KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECNOLOGY,

KUMASI

COLLEGE OF AGRICULTURE AND NATURAL RESOURCES

FACULTY OF AGRICULTURE

EFFECT OF VARIETY AND PROCESSING METHODS(HOLDING PERIOD AND DRYING METHOD) ON QUALITY OF CASSAVA FLOUR (KOKONTE) IN THE HOHOE MUNICIPALITY OF THE VOLTA REGION OF GHANA

BY

QUINTSON PHILIP ATTAH-KUMAH

APRIL, 2015.

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A THESIS SUBMITTED TO THE SCHOOL OF RESEARCH AND GRADUATE STUDIES, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF A MASTER OF PHILOSOPHY IN POSTHARVEST TECHNOLOGY

APRIL, 2015.

DECLARATION

I hereby declare that with the exception of the references to other research works which have been duly cited, this thesis is the result of my own work and that it has neither in whole nor in part been presented as a dissertation for a degree in this University (KNUST) or elsewhere.

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DEDICATION

To the glory of God, this work is dedicated to my wife (Esther Fafali Vinyo), my parents, my pastors, my Christian brothers, my siblings and dearest friends. God richly bless you all.

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ABSTRACT

The study was undertaken to identify the „Kotonte‟ methods prevailing in the Hohoe Municipality of the Volta region of Ghana leading to improvement in the product quality. Samples processed from two varieties, namely Ankra and Afisiafi held in temporary storage containers for 0, 2, 4 and 6 hours and subjected to sun and solar drying were analysed for sensory qualities using a preference test. Twenty one (21) untrained judges or consumers from the study area were asked to observe, feel, smell, taste and indicate how much they liked or disliked each sample based on 7 point hedonic scale. The survey results showed that all the „Kokonte‟ producers in the study area used or depended solely on sun drying to dry their fresh cassava chips. Majority (90%) of the producers processed cassava from their own farms into „kokonte‟ while the minority (10%) depended on the cassava sold in some major markets as sources of raw material for the processing which is clear indication that the „Kokonte‟ business in the area is sustainable. The results also showed that varietal differences did not affect the sensory qualities significantly. However, there were significant differences in their protein and carbohydrate contents. Afisiafi had higher protein content (1.4%) as compared to Ankra (1.3%). On the other hand, Ankra had significantly higher carbohydrate content (84.3%) than Afisiafi (84.1%). There were also significant varietal differences in the pasting temperatures and breakdown in viscosity but not peak viscosity and setback of the sample flours when cooked. Ankra recorded the higher pasting temperature (71.0ºC) over Afisiafi (68.3ºC). Ankra also recorded the higher breakdown indicating low product stability. The difference in drying method (solar dryer and sun drying) did not record any significant variation among the sensory properties (aroma, taste, colour and texture). Also, contrary to expectation, there was no significant difference recorded in protein content due to difference in drying methods employed. However, sun drying retained significantly higher carbohydrate content

(84.3%) than solar dryer (84.2%). Drying method affected only the breakdown and setback significantly. Sample held for 4hours recorded the higher carbohydrate content of 84.3% as compared to zero hour hold (84.2%).With regards to pasting temperature, peak viscosity, breakdown and setback 6hour hold recorded the highest pasting temperature (71.1ºC) which is associated with higher cost of fuel and energy as compared to 2hours hold (68.5ºC). Zero period of hold recorded the highest peak viscosity (539.8BU) as against 6hours of hold (481.6BU). Highest breakdown was recorded by zero hour of hold with 263BU as compared to 207.5BU of 6hours of hold. Setback was highest in 6hours hold (8.8BU) and least in zero hour holds (4.6BU). It was discovered that the solar dryer took three more days to dry the

„Kokonte" chips completely as compared to sun drying due the unventilated nature of it which could lead to rapid mold growth. Since consumers perceived the sensory attributes equally but possible mold growth, ease break down in viscosity of product at high temperatures, delay in drying process and relatively high cost of drying associated with the solar dryer, sun drying method was better. In terms of variety,

Afisiafi is of better quality than Ankra. In all, „Kokonte" business in the study area had good prospect and hence sustainable.

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CHAPTER ONE

1.0 INTRODUCTION

Cassava is established as a commercial crop in many tropical countries and was originally a perennial shrub of the New World. Its roots and leaves are processed into different products.

The crop is widely grown as a staple food and animal feed in countries of tropical and sub-tropical Africa, Asia and Latin America between 30ºN and 30ºS with a total cultivated area over 13 million hectares, more than 70% of it being in Africa and Asia (El-Sharkawy, 1993). It is currently the most important food source for carbohydrate, after rice, sugarcane and maize, for over 500 million people in the developing countries of the tropics and sub-tropics. Its main value is in its storage roots with dry matter containing more than 80% starch. Due to the very low protein content in storage roots (values range among cultivars from 5 to 19g per kg dry matter, based on an average conservative Kjeldahl nitrogen to protein conversion factor of 2.49 – 3.6 (Yeoh and Truong, 1996), human requirements for protein and other essential nutrients are commonly fulfilled by other food sources.

It is grown on marginal, low-fertility acidic soils under variable rain-fed conditions ranging from less than 600 mm per year in semi-arid tropics (De Tafur *et al.*, 1997) to more than 1000 mm in the sub-humid and humid tropics (Pellet and El-Sharkawy, 1997). The most common production system is intercropping with other staple food crops such as maize, sorghum and grain legumes (Leihner, 1983) but a significant proportion of production occurs in single-crop system. Although cassava requires a warm climate (>20ºC mean day temperature) for optimum growth and production, and for maximum leaf photosynthesis (with an optimum leaf temperature of 25–35ºC; (El-

Sharkawy *et al.*, 1992)), it is often cultivated in the high-altitude tropics (up to 1800m above sea level) and in the sub-tropics with a lower mean annual temperature where crop growth is slower (Irikura *et al.*, 1979), leaf photosynthetic activities are reduced and storage roots bulking and harvesting time are much delayed compared to what occurs in the warmer climates of the lowland tropics. The crop is vegetatively propagated by mature woody stem cuttings (or stakes, 15–30cm long) planted horizontally, vertically, or inclined on flat or ridged soils at densities ranging from 5000 to 20000 cuttings per hectare, depending on the cropping system and purpose of production (Keating *et al.*, 1988). Seeds are used mainly in breeding programs, though its use in commercial cassava production is a promising option to obviate constraints, particularly diseases, associated with vegetative propagation (Iglesias *et al.*, 1994). Storage roots are generally harvested 7 – 24 months after planting, depending on cultivar, purpose of use and growing conditions. Due to root perishability and rapid deterioration after harvest, fresh roots have to be used immediately after harvesting, either eaten on the farm, marketed for consumption, processed for starch extraction, dried for flour production, roasted for food products and/or used for animal feed. Some of the processed food products are commonly known as "farinha da mandioca" in Brazil and bordering countries, "gablek" in Indonesia, and "gari" and "fufu" in West Africa. However, pre-harvest pruning in the three weeks before harvest decreases root deterioration because of increases in the total sugar/starch ratio in the roots (Van Oirschot *et al.,* 2000).

Problem statement

„Kokonte" producers in the study area use or depend solely on sun drying to dry their cassava chips. The very nature of sun dying exposes the product to insect and other contaminants. Ministry of Food and Agriculture had constructed an enclosed structure (solar dryer) which allows heat into the system to dry the produce as well as to shield it from contaminants. Since the conditions of the system may not be the same as those of the sun drying, there is the likelihood of differences in the physicochemical properties of the products resulting in its overall acceptability over the sun drying method.

