30 min until the carbonaceous substance was burnt.

The remains on the crucible was then cooled in desiccators and weighed again. The weight loss was recorded and expressed as percentage crude fibre.

Calculation

$$\% \text{ Crude fibre} = \frac{A - B}{C} \times 100$$

Where A = weight of sample and dry crucible, B = weight of ash and incinerated crucible, C = weight of sample.

3.6.4 Ash content Determination

The content of ash was determined using official method 982.23 as indicated by AOAC, (1995). Ash crucible was taken from an oven and put in desiccators to cool after which it was weighed again. 2.0 g of gari sample was weighed into porcelain crucible, put into a furnace at 600 ˚C and ignited for 2 hours. The furnace was allowed to cool below 200 ˚C and this was maintained for 20 min. The crucibles and their contents were removed and placed in desiccators with stopper top. They were allowed to cool and again weighed. The percentage ash was then calculated as shown below.

Calculation:

(A + B) - A = B

(A + C)-A =C

% Ash = C/B x 100

Where A= weight of crucible, B= sample weight, C= ash weigh.

3.6.5 Protein content determination

Protein content was determined using the Kjeldahl digestion technique (AOAC, 1995), official method 920.87. The process involve three steps namely digestion of sample, distillation of digest and titration of distillate.

<u>Sample digestion</u>

Two (2) grams of gari was weighed and put into a 500 ml digestion flask. A spoonful of $CuSO_4$-$NaSO_4$ mixture was added to serve as catalyst. Again, 20 ml of concentrated H_2SO_4 was added to the content of the digestion flask. Boiling chips were then added and the sample was digested until the solution became colourless.

Distillation of digest

The digest obtained was cooled, diluted using small amount of distilled ammonia free water and then placed into a distillation apparatus. The Kjeldahl flask was rinsed successively using small quantities of distilled water. A 100 ml conical flask which contained 25 ml Boric acid was placed and a few drops of mixed indicator was added. Again, 50 ml of 40% Sodium hydroxide solution was added to the test solution in the apparatus. The mixtures was then distilled and the ammonia was collected on Boric acid. 100 ml of the distillate was then collected for titration.

Titration of distillate

The solution obtained was titrated against the standard acid (0.1 M HCl) until a pink colour appeared (the end-point). Regent blank was run using 100 ml of the distilled water. The volume used for the titration was then subtracted from the sample titration volume.

Calculation:

Nitrogen content of the samples was determined by the formula:

$$\text{Total Nitrogen } (N_T)\ (g\ kg^{-1}) = \frac{(\text{ml HCl- ml blank}) \times \text{Normality} \times 14.01}{\text{Sample weight (g)} \times 10}$$

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

3.6.6 Carbohydrate determination

Carbohydrate in the sample was determined after completing the analysis for moisture, ash, crude fibre and crude protein. It was obtained by calculation as shown below.

Calculation:

% Carbohydrate = 100% - (% moisture + % ash + % crude fibre + ether extract (fat) + % crude protein)

3.7 FUNCTIONAL PROPERTIES OF GARI

3.7.1 Water Absorption Capacity (WAC)

0.5 g of each gari sample was mixed with 5 ml distilled water in a 20 ml centrifuge tube. The slurry obtained was agitated for 2 minutes. The mixture was left at room temperature (28 ˚C) for 30 minutes after which it was centrifuged for 20 minutes at 500 rpm. The clear supernatant was carefully decanted and discarded. Cotton wool was used to remove water drops adhering to the centrifuge tube and the weight of the tube was taken. Then the weight of water absorbed by the 0.5 g of gari was calculated and expressed as Water Absorption Capacity (WAC).

$$WAC = \frac{\text{Volume of water absorbed (ml)}}{\text{Mass of dry sample (g)}}$$

3.7.2 Swelling power of gari

0.5 g of gari sample was weighed and mixed in 10 ml of distilled water in a centrifuge tube. The mixture was heated using hot water bath at a temperature of 80 ˚C for 30 minutes, while the tube was shaken continuously. The suspension was centrifuged at 500 rpm for 30 minutes after the heating. The supernatant was decanted after which the weight of soaked gari was taken and the swelling power calculated using the formula:

$$\textit{Swelling power} = \frac{\textit{Weight of the soaked gari (g)}}{\textit{Weight of dry gari (g)}}$$

3.7.3 Bulk Density (BD)

Two grams (2.0 g) of gari sample was placed in a 10 ml measuring cylinder. It was then tapped to constant volume. Bulk density (gcm^{-3}) was determined by the formula:

Bulk Density = <u>Weight of gari (g)</u>

Volume of gari (cm^3)

3.8 PHYSICOCHEMICAL PROPERTIES

3.8.1 Determination of pH

The pH meter used was first calibrated at 20 ˚C with two buffers at pH 4.00 and 7.00. Forty (40) grams of gari sample was measured and transferred into a 100 ml beaker. While stirring slowly, 60 ml of boiling distilled water was added. The content was left to cool in a cold bath, while it was stirred occasionally. The pH was determined using the pH meter when the suspension was cooled to 20 ˚C.

3.8.2 Total Titratable Acidity (TTA)

The colour indicator method (Obilie *et. al.* 2004) was used to determine Total Titratable Acidity. Gari suspension used for pH determination was filtered thoroughly using a filter paper.

A funnel was used to pour 0.1 M NaOH into a 25 ml burette until it reached the zero mark. Exactly 10 ml of the suspension was pipetted into a beaker. Three drops of phenolphthalein indicator from a dropping pipette was added to the suspension in the beaker. The NaOH in the 25 ml burette was then slowly titrated into the gari suspension. The Total Titratable Acidity was then calculated using the formula below.

Calculation:

$$TTA = \frac{\text{Titre x Acid factor x100}}{\text{Volume of sample}}$$

$$= \frac{\text{Titre x 0.009 x100}}{\text{10ml}}$$

$$= \frac{\text{Titre x 0.9}}{\text{10ml}}$$

3.8.3 Total Soluble Solids (TSS) or Degree Brix (˚Brix)

One (1) gram of gari was thoroughly mixed with 100 ml distilled water in a beaker to form a suspension. Total Soluble Solids (TTS) of the gari suspension was determined using a digital refractometer which had been calibrated. Distilled water was used to set the baseline readings to zero. Few drops of the suspension were placed on the prism plate of the refractometer. The reading on the prisms scales was recorded. The prism plate was cleaned with distilled water and wiped dry with a soft tissue after each test. The refractometer was recalibrated to zero before determining the Brix of the other samples.

3.8.4 Hydrocyanic Acid Determination

Hydrocyanic acid content of gari samples was determined using the alkaline titrating method as indicated by AOAC (1995), official method 915.03 B. Hundred grams (100.0 g) of gari was placed in a Kjeldahl flask. 200 ml distilled water was added to the sample and made to stand for 2 hours. Steam distillation was used to collect distillate over 2.5% Sodium hydroxide solution. Again, 8 ml of NH_4OH was mixed with 2 ml of 5% K I and added to 100 ml of the distillate. The distillate was then titrated against 0.02 M $AgNO_3$.

Calculation:

Hydrocyanic acid was calculated using the equation below:

$$\text{HCN (mg)} = \frac{\text{ml titrate (sample-blank)}}{\text{ml titrate}} \times 20 \times \frac{\text{Normality of } AgNO_3 \times 0.54}{0.02}$$

$$= \frac{\text{HCN (mg)}}{\text{sample}} \times 100\% \quad \text{mg}$$

3.9 SENSORY EVALUATION OF GARI

Evaluation of the sensory attributes of the six samples was conducted using a 9- point hedonic scale. A mixed panel made up of 30 members was used. The panelists were chosen on the bases of their past experience of consuming gari. They were then trained on how to evaluate the sensory properties of gari. The sensory characteristics considered included colour, taste, aroma, texture and overall acceptability. Each attribute was scored on level of likeness from 1 to 9. The 9-point hedonic scale in ascending order is as follows. 1 = dislike, 2 = dislike very much, 3 =dislike, moderately,

4 = dislike slightly, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = like very much and 9 = like extremely.

3.9.1 Statistical Analysis of Sensory Attributes

Statistical analysis was performed by subjecting the data obtained to statistical package (Student Edition of Statistix 9.0). The effect of variety and processing methods on the attributes measured was tested using Analysis of Variance (ANOVA).Treatment means were separated using Least Significant Difference (LSD) whenever there were significance differences. Spearman's rank correlation was used to determine the relationship between the physicochemical properties and sensory attributes.

CHAPTER FOUR

4.0 RESULTS

This chapter presents the results of the survey conducted for cassava producers, gari processors and gari traders, as well as the results of physicochemical and sensory analyses of gari samples.

4.1 SURVEY

4.1.1 Cassava Producers

4.1.1.1 Demographic information of producers.

The demographic information presented here include gender, age and educational level of cassava producers. Table 4.1 shows that out of the sixty (60) farmers interviewed, 43% were males and 57% were females. The age distribution of farmers showed that the majority of the respondents were 31-40 years, representing 33% of the population. 25% were between 51-60 years and 18% in the age of 41-50 years. Farmers over 70 years formed 7% of the population. Those in the age range of 20-30 years and 61-70 years were 8% and 9%, respectively. Also, 40% of the respondents had no formal education, 41% of them had Basic/SHS/Middle School education while 13% terminated their formal education at the primary level. Only 1% had tertiary education, 2% had O' Level and 3% attended Commercial schools.

Table 4.1: Demographic information of cassava producers

CHARACTERISTICS	DESCRIPTION	PERCENTAGE (%)
Gender of Producers	Male	43
	Female	57
	TOTAL	**100**
Age Distribution of Producers	20-30	8
	31-40	33
	41-50	18
	51-60	25
	61-70	9

	More than 70 years	7
	TOTAL	**100**
Educational Level of Producers	No formal education	40
	Primary education	13
	JHS/SHS/Middle School Education	41
	O' Level education	2
	Tertiary education	1
	Commercial school education	3
	TOTAL	**100**

Source: Field survey, September, 2015.

4.1.1.2 Local varieties cultivated by producers

Table 4.2 shows some popular cassava varieties cultivated by farmers in the studyarea. Out of the sixty (60) respondents, 25% cultivated Kentema while 11.67% of them each cultivated Bensre, Asuma and Ahenemma and 5% each cultivated Menma wo and Akosua Tuntum.

Table 4.2: Local varieties cultivated by producers

LOCAL VARIETIES CULTIVATED	PERCENTAGE (%)
Kentema	25
Afosa	8.33
Asuma	11.67
Bankye kokoo	6.66
Bankye fitaa	3.33
Buoyam	3.33
Bensre	11.67
	1.67
Bankye brode	1.67
Pole	

Ahenemma	11.67
Akosua tuntum	5
Tweneboah	1.67
Menma wo	5
Tomo	3.33
TOTAL	**100**

SOURCE: FIELD SURVEY, SEPTEMBER, 2015.

4.1.1.3 Improved varieties cultivated by producers

Table 4.3 shows some improved cassava varieties cultivated by farmers. It indicates that 42% of the respondents cultivated *Bankyehemaa* and 24% grow *Ampong,* while 17%, 12% and 5% out of the sixty (60) respondents cultivated *Essam bankye*, *Sika bankye* and IFAD, respectively.

Table 4.3: Improved cassava varieties cultivated by producers

Varieties	Percentage (%)
Bankyehemaa	42
Essam bankye	17
Sika bankye	12
IFAD	5
Ampong	24
TOTAL	**100**

SOURCE: FIELD SURVEY, 2015.

4.1.1.4 Source of cassava planting materials

Figure 4.1 indicates that out of the sixty (60) respondents, 65% used planting materials from their own farms, 18% obtained planting materials from friends and relatives 17% got theirs from MoFA.

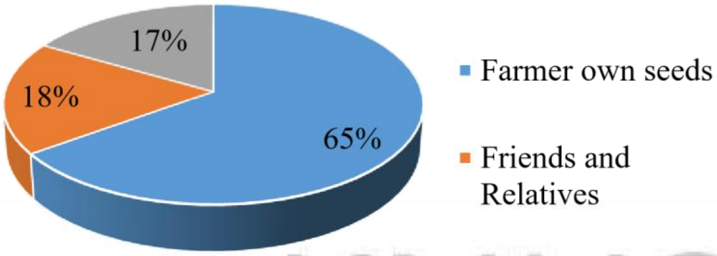


Figure 4.1: Source of planting materials

4.1.1.5 Land acquisition by producers

Figure 4.2 shows the mode of land acquisition for cassava cultivation. Most of the farmers, constituting 43.33% worked on family land and 20% hired land for cassava production. About 11.67% each of the respondents cultivated cassava on personal and government land respectively. An average of 10% hired land by the "Abunu" system and only 3.3% purchased land outright for cassava production.

	Family land	Purchased	Hired	Abunu	Personal land	Government land
Series1	43.33	3.33	20	10	11.67	11.67

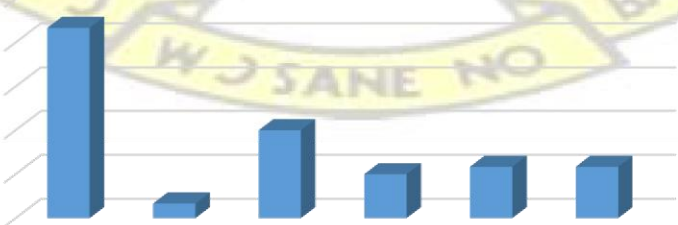


Figure 4.2: How farmers acquire land for production

4.1.1.6 Technical assistance

Figure 4.3 shows that 53%

percent of the respondents received some level of technical assistance from Agricultural Extension Agents (AEA's) but 47% percent have never had any technical assistance in cassava production from AEA's.