Justification

According to Ministry of Food and Agriculture, Hohoe Municipal, information are not available on the influence of holding fresh cassava chips various hours without soaking, before subjecting to various drying techniques on the physicochemical properties of processed cassava flour (Kokonte). Investigating sensory properties is necessary because they contribute greatly to the overall acceptability of the product by cosumers and are important attributes to food (Fellows, 2000). Pasting temperature which is also the cooking temperature, provides knowledge on cost of energy(fuel) and time saving, breakdown indicates what happens to the thickness after peak viscosity when heating continues giving idea on stability of the food while setback indicate the eating texture or suitability of the food for consumption when cooled. It is therefore necessary to investigate the suitability of this new technology before its introduction to the producers.

The world‟s cassava use is expected to increase from 172.7 million tonne to 275 million tonnes in the year 1993 – 2020 using the International Food Policy Research Institute‟s (IFPRI‟s) base line data. A higher prediction of demand and production growth puts the 2020 production at 291 million tonnes (Scott *et al*., 2000). In both projections, cassava use in Africa is equivalent to 62% of the world production. It is therefore necessary to improve upon the quality of „Kokonte‟ in the study area in order to enhance patronage so as to contribute to meeting the world‟s projected target.

Based on the assumptions in the problem statement, the following objectives were put forward.

The main objective was to identify „Kokonte‟ methods prevailing in the study area and how best to improve upon them to improve product quality, overall acceptability and patronage.

Specific objectives were to:

1. evaluate the effect of newly constructed solar dryer on the sensory, nutritional composition(protein and carbohydrate) and pasting qualities of „Kokonte‟ over the sun drying which is mainly employed by „Kokonte‟ producers in the study area;
2. evaluate effect of cassava variety and increasing the hours of holding fresh cassava chips prior to drying impact on the sensory, nutritional composition (protein and carbohydrate), and the pasting properties and hence overall acceptability and patronage of „Kokonte‟ in the study area; and
3. ascertain the prospect and sustainability of „Kokonte‟ business in the study area.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 AGRONOMIC INFORMATION

2.1.1 ROOT AND TUBERS

Root and tubers are the most important staple in most tropical countries especially Africa. They are excellent source of calories and therefore serve as food worldwide (Driar, 1993). Examples include cassava, yam, cocoyam, potato and sweet potatoes. Cassava is established as a commercial crop in many tropical countries around the world and the root and leaves are processed into different products. The cassava roots have an optimum harvest age after which there is a loss in yield. At the same time the roots become woody and there can be impairments to flavour (Lancaster and Coursey, 1984).

2.1.2 CASSAVA VARIETIES

Many local varieties of cassava exist and the names given by farmers or locals demonstrate the major attributes of these varieties (Sarfo-Kantanka, 2004). "Bankye Broni" is the name given to a variety of cassava which has aesthetic morphological parts. Others include "Kronfo mmpe" variety which has relatively high concentrations of cyanogenic glucosides rendering it bitter so that even thieves will not bother to steal it, and "Bosome Nsia"; which matures within six months after cultivation.

Over ninety cultivated varieties have been collected in Ghana, with heights ranging from 0.92 – 3.0 meters, depending on the variety and growing conditions (Bennion, 1990). The local varieties can be identified by considering varietal differences in aboveground vegetative characteristics especially when plants are about six months old (Grace, 1977). In addition to the local varieties already existing in Ghana certain improved varieties have been introduced which compared to the local varieties has certain beneficial qualities. They are found to be less susceptible to pest and diseases as compared to the local varieties. They also have higher yield and lower cyanide content in some case (Ababio, 1993). However, some of the improve varieties are not suitable for use in the preparation of certain popular foods such as "ampesi and fufu" because of their low starch content. Other improved varieties are developed solely for the starch industry and they include TMS 30572 (Afisiafi), TMS 50395 (Gblemo Duade), and TMS 4(2)1425 (Abasa Fitaa) (MoFA, 1996).

2.1.3 PRODUCTION OF CASSAVA

Women, mostly in the rural communities continue to derive their livelihood from production, processing and sales of products from most root and tubers including cassava. Women also handle and undertake most of the production activities such as land tillage and planting. In Ghana, the Eastern region is the greatest producer of cassava followed by Brong Ahafo, Ashanti, Volta, Central, Western, Northern and Greater Accra region in that order. The two Upper regions have not recorded production of cassava according to MoFA (1996). Cassava production in Ghana has increased over the years. There was an increase from 1991 to 1995 of about 2 metric tons per hectare (MoFA, 1996). New varieties of cassava have been produced which have high resistance to pest and disease and are very high yielding.

2.2 PROCESSING INFORMATION

2.2.1 SAFETY OF CASSAVA FOODS AND ELIMINATION OF CASAVA CYANOGENS BY PROCESSING

Production of a cyanogenic cassava by manipulation of linamarin metabolism in tubers is a long term process. Processing has been recognized as the most efficient way of controlling cassava cyanogens in the short term (Cardoso *et al.*, 2005). For populations which rely on cassava as a staple, the problem of dietary cyanogens exposure can be solved only by using cultivars with low cyanogens (linamarin) content or alternatively, if high cyanogens cultivars are used, they should be adequately processed to reduce the cyanogens content to safe levels (Bediako *et al.*, 1981)

A wide diversity of processing methods is used in cassava consuming communities. These include peeling and slicing fresh tubers followed by boiling, steaming, drying, deep frying, fermentation, grating/pounding followed by drying or roasting. Most of these processing methods are effective in reducing cyanide content (Bradbury, 2006). Depending on the nature of the process, they either lead to hydrolysis of cyanohydrins to release acetone and hydrogen cyanide, which are volatilized and subsequently lost, or the highly soluble cyanohydrins and its hydrolytic products are leached out in water as in the process of soaking or boiling. However the acetone release impart on the flavour of the product (Amoa-Awua, 1996). Cassava may be mixed with cereals to increase food protein and enhance palatability by improving consistency while indirectly reducing the effect of cyanogens on the body (Ababio, 1993).

When cassava tubers are cut into small pieces and cooked in water, up to 80% of cyanohydrins is removed. The cyanohydrins in the tuber is leached out the water, hence it is necessary to decant the water completely. The volume of water should be adequate for optimum dissolution of cyanohydrins. Sun drying of cassava chips also removes 80% of cyanohydrins (Bediako *et al.*, 1981). In contrast to the boiling process, processes such as baking, steaming and frying result in very little loss of cyanohydrins (20%).

This is due to inactivation of linamarase and stability of linamarin at high temperature (Tewe and Iyayi, 1989). The process of grating/pounding followed by sun drying is most effective since it facilitates the enzyme reaction and results in 95 – 99% removal of cyanohydrins as observed during the processing of „gari" (Cardoso *et al.*, 2005) made a comparative study on the retention of cyanogens during different processing methods and calculated the maximum root total cyanide content for a particular processing method in order to obtain products with World Health Organisation safe levels of 10 mg/kg and found out that, efficient processing involving grating, fermentation, soaking of the roots followed by sun drying.

Many methods of processing cassava roots commence with the peeling of the tubers. Generally the cassava peel contains higher cyanide content than the pulp. Removal of peels therefore reduces the cyanogenic glucoside content considerably. Peeling therefore can be an effective way to reduce the cyanide content by at least 50% in cassava tubers (Bediako *et al.*, 1981). In most traditional processing of cassava roots into other products, grating of cassava roots takes place after peeling and sometimes applied to the whole tuber. Grating ensures even distribution of cyanide in the product and obviously provides a greater surface area for fermentation to take place. This also leads to higher levels of cyanide removal as in the processing of "gari" and "agbelima" due to the high enzyme – tissue interaction (Amoa-Awua, 1996).

2.2.2 FUNDAMENTALS OF DRYING

Drying is defined as a process of moisture removal due to simultaneous heat and mass transfer. Heat transfer from the surrounding environment evaporates the surface moisture. The moisture can either be transported to the surface of the product and then evaporated, or evaporated internally at a liquid vapour interface and transported as vapour to the surface.

The transfer of energy (heat) depends on the air temperature, air humidity, air flow rate, exposed area of food material and pressure. The physical nature of the food, including temperature, composition, and in particular moisture content, governs the rate of moisture transfer. The dehydration equipment generally utilizes conduction, convection, or radiation to transfer energy from a heat source to the food material. The heat is transferred directly from a hot gas or indirectly through a metal surface.

The typical drying cycle consists of three stages: heating the food to the drying temperature, evaporation of the moisture from the product surface occurring at a rate proportional to the moisture content, and once the critical moisture point is reached, the falling of the drying rate. The critical moisture point depends greatly on the rate since high drying rates will raise the critical point and low drying rates will decrease them (Okos *et.al*., 1992)

2.2.3 PROCESSING OF CASSAVA FLOUR "KOKONTE"

Cassava flour („kokonte‟) processing is among the traditional processing techniques engaged to reduce postharvest losses of cassava and also make it safer for consumption. It is prepared either by sun drying or oven drying of the cassava chips and then milled into smooth flour. In rural areas, the chips are pounded into flour with a mortar and pestle. Sun drying is known to give cream coloured flour while oven drying the chips gives whiter flour (Driar, 1993). Another pre-treatment is to grate the peeled tubers and ferment the pulp, then de-water before drying and milling (Ayernor, 1985). Yet another way is to soak the tubers in water (retting), extract the meal and then ferment before drying and milling. Also slower drying rate as in the case of sun drying is known to gives a greater degree of cyanogens elimination than the faster air drying during processing (Grace, 1977). It has been shown that the second and third methods produce more detoxified cassava flour compared to the first method because of the fermentation involved.

The dried cassava chips may be bagged which can also store for years for later usage. Dried cassava chips may also be exported to other countries for used in the food and paper industries

2.3 QUALITY ATTRIBUTES

2.3.1 NUTRITIONAL CONSIDERATIONS AND CONTRIBUTION TO DIET

The edible or mostly utilized parts of cassava plant are the leaves and the tubers (roots). In most cassava growing countries in Africa, the leaves are also consumed as a green vegetable which provide protein and vitamin A and C. In Africa, cassava is beginning to be used in partial substitution for wheat flour especially for bread making. In Ghana, cassava is one of the most important staple foods prepared in various ways for consumption. Some of the popular products are „fufu‟, „akple‟, „yakeyake‟, „gari‟, „tapioca‟, „kokonte‟ and „ampesi‟. Cassava is one of the cheapest sources of calories in the Ghanaian diet, it is rich in carbohydrates and contain little protein and fat (Ihekornye and Ngoddy, 1985). In Ghana, the tubers are those that mostly form part of the diet not the leaves. The fresh tubers may also be grated and fermented to “agbelima”, which is used to prepare “akple” and “banku” which are dumplings.

Traditionally, cassava roots are a major and cheap source of carbohydrates and are processed by various methods into numerous products which are utilized into diverse ways depending on the local custom and preferences. Most of the carbohydrate is present as starch (31% of fresh weight) (Scott *et al.,* 2000).

Starch, the main plant carbohydrate is the most important plant derivative used by man. It has unlimited importance in industry and food and can be modified to suit various applications using inexpensive methods making it ideal for a number of uses (Satin, 2006). One of the major sources of starch is cassava which produces high purity and quality starch compared to other tuber and cereal crop sources. Cassava is an important root crop in sub Saharan Africa being consumed by more than 600 million people worldwide. The starch produced by cassava is amenable for use in various applications both dietary and industrial. In the improvement of cassava, the importance and use of starch plays a significant role.

Cassava carbohydrate has a mean starch content of 20% amylose and 70% amylopectin. In the preparation of cooked „kokonte‟ for instance, the starch in the cassava flour is exposed to moist heat which increases in viscosity undergoing more gelatinization and producing with a smoother texture as temperature increases. The starch produced during heating exhibits varying pasting properties which include peak viscosity, pasting temperature, setback viscosity and break down viscosity.

2.3.1.1 Pasting Properties of Cassava

Pasting temperature is the temperature at which the first detectable viscosity is measured (when the stirred starch suspension begins). It gives an indication of the minimum temperature to cook a given sample (Swinkel, 1985). Peak viscosity (PV) is the maximum viscosity attained by gelatinised starch during heating in water. It indicates water binding capacity of the starch granules (Shimelis *et al;* 2006). Break down viscosity (BV) is the measure of the vulnerability or susceptibility of the cooked starch to disintegration. The higher the breakdown in viscosity, the lower the ability of starch sample to withstand heating and shear stress during cooking (Adebowale *et al.,* 2005). Setback viscosity measures the recrystallization of starch during cooling. The differences in setback among difference starches may be due to the amount and the molecular weight of Amylose leached from the granules and the ghost of gelatinized starch (Loh, 1992).

According to Juliano *et al.* (1987), varietal differences in amylopectin molecular structure influences variation rather than amylose. Other differences reasons may be inherent differences in the structure of starch or may be due to different degree of interactions between starch and its associated compounds during pasting (Zhang and Hamaker, 2008).

2.3.1.2 Nutritional Composition of Cassava

Cassava is an important source of energy with a calories value of 250kcal/ha/day compared to other staple foods in Ghana (Kemdirim *et al.,* 1995). The crop is however, poor in protein content with about 1.3% (Table 2.1).

Table 2.1: Proximate Composition of French Cassava Roots

Nutrient	**Composition (%)**
Starch	20 – 30
Water	75 – 80
Protein	2 – 3
Fat	0 – 1
Fiber	1
Ash	1 – 1.5
Sugar	5 - 13

Source: Ihekornye and Ngoddy (1985)

2.3.2 EFFECTS OF PROCESSING TREATMENTS ON CASSAVA FLOUR QUALITY

Cassava tubers are traditionally processed by a wide range of methods, which reduce their toxicity, improve palatability and convert the perishable fresh root into stable products. Soaking of cassava roots according to Ayernor (1985) provides a suitably larger medium for fermentation and allows for greater extraction of the soluble cyanide into soaking water. The process removes about 20% of the free cyanide in fresh roots chips. The fermentation process initiated during soaking also affect the functional properties of the flour after processing. Functional properties affected include the pasting property of the flour due to the breakdown of starch which acts mainly as a fermentative substrate for cyanide removal (Cooke and Maduagwu, 1985). Sensory properties such as taste and aroma are also affected during soaking as the breakdown and removal of hydrogen cyanide also leads to the formation of acetone affecting the taste, aroma and flavour (Gomez *et al.*, 1985). Size reduction of very large surface area has also been shown to facilitate cyanide removal and larger surface area for fermentation (Gomez *et al.*, 1985).

Sun drying of cassava roots has been shown to result in greater loss in total cyanide compared to oven drying. It also tends to produce greater removal of bound cyanide due to slower drying rate. Again sun drying facilitates the continuation of the fermentation process which gives the end products their characteristics quality attributes especially texture and flavour (Tewe and Iyayi, 1989). Sun drying continues to remain the simplest method of cassava processing at traditional and household levels.

It reduces moisture and volume aside the removal of cyanide thereby prolonging product shelf life.

CHAPTER THREE

3.0 MATERIALS AND METHODS

The study was in two folds; a survey and a laboratory work. The laboratory work was carried out at the Department of Biochemistry Laboratory, Kwame Nkrumah Universiy of Science and Technology for the analyses of protein and carbohydrate contents and Food Research Institute, Accra where the pasting properties of the samples were determined. The survey was carried out in the Hohoe Municipality.