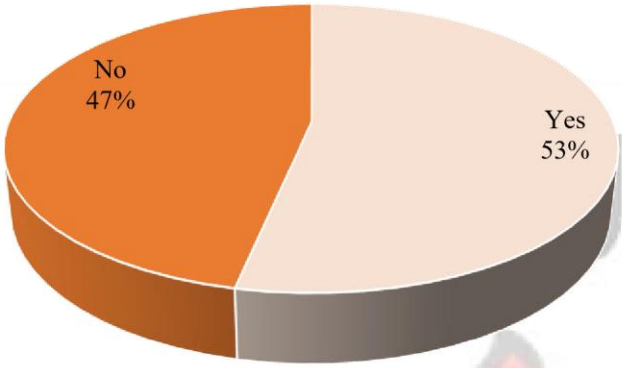


Figure 4.3: Does producers receive technical assistance?

4.1.1.7 Weed Control Methods

Figure 4.4 shows the results of methods used by respondents to control weeds. The majority of the farmers, made up of 70% used manual weed control method, 18.33% controlled weeds by the chemical method while 11.67% of the respondents used both manual and chemical weed control methods.

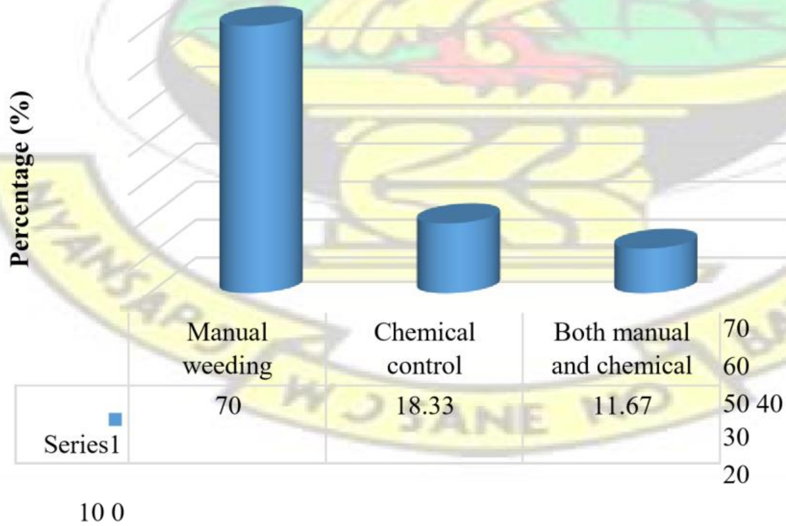


Figure 4.4: Weed control methods used by producers

4.2 GARI PROCESSORS

4.2.1 Demographic Information of Gari Processors

The gender, age distribution and educational level of gari processors in the study area is shown in Table 4.4. Out of the thirty-five (35) respondents interviewed, 88.57% were females and 11.43% were males. The majority of the respondents were within the a ge ranges of 41-50 years and 51-60 years, each representing 34.29%. Table 4.2 also shows that 42.86% of the gari processors had no formal education, 34.28% had JHS/SHS/Middle School education while 14.28% of them terminated their formal education at the primary school level.

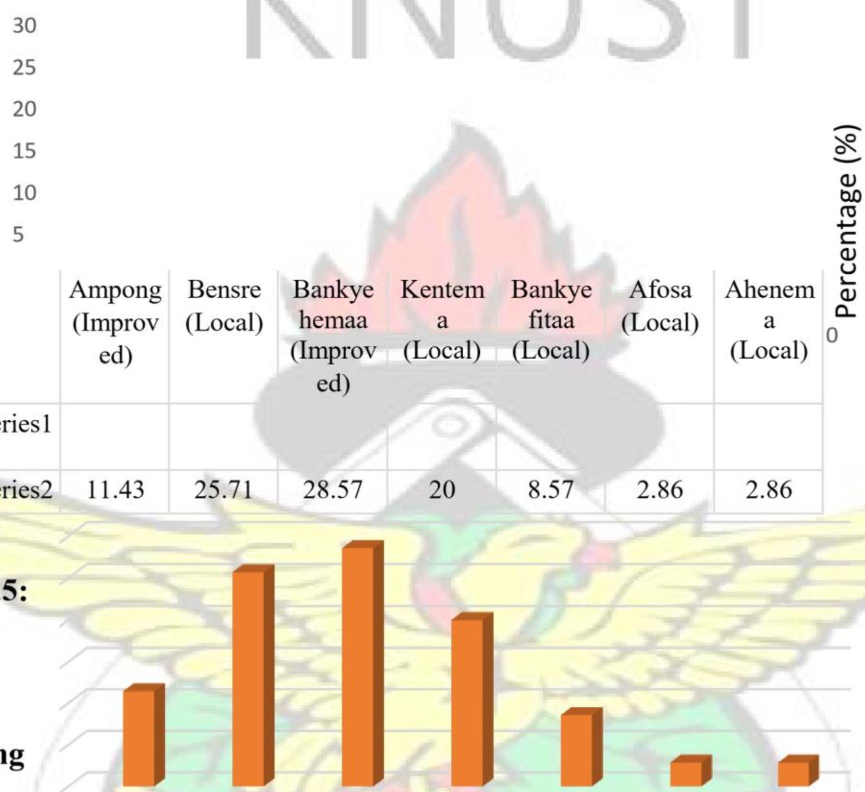
Table 4.4: Demographic information of gari processors

CHARACTERISTICS	DESCRIPTION	PERCENTAGE (%)
Gender of Processors	Male	11.43
	Female	88.57
	TOTAL	**100**
Age Distribution of Processors	31-40	20
	41-50	34.29
	51-60	34.29
	61-70	11.42
	TOTAL	**100**
Educational Level of Processors	No formal education	42.86
	Primary education	14.28
	JHS/SHS/Middle School education	34.28
	O' Level education	2.86
	Vocational education	2.86
	Commercial school education	2.86
	TOTAL	**100**

SOURCE: FIELD SURVEY, SEPTEMBER, 2015

4.2.2 Cassava varieties used for gari processing

Figure 4.5 represents the results of the various local and improved cassava varieties used for gari processing in the study area. Out of the thirty-five (35) gari processors, 28.57% of them used *Bankyehemaa*, 25.71% used *Bensre*, 20% processed *Kentema* into gari and 2.86 % used *Ahenemma* and *Afosa* varieties.



	Ampong (Improved)	Bensre (Local)	Bankyehemaa (Improved)	Kentema (Local)	Bankyefitaa (Local)	Afosa (Local)	Ahenema (Local)
Series1							
Series2	11.43	25.71	28.57	20	8.57	2.86	2.86

Figure 4.5: Cassava varieties used for gari processing

4.2.3 Processing methods used by gari processors

Figure 4.6 shows the results of gari processing methods used by respondents. The majority of the processors, constituting 86%, used the modern method and 14% of them used the traditional method.

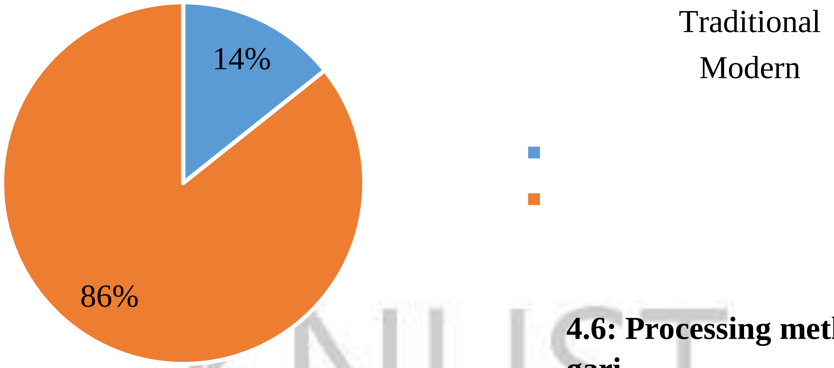


Figure 4.6: Processing methods used for gari

4.2.4 Quality of gari

Table 4.5 describes how some factors affect the quality of gari. Out of the thirty -five (35) gari processors interviewed, 80% of them indicated that variety affected the quality of gari but 20% were of the view that variety did not affect the quality of gari produced. Also, 51.43% of the respondents confirmed that mechanically damaged cassava tubers affected the quality of gari while 48.57% of the respondents said mechanical damage did not affect the quality of gari.

Table 4.5: How some factors affect quality of gari

CHARACTERISTICS	DESCRIPTION	PERCENTAGE (%)
Does variety affect quality of gari	Yes	80
	No	20
	TOTAL	**100**
Does mechanical damage of cassava affect quality of gari	Yes	51.43
	No	48.57
	TOTAL	**100**

Source: Field survey, September, 2015.

4.3 GARI TRADERS.

4.3.1 Demographic information of gari traders

Table 4.6 represents the gender, age distribution and educational level of gari traders in the study area. It shows that 94.29% of the respondents were females and only 5.71%

were males. Out of the thirty-five (35) respondents, 34.29% each were in the age groups of 31-40 years and 41-50 years. Also 20% were in the age bracket 20-30 years, while the age brackets 51-60 and 61-70 years had 5.71% each. The majority of the gari traders constituting 60% had JHS/SHS/Middle School education and 20% had no formal education. Also, 14.29% of the respondents had primary education and

5.71% had O' Level education.

Table 4.6: Demographic information of gari traders

CHARACTERISTICS	DESCRIPTION	PERCENTAGE (%)
Gender of Traders	Male	5.71
	Female	94.29
	TOTAL	**100**
Age Distribution of Traders	20-30	20
	31-40	34.29
	41-50	34.29
	51-60	5.71
	61-70	5.71
	TOTAL	**100**
Educational Level of Traders	No formal education	20
	Primary education	14.29
	JHS/SHS/Middle School education	60
	O' Level education	5.71
	TOTAL	**100**

Source: Field survey, September, 2015.

4.3.2 Processing methods used by processors of traders

Figure 4.7 shows the methods used by respondents for gari processing. The majority of the processors, constituting 97% used the modern method while only 3% processed gari using the traditional method.

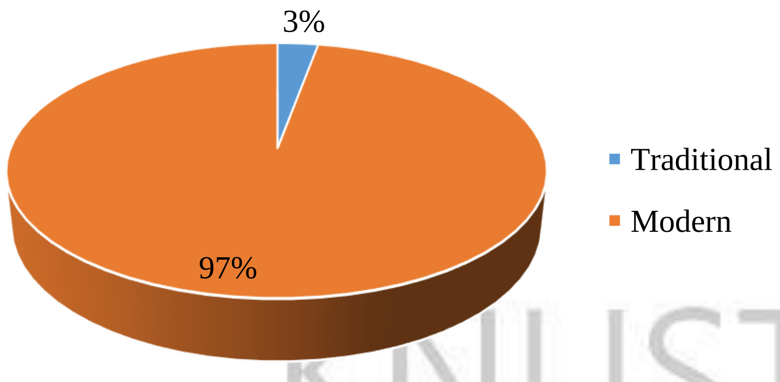


Figure 4.7: Processing methods used by processors of traders.

4.3.3 Opinion of traders about quality of gari

Table 4.7 indicates the opinion of gari traders about the effect of cassava variety on the quality of the gari they sell, as well as complaints received from consumers about the quality of gari sold. Out of the thirty-five (35) traders, 48.57% said that variety affected the quality of gari. In the opinion of 51.43% of the respondents, variety did not affect gari quality. Table 4.7 also shows that 45.71% of the traders received complaints from consumers about the quality of gari purchased, while 54.29% of the sellers did not receive any complaints on gari quality.

Table 4.7: Opinion of traders about quality of gari

CHARACTERISTICS	DESCRIPTION	PERCENTAGE (%)
Do you think variety affect quality of gari	Yes	48.57
	No	51.43
	TOTAL	**100**
Do you receive complaints about quality of gari from consumers	Yes	45.71
	No	54.29
	TOTAL	**100**

Source: Field Survey, September, 2015

4.4 PROXIMATE ANALYSIS

4.4.1 Effect of Cassava Variety on the Proximate Analysis of Gari

Table 4.8: The effect of cassava varieties on the proximate composition of gari

Variety	% Ash	% CHO	% Fat	% Fibre	% Moisture	% Protein
Bankyehemaa	0.65 [b]	90.31 [a]	0.63 [a]	1.92 [a]	4.13 [c]	3.41 [a]
Bensre	0.63 [b]	87.51 [b]	0.50 [a]	1.96 [a]	7.13 [b]	2.29 [c]
Ampong	0.85 [a]	84.79 [c]	0.63 [a]	2.92 [a]	8.26 [a]	2.57 [b]
Lsd (0.01)	0.18	1.94	0.29	1.33	0.9	0.18
CV	13.42	1.21	26.97	32.14	7.56	0.35

The effect of cassava variety was significant ($p<0.01$) on the percentage ash detected in gari processed from *Ampong* compared to *Bankyehemaa* and *Bensre*. The varieties had 0.85, 0.65 and 0.63 percent ash, respectively. The carbohydrate content in gari from the three varieties were significantly different ($p<0.01$). *Bankyehemaa* gari had the highest carbohydrate content (90.31%). This was followed by *Bensre* and then *Ampong* gari with 87.51 and 84.79 percent respectively. The variety of cassava used for the processing of gari did not have significant impact ($p>0.01$) on the fat and fibre content.

The fat content in gari of the three cassava varieties was within the range 0.50 – 0.63 percent while fibre level range within 1.92 – 2.92 percent. Gari from the different cassava varieties were significantly different ($p<0.01$) from one another in terms of moisture content. From the highest to the least, gari of *Ampong*, *Bensre* and *Bankyehemaa* had 8.26, 7.13 and 4.13 percent moisture, respectively. Likewise, gari from *Bankyehemaa* variety was very rich in protein (3.41%) and significantly different ($p<0.01$) compared to *Ampong* (2.57 %) and *Bensre* (2.29%).

4.4.2 Effect of Processing Method on the Proximate Analysis of Gari Table 4.9: The effect of processing methods on the proximate composition of gari

Processing Method	% Ash	% CHO	% Fat	% Fibre	% Moisture	% Protein
Traditional	0.79 [a]	88.73 [a]	0.50 [a]	1.88 [a]	5.42 [b]	2.69 [b]

Modern	0.63 b	86.35 b	0.68 a	2.56 a	7.60 a	2.82 a
Lsd (0.01)	0.14	1.58	0.24	1.09	0.73	0.01
CV	13.42	1.21	26.97	32.14	7.56	0.35

The result as indicated in table 4.9 revealed that the traditional processing method led to ash and carbohydrate content of 0.79 and 88.73 percent as compared to the modern processing method with 0.63 and 86.35 percent, respectively. That is, the effect of the processing methods on the ash and carbohydrate content were significantly different ($p<0.01$). The processing methods however did not significantly affect the crude fat (ether extract) and fibre content in gari.

The modern processing method influenced significantly the moisture content (7.60%) and protein (2.82%) content in the processed gari compared to the traditional processing method with 5.42% moisture and 2.69% protein.

4.4.3 Interaction Effect of Variety and Processing Method on the Proximate Analysis of Gari

Table 4.10: The effect of variety and processing method interaction on the proximate composition of gari

Variety*Processing Method	**% Ash**	**% CHO**	**% Fat**	**% Fibre**	**% Moisture**	**% Protein**
B. hemaa*Traditional	0.71 ab	90.71 a	0.50 a	1.77 b	3.00 d	3.31 b
*Bensre**Traditional	0.86 a	87.61 b	0.50 a	2.04 b	7.00 b	2.00 f
Ampong*Traditional	0.81 ab	87.88 b	0.50 a	1.82 b	6.25 bc	2.75 c
B.hemaa*Modern	0.59 bc	89.92 ab	0.77 a	2.08 b	5.27 c	3.50 a
*Bensre**Modern	0.42 c	87.40 b	0.50 a	1.88 b	7.27 b	2.58 d
Ampong*Modern	0.90 a	81.71 c	0.77 a	4.01 a	10.27 a	2.38 e
Lsd (0.01)	0.25	2.74	0.41	1.88	1.27	0.02
CV	13.42	1.21	26.97	32.14	7.56	0.35

The interaction of the varietal and processing effect largely resulted in a significant difference ($p<0.01$) among mean ash in the processed gari. *Ampong* processed gari using modern method had the highest ash content (0.90%). Yet, the modernized method also influenced the lowest ash content (0.42%) noted in gari processed from *Bensre* variety. The 0.90% ash was significantly not different from mean ash content which ranged within 0.71 to 0.86 percent. The interaction of varieties and processing methods did not result in significant difference in ash when *Bankyehemaa* (0.59%) and *Bensere* (0.42%) were subjected to the modern processing method.

The effect of 0.71 and 0.81 percent ash in traditionally processed gari from *Bankyehemaa* and *Ampong* was equal ($p>0.01$) to the effect of 0.59% ash. The effect of the varietal and processing difference caused significance variation ($p<0.01$) on mean carbohydrate content in processed gari. The highest and lowest carbohydrate content were 90.71 and 81.71 percent detected in gari processed from *Bankyehemaa a*nd *Ampong* varieties through the traditional and modern methods respectively. The effect of 90.71% carbohydrate is different from all the means except 89.92% in gari processed from the cassava variety but through the modernized method. Also, mean carbohydrate percentages; 87.40 to 89.92 have the same effect ($p>0.01$). This range of means is different from the 81.71% in term of the effect.

Fat content of the studied gari processed from the cassava varieties using the two processing methods ranged from 0.50 to 0.77 percent. The effect of these means is not significantly different ($p>0.01$).

Traditionally processed gari from *Bankyehemaa* contained the lowest fibre content of 1.77%. This was significantly not different ($p>0.01$) from mean fibre content which ranged from 1.82 to 2.08 percent. The effect of these mentioned means were significantly different when compared to 4.01% fibre in gari processed from *Ampong* variety subjected to modern processing method. That is, the effect of the highest fibre content was statistically different ($p<0.01$) from the effect of other mean fibre levels. Gari from traditionally processed *Bankyehemaa* had the lowest content of moisture (3.00%) compared to one processed from *Ampong* variety by use of modernized method (10.27%). The highest was 3.4 times more compared to the lowest level. Their effect varied significantly ($p<0.01$) against each other.

Bensre gari contained moisture content (7.00 /+0.27 %) of same effect to gari traditionally processed from *Ampong* variety (6.25%) irrespectively of the processing method. Similarly, gari processed from *Bankyehemaa* by use of modern method had moisture level (5.27%) of the same effect to 6.25% moisture. Protein content of gari due to the cassava variety and the processing method varied significantly ($p<0.01$) in effect from one another. The protein level in the processed gari ranged from 2.00 – 3.50 percent. *Bankyehemaa* cassava processed into gari by means of the modern and traditional methods contained 3.50 and 3.31 percent protein; followed by 2.75% protein contained in gari traditionally processed from *Ampong* cassava variety; 2.58 and 2.38 percent protein in *Bensre* and *Ampong* gari processed by use of modern method; and then least, 2.00% detected in gari from *Bensre* cassava variety processed with the traditional method.

4.5 FUNCTIONAL PROPERTIES OF GARI

4.5.1 Effect of Cassava Variety on the Functional Properties of Gari

Table 4.11: The effect of cassava varieties on the functional properties of gari

Variety	Bulk Density (g/cm^3)	Swelling Power (%)	Water Absorption Capacity (ml/g)
Bankyehemaa	0.76 ^{a}	7.47 ^{c}	6.15 ^{b}
Bensre	0.68 ^{b}	8.82 ^{a}	6.90 ^{a}
Ampong	0.66 ^{b}	8.12 ^{b}	6.00 ^{b}
Lsd (0.01)	0.04	0.36	0.24

CV	3.00	2.43	2.09

4.5.1.1 Variety effect on Bulk Density of gari.

The bulk density of gari processed from *Ampong* (0.66 g/cm^3) and *Bensre* (0.68g/cm^3) were of the same effect and insignificant (p>0.01). However, their effect varied significantly (p<0.01) when compared to that detected in gari from *Bankyehemaa* which recorded a bulk density of 0.76 g/cm^3.

4.5.1.2 Variety effect on Swelling Power of gari.

The swelling power of gari from the three cassava varieties differed significantly (p<0.01) from one another. The swelling power of gari processed from *Bensre* was greatest, followed by *Ampong* and *Bankyehemaa* with 8.82, 8.12 and 7.47 percent.

4.5.1.3 Variety effect on Water Absorption Capacity.

Gari processed from *Ampong* variety recorded a mean water absorption capacity of 6.00 ml/g and its effect was significantly not different from 6.15 ml/g recorded for gari processed from *Bankyehemaa*. Both however varied significantly from 6.90 ml/g detected for gari from *Bensre* cassava variety.

4.5.2 Effect of Processing Method on the Functional Properties of Gari

Table 4.12: The effect of processing method on the functional properties of gari

Processing Method	Bulk Density (g/cm^3)	Swelling Power (%)	Water Absorption Capacity (ml/g)
Traditional	0.70 ^{a}	8.14 ^{a}	6.27 ^{a}
Modern	0.70 ^{a}	8.12 ^{a}	6.43 ^{a}
Lsd (0.01)	0.03	0.29	0.2
CV	3.00	2.43	2.09

The processing methods adopted did not have any significant impact (p>0.01) in causing variation in bulk density, swelling power and water absorption capacity of the processed gari.

4.5.3 Interaction Effect of Variety and Processing Method on the Functional Properties of Gari

Table 4.13: The effect of variety and processing methods interaction on the functional properties of gari

Variety*Processing Method	Bulk Density (g/cm^3)	Swelling Power (%)	Water Absorption Capacity (ml/g)
Bankyehemaa*Traditional	0.74 [ab]	7.26 [d]	5.40 [e]
*Bensre**Traditional	0.66 [cd]	9.26 [a]	7.90 [a]
Ampong*Traditional	0.71 [bc]	7.91 [bc]	5.50 [e]
Bankyehemaa*Modern	0.77 [a]	7.68 [cd]	6.90 [b]
*Bensre**Modern	0.70 [bc]	8.39 [b]	5.90 [d]
Ampong*Modern	0.61 [d]	8.32 [b]	6.50 [c]
Lsd (0.01)	0.05	0.51	0.34
CV	3.00	2.43	2.09

4.5.3.1 Interaction effect on Bulk Density of gari

The bulk density of the processed gari ranged from 0.61 to 0.77 g/cm^3 for which the lowest and highest bulk densities were recorded by gari processed from *Ampong* (0.61 g/cm^3) and *Bankyehemaa* (0.77 g/cm^3) by adopting the modern processing method respectively. The difference with respect to their effect was significant (p<0.01). On the contrary, gari from both varieties (A*mpong* and *Bankyehemaaa*) had bulk densities of 0.71 g/cm^3 and 0.74 g/cm^3 of no significant difference (p>0.01) when subjected to the traditional processing method. There was of no difference when compared to 0.70 g/cm^3 of gari from *Bensre* subjected to the modernized method.

Traditionally processed *Bensre* gari had the same effect to 0.70 + 0.01 g/cm^3 with 0.66 g/cm^3 bulk density.

4.5.3.2 Interaction effect on Swelling Power of gari

The swelling power of gari due to the variety and processing method was significant in terms of variation among the means. Specifically, *Bankyehemaa* processed into gari by traditional method had a swelling power of 7.26% and varied significantly from 9.26% swelling power detected for gari processed from *Bensre* of the same processing method (traditional). These were the lowest and highest swelling power detected in gari.

However, the lowest swelling power (7.26 %) had a similar effect to 7.68% for gari processed from the same cassava variety (*Bankyehemaa*) by the alternative method adopted. Also, the effect of mean swelling power of 7.91, 8.32 and 8.39 percent are significantly not different ($p>0.01$).These were noted for gari processed from *Ampong* variety by use of the traditional method and its alternative, and *Bensre* subjected to modern processing method respectively. Similarly, the effect of 7.68 and 7.91 percent are significantly equal with respect to the swelling power.

4.5.3.3 Interaction effect on Water Absorption Capacity of gari

The interaction of the cassava variety and the processing method significantly ($p<0.01$) impacted on the variation among the means except *Ampong* (5.50 ml/g) and *Bankyehemaa's* (5.40 ml/g) gari which underwent the traditional processing. These two means recorded the lowest water absorption capacity and differed significantly ($p<0.01$) when compared against the rest of the means which ranged from 5.90 to 7.90 ml/g. Traditionally processed gari from *Bensre* cassava variety recorded the highest water absorption capacity with 7.90 ml/g. It is followed by *Bankyehemaa*, *Ampong*, and *Bensre* gari processed using the modern method with 6.90 ml/g, 6.50 ml/g, and

5.90 ml/g respectively.

4.6 PHYSICOCHEMICAL PROPERTIES OF GARI

4.6.1 Effect of Cassava Variety on the Physicochemical Properties of Gari

Table 4.14: The effect of cassava varieties on the physicochemical properties of gari.

		HCN Acid Variety (mg/100g)	**pH**	**TTA**	**TSS**
Bankyehemaa	5.0 [a]	8.4E-03 [a]	1.03 [a]	19.93 [a]	
Bensre	4.5 [b]	6.1E-03 [c]	0.95 [a]	21.49 [a]	
Ampong	4.0 [c]	6.8E-03 [b]	0.60 [b]	20.09 [a]	
Lsd (0.01)	0.3	3.80E-04	0.09	3.09	
CV	3.27	2.96	5.73	8.23	

4.6.1.1 Variety effect on pH of gari

The pH of gari from the cassava varieties differed significantly ($p<0.01$). The pH of the processed product ranged from 4.0 to 5.0 and basically acidic. The acidity level of gari from *Ampong* is very high compared to *Bensre* and *Bankyehemaa* with 4.0, 4.5 and 5.0 respectively.

4.6.1.2 Variety effect on Total Titratable Acidity (TTA) of gari

Total Titratable Acidity of gari varied significantly ($p<0.01$) due to varietal differences. Gari processed from *Bankyehemaa* contained the highest TTA level of 0.0084, followed by 0.0068 and the least, 0.0061 was detected in *Ampong* and *Bensre* respectively.

4.6.1.3 Variety effect on Total Soluble Sugar (TSS) of gari

Ampong processed in gari contained a low TSS of 0.60^{o} Brix. It was significantly different ($p<0.01$) from 0.95 and 1.03 ^{o}Brix which were significantly equal in effect.

4.6.1.4 Variety effect on Hydrocyanic Acid of gari

Hydrocyanic Acid significantly did not influence ($p>0.01$) any difference in the variety of cassava.

4.6.2 Effect of Processing Method on the Physicochemical Properties of Gari.

Table 4.15: The effect of processing methods on the physicochemical properties of gari.