3.1 BRIEF HISTORY OF THE STUDY AREA

The study was carried out in the Hohoe municipality. Hohoe Municipality is situated in the centre of the Volta Region, with Hohoe as its capital, was created in 1979. The republic of Togo borders the municipal to the east, while to the west is Kpando District. In the north-west is Jasikan District and to the south Ho Municipality. The Municipality houses part of the Akwapim-Togo ranges extending beyond the country"s eastern boundary all the way to Western Nigeria (MoFA, 2013).

3.1.1 Physical and Natural Environment

3.1.1.1 Location and size

The Municipality is located within longitude 0º15‟E and 0º45‟E and Latitude 6º45„N and 7º15‟N at the heart of the Volta – Region. The Municipality covers an area of 1,172 square kilometres (117,200 ha), which is 5.6% of the regional size and represents 0.5% of the national land area. It share common boarders with the Republic of Togo on the east, south by the Ho Municipal, on the west by the Kpando District and in the north-west with the Jasikan District (MoFA, 2013).

3.1.1.2 Climate

The annual rainfall total ranges between 1100mm and 1500mm, averaging 1300mm. The rainfall pattern is bimodal with two distinct rainy seasons. The major rains start from April through to July while the minor season covers the period from September through November. Occasionally the municipal bimodal pattern gives way to continuous rain from April through to November. On the average, the major season receives about 43% of the total annual rainfall as compared to about 40% for the minor season. Comparative figures however establish a greater reliability of the rain both in quantity and distribution during the minor season than the major season (MoFA, 2013).

3.1.1.3 Vegetation

The municipality falls within the Forest-Savannah transitional ecological zone of Ghana, with the forest part at its southern and eastern sectors and tapering into the middle of the municipality. The vegetation of the transitional zone is considered to have developed from the forest. The eastern highlands are clothed with high forest (MoFA, 2013).

3.1.2 Agriculture

The Climate and Soils support varieties of crops and livestock. Crop production includes food and cash crops. The livestock include small ruminants (sheep and goats), poultry, piggery and cattle on a small scale. Fish farming or aqua-culture is carried out mostly in the central portions of the municipality around Logba, Ve, Hohoe and Santrokofi. The farming systems include mixed cropping, crop rotation and mixed farming. Local vegetables namely okro, tomato and garden eggs are cultivated extensively mostly in the Ve, Logba and Nyagbo areas of the Municipality (MoFA, 2013).

3.1.2.1 Cassava processing factory

The Municipal produces about 75,000 metric tons of cassava annually. It has the potential to increase the yield to over 100,000 metric tons within one year. Therefore, investment in the production and establishment of a Cassava Processing Factory or facility to process raw cassava into the following under listed products are of a very profitable business:

i. Starch for industrial use ii. Gari iii. Tapioca and biscuits

iv. Animal feed–for livestock and poultry (MoFA, 2013).

3.2 THE SURVEY

3.2.1 Sampling Technique

In the study area (Hohoe Municipality), random sampling was used to ensure that stakeholders were selected; 20 farmers/producers, 50 sellers and 50 consumers.

3.2.2 Data collection

Primary and secondary data were used. The primary data collections were carried out through the use of a well-structured questionnaire administered to one hundred and twenty (120) selected respondents including 20 producers 50 sellers and 50 consumers through interview schedules. Secondary data collected were obtained from text, journals and abstracts.

3.3 LABORATORY EXPERIMENT

3.3.1 Experimental Materials and its source

The experimental material used was cassava flours obtained from two varieties namely Afisiafi and Ankra obtained from two separate farms in the study area at Have and Gbi-Godenu, respectively. The cassava varieties were peeled and made into chips and solar dried or sun-dried when held for a period of 0hr, 2hr, 4hr and 6hr before usage. The chips were then pounded and milled into „Kokonte" flours sample for analysis.

The experimental materials used were arranged as follows:

Afisiafi solar dried (0), Afisiafi solar dried (2), Afisiafi solar dried (4), Afisiafi solar dried (6), Afisiafi sun-dried (0), Afisiafi sun-dried (2), Afisiafi sun-dried (4), Afisiafi sun-dried(6), Ankra solar dried (0), Ankra solar dried (2), Ankra solar dried (4), Ankra solar dried (6), Ankra sun-dried (0), Ankra sun-dried (2), Ankra sun-dried (4), Ankra sun-dried (6). The figures 0, 2, 4, and 6 are the number of hours

3.3.2 Experimental design

The experiment was conducted using 2 x 2 x 4 factorial in a Completely Randomised Design with three replications. The factors were two cassava varieties (Ankra and Afisiafi), two drying methods (sun and solar) and four holding periods (0, 2, 4, and 6 hours).

3.3.3 Parameters Assessed

A. Nutritional compositions include;
   i. Protein
   ii. Carbohydrate

B. Sensory properties includes;
   i. Texture
   ii. Colour iii. Aroma
   iv. Taste

C. Pasting properties include;
   i. Pasting temperature
   ii. Peak viscosity
   iii. Breakdown in viscosity
   iv. Setback viscosity

DETERMINATION OF PARAMETERS

Cassava is one of the cheapest sources of calories in the Ghanaian diet, it is rich in carbohydrates and contain little protein and fat (Ihekornye and Ngoddy, 1985). It was in line with this statement that the main energy source (carbohydrate) and protein contents were to be investigated and the other components determined in subsequent work or by another researcher.

Determination of Carbohydrate Content

3.4.1.1 Crude fiber determination

The crude fiber was determined by reacting the food sample with 0.255N of H_2SO_4 and 0.312N of NaOH solution to digest the soluble carbohydrate component.

3.4.1.2 Nitrogen Free Extract (NFE) determination

This consists of the analytical determinations of ash, crude fat (ether extract), crude protein and crude fiber on dry matter bases after which Nitrogen-free extract (NFE), more or less representing sugars and starches, was calculated by difference rather than measured by analysis.

NFE was calculated as 100% minus the sum of %ash, %crude fat (ether extract), %crude protein and %crude fiber on dry matter bases

Total carbohydrate on dry matter basis = percentage of NFE (dry matter basis)+ percentage crude fibre (dry matter basis) (FAO, 2003).

3.4.2 Determination of protein content in samples

3.4.2.1 Kjeldahl method

The Kjeldahl method was used and can conveniently be divided into three steps: digestion, neutralization and titration.

3.4.2.2 Principles

Digestion

The food sample to be analyzed was weighed into a *digestion flask* and then digested by heating it in the presence of sulfuric acid (an oxidizing agent which digests the food), anhydrous sodium sulfate (to speed up the reaction by raising the boiling point) and a catalyst, such as copper, selenium, titanium, or mercury (to speed up the reaction). Digestion converted any nitrogen in the food (other than that which is in the form of nitrates or nitrites) into ammonia, and other organic matter to $C0_2$ and H_20. Ammonia gas was not liberated in an acid solution because the ammonia was in the form of the ammonium ion (NH_4^+) which bound to the sulfate ion (SO_4^{2-}) and thus remained in solution as $(NH_4)_2SO_4$.

Neutralization

After the digestion has been completed the digestion flask was connected to a *recieving flask* by a tube. The solution in the digestion flask was then made alkaline by addition of sodium hydroxide, which converted the ammonium sulfate into ammonia gas:

$(NH_4)_2SO_4 + 2\ NaOH \rightarrow 2NH_3 + 2H_2O + Na_2SO_4.$

The ammonia gas formed was liberated from the solution and moved out of the digestion flask and into the receiving flask - which contained an excess of boric acid. The low pH of the solution in the receiving flask converted the ammonia gas into the ammonium ion, and simultaneously converted the boric acid to the borate ion:

$NH_3 + H_3BO_3$ (boric acid) $\rightarrow NH_4^+ + H_2BO_3^-$ (borate ion).

Titration

The nitrogen content was then estimated by titration of the ammonium borate formed with standard sulfuric or hydrochloric acid, using a suitable indicator to determine the end-point of the reaction.

$H_2BO_3^- + H^+ \rightarrow H_3BO_3.$

The concentration of hydrogen ions (in moles) required to reach the end-point was equivalent to the concentration of nitrogen that was in the original food. The following equation was used to determine the nitrogen concentration of a sample that weighed *m* grams using a *x*M HCl acid solution for the titration:

$$\%N = \frac{x \text{ moles}}{1000 \text{ cm}^3} \times \frac{(v_s - v_b) \text{ cm}^3}{m \text{ g}} \times \frac{14 \text{ g}}{\text{moles}} \times 100$$

Where *v*s and *v*b are the titration volumes of the sample and blank, and 14g is the molecular weight of nitrogen N. A blank sample is usually ran at the same time as the material being analyzed to take into account any residual nitrogen which may be in the reagents used to carry out the analysis. Once the nitrogen content has been determined it was converted to a protein content using the appropriate conversion factor: %Protein = F x%N where N=6.25 (Kjeldahl, 1883).

3.4.3 Sensory Analysis

The acceptability of colour, aroma, taste and texture of the cooked ‟kokonte‟ flours processed at different holding times were assessed using a preference test. Twenty one (21) untrained judges or consumers from the study area were asked to observe, feel, smell, taste and indicate how much they liked or disliked each sample based on 7 point hedonic scale. They were also to give the overall assessment. On the scale, like extremely=1, like very much =2, like moderately=3, neither like nor dislike =4 dislike moderately=5, dislike very much=6 and dislike extremely=7

Average or the mean scores were calculated as the sum of the scores divided by 21 for each sample. The closer the score to one (1) or the smaller it is, the better the sensory quality as perceived by the consumers (SIMS, 2000).

3.4.4 Determination of pasting characteristics

The pasting characteristics of the „kokonte‟ flours were determined using the Brabender visco amylograph (Brabender viscograph E). The moisture content of the cassava flour sample was determined and noted. The following settings of the Brabender amylograph gadget were used:

- Start temperature 25°C
- Hold time 15minutes
- Hold temperature (1) 95°C
- Hold temperature(2) 50°C

- Rate of temperature increase 1.5°C/min.

Ten per cent (10%) slurry (dry matter basis) was prepared making sure there were no lumps. It was poured into a volumetric flask, made up to 500ml and then transferred into the amylograph bowl. When the start temperature was attained the marker pen was flicked to mark the start of the run on the recording chart. The suspension was allowed to heat uniformly from 25°C to 95°C at a constant rate of 1.5°C/min., allowed to remain at the hold temperature of 95°C for 15 minutes, cooled down to 50°C at a rate of 1.5°C/min. The instrument was left to run for further 15 minutes to measure the potential for setback (retro-gradation) of the paste on cooling. The parameters were obtained as follows:

Pasting temperature = was recorded directly from the Brabender visco amylograph gadget.

Peak Viscosity = was recorded directly from the Brabender visco amylograph gadget.

Breakdown = Peak viscosity- Viscosity at cooling period.

Setback = viscosity at the end of cooling- Viscosity at the start of cooling.

(IACST, 2000).

3.5 DATA ANALYSES

The survey data obtained were analysed using Statistical Package for Social Sciences while the laboratory data were subjected to ANOVA using the Statistix Student version 9. Means were separated at Lsd of 5%.

CHAPTER FOUR

4.0 RESULTS

4.1 BIO-DATA OF RESPONDENTS

This section presents findings of questionnaires that were administered to sellers, producers and consumers of „Kokonte" in the Hohoe Municipality of the Volta Region of Ghana. Pie charts, Bar graphs, Columns, and Percentages were used to ascertain better understanding of the analysis and findings. A total number of one hundred and twenty (120) questionnaires were sent out and received by the researcher.

4.2 PRODUCERS

4.2.1 Duration of „Kokonte" Production Business

From Figure 4.1, 70% of the producers have engaged in the „Kokonte" production for about ten (10) and above years. This figure also shows that 10% have been in the business for one to two years, another 10% for three to five years and the rest 10% for six and nine years.

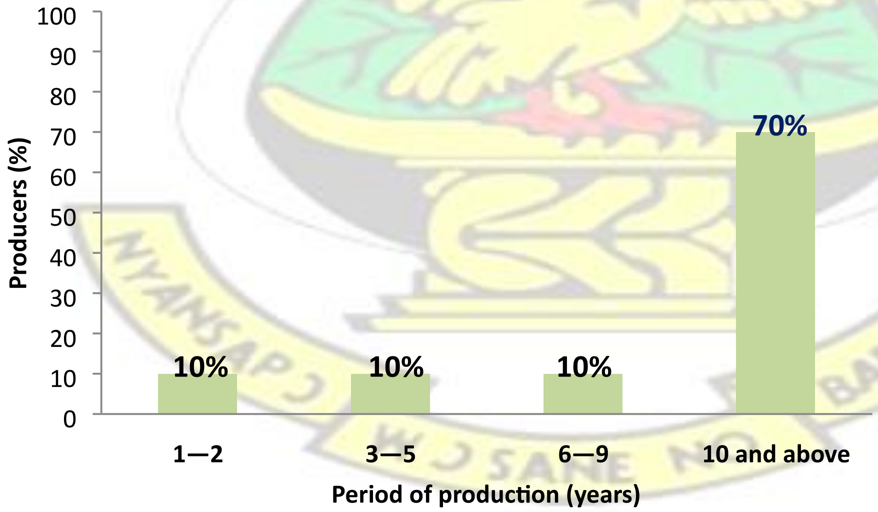

Figure4.1: Period of „Kokonte" production business

4.2.2 Some „Kokonte‟ Processing Activities

It is obvious from Table 4.1 that, some of the producers actually practiced holding freshly peeled cassava chips for quite a number of hours before drying where 45% of them peeled, washed and dried their cassava chips after two to twelve hours. Another 45% also peeled and dried their fresh cassava chips after about 30 minute and the rest 10% after peeling and washing dried their cassava chips immediately.

Table 4.1: Some important activities involved in „Kokonte‟ production by producers

Processing activities	Number of Producers	Percentage
Peel ,wash and dry immediately	2	10
Peel, wash and dry after two to twelve hours	9	45
Peel and dry after about 30 minutes	9	45
One and above hours	0	0

Total	20	100

4.2.3 Source of Cassava used for producing the „Kokonte" in the study area.

From Table 4.2, majority (90%) processed cassava from their own farms into „kokonte" while the minority, (10%) depended on the cassava sold at the market as source of raw material for processing „Kokonte".

Table 4.2: Source of cassava used for the „kokonte"

Source of Cassava	Frequency	Percentage
The market	2	10
Own farm	18	90
Crop research Institute	0	0
TOTAL	20	100

4.2.4 Drying methods employed

From Table 4.3, 95% of the producers mainly used sun drying method to dry their fresh cassava chips. Only 5% of the producers dried cassava chips in an enclosed room but none of them used neither solar dryer nor electric dryer.