Processing Method	pH	TTA	TSS	HCN Acid (mg/100g)
Traditional	4.7 ^{a}	7.7e-03 ^{a}	0.63 ^{b}	15.98 ^{b}
Modern	4.3 ^{b}	6.6e-03 ^{b}	1.08 ^{a}	25.04 ^{a}
Lsd (0.01)	0.2	3.14e-04	0.07	2.52
CV	3.27	2.96	5.73	8.23

4.6.2.1 Processing effect on pH of gari

The pH of gari was largely influenced by the processing method employed with the modern method influencing a significantly ($p<0.01$) higher acidity level compared the traditional method with 4.3 and 4.7 respectively.

4.6.2.2 Processing effect on Total Titratable Acidity (TTA) of gari

Similarly, Total Titratable Acidity (TTA) of gari due to the processing method was significant in causing a difference. The traditional processing method (0.0077) influenced significantly a higher TTA in gari compared to the modernised method (0.0066).

4.6.2.3 Processing effect on Total Soluble Solids (TSS) of gari

Total Soluble Solids of gari processed by use of the modernized processing method largely contained a higher TSS of 1.08^{o} Brix compared to 0.63^{o} Brix influenced by the traditional processing method.

4.6.2.4 Processing effect on the Hydrocyanic Acid of gari

The processing method employed significantly caused variation in the hydrocyanic acid content detected in gari. The product largely processed by use of the modern method had a higher hydrocyanic acid content of 25.04 mg/100 g and of a varied significant effect compare to 15.98 mg/100 g in gari subjected to the traditional processing method.

4.6.3 Interaction Effect of Variety and Processing Method on the Physicochemical Properties of Gari

Table 4.16: The effect of variety and processing method interaction on the physicochemical properties of gari

Variety*Processing Method	pH	TTA	TSS	HCN Acid (mg/100 g)
Bankyehemaa*Traditional	5.0 ^{a}	9.5E-03 ^{a}	0.90 ^{cd}	15.76 ^{b}
*Bensre**Traditional	5.0 ^{a}	5.9E-03 ^{c}	0.80 ^{d}	16.13 ^{b}
Ampong*Traditional	5.0 ^{a}	7.7E-03 ^{b}	0.20 ^{e}	16.04 ^{b}
Bankyehemaa*Modern	4.0 ^{b}	7.4E-03 ^{b}	1.15 ^{a}	24.10 ^{a}
*Bensre**Modern	4.0 ^{b}	6.3E-03 ^{c}	1.10 ^{ab}	26.86 ^{a}
Ampong*Modern	4.0 ^{b}	6.0E-03 ^{c}	1.00 ^{bc}	24.15 ^{a}
Lsd (0.01)	0.4	5.40E-04	0.13	4.37
CV	3.27	2.96	5.73	8.23

4.6.3.1 Interaction effect on pH of gari

A significant difference was noted among mean pH of gari processed from the cassava varieties using the two evaluated processing methods. That is, traditionally processed gari from the three cassava varieties recorded a higher pH of 5.0 which is of low acidity compared to 4.0 pH in gari produced using the modernized method.

4.6.3.2 Interaction effect on Total Titritable Acidity (TTA) of gari

The TTA of gari ranged from 0.0059 to 0.0095 with respect to the interaction means. There was a significant different ($p<0.01$) among the means 0.0095, 0.0074 – 0.0077 and 0.0059 – 0.0063.

The means within the ranges however had the same effect ($p>0.01$) and insignificant. The highest TTA (0.0095) was recorded by traditionally processed *Bankyehemaa* gari while the lowest TTA (0.0059) was contained in *Bensre* gari which was also processed by use of the traditional method. Through the modernised method, *Ampong* and *Bensre* processed gari had 0.0060 and 0.0063 TTA of the same effect. Also the modernized and traditionally processed *Bankyehemaa* and *Ampong* gari had 0.0074 and 0.0077 TTA of the same effect respectively.

4.6.3.3 Interaction effect of Total Soluble Solids (TSS) on gari.

0.20 to 1.15 ° Brix TSS was detected in gari processed from the cassava varieties subjected to the various processing methods. The lowest and highest TSS was noted in gari from *Ampong* and *Bankyehemaa* subjected to the traditional and modern processing respectively. Both were significantly different with regard to the sugar level. The effect of 1.00 and 1.10 ° Brix was statistically same. Likewise, the effect of 0.90 °Brix is not different from 1.00 ° Brix. And 0.80 ° Brix is equally not different from the 0.90 ° Brix. The effect of the lowest TSS (0.20° Brix) was however different from all the means just as the effect of the highest TSS, except that the 1.15 °Brix is insignificant from 1.10 °Brix.

4.6.3.4 Interaction effect of Hydrocyanic Acid on gari.

Traditionally processed gari from the three cassava varieties contained 15.76 to 16.13 mg/100 g of the same insignificant effect (p>0.01). Likewise, gari from the varieties through the modern processing methods adopted had 24.10 to 26.86 mg/100 g hydrocyanic acid which showed same effect when compared. The effect of the two ranges of means differed significantly (p<0.01) from each other with *Bankyehemaa* and *Bensre* having the lowest and highest levels of Hydrocyanic acid when subjected to the traditional and modern processing methods respectively.

4.7 SENSORY EVALUATION OF GARI. 4.7.1 Effect of Cassava Variety and Processing Method on Sensory Attributes of

Gari

Table 4.17: The effect of assessed factors on sensory attributes of gari

***SAMPLE CODE**	**SENSORY ATTRIBUTES**				
	Aroma	**Colour**	**Taste**	**Texture**	**Overall Acceptability**
BHM	6.93[a]	6.97[ab]	6.57[ab]	6.43[ab]	7.43[a]
BHT	6.80[a]	7.67[a]	7.20[a]	7.47[a]	7.90[a]
APT	6.17[a]	6.30[bc]	5.93[bc]	5.90[bc]	6.20[b]
BM	4.83[b]	5.20[cd]	5.10[cd]	5.03[cd]	5.73[bc]
APM	4.63[b]	5.17[d]	4.37[d]	4.87[cd]	5.33[bc]
BT	4.07[b]	4.83[d]	3.93[d]	4.43[d]	5.07[c]
Lsd (0.01)	1.232	1.116	1.236	1.114	0.956
CV	27.87	26.82	27.65	24.64	19.92

*BHM = *Bankyehemaa* processed by *modern* method, BHT = *Bankyehemaa* processed by traditional method, APM = *Ampong* processed by *modern* method, APT= *Ampong* processed by *traditional* method, BM = *Bensre* processed by *modern* method, and BT = *Bensre* processed by *traditional* method.

The processed *gari* samples coded BHM, BHT and APT were judged to have comparatively higher aroma compared to statistically low level in BM, APM and BT of mean scores of 6.17 – 6.93 and as compared to 4.07 – 4.83 respectively. Colour of the processed gari samples were judged to have no significant difference (p>0.01) except ones of mean score of 7.67 compared to scores of 5.20 to 6.30, and 4.83 to 5.17. That is the colour of BHT differed from all except BHM. The colour of BHM and BHT were not different. Likewise, the colour of APT and BM was statistically equal and the colour of BT, APM and BM were not different. *Bankyehemaa* processed gari by traditional method (BHT) was judged to be the tastiest (p<0.01) as compared to *Bensre* gari processed traditionally (BT) which is the least preferred in terms of taste with a score of 7.20 and 3.93 respectively. It is statistically noted that the taste of *Ampong* (4.37) and *Bensre* (5.10) gari samples by modern method is not different (p>0.01) from traditionally processed *Bensre* roots into gari. Also, the taste of APT and BHM did not vary with mean scores of 5.93 and 6.57 respectively.

The texture of the gari samples scores did not vary significantly ($p<0.01$) except ones with mean judged scores of 7.47 and 4.43 recorded for *Bankyehemaa* and *Bensre* roots traditionally processed into the gari with much variation in texture of grains.

The texture of the above mentioned samples also varied from that of *Ampong* roots traditionally processed into the product. The overall acceptability as indicated by their scores indicated that gari largely processed from *Bankyehemaa* roots regardless of the processing method is most preferred, in contrast to gari traditionally processed from *Bensre* (BT) variety.

The acceptability of APT, BM and APM were statistically equal ($p<0.01$) with scores which ranged from 5.33 to 6.20. The most and least preferred samples: BHT, BHM and BT respectively also showed varied acceptability level in comparison to APT.

Table 4.18: The relationship among some quality characteristics of gari

	BkD	**SPw**	**WAC**	**pH**	**TTA**	**TSS**	**HCN_A**	**AR**	**CR**	**TST**	**TXT**
SPw	-0.6630										
P-VALUE	*0.1513*										
WAC	-0.3066	0.7365									
	0.5545	*0.0950*									
pH	0.0960	0.0106	-0.0956								
	0.8565	*0.9841*	*0.8570*								
TTA	0.6876	-0.8672	-0.6524	0.4505							
	0.1312	*0.0253*	*0.1603*	*0.3700*							
TSS	0.0513	0.0010	0.3034	-0.7103	-0.2036						
	0.9213	*0.9985*	*0.5588*	*0.1137*	*0.6989*						

HCN_A	-0.0944	0.0504	0.0503	-0.9808	-0.4825

0.6945

	0.8589	*0.9245*	*0.9245*	***0.0005***	*0.3324*	*0.1257*					
AR	0.2719	-0.0290	-0.0180	0.9557	0.5162	-0.5047	-0.9298				
	0.6022	*0.9566*	*0.9730*	***0.0029***	*0.2945*	*0.3072*	***0.0072***				
CR	0.0753	0.2277	0.2148	0.9181	0.2811	-0.4313	-0.8890	0.9619			
	0.8872	*0.6643*	*0.6828*	***0.0098***	*0.5895*	*0.3932*	*0.0178*	***0.0021***			
TST	0.2546	0.1096	0.2147	0.9026	0.3751	-0.4296	-0.8925	0.9695	0.9760		
	0.6264	*0.8362*	*0.6828*	*0.0138*	*0.4637*	*0.3953*	*0.0167*	***0.0014***	***0.0009***		
TXT	0.0854	0.2969	0.1325	0.8789	0.2057	-0.3958	-0.8495	0.9360	0.9925	0.9775	
	0.8722	*0.5677*	*0.5465*	*0.0211*	*0.6958*	*0.4372*	*0.0323*	***0.0060***	***<0.0001***	***0.0008***	
OAC	0.1546	0.1555	0.2604	0.8567	0.3399	-0.2781	-0.8453	0.9459	0.9807	0.9742	0.9764
	0.7700	*0.7686*	*0.6183*	*0.0293*	*0.5098*	*0.5936*	*0.0341*	***0.0043***	***0.0006***	***0.0010***	***0.0008***

AR*

Values in bold are different from 0 with a significance level alpha=0.01

= *Aroma*, CR = *Colour*, TST = *Taste*, TXT = *Texture*, OAC = *Overall Acceptability*, HCN-A = *Hydrocyanic Acid*, TSS = *Total Soluble Solids*, TTA = *Total Titratable Acidity*, WAC = *Water Absorption Capacity*, SPw = *Swelling Power*, BkD = *Bulk Density*

4.7.2 Correlation of Quality Attributes of Gari.

No significant correlations ($p>0.01$) were noted among the quality attributes (physicochemical) and sensory evaluation of *gari* except pH which had an associative impact on the hydrocyanic (HCN) acid, aroma (AR) and colour (CR) of values higher than average with -0.9808, 0.9557 and 0.9181 respectively. The correlation between pH and HCN acid is a negative relationship. This suggests that an increase in pH would relatively influence a decline in HCN acid.

Similarly, HCN acid had a negative correlation on AR (-0.9298) score indicating a lower HCN acid tends to increase the aromatic component of *gari* to a more pleasant aroma. Unlike this implication, the relationship of pH to AR and CR is positive; a higher pH level suggests better aroma and colour and hence affected the general acceptability of *gari*. Correlations of the sensory attributes against one another were highly significant ($p<0.01$). Their relationships are the kind of criterion, "the more the better". That is the likeness of *gari* based on sensory attributes positively influenced other attributes. Sensory evaluation scores by panelist were largely high and correlations were higher above the average and intermediate optimal levels (above 87%) where consumers will show dissatisfactions. Thus, overall acceptability (OAC) is due to high likeness scores of inter-relations of the sensory attributes with a significant correlation.

CHAPTER FIVE

5.0 DISCUSSION

To ascertain the varieties and processing methods employed in the production of *gari*, a survey was undertaken focusing on producers (growers) of cassava, processors and traders of *gari*. These actors involved in processing and sales of *gari* were largely within the age bracket 31 to 60 years, and the majority of them (55 – 80 percent) had received formal education at various levels.

The survey showed that handling of cassava and its product, *gari,* in the study area is principally the work of women. Roots of different cassava varieties (both local and improved) were noted to be grown and processed into *gari*. *Bensre* (local), *Ampong* (improved) and *Bankyehemaa* (improved) are cassava types commonly processed into *gari* using either the traditional or modern processing techniques. The study revealed that the modern method is mostly adopted. Also the processors indicated that different cassava varieties and ways of handling them may affect the quality of *gari.*

5.1 PROXIMATE COMPOSITION OF GARI

The measured values of the six proximate components varied in percentage levels in the processed gari from the three cassava varieties. The variations in the components; ash, carbohydrate, fat, fibre, moisture and protein was mainly due to the inherent and external factors; that is genetic variations of the cassava varieties and processing variables may affect and cause changes in the quality of gari.