Table 4.3: The most common drying method employed by producers

Drying methods	Number of producers	Percentage
Sun drying	19	95
Solar drying	0	0
Electric drying	0	0
Drying in an enclosed room	1	5

Total	20	100

4.2.5 Drying of the fresh cassava

From Table 4.4, 45% of the producers dried cassava chips (Kokonte) on uncovered mat, 35%, dried on covered floor and 20% dried on covered mat above the ground. However, none of the producers dried on the bare floor.

Table 4.4: Frequency distribution of the places where the fresh cassava chips were dried

Place of Drying	Number of producers	Percentage
On a bare floor	0	20
On covered floor		
	7	35
On covered mat above the ground	4	20
On uncovered mat above the ground	9	45
Total	20	100

4.2.6 Producers‟ knowledge on solar dryer

Table 4.5 shows that (100%) of the producers did not have any knowledge about solar dryer.

Table 4.5: Frequency distribution of whether or not producers have knowledge about solar dryer

Response	Number of producers	Percentage
Yes	0	0
No	20	100
TOTAL	20	1000

4.2.7 Influence of Storage on Colour Development as experienced by the producers

Table 4.6 shows that 80% of the producers confirmed that colour of „Kokonte‟ does not change during storage. A few of the respondents (20%) however, said, colour of „Kokonte‟ changes during storage.

Table 4.6: Frequency distribution of whether or not the colour of the „kokonte‟ chips changes during storage

Response	**Number of producers**	**Percentage**
Yes	4	20
No	16	80
Total	20	100

4.3 SELLERS

4.3.1 The sensory factor most influencing acceptability of cooked „kokonte‟ Table 4.7 presents the results of the most influencing quality characteristic that influences consumers‟ acceptability. From the results, (56%) of the consumers were of the view that colour is the most sensory quality that influences consumers‟ acceptability. It also shows that 20% of the sellers were of the view that based on experience, taste is the most influencing characteristics that influences consumers‟ acceptability. Another 20%, also said that aroma is the most influencing characteristics that influences consumers‟ acceptability. Finally, 4%, of the respondents said texture is the most influencing characteristics that influences consumers‟ acceptability.

Table 4.7: The most influencing characteristic on consumer acceptability as indicated by the sellers

Sensory quality	Number of sellers	Percentage
Taste	10	20
Colour	28	56
Smell	10	20
Texture	2	4
Total	50	100

4.4 CONSUMERS

4.4.1 Perception of nutritional qualities of Kokonte , Banku and Akple

Table 4.8 shows the results of the response of the questions as whether cooked „Kokonte‟ is more nutritious than Banku or Akple. From the Table, 50% of the consumers were of the view that „Kokonte‟ is more nutritious as compared to „Banku‟and „Akple‟ while the rest 50% were of the view that „Kokonte‟ is not more nutritious than „Banku‟ and „Akple‟.

Table 4.8: Consumers‟ view of „kokonte‟ being richer in nutritional qualities than „Banku‟ and „Akple‟

Response	Number of Consumers	Percentage
Yes	25	50
No	25	50
Total	50	100

4.4.2 Expression of discomfort after eating cooked „kokonte‟

In answer to the question as to whether cooked „Kokonte‟ caused any discomfort in the consumers or not, 16% said yes while 84% said no in Figure 4.2 below.

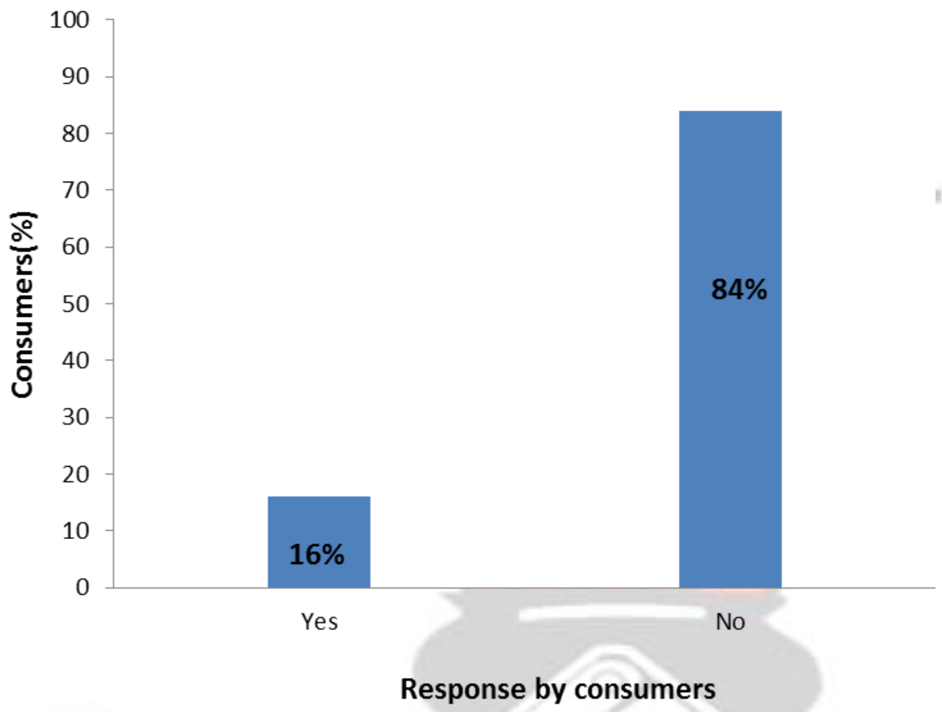

Figure 4.2: Bar chart showing frequency distribution of expression of stomach discomfort following intake of „Kokonte"

4.4.3 Reasons for colour preference

Table 4.9 shows the results of the answers to the question `seeking the most obvious reason why some consumers prefer certain colours to others. It is clear from the table that 54% choose particular colours because of how attractive they are to them, 22% indicated that they make such choices because they think those colours are the most hygienic. In addition, 16% claimed their choices are purely based on what colours other people buy at a time and 8% however, indicated that their choices are dependent on the price.

Table 4.9: Reasons for choice of colour particular of cooked „Kokonte"

Reasons for colour preference	Number of consumers	Percentage

Because it is the most hygienic	11	22
Because most people patronise this colour	8	16
Because it is relatively cheaper	4	8
Because it is attractive	27	54
Total	50	100

4.4.4 Preference for soup by consumers

Figure 4.3 shows the frequency distribution of the type of soup that best goes with cooked „Kokonte". The results indicate that, 78% of consumers eat cooked „Kokonte" with groundnut soup, 12% prefer cooked „Kokonte" with palm nut soup while 10% eat cooked „Kokonte" with Okro soup. None of the respondents (consumers) eats cooked „Kokonte" with light soup.

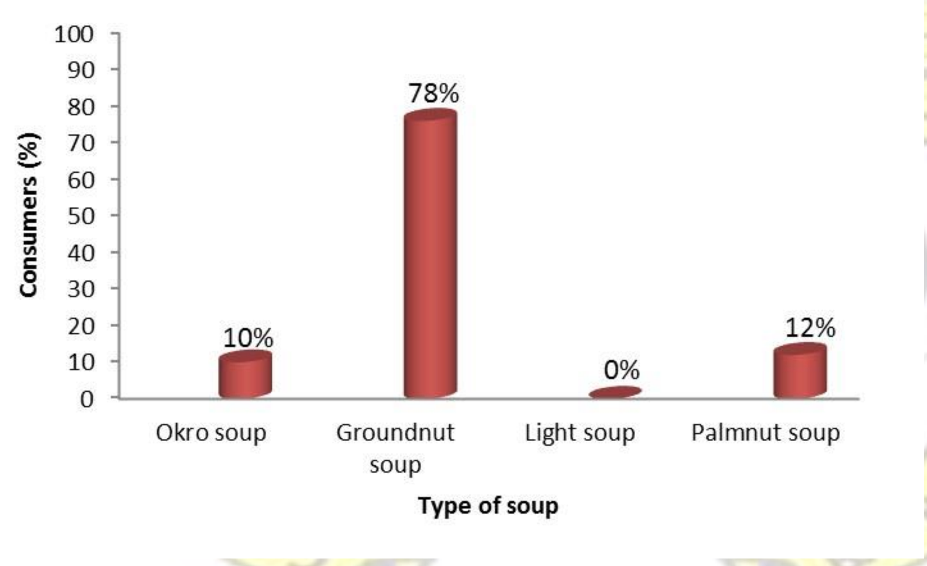

Figure 4.3: Response of consumers" preference for soups that best goes with cooked „Kokonte"

4.5 PHYSIOCHEMICAL PROPERTIES OF CASSAVA FLOUR

Values are means of triplicate determinations. Means in the same columns with different superscripts differ significantly ($p<0.05$).