Total mineral elements in food which may be measured by the level of ash varied significantly ($p<0.01$) in gari with respect to the impact of genetic variation of cassava varieties assessed. That is ash content may differ significantly with variation in the varieties (Table 4.8). Likewise, the processing method adopted caused variation in the level of ash in gari the and interaction of these assessed factors; variety and processing methods at different degree impacted on the ash influencing a difference ($p<0.01$) in the values which ranged from 0.42 to 0.9 percent. The ash values were lower compared to 1.33 – 1.70% reported by Udoro *et.al*, (2014). The differences in ash values may be due to the varietal difference and varied processing variables.

Variation in the level of carbohydrate in gari was significant due to varietal variation. This was not different with regard to the processing methods evaluated as their effect varied significantly. That is the processing variables due to the approach is a contributing factor for the variation among different gari samples. Finding indicates that microorganisms have the capability of converting carbohydrates to protein during fermentation (Gregory *et. al.*, 1976). Therefore, the low carbohydrate content influenced by the modern processing method (Table 4.9) could be due the processing approach allowing for more microbial activity and also prolong fermentation period. Mean carbohydrate content due to the combined effect of the assessed factor showed variation among of the samples with the majority showing no difference. Such similarity in the effect of the carbohydrate levels might greatly be due to the processing variations.

Fat content was at the same level in gari without significant ($p>0.01$) variation. Makanjuola *et.al*, (2012) report on fat content of gari from different processing centres had low fat values of insignificant effect. The result affirms their report and thus suggests that there is no significant variation in the level of fats in gari. Even palm oil (an additive) mostly added to enhance flavour and colour would not necessarily influence a significant increase. This is because the cassava varieties and processing methods singly and interactively caused no variation in the level of fat in gari. Makanjuola *et al.* (2012) further stated that their result was similar to the outcome reported by Ekwu and Ehirim (2008) on fat values. Hence, there is much indication that fat content is generally low in cassava and processing variables could not effect variations in gari. With regard to fibre content, the varietal variation and processing methods singly did not cause a difference ($p>0.01$). That is, the three cassava varieties processed into gari contain a similar amount of fibre of the same effect. Also, the processing methods adopted caused no difference in the level of fibre in gari. Thus, the processing method did not cause a change in level of fibre in the product.

The effect due to the interaction of the variety and the processing method was same and insignificant ($p>0.01$) among all the mean fibre content (1.77 – 2.08 %) except 4.01% fibre noted in gari processed from *Ampong* variety under the modernized method. Such change in fibre against other mean fibre value could be due to chance and not necessarily the combined effect as the probability of it occurring indicated by the pvalue (0.0437) is insignificant ($p>0.01$). Reports as indicated by Ibe (1981) postulates a recommended crude fibre of not more than 3.0% respectively. This may serve as a base value for acceptable mean fibre content in gari. The mean fibre values recorded for gari in this research showed they were within the limits but more than values reported by Makanjuola *et.al*, (2012) and Ekwu and Ehirim (2008).

The level of moisture in food samples is an index of its stability and quality as well as a measure of yield and quantity of food solids (Joslyn, 1970). The results indicated that gari from the studied cassava varieties contained significantly different ($p<0.01$) amount of moisture with a considerably very high level in *Ampong* variety, double the amount in *Bankyehemaa* (Table 4.8). This outcome informs that selection of a variety for processing into gari is vital as such product is likely to go bad early compared to one with less moisture content. The effect of the variation in processing variables was also significant ($p<0.01$) on the amount of moisture in gari. The processed product which underwent the modernized method largely contain high moisture compared to the traditionally processed ones. The impact of the individual effects of the variety and the processing factors was noted in the interaction effect; 10.27 and 3.00 percent moisture, the highest and lowest detected in gari processed from *Ampong* and

Bankyehemaa varieties which underwent the modernized and traditional methods respectively (Table 4.10).The result indicated that too much moisture is bound to affect the quality (sticky grains) of gari and could allow for microbial activities if the amount is considerably high. The moisture level in the studied samples were within a range similar to 7.31 - 11.04 percent recorded by Udoro *et. al.*, (2014) for gari processed from dried cassava chips. Udoro *et. al.*,(2014) reported that the moisture content values recorded in their gari samples fell within the acceptable values for dried foods and also within the range of values reported for gari and other dried samples by earlier researchers (Oluwole *et. al.*, 2004; Taiwo and Okesola, 2009; Ashaye *et.al.*, 2005; Udofia *et. al*., 2010). It thus explains that the moisture content values of this experiment is not different but within the acceptable reported values.

Variation in the protein content of gari was largely influenced by the difference in the varieties and the processing method. The result as indicated (Table 4.8 – 4.10) discloses that the different level of protein in gari is either due to the singly or combined effect of inherent factors of cassava variety and the difference in the processing method is in view of modification. It further implies that varied amount of protein due to varietal variation in cassava tubers tend to have a greater effect on the level of the nutrient in the product, regardless of the impact of the processing. This is because processing could retain, improve or cause depletion of the nutrient.

The modernized processing method (Table 4.9) tends to impact positively on the protein level compared to the traditional method. A typical example from the results (Table 4.10) revealed that *Bankyehemaa* with the same carbohydrate content varied in protein content when subjected to the different processing method; 3.31% and 3.50 protein in gari processed by the orthodox and modern processing methods respectively. Protein yield in processed cassava products relate positively to activities of microorganisms involved in the fermentation (Chika *et al.* 2013).

Gregory *et. al*., (1976) reported that microorganisms, more often than not, change carbohydrates to proteins during fermentation. The variation in the protein content due to processing methods of the same cassava variety (as noted in the example above) may be attributed to the microbial activity during fermentation.

5.2 FUNCTIONAL PROPERTIES OF GARI

5.2.1 Bulk Density (BD)

Bulk density (BD) of gari was significantly ($p<0.01$) affected by the variation due to genetic composition of the cassava varieties that defines their qualities. That is the bulk density of gari processed from *Bankyehemaa* was higher as compared to that detected from *Bensre* and *Ampong* processed gari with the same effect. This outcome suggested that bulk density of gari could be affected by variation in genetic variation of cassava. Processing methods evaluated did not have any significant impact on the bulk density of gari as both processing approach had the same effect on gari. Variation due to the interaction of the assessed factors; variety and processing method was significant, but the effect of the mean bulk density of some gari samples as indicated in the result (Table 4.13) were as well equal. This reveals that the variation was mainly due to the genetic variation. Bulk density according to Ekwu *et al.*(2011) governs the fill weight of food materials; a quality characteristic of mostly flour. The BD mean values from the results showed gari from the cassava varieties range from 0.61 to 0.77 g/cm^3. The values are similar to 0.57 to 0.91 g/cm^3 reported by Ukpabi and Ndimele (1999) but more than 0.40 g/cm^3 (Abu *et al.*, 2006) in gari.

5.2.2 Swelling Power

Swelling power (*Sw*P), which is a vital parameter in characterisation of starches (Charles *et al.*, 2004) gives an indication of the strength of hydrogen bonding between the granules. Its nature and strength of the associate force between the granules (SafoKantanka and Acquistucci, 1996) determines starch quality, and hence suggests the swelling capacity of starchy foods and product.

Statistically, significant differences ($p<0.01$) were established between the varieties (Table 4.11). The result therefore shows that the bonding forces between the granules vary between varieties. That is, variation in the inherent qualities and/or genetic composition of the cassava varieties could pre-determine granules quality. The differences as observed in the swelling capacity of *gari* may signal non-covalent bonding between the molecules within the starch granules or differences in the character and strength of the micellar network with the granules (Rasper, 1969). Variation in the processing of gari did not statistically have a significant impact on the swelling power of *gari*. This outcome suggests that the differences in the values was greatly due to the varietal effect. Mean Swelling Power values due to the interaction effect ranged from 7.26 to 9.26 percent (Table 4.13). Eating quality (Moorthy, 2002) of food of very high significant starch composition is affected and characterised by this property.

A high swelling power which result in high digestibility and improvement of dietary properties suggests a relatively weak bonding forces of the granules as reported by Ajala *et al.* (2012).

It can hence be inferred that varieties of *gari* with varied Swelling Power values have different digestibility. In a different view, varieties of *gari* with low swelling power have a strong bonding force of granules and a possibly lower digestibility. Good quality gari as reported by Ingram (1975) and Almazan *et al.* (1987) should have swelling capacity of 3.0 – 5.0 volume increase.

The Swelling Power values of the processed *gari* samples were comparatively more than that defined as variations in cassava varieties greatly impact on the means due to this results. As such, consumes demand gari with good swelling power (Owuamanam *et al.,* 2011).

5.2.3 Water Absorption Capacity

Water Absorption Capacity (WAC) is also an important property or characteristic in the development of ready to eat food. It suggests the cohesiveness of a starch. Houson and Ayenor, (2002) studies on the functional properties of maize flour reported that high water absorption capacity assures product cohesiveness. This characteristic is an important indicator of whether protein can be integrated with an aqueous food formulation (Etudiaye *et al.,* 2009). The results showed that *gari* processed from *Ampong* and *Bankyehemaa* cassava had WAC mean values of same effect and insignificant ($p>0.01$) but varied ($p<0.01$) from that of *Bensre* variety. The outcome expresses a similarity in varieties developed from a common parental material or the varieties expressing qualities to the same degree unlike the *Bensre* variety. No variation ($p>0.01$) was recorded among gari samples due to the effect of the processing method. This explains that the ability of gari to absorb water depends mainly on the variety of cassava from which it is processed from. The varieties of *gari* assessed recorded mean WAC values that range from 5.40 to 7.90 ml/g in respect to the interaction effect. The variation was significant ($p<0.01$) and mainly due to the inherent quality of the root tubers in respect to genetic composition of the cassava varieties and not the influence of the processing procedures adopted. This strong WAC value may allow for new *mix gari* from cassava and protein rich legume composite.

5.3 PHYSICOCHEMICAL PROPERTIES OF GARI

5.3.1 pH

Variation in pH of gari as showed in Table 4.14 is due to varietal difference as a result of genetic composition. The method of processing also significantly affected pH of gari with the modern method influencing a high acidity in the product. The impact of the processing was clearly noted in the means pH values in respect to the interaction of the assessed factors. In a broad view, gari processing consist of peeling, washing and grating, fermentation and dewatering for not less than 48 hours and finally toasting (Nwancho *et al.*, 2014). Number of days or length of fermentation is a key which impact on pH values due to microbial activity. The effect is present in causing variation of pH due to difference in the processing methods. Sour taste of foods relates much to the acidity level. There is much indication that fermentation due to processing method varied. Hence, lowering the acidity of gari processed by using the orthodox method as samples influenced by its effect recorded the same pH of 5 compared to a relatively high value in ones processed by adopting the modern method. The results hence suggest that traditionally processed gari is of a better taste with minimal sourness. Samples with high acidity may have resulted from short fermentation period as prolong fermentation periods tend to lower acidity level.

5.3.2 Total Titratable Acidity (TTA)

Total Titratable Acidity (TTA) varied significantly ($p<0.01$) among the cassava varieties processed into gari. The variation was largely due to an inherent quality triggered by the genetic composition. According to a report, organic acids produced due to the activities of fermenting microorganisms native to fresh cassava and other organisms present at ambient temperature could influence increases in TTA (Oghenechawuko *et.al*, 2013). The effect of processing did influence a variation in the

TTA of gari with the orthodox method influencing a more level of TTA than the modern method. The result further explains that orthodox processing variables may have allowed for a more fermenting microbial activities. Yet the quantity in volume in all the gari samples is very low. That is, variation in the values of TTA due to the interaction effect ranged from 0.0059 to 0.0095%. The difference could be attributed to the combined effect of the factors. Volumes of TTA noted for gari samples from the three cassava varieties subjected to the traditional method varied unlike the modern method. *Bensre* and *Ampong* TTA showed same effect. It could be deduced that the modern gari processing method does not influence a more microbial fermentation activity acidity change in the total titratable acid of gari.

5.3.3 Total Soluble Solids (TSS)

The TSS of gari ranged from 0.20 to 1.15 ^{o} Brix (Table 4.16) with the ones processed by use of modern method generally containing a considerably high sugar level (1.00 – 1.15^{o} Brix) than gari processed by use of the orthodox method (0.20 – 0.90^{o} Brix). *Ampong* gari largely had low TSS of a varied effect as compared to *Bensre* and *Bankyehemaa* of similar quantity of same effect. The outcome indicates that TSS of gari may differ due to varietal variation and processing effect. Samples of gari with higher TSS could result from a sparsely fermenting microorganism activities which correlate much to low TTA values. The reverse is true for gari samples with low TSS.

5.3.4 Hydrocyanic Acid

Aqueous hydrogen cyanide also known as hydrocyanic or prussic acid is highly volatile, colourless and poisonous and inhibits cellular oxidative process (Carlisle, 1933). The level of hydrocyanic acid in the processed gari ranged from 16.04 – 26.86 mg/100 g or mg/0.1 kg (Table 4.16). This suggests and affirms that the cultivars are *sweet cassava* with limits $<$ 100 mg/kg hydrogen cyanide (Wheatley *et al.,* 1993). The result further informs that the levels in gari were within safe limits, insignificantly in their effect ($p>0.01$) with respect to the varietal effect (Table 4.14).

The processing methods adopted significantly varied in influencing variations ($p<0.01$) in the level of HCN acid in processed gari. That is, processing has the tendency of causing a change in hydrocyanic acid content depending on the processing method; example as seen in traditionally processed ones with comparatively lower quantities. The interaction of the factors also caused variation in the level of HCN acid in gari. The outcome of the results reflect much on the effect of the processing methods. That is, all the traditionally processed gari had a lower level of HCN acid as compared to the ones processed using the modern processing method.

5.4 SENSORY ATTRIBUTES OF GARI

Acceptability of *gari* based on likeness (as shown in Table 4.17) were largely influenced by the varietal difference and processing effect as these factors significantly influenced the aroma, colour, taste and texture for which the panelists based their scores on. These sensory attributes impacted on the overall acceptability of *gari.* That is, consumers' satisfaction of gari based on the attributes may vary with variation in cassava varieties and impact of the processing procedures as these largely affect the quality of the product. Further analysis in assessing if the physicochemical properties influenced the preferences of panelist showed no significance except pH, which had a positive correlation on aroma and colour. This suggests that higher pH values may influence the likeness or preferences of varied *gari* products in terms of aroma and colour.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

The findings of the study were:

- The proximate components analyzed varied due to both genetic variation of cassava varieties and processing methods.
- The effect of cassava varieties caused variation among the physicochemical properties (pH, Total Titratable Acidity and Total Soluble Solids), except Hydrocyanic acid which was significantly not different.
- The processing methods adopted caused significant difference ($p<0.01$) in the proximate components except percentage fat and fibre which were not significantly different.
- All the three cassava varieties processes through the traditional method had lower levels of Hydrocyanic acid (i.e. less toxic) as compared to the modern processing method.
- The interaction of variety and processing method caused significant variation ($p<0.01$) among carbohydrate, protein and ash contents. However, fat and fibre contents were significantly not different from each other.
- Processing methods used did not cause any significant variation ($p>0.01$) among the functional properties (Water Absorption Capacity, Swelling Power and Bulk Density)
- The effect of variety and processing method interaction influenced significant difference ($p<0.01$) among the functional properties.

- *Bankyehemaa* gari produced by the modern method had the highest carbohydrate and protein contents, and the least recorded in *Ampong* and *Bensre* gari processed by the modern and traditional methods respectively.

- No significant correlations ($p>0.01$) was found among the physicochemical and sensory evaluation of *gari* except pH, which impacted on Hydrocyanic acid, aroma and colour.
- The overall acceptability from sensory evaluation showed that *Bankyehemaa's* gari was the most preferred, irrespective of the processing method.

6.2 RECOMMENDATIONS

The following recommendations could be made based on the findings of this study.

- Among the three cassava varieties studied, *Bankyehemaa* is recommended as the most suitable variety for gari due to the high level of carbohydrate, fat and protein as well as the low level of cyanide (HCN).
- It is also recommended that the traditional method be used for producing gari which is safer for human consumption, considering the good physicochemical properties (Hydrocyanic acid and pH) of all the three varieties.
- Further research on the topic should be carried out in a different location using different varieties so as to compare the result of the physicochemical properties analyzed in this study.
- 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.

REFERENCES

Abu, J.O., Badifu, G.I.O and Akpapunam, M.A. (2006). Effect of crude palm oil inclusion on some physico-chemical properties of gari- a fermented cassava food product. *Nigerian Food Journal* 24(1):73-79.

Ajala L.,Otutu, O.L. and Bangbose, A. (2012). Effect of delayed processing on some physicochemical properties of cassava starch. *Am. J. Food Nutr*. 2(2): 31-36 **Almazan, A. M; Hahn, S.K. Mahanga, N.M. and Yamachi, Y. (1987)**.

Production of Cyanide during processing of cassava into some traditional African Food. *Journal of Science Food Agric:* 11-15.

Amaner, D.R. (2011). Growth partitioning of crops in West Africa. pp 30-32

Anderson, J. M and Igram J.S. I. (1993 b). Tropical Soil Biology and Fertility; A handbook of methods. Second edition. CAB International. Wallingford, UK. Page 37.

AOAC, (1995) Official Method of Analysis of the Association of Official Analytical Chemists. Vol. 1 and 2, 16th edition, ***Editor P. Cunniff***, Published AOAC International, Arlington, Verginia

Arko H, and Kelly, S. (2001). Cassava Our Crop II. Pages 100-102.

Ashaye, O.A, Couple, A.A, Fasoyiro, S.B, Adeniji A.M. (2005). Effect of location and Storage Environment on the Quality Attributes of gari in South-West Nigeria. *World J AgriSci* 1: 52-55.

Ayankumbi, M.O. Keshinro and P. Egele, 1991. The effect of different methods of nutrient Composition on some cassava food product, Gari (eba), Lafun and fufu. Food Chem., 41:349-354.

Benesi, I.R.M., (2002): Native starch evaluation and analysis of genetic distance using AFLP of elite cassava (*Manihot esculenta* Crantz) genotype from Malawi. MSc Thesis in Plant Breeding, Department of Plant Sciences (Plant Breeding), Faculty of Natural and Agricultural, University of Free State, Bloemfontein, South Africa.

Bokanga, M (1994). Distribution of Cyanogenic potential in cassava germ plasm, in Proceeding Workshop on Cassava Safty (Bokanga M; Esser, A.J.A; Poulter N; Roseling. H and Tewe, O. (Eds) 1st - 4th March, Ibadan, Nigeria, Acta Holt.375; 117-123.

Carlisle, P.J. (1933). Manufacture, handling, and use of hydrocyanic acid. *Ind. Eng. Chem.*, 25(9): 959-964. DOI: 10.1021/ie50285a003.

Charles A.L, Chang Y.H, Ko W.C, Sriroth K, Huang T.C. (2004). Some physical and chemical properties of isolates of cassava genotypes. Starch/starke 54:413418.

Charles A.L, Sriroth K, Huang T.C. (2005). Proximate composition, mineral contents, hydrogen cyanide and phytic acid of five cassava genotypes. Food Chem. 92:615-620.

Chika C.O., Chisom E., Owuamanam, C.I., Ihuoma, A. and Ijeoma A.O. (2013). Quality characteristics and HCN in gari as affected by fermentation variables. *Intl. J. Life Sci.* 2(1): 2128

Dorosh, P. (1988). The economics of root and tuber crops in Africa. Resource and crop management programme monograph No.1. International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria.

Duke R.T (2013). Causes of low yield by cassava farmers. Pages 20-22.

Egesi C, Okogbenin E, Mbanaso, E. and Fregene, M. 2006. Development of cassava varieties with high value root quality through induced mutations markeraided breeding. NRCRI, Umudike Annual Report 2006:2-6.

Ekwu, F.C. and C. Ehirim, (2008). Comparative evaluation of gari samples produced from Fresh cassava roots and dried cassava chips. *Nigerian Food J.*, 26 (2): 60-68.

Ekwu, F.C., Ngoddy P.O. and Uvere P.O. (2011). Functional and rheological properties of cassava flour processed by adaptation of traditional 'abacha' processing technology. *JORMAR* 6(1): 17 – 30

El-Sharkawy, M. A. (2003). Cassava biology and physiology. Plant Mol., Biol. 53:621-641. Ernesto, M; Cardoso, A. P; Cliff, J and Bradbury, J. H. (2002).Cyanogens in cassava flour and roots urinary thiocyanate concentration in Mozambique. Journal of Food Composition Analysis. 13:1-12.

El-Sharkawy, M.A. (2004). Cassava biology and physiology. Plant Mol. Biol., 56:481501.Pages 202-206.

Ernesto, M; Cardoso, A. P; Cliff, J and Bradbury, J.H. (2002). Cyanogens in cassava flour and roots urinary thiocyanate concentration in Mozambique. Journal of Food Composition Analysis. 13:1-12.

Etudaiye, H.A. Nwabueze T.U. and Sanni L.O (2009). Quality of fufu processed from cassava mosaic diseases (CMD) resistant varieties. *Africa Journal of Food Science*. 3(3): 061- 067

FAO, (2013). Cassava Processing and Utilization. Public journal vol. no.55. Pages 6668.

Flach. M. (1990). Gari processing in North West province of Cameroun. Working document No.5, FAO project.

Fokunang, C.N., Akem, C.N., Ikotum, T and Dixon, A. G.O (1999b). Effect of planting season on cassava anthracnose disease development. Crop Prot., 18: 407-413.

Gregory, K.F., Reae, A.E., Khor, G.L., Alexander, J.C., Lumsden, J.H. and Losos, G, (1976).Conversion of carbohydrate to protein byhigh temperature fungi. *Journal of Food Technology*. 30 (3): 30

Hahn, S.K (1988): Overview of traditional processing and utilization in Africa. In: Hahn, S.K., L. Reynolds and G.N. Egbunike (eds). Proceedings of workshop on the potential utilization of cassava as livestock feed in Africa, Ibadan, Nigeria. IITA/ILCA/Univ. pp. 16-27.171.

Hahn, S.K; 1998. An overview of African traditional cassava processing and utilization. Outlook Agric., 18:110-118.

Housson, P. and Ayenor, G.S. (2002). Appropriate processing and food functional properties of maize flour. *Afr. J. Sci. Technol*. 3(1): 121-126.

Ibe, D.C., (1981). Semi Mechanized Gari Processing for Rural Communities in Nigeria. In: Terry E.R., K.A. Oduro and E. Caveness, (Eds.), Tropical Root Crops: Research Strategies, for the 1980s. International Society for Tropical Root Crops. African Branch, Ibadan, pp: 159.

Ihekoronye, A.I and P.O Ngoddy, 1985. Integrated Food Science and Technology for the Tropics. Macmillian Press, London, U.K, pp: 189-241.

IITA, (2001): Cassava. IITA/ Crops. International Institute of Tropical Agriculture (1982). Annual Report for 1981. Ibadan, Nigeria.

Ingram, J. S. (1975). Standard, specification and quality requirement for processed cassava products. Reports of Tropical Development and Research Institute

James, B., Okechuku, R., Abass, A., Fannah, S., Maziya-Dixton, B., Sanni, L., Osei-Sarfoh, A., Fomba, S. and Lukombo, S. 2012. Producing Gari from Cassava: An illustrated guide for small holder cassava processors. International Institute of Tropical Agriculture (IITAA): Ibadan, Nigeria.

Joslyn, M.A. (1970). *Methods in Food Analysis, 2nd Edition*. Academic Press, London. p 67

Julie A.M, Christopher R.D, Sherry A.T. (2009). Nutritional value of cassava for use as staple food and recent advances for improvement. Institute of food technologists. Comprehensive review in food science and food safety. 8:181-192.

Lazano, J.C., A.C. Bellotti, J.A. Reyes, R.H. Howland, D. Leihner and J. Dol, 1981. Field Problems in Cassava. CIAT Cali, Columbia, pp: 16-25.

Lazano, J.C., Byme D. and Belloti, A. (1980). Cassava and ecosystem relationships and heir influence on breeding strategy. *Tropical Pest Management* 26:180-187.

Legg, J., Whyte, J., Kapinga, R. and Teri, J. (2005). Management of the Cassava Mosaic Disease Pandemic in East Africa. In: Whitefly and Whitefly-Borne Viruses in the Tropics: Building a Knowledge Base for Global Action. Tropical Whitefly Project. ISBN: 958 694 074 8

Lynam, J., (1993): Potential impact of biotechnology on cassava production in the third world. In: Roca W.M. and A.M. Thro (eds). Proceeding of the first International Scientific Meeting of Cassava Biotechnology Network. 25-28 August 1992. Cartegena, Colombia. pp. 22-30.

Makanjuola, O.M., Ogunmodede, A.S., Makanjuola, J.O. and Awonorin, S.O. (2012). Comparative study on quality attributes of gari obtained from some processing centres in South West, Nigeria. *Adv. J. Food. Sci. Technol*., 4(3): 135140.

Mkumbira, J., (2002): Cassava development for small scale farmers: approaches to breeding in Malawi, Doctorial thesis. Swedish University of Agricultural Sciences, Uppsala, Sweden, Acta Universitatis Agriculturae Sueciae. Agaria 365, Tryck: SLU Service/Repro, Uppsala 2002.

Moorthy, S. (2002). Tuber crop starches. Tech Bulletin No. 18. CTCRI, Trivandrum.

Nassar, N.M.A., (2005): Cassava: Some ecological and physiological aspects related to plant breeding. An article published online with *Gene Conserve*.URL http:/www.geneconserve.pro.br/.

Nwancho, S.O., Ekwu, F.C., Mbgebu, P.O., Njoku, C.K. and Okoro, C. (2014). Effect of Particle size on the functional, pasting and textural properties of gari produced from fresh cassava roots and dry chips. *International Journal of Engineering and Science (IJES)*. 3(3): 50-55.

Nweke, F.I., Spencer, D.S.C and Lynam, K. J. (2002). The Cassava Transformation (Africa'sBest-kept secret). Michigan State University Press, East Lansing USA, pp 7-207. Official methods of analysis of AOAC International, 16th edition. Volume 1.

Obilie, E. M., Tano – Debrah, K., Amoa- Awua, W. K. (2004). Souring and breakdown of cyanogenic glucoside during the processing of cassava into akyeke. International Journal of Food Microbiology. 93: 115-1212

Oghenechawuko, U.E., Saka, G.O., Adekunbi, T.K. and Taiwo, A.C. (2013).Effect of processing on the physico-chemical properties and yield of gari from dried chips. *J. Food Process Technol.* 4(8): 255. doi: 10.4172/21577110.1000255

Oluwole, O.B, Olatunji, O.O., Odunfa, S.A. (2004). A process technology for conversion of Dried cassava chips into gari. *Nigerian Food Journal* 22: 65-77.

Onwueme, J.C. (1978): The Tropical Tuber Crops: Yams, Cassava, Sweet potato, Cocoyam. John Wiley and Sons Ltd. pp.234.

Onyeagba, R.A., R.P. Unamma and A. Enyinnia, 1978. Effects of duration of weed Interference and intercropping on incidence and severity of cassava anthracnose disease in cassava, yam, maize intercrop. J. Plant Prot. Trop., 5: 51-54.