4.5.1 Effect of Cassava Variety on sensory attributes of Cassava Flour

The results from Table 4.26 shows no significant difference (p>0.05) of cassava varietal variation on the texture, colour, aroma and taste of the flour.

The table shows Ankra gaining a lower acceptability level of 3.5, significantly different (p<0.05) from 3.0 recorded by Afisiafi. (The lower the mean score the higher the acceptability).

Table 4.10: Influence of cassava variety on the sensory quality, functional properties and the overall acceptability of cassava flour samples

Varieties	**Texture**	**Colour**	**Aroma**	**Taste**	**acceptability**
Ankra	3.7 a	3.5 a	4.0 a	3.7 a	3.5 a
Afisiafi	3.4 a	3.5	3.6 a	3.7 a	3.0 b
Lsd (0.05)	0.33	0.62	0.43	0.49	0.37

*Mean followed by different letters are significantly different (p<0.05)

4.5.2 Effect of Drying Methods on Sensory attributes of Cassava Flour

From Table 4.11, there were no significant variations due to the drying method on the sensory quality of the two cassava variety processed into flour. That is, the sun and solar dried treated cassava flours had a similar texture, colour, aroma and taste.

No significant difference (p<0.05) was recorded on the level of acceptability with regards to the effect of drying treatment.

Table 4.11: Influence of drying methods on sensory quality, functional properties and overall acceptability of cassava flour samples

Drying Method	Texture	Colour	Aroma	Taste	acceptability
sun dried	3.5 a	3.5 a	3.6 a	3.8 a	3.4 a
solar dried	3.6 a	3.4 a	4.0 a	3.7 a	3.2 a
Lsd (0.05)	0.33	0.62	0.43	0.49	0.37

4.5.3 Effect of Holding Period on Sensory attributes of Cassava Flour

The holding periods had no significant difference (p>0.05) on the sensory qualities; texture, colour, aroma and taste of the cassava as shown in Table 4.12

Except for samples held for 0 and 6 hours that differed significantly (p<0.05) from each other in terms of preference, they however, performed equally to those held at 2 and 4 hours.

Table 4.12: Influence of holding period on sensory quality and overall acceptability of cassava flour samples

Holding period (hours)	Texture	Colour	Aroma	Taste	acceptability
0	3.6 a	3.3 a	4.0 a	3.8 a	3.5
2	3.4 a	3.0 a	3.8 a	3.7 a	3.4 ab
4	3.6 a	3.9 a	3.9 a	3.6 a	3.4 ab
6	3.5 a	3.6 a	3.5	3.7 a	2.9 b
Lsd (0.05)	0.5	0.87	0.61	0.69	0.52

4.5.4 Interaction Effect of Varieties and Drying Methods on Sensory attributes of Cassava Flour.

From Table 4.13 interaction effect of cassava variety and drying method shows no significant difference (p>0.05) among texture, colour and taste except the aroma, where solar dried a Ankra (4.1) shows a least taste preference against the highest recorded by sun dried Afisiafi (3.4) but were significantly not different from sun dried Ankra (3.9) and solar dried a Afisiafi (3.8).

Afisiafi flour irrespective of the drying method employed, had an equal level of acceptability but was judged the least preferred when compared to sun dried Ankra, the most preferred. All the fore mentioned interactions were however not different from solar dried Ankra.

Table 4.13: Interaction effect of varieties and drying methods on sensory qualities and overall acceptability of cassava flour sample

Interaction between Varieties and Drying method	**Texture**	**Colour**	**Aroma**	**Taste**	**Overall acceptability**
Ankra*sun dryinng	3.6 a	3.5 a	3.9 ab	3.8 a	3.8 a
Ankra*solar drying	3.7 a	3.4 a	4.1 a	3.7 a	3.3 ab
Afisiafi*sun drying	3.4 a	3.6 a	3.4 b	3.7 a	3.1 b
Afisiafi*solar drying	3.4 a	3.4 a	3.8 ab	3.7 a	3.0 b
Lsd (0.05)	0.5	0.87	0.61	0.69	0.52

4.5.5 Interaction Effect of Varieties and Holding Period on Sensory attributes of Cassava Flour.

Table 4.14 shows that interaction effect of variety and holding period had a significant difference ($p<0.05$) among the texture, colour and aroma except taste of processed cassava flour. Ankra held for 0 and 2 hours equally varied from Afisiafi held for 2 hours with 3.7, 3.8 and 3.0, respectively. Afisiafi held for 4 hours (4.7) was judged the least and different from all other samples that significantly had a similar colour except Ankra, held for 6 hours (4.3). Similarly, the processed flour had the same aroma except for

Ankra, held for 2 hour (4.2) which was different from Afisiafi, held for 2 and 6 hours of 3.3 and 3.2 respectively, the most and least preferred.

The influence of the interaction of the varieties and holding periods on overall acceptability caused significant differences (p<0.05). Except for Ankra (3.8), Afisiafi (2.5) held for 2 and 6 hours respectively judged the least and most preferred and shows a significant difference (p<0.05), the rest were significantly not different (p>0.05) from one another that ranged from 3.0 – 3.7

Table 4.14: Interaction effect of variety and holding period on sensory qualities, functional and overall acceptability of cassava flour sample

Interaction between variety and holding period (hours)	**Texture**	**Colour**	**Aroma**	**Taste**	**Overall acceptability**
Ankra*0	3.7 a	3.5 bc	3.9 ab	3.8 a	3.7 ab
Ankra*2	3.8 a	3.0 c	4.2 a	3.7 a	3.8 a
Ankra*4	3.6 ab	3.0 c	4.0 ab	3.7 a	3.3 ab
Ankra*6	3.6 ab	4.3 ab	3.8 ab	3.7 a	3.3 ab
Afisiafi*0	3.5 ab	3.2 bc	4.0 ab	3.8 a	3.3 ab
Afisiafi*2	3.0 b	3.0 c	3.3 b	3.7 a	3.0 bc
Afisiafi*4	3.6 ab	4.7 a	3.9 ab	3.4 a	3.5 ab
Afisiafi*6	3.4 ab	3.0 c	3.2 b	3.8 a	2.5 c
Lsd (0.05)	0.65	1.23	0.86	0.98	0.73
CV	15.65	30.09	19.25	22.33	18.88

4.6 CARBOHYDRATE AND PROTEIN CONTENTS OF PROCESSED

CASSAVA FLOUR (KOKONTE) SAMPLES

This part of the results gives an account on the carbohydrate and protein contents of the two varieties of cassava subjected to processing treatments; drying method and holding period and milled into flour samples.