Owuamanam, C.I., Ogueke, C.C., Achinewhu, S.C. and Barimalaa, I.S. (2011). Quality characteristics of gari as affected by preferment liquor, temperature and duration of fermentation. *Am. J. Food Technol*., 6(5): 374-384.

Rasper, V. (1969). Investigations on starches from major starch crops grown in Ghana II: Swelling and solubility patterns and amylo-elastic susceptibility. *J. Sci. Food Agric*. 20: 642-646.

Safo-Kantanka, O. and Acquistucci, R. (1996). The physicochemical properties of cassava starch in relation to the texture of the cooked root. *Ghana J. Agric. Sci.* 28(29): 69-80.

Saidou T.K. (2004). Global assessment of cassava growth and yield. Page 50-55.

Sanni, L.O., Ikumola D.O., Sann S.A (2001). Effect of length of fermentation and varieties on the qualities of sweet potato gari. Proceedings of the 8th triennial symposium of the International Society for Tropical Root Crop, African Branch (ISTRC-AB) (Akorada M.O), IITA, Ibadan, Nigeria. 12-16 November, 2001. Pp 208-211

Scott G, Rosegrant M.W, Ringer C. (2000). Roots and Tubers from the 21st Century: Trends, Projections and Policy Options. Food, Agriculture and Environment Discussion paper 31. International Food Policy Research Institute (IFPRI) and International Potato Centre (CIP); Washinton, DC 2000; 64

Seif, A.A. (1982). Effect of cassava mosaic virus on yield of cassava. Plant Disease Reporter 66 (8): 661-662.

Taiwo, K.A., Okesola C.O. (2009). A study of some processing factors on the production of Gari (A fermented product) from dehydrated Cassava Chips. AICHE.

Udofia, P.G, Udoudo, P.J., Eyen N.O., Udoekong N.S. (2010). Optimizing gari quality attributes for different groups of consumers with response surface methodology. *J AgriBiotechnol Sustain Develop* 3: 28-34.

Udoro, E.O., Kehinde, A.T., Olasunkanmi, S.G., Charles, T.A. (2014). Studies on the Physicochemical, Functional and Sensory Properties of Gari Processed from Dried Cassava Chips. *J Food Process Technol* 5: 293. doi: 10.4172/21577110.1000293.

Ukpabi, U.I. and Ndimele, C. (1999). Evaluation of the quality of gari produced in Imo State, Nigeria. *Nigerian Food Journal* 8:105-110

Wheatly, C.C., Orrego, J.K., Sanchez, T. and Granados, E. (1993). Quality evaluation of cassava core collection at CIAT. In: Roca, W.M. and Thro, A.M. (eds). *Proceedings of the First International Scientific Meeting of the Cassava Biotechnology Network.* CIAT, Cartagena, Colombia, pp. 255-264.

Wingertzahn, M.A., Teichberge S. and Wapnir R.A. (1999). Starch production in cassava. Pages 51-66.

www.theafricareport.com/West-africa/ghana.

Yan H.M, Pottus R.J and Fynn Y.K. (2001). Diseases and Pests response of Cassava in the derived savanna zone. Pages 40-44.

APPENDICES

APPENDIX I: QUESTIONNAIRE FOR THE ASSESSMENT OF THE EFFECT OF VARIETY AND PROCESSING METHODS ON THE PHYSICOCHEMICAL AND SENSORY PROPERTIES OF GARI IN THREE DISTRICTS OF THE BRONG AHAFO REGION.

QUESTIONNAIRE FOR FARMERS

PART A: PERSONAL DATA

1. What is the name of this community? ....

2. Age of respondent ………………………………………………………..

3. Gender of respondent: (tick)

   A. Male [ ]

   B. Female [ ]

4. Marital status :(tick)

   A. Married [ ]

   B. Single [ ]

5. Religion:

A. Christian [ ]

B. Moslem [ ]

C. Traditionalist [ ]

D. Others………………………………………………… (Specify)

6. What is your main occupation?

A. Farming [ ]

B. Others……………………………………………. (Specify)

7. Have you had any formal education? (tick)

A. Yes [ ]

B. No [ ]

8. If yes, what is your educational level?

A. Primary [ ]

B. Middle/J H S/S H S [ ]

C. Tertiary [ ]

D. Others………………………………………………… (Specify)

PART B: CHALLENGES OF CASSAVA PRODUCTION

9. How did you acquire the land on which you farm?

A. Family land [ ]

B. Purchase [ ]

C. Hired [ ]

D. Others…………………………………………… (Specify)

10. Do you face any problem in acquiring land for cassava production? (tick)

A. Yes [ ]

B. No [ ]

11. If yes, what is/are the problem(s)?

…………………………………………………………………………………………
…………………………………………………………………………………………

12. What is the size of your farm? (In acres) ………………………………………

13. Do you do any other work apart from farming? (tick)

A. Yes [ ]

B. No [ ]

14. If yes, what is the other work that you do?

....

....

15. How long have you been in cassava production?

A. 0-5 years [ ]

B. 6-10 year [ ]

C. 11- 15 years [ ]

D. over 15 years ……………………………………….(Specify)

16. Do you get fair producer prices for your fresh cassava? (tick)

A. Yes [ ]

B. No [ ]

17. Do you face any challenge(s) in producing cassava? (tick)

A. Yes [ ]

B. No [ ]

18. If yes, what is/ are the challenge(s)?

....

…………………………………………………………………………………………

19. How is/ are the challenge(s) being addressed?

....

……………………………………………………………………………………………

PART C: SOURCE OF FINANCE AND TECHNICAL ASSISTANCE

20. What is the source of income for your farming activities?

A. Personal savings [ ]

B. Loans [ ]

C. Government support [ ]

D .Others ………………………………………………………………… (Specify)

21. Do you belong to any Farmers' co-operative? (tick)

A. Yes [ ]

B. No [ ]

22. If yes, do you receive any form of assistance from the co-operative? (tick)

A. Yes [ ]

B. No [ ]

23. If yes, what form of assistance do you get?

……………………………………………………………………………………………

24. Have you ever received any technical assistance from Agricultural Extension Agents (AEA's)? (tick)

A. Yes [ ]

B. No [ ]

25. If yes, what assistance did you receive? ....

……………………………………………………………………………………………

26. Do you apply the new knowledge given by AEAs? (tick)

A. Yes [ ]

B. No [ ]

27. Give reason for your answer…………………………………………………

PART D: AGRONOMIC PRACTICES

28. What is the source of your planting materials?

A. Self [ ] B.

Friends and relatives [ ]

C. MoFA [ ]

D. Others……………………………………………………… (Specify)

29. What variety do you cultivate?

…………………………………………………………………………………………

30. Has any improved cassava variety been introduced to you? (tick)
A. Yes [ ]

B. No [ ]
31. If yes, state the new

variety /varieties ……………………………………………………..……………..

32. Did you use recommended spacing? (tick)

A. Yes [ ]

B. No [ ]

33. Did you apply fertilizer to your cassava plants? (tick)

A. [ ]

B. No [ ]

34. If yes, what type of fertilizer did you use? (tick)

A. Organic [ ]

B. Inorganic [ ]

C. Both [ ]

PART E: PESTS AND DISEASE CONTROL

35. How did you control weeds in your farm before harvesting your cassava?

A. Manual weeding [ ]

B. Chemical [ ]

C. Cultural [ ]

D. Others………………………………………………………… (Specify)

36. How many times did you control weeds in the season?

....

37. Did you control any pests on your farm? (tick)

A. Yes [ ]

B. No [ ]

38. If yes, what specific pest is normally found? ....

39. What method of pest control did you use?

A. Biological [ ]

B. Physical [ ]

C. Chemical [ ]

D. Others ……………………………………………………… (Specify)

40. Has your cassava been attacked before by any disease(s) before? (tick)

A. Yes [ ]

B. No [ ]

41. If yes, mention the disease(s)/symptom(s) you observed

………………………………………………………………………………………

PART F: COST BENEFIT ANALYSIS

42. Do you employ labour for your farming activities? (tick)

A. Yes [ ]

B. No [ ]

43. If no, why? ....

44. If yes, what type of labour do you employ? (tick)

A. Casual [ ]

B. Permanent [ ]

45. How much do you pay each worker per day? ....

46. What is the estimated cost of other production inputs spent on one acre of farm during the growing season?...

47. What is the selling price of cassava harvested from one acre of farm?

....

48. Do you make profit from the sale of your fresh cassava? (tick)

A. Yes [ ]

B. No [ ]

49. If yes, how much profit do you make on the sale of cassava from one acre farm?

....

50. If no, what is/are the cause(s) of the loss you incur?

....

……………………………………………………………………………………

51. What do you think you can do to avoid running at a loss?

…..

THANK YOU.

cassava

QUESTIONNAIRE TO GARI PROCESSORS

PART A: PERSONAL DATA.

1. What is the name of this community? ....

2. Age of respondent…………………………………………………………..

3. Gender of respondent: (tick)

   A. Male [ ]

   B. Female [ ]

4. Marital status: (tick)

   A. Married [ ]

   B. Single [ ]

5. Religion:

   A. Christian [ ]

   B. Moslem [ ]

   C. Traditionalist [ ]

   D. Others (Specify) …………………………………………………………..

6. What is your main occupation?

   A. Farming [ ]

   B. Others (Specify)………………………………………………………….

7. Have you had any formal education? (tick)

   A. Yes [ ]

   B. No [ ]

8. If yes, what is your educational level?

   A. Primary [ ]

   B. Middle/J H S/S H S [ ]

C. Tertiary [ ]

D. Others…………………………………………………………… (Specify) ***PART B: SOURCE OF RAW MATERIALS***

9. How do you get raw materials (fresh cassava) for your processing?

A. Buy directly from farmers [ ]

B. Buy from middlemen [ ]

C. Buy through agents [ ]

D. Others………………………………………………………… (Specify)

10. Do you get enough quantities of fresh cassava for processing? (tick)

A. Yes [ ]

B. No [ ]

11. If no, what is/are the reason(s)…………………………………………………

12. What variety/varieties do you usually buy for processing?

(i)…………………………………………………………………………………

(ii)…..…………………………………………………………………………...

13. Does the variety affect the quality of gari you process? (tick)

A. Yes [ ]

B. No [ ]

14. If yes, how is the quality affected?

....

……………………………………………………………………………………

15. How did you convey your fresh cassava tubers to the house?

A. Head [ ]

B. Motor king [ ]

C. Vehicle [ ]

D. Others ……………………………………………………… (Specify)

16. Did you observe any mechanical damage on your cassava with the transportation method you used? (tick)

A. Yes [ ]

B. No [ ]

17. If yes, you think the damage caused to the fresh cassava affected the quality of the gari? (tick)

A. Yes [ ]

B. No [ ]

18. Do you process any other product apart from gari? (tick)

A. Yes [ ]

B. No [ ]

19. If yes, name the product

………………………………………………………………………………………..

20. State any two problems you encounter in gari processing

(i)……………………………………………………………………………………

(ii)……………………………………………………………………………………

PART C: VARIETY, PROCESSING METHODS AND STORAGE OF GARI

21. What variety do you normally use for processing gari? (tick)

A. Local [ ]

B. Improved/exotic [ ]

22. Name the variety/varieties you often use

………………………………………………...

23. Does the variety you use affect the quality of the gari produced? (tick)

A. Yes [ ]

B. No [ ]

24. If yes, how is the quality affected?

....

25. How long do you keep the fresh cassava before they are processed? (tick)

A. 1 to 2 days [ ]

B. 3 to 4 days [ ]

C. 5 to 6 days [ ]

D.7 days and above [ ]

26. Does the duration of storage affect the quality of gari processed? (tick)

A. Yes [ ]

B. No [ ]

27. If yes, how is the quality affected?

....

28. Are you a small scale or a commercial processor of gari? (tick)

A. Small scale processor [ ]

B. Commercial processor [ ]

29. What processing method(s) do you use?

A. Traditional [ ]

B. Modern [ ]

C. Both [ ]

D. Others ……………………………………………………… (Specify)

30. If you use the traditional method of gari processing, how long do you press the grated cassava to allow fermentation to occur? (tick)

A. 4 days [ ]

B. 5 days [ ]

C. 6 days [ ]

D. 7 days and above [ ]

31. If you process gari through the modern method, how long do you press the grated cassava to allow fermentation to occur? (tick)

A. 2 days [ ]

B. days [ ]

C. 4 days [ ]

D. 5 days [ ]

32. With the processing method you use, does the duration of fermentation affect the quality of gari produced? (tick)

A. Yes [ ]

B. No [ ]

33. If yes, how is the quality of the gari affected?

....

34. Do you store your gari after processing for sometime before they are sold? (tick)

A. Yes [ ]

B. No [ ]

35. If yes, how long do you store it?

....

36. Do you think the duration of storage can affect the quality of the gari? (tick)

A. Yes [ ]

B. No [ ]

37. If yes, how is the quality affected?

....

....

PART D: COST BENEFIT ANALYSIS

38. What quantity of cassava do you normally use for each processing? ....

39. What is the cost of that quantity of cassava you buy for processing?

....

40. How much do you pay for transporting the cassava from the farm to the processing centre?

……………………………………………………………………………………………

41. What source of heat do you use for roasting your gari?

A. Firewood [ ]

B. Charcoal [ ]

C. L P G [ ]

D. Others……………………………………………................. (Specify)

42. How much do you spend on fuel for each processing? ....

43. How many workers do you usually employ for each processing? ....

44. How much money do you pay each worker per day?

....

45. What is the estimated cost of other processing inputs or materials you use?

....

46. Do you have your own processing facility? (tick)

A. Yes [ ] B.

No [ ]

47. If yes, how did you acquire the land for your facility?

A. Hired [ ]

B. .Family owned [ ]

C. Purchase [ ]

D. Others ………………………………………………………… (Specify)

48. If no, do you have any processing facility in your community which you use? (tick)

A. Yes [ ]

B. No [ ]

49. If yes, how much are you charged for using the processing facility in the community?

....

50. How much money do you get from the sale of gari you process?

....

51. Do you make profit at the end of each processing? (tick) A. Yes [ ]

B. No [ ]

52. If yes, how much profit do you make?

....

53. If no, how much loss do you incur?

....

54. What is/are the reasons of incurring loss?

(i)…………………………………………………………………………………

(ii)…………………………………………………………………………………

55. What do you think can be done to avoid loss?

....

……………………………………………………………………………………..

THANK YOU

QUESTIONNAIRE TO GARI SELLERS

PART A: PERSONAL DATA.

1. What is the name of this community? ....

2. Age of respondent…………………………………………………………………….

3. Gender of respondent: (tick)

A. Male [ ]

B. Female [ ]

4. Marital status :(tick)

A. Married [ ]

B. Single [ ]

5. Religion:

A. Christian [ ]

B. Moslem [ ]

C. Traditionalist [ ]

D. Others …………………………………………………………… (Specify)

6. What is your main occupation?

A. Farming [ ]

B. Others ……………………………….. (Specify)

7. Have you had any formal education? (tick)

A. Yes [ ]

B. No [ ]

8. If yes what is your educational level?

A. Primary [ ]

B. Middle/J H S/S H S [ ]

C. Tertiary [ ]

D. Others ………………………………………………………… (Specify)

PART B: STORAGE AND MARKETING OF GARI

9. Where do you buy your gari for sale?

A. Processors [ ]

B. Middlemen [ ]

C. market [ ]

D. Others ……………………………………………………… (Specify)

10. Does the gari you buy have the qualities you need? (tick)

A. Yes [ ]

B. No [ ]

11. Do you store your gari for sometime before they are sold? (tick)

A. Yes [ ] B. No [ ]

12. If yes, how long do you store the gari before they are sold?

....

13. How is the gari stored?

A. Bagging [ ]

B. In plastic containers [ ]

C. In polythene bags [ ]

D. Others ……………………………………………… (Specify)

14. Do you think your method of storage affect the quality of gari? (tick)

A. Yes [ ]

B. No [ ]

15. If yes, give one reason

………………………………………………………………………………………

16. Which method would you have chosen if you have the chance?

A. Bagging [ ]

B. In plastic containers [ ]

C. In polythene bags [ ]

D. Others ………………………………………………………… (Specify)

17. How do you sell your gari?

A. Whole sale [ ]

B. Retail [ ]

C. Others ………………………………………………………… (Specify)

18. Do you get fair prices for your product? (tick)

A. Yes [ ]

B. No [ ]

19. Do you find the marketing system convenient? (tick)

A. Yes [ ]

B. No [ ]

20. If no, give reason(s)...

....

21. What quantity of gari do you buy from the processors in a week?

………………………………………………………………………………………

22. Do you get the required quantities to buy from the processors? (tick)

A. Yes [ ]

B. No [ ]

23. If no, what do you think is/are the reason(s)?

....

………………………………………………………………………………………

PART C: COST BENEFIT ANALYSIS AND MARKET RESPONSE

24. On the average, what quantity of gari are you able to sell every week?

....

25. What measure do you use to sell the product?

....

26. How many measures do you get out of the quantity of gari you purchase?

....

27. What is the price per measure?

....

28. What is the weight of the measure used to sell the gari?

....

29. Do you make profit from the sale of the gari?

....

30. If yes, how much profit do you make?

....

31. Do you sell packaged product? (tick)

A. Yes [ ]

B. No [ ]

32. If yes, what is the weight of packaged gari (in kg)

………………………………………………..

33. How much is the pack sold? ....

34. Do you receive any complaints from your consumers after they buy your gari?

A. Yes [ ]

B. No [ ]

35. If yes, what complaints do you normally receive from the consumers?

………………………………………………………………………………………

………………………………………………………………………………………

36. What can you do to address their complaints?

………………………………………………………………………………………

37. How are the prices of gari determined?

A. By demand and supply [ ]

B. By producers [ ]

C. By buyers [ ]

Total 17 0.66755

D. Others …………………………………………………………… (Specify)

38. What processing method(s) does your supplier use? (tick)

A. Traditional method [ ]

B. Modern method [ ]

C. Both [ ]

39. Does the processing method(s) used affect the quality of the gari you purchase? (tick)

A. Yes [ ]

B. No [ ]

THANK YOU.

APPENDIX II: ANOVA TABLES

PROXIMATE COMPOSITION OF GARI

Analysis of Variance Table for Ash

Source	DF	SS	MS	F	P
Reps	2	0.08251	0.04126		
Variety	2	0.17138	0.08569	9.36	0.0051
Proc Met	1	0.10850	0.10850	11.85	0.0063
Variety*Proc Met	2	0.21361	0.10680	11.67	0.0024
Error	10	0.09155	0.00915		

Grand Mean 0.7132   CV 13.42

Analysis of Variance Table for CHO

Source	DF	SS	MS	F	P
Reps	2	2.280	1.1399		
Variety	2	91.421	45.7104	40.63	0.0000
Proc Met	1	25.585	25.5851	22.74	0.0008
Variety*Proc Met	2	32.347	16.1734	14.38	0.0011
Error	10	11.250	1.1250		
Total	17	162.883			

Grand Mean 87.538   CV 1.21

Analysis of Variance Table for Fat

Source	DF	SS	MS	F	P
Reps	2	0.00111	0.00056		
Variety	2	0.07111	0.03556	1.41	0.2888
Proc Met	1	0.14222	0.14222	5.64	0.0390
Variety*Proc Met	2	0.07111	0.03556	1.41	0.2888
Error	10	0.25222	0.02522		
Total	17	0.53778			

Grand Mean 0.5889   CV 26.97

Analysis of Variance Table for Fibre

Source	DF	SS	MS	F	P
Reps	2	0.7756	0.38780		
Variety	2	3.8062	1.90309	3.59	0.0669
Proc Met	1	2.7028	2.70281	5.10	0.0476
Variety*Proc Met	2	4.6178	2.30889	4.35	0.0437
Error	10	5.3040	0.53040		
Total	17	17.2064			

Grand Mean 2.2658   CV 32.14 **Analysis of Variance Table for Moisture**

Source	**DF**	**SS**	**MS**	**F**	**P**
Reps	2	0.0858	0.0429		
Variety	2	54.5625	27.2812	112.77	0.0000
Proc Met	1	21.4513	21.4513	88.67	0.0000
Variety*Proc Met	2	10.5625	5.2813	21.83	0.0002
Error	10	2.4192	0.2419		
Total	17	89.0813			

Grand Mean 6.5083   CV 7.56

Analysis of Variance Table for Protein

Source	**DF**	**SS**	**MS**	**F**	**P**
Reps	2	0.00043	0.00022		
Variety	2	4.06887	2.03444	22110.1	0.0000
Proc Met	1	0.07834	0.07834	851.42	0.0000
Variety*Proc Met	2	0.67200	0.33600	3651.60	0.0000
Error	10	0.00092	0.00009		
Total	17	4.82056			

Grand Mean 2.7535   CV 0.35

PHYSICOCHEMICAL PROPERTIES

Analysis of Variance Table for HCN_A

Source	**DF**	**SS**	**MS**	**F**	**P**
Reps	2	0.016	0.008		
Variety	2	8.856	4.428	1.56	0.2582
Proc Met	1	369.376	369.376	129.73	0.0000
Variety*Proc Met	2	6.354	3.177	1.12	0.3652

Error	10	28.472	2.847
Total	17	413.074	

Grand Mean 20.505   CV 8.23

Analysis of Variance Table for pH

Source	DF	SS	MS	F	P
Reps	2	0.04333	0.02167		
Variety	2	3.00000	1.50000	69.23	0.0000
Proc Met	1	0.50000	0.50000	23.08	0.0007
Variety*Proc Met	2	1.00000	0.50000	23.08	0.0002
Error	10	0.21667	0.02167		
Total	17	4.76000			

Grand Mean 4.5000 CV 3.27

Analysis of Variance Table for TSS

Source	DF	SS	MS	F	P
Reps	2	0.00083	0.00042		
Variety	2	0.61750	0.30875	127.76	0.0000
Proc Met	1	0.91125	0.91125	377.07	0.0000
Variety*Proc Met	2	0.27750	0.13875	57.41	0.0000
Error	10	0.02417	0.00242		
Total	17	1.83125			

Grand Mean 0.8583 CV 5.73

Analysis of Variance Table for TTA

Source	DF	SS	MS	F	P
Reps	2	8.802E-07	4.401E-07		
Variety	2	1.758E-05	8.788E-06	199.27	0.0000
Proc Met	1	5.363E-06	5.363E-06	121.59	0.0000
Variety*Proc Met	2	5.427E-06	2.713E-06	61.52	0.0000
Error	10	4.410E-07	4.410E-08		
Total	17	2.969E-05			

Grand Mean 7.10E-03 CV 2.96 **FUNCTIONAL PROPERTIES**

Analysis of Variance Table for Bulk Density

Source	DF	SS	MS	F	P
Reps	2	0.00001	0.00001		
Variety	2	0.02974	0.01487	33.89	0.0000
Proc Met	1	0.00020	0.00020	0.46	0.5149
Variety*Proc Met	2	0.01703	0.00852	19.41	0.0004
Error	10	0.00439	0.00044		
Total	17	0.05138			

Grand Mean 0.6989 CV 3.00

Analysis of Variance Table for Swelling Power

Source	DF	SS	MS	F	P
Reps	2	0.10453	0.05227		
Variety	2	5.49813	2.74907	70.56	0.0000
Proc Met	1	0.00109	0.00109	0.03	0.8706
Variety*Proc Met	2	1.65564	0.82782	21.25	0.0003
Error	10	0.38960	0.03896		
Total	17	7.64900			

Grand Mean 8.1367 CV 2.43

Analysis of Variance Table for WAC

Source	DF	SS	MS	F	P
Reps	2	0.0033	0.00167		
Variety	2	2.7900	1.39500	78.96	0.0000
Proc Met	1	0.1250	0.12500	7.08	0.0239
Variety*Proc Met	2	10.7500	5.37500	304.25	0.0000
Error	10	0.1767	0.01767		
Total	17	13.8450			

Grand Mean 6.3500 CV 2.09

APPENDIX III: SENSORY CORRELATION TABLE

Correlations (Pearson)

	BkD	SPw	WAC	PH	TTA	TSS	HCN_A
SPw	-0.6630						
P-VALUE	0.1513						
WAC	-0.3066	0.7365					
	0.5545	0.0950					
PH	0.0960	0.0106	-0.0956				
	0.8565	0.9841	0.8570				
TTA	0.6876	-0.8672	-0.6524	0.4505			
	0.1312	0.0253	0.1603	0.3700			
TSS	0.0513	0.0010	0.3034	-0.7103	-0.2036		
	0.9231	0.9985	0.5588	0.1137	0.6989		
HCN_A	-0.0944	0.0504	0.0503	-0.9808	-0.4825	0.6945	
	0.8589	0.9245	0.9245	0.0005	0.3324	0.1257	
AR	0.2719	-0.0290	-0.0180	0.9557	0.5162	-0.5047	-0.9298
	0.6022	0.9566	0.9730	0.0029	0.2945	0.3072	0.0072
CR	0.0753	0.2277	0.2148	0.9181	0.2811	-0.4313	-0.8890
	0.8872	0.6643	0.6828	0.0098	0.5895	0.3932	0.0178
TST	0.2546	0.1096	0.2147	0.9026	0.3751	-0.4296	-0.8925
	0.6264	0.8362	0.6828	0.0138	0.4637	0.3953	0.0167
TXT	0.0854	0.2969	0.3125	0.8789	0.2057	-0.3958	-0.8495
	0.8722	0.5677	0.5465	0.0211	0.6958	0.4372	0.0323

OAC	0.1546	0.1555	0.2604	0.8567	0.3399	-0.2781	-0.8453
	0.7700	0.7686	0.6183	0.0293	0.5098	0.5936	0.0341

	AR	CR	TST	TXT
CR	0.9619			
P-VALUE	0.0021			
TST	0.9695	0.9760		
	0.0014	0.0009		
TXT	0.9360	0.9925	0.9775	
	0.0060	0.0001	0.0008	
OAC	0.9459	0.9807	0.9742	0.9764
	0.0043	0.0006	0.0010	0.0008

Cases Included 6 Missing Cases

APPENDIX IV: SENSORY EVALUATION SHEET

The table below shows a list of six gari sample produced from three cassava varieties. They are coded BHT, BHM, APT, APM, BT and BM. Each Sample has descriptive terms from

Like extremely to *Dislike extremely.*

Write the most appropriate number (1- 9) which matches with your choice of description for a particular sample on the scale. The rating of samples on the 9-point hedonic scale is as follows:

9 = Like extremely

8 = Like very much

7 = Like moderately

6 = Like slightly

5 = Neither like nor dislike

4 = Dislike slightly

3 = Dislike moderately

2 = Dislike very much 1

= Dislike extremely.

Sensory Attributes

Sample Code	COLOUR	TASTE	AROMA	TEXTURE	Overall Acceptability (%)
BHT					
BHM					
APT					
APM					
BT					
BM					

THANK YOU.