4.6.1 Effect of variety on Protein and Carbohydrate Content of „Kokonte‟ Flour

Table 4.15 shows the effect of variety on protein and carbohydrate content of „kokonte‟ flour processed from Ankra and Afisiafi. There was a significant variation ($p<0.05$) due to varieties on the protein and carbohydrate contents of the flours. Thus, Ankra variety with low protein content of 1.3% recorded a higher carbohydrate content of 84.3% while Afisiafi had a higher protein but a low carbohydrate content of 1.5% and 84.1% respectively.

Table 4.15: Varietal effect on protein and carbohydrate content of kokonte flour

Varieties	Protein (%)	Carbohydrate (%)
Ankra	1.3 b	84.3 a
Afisiafi	1.5 a	84.1 b
Lsd (0.05)	0.08	0.01

4.6.2 Effect of drying method on Protein and Carbohydrate Content of „Kokonte‟ Flour

According to Table 4.16, drying method had no significant difference ($p>0.05$) on the protein content of the processed flours. However, it significantly caused a difference ($p<0.05$) between the carbohydrate means. Cassava chips that were sun dried and milled into flour was richer in carbohydrate content than solar dried one.

Table 4.16: Effect of drying method on protein and carbohydrate content of kokonte flour

Drying Method	Protein (%)	Carbohydrate (%)
sun drying	1.4 a	84.3 a
solar drying	1.4 a	84.2 b
Lsd (0.05)	0.08	0.01

4.6.3 Effect of Holding Period on Protein and Carbohydrate of „Kokonte" Flour

In Table 4.17 protein content was not significantly different ($p>0.05$) as a result of different holding period as a processing treatment. But, its impact on the carbohydrate content was significant ($p<0.05$) of which the effect of the 2 and 6 hours of holding was significantly equal ($p>0.05$), yet different from the highest and least recorded. Cassava chips held for 4 hours recorded the highest carbohydrate content of 84.3% when milled into flour while the ones milled without being held for any period of time (0hour) recorded the least (84.1%).

Table 4.17: Effect of holding period on protein and carbohydrate content of „kokonte" flour

Holding period (hours)	Protein (%)	Carbohydrate (%)
0	1.4 a	84.1 c
2	1.5 a	84.2b
4	1.4 a	84.3 a
6	1.4 a	84.2 b

Lsd (0.05)	0.12	0.02

4.6.4 Interaction Effect of Variety and Drying Method on Protein and Carbohydrate of „Kokonte" Flour

From Table 4.18, significant differences ($p<0.05$) were recorded among the interaction means with regard to protein content. Except for Afisiafi, solar dried and milled into flour, the same variety subjected to sun drying had the highest protein content of 1.5% and was significantly different from Ankra, regardless of the drying method used with comparatively low protein content of 1.3% and 1.4%.

Similarly, significant differences ($p<0.05$) were recorded among the mean values of carbohydrate contents due to the interaction. The means were distinctively different from one another. In a decreasing order of magnitude, flour from Ankra sun and solar dried had the first and second highest carbohydrate, then followed by Afisiafi sun dried and least, recorded by Afisiafi solar dried with 84.4, 84.3, 84.2 and 84.1 per cent respectively (Table 4.18).

Table 4.18: Interaction effect of the varieties and drying methods on the protein and carbohydrate content of „kokonte" flour

Interaction between variety and drying method	**Protein (%)**	**Carbohydrate (%)**
Ankra*sun drying	1.3 b	84.4 a
Ankra*solar drying	1.4 b	84.3 b
Afisiafi*sun drying	1.5a	84.2 c
Afisiafi*solar drying	1.4 ab	84.1 d
Lsd (0.05)	0.12	0.02

4.6.5 Interaction Effect of Variety and Holding Period on Protein and Carbohydrate of „Kokonte" Flour

According to Table 4.19, Afisiafi regardless of the number hours it was held, had significantly a similar ($p>0.05$) protein content as well as Ankra held for 2 hours. Their protein content ranged from 1.4 – 1.5 per cent. They were significantly different ($p<0.05$) from 1.3%, the least recorded by Ankra held for 0 hour. Ankra held for 4 and 6 hours respectively were also similar and not significantly different from the least protein noted.

Sample flours means from Ankra were all significantly different. Ankra held for 4 hours recorded the highest carbohydrate content (84.4%), followed by the same variety held at 6, 2 and 0 hours with 84.3, 84.3 per cent and 84.2, then 84.1, 84.1, 84.1 and 84.1 per cent recorded by Afisiafi samples held for 0, 4, 2 and 6 hours respectively of which 84.1per cent is the least. Samples from Afisiafi held for 2, 4 and 6 hours were significantly the same. Also, samples from Afisiafi held for 0, 2 and 4 hour were significantly similar.

Table 4.19: Interaction effect of varieties and holding period on the protein and carbohydrate content of „kokonte" flour

Interaction between variety and holding period (hours)	Protein (%)	Carbohydrate (%)
Ankra*0	1.3 c	84.2 d
Ankra*2	1.5 a	84.3c
Ankra*4	1.3 bc	84.4 a
Ankra*6	1.3bc	84.3 b
Afisiafi*0	1.4 ab	84.1 e
Afisiafi*2	1.5 a	84.1 ef
Afisiafi*4	1.5a	84.1 ef

Afisiafi*6	1.5 a	84.1 f
Lsd (0.05)	0.17	0.02

4.7 PASTING PROPERTIES OF „KOKONTE FLOUR

This section of the result report on a vital information on hot and cold paste viscoelastic properties (pasting-characteristics) of the „kokonte", a starch-based food measured with Bra bender visco-amylograph gadget which detect changes in viscosity of starch per an almost 1.5ºC rise at every minute as indicated by Pomeranz and Meloan (1977). The pasting properties of the sampled flours were focused on pasting temperature, peak viscosity, breakdown viscosity and setback viscosity of „kokonte" starch.

4.7.1 Effect of Cassava Variety on the Pasting Properties of „Kokonte" Flour

The pasting temperatures of pastes from the two cassava varieties according to Table 4.20 varied significantly ($p<0.05$) with Ankra (71.0 ºC) recording a high temperature than Afisiafi (68.3ºC). However, both varieties had no significant difference ($p>0.05$) in the level of peak viscosity.

A significant difference ($p<0.05$) was recorded between the cassava varieties with regards to the breakdown viscosity (BV). Table 4.20 indicates flour processed from Afisiafi variety has a higher breakdown viscosity compared to Ankra with 255.9BU and 228.8 BU. Both cassava varieties showed no significant difference ($p>0.05$) with respect to setback viscosity (SV) measured in their respective flour.

Table 4.20: Varietal effect of cassava on the pasting properties of „kokonte" flour

Varieties	Pasting temperature	Peak Viscosity (BU)	Breakdown in Viscosity (BU)	Setback Viscosity (BU)
Ankra	71.0 a	515.7 a	228.8b	6.0 a
Afisiafe	68.3 b	519.8 a	255.9 a	6.4a
Lsd (0.05)	1.18	13.3	9.34	0.80

4.7.2 Effect of Drying Method on the Pasting Properties of „Kokonte" Flour Table 4.21 shows the impact of the drying methods on pasting temperature, peak viscosity, breakdown viscosity and setback viscosity of cassava flours. From the result, the drying method did not cause significant difference ($p>0.05$) among the pasting temperatures and peak viscosities.

The effect of the drying methods on breakdown viscosity varied significantly ($p<0.05$). That is, flour made from a solar dried cassava chips recorded a higher breakdown viscosity (BV) of 253.9 BU compared to the one that was subjected sun drying (230.9 BU) during the processing (Table 4.21).

Setback viscosities (SV) measured in cassava flours with a varied drying methods were significantly different ($p<0.05$). Thus, the impact of the kind of drying method used was significant on the setback viscosity as flours processed from both sun dried and solar dried cassava chips had 7.7 and 4.8 BU respectively (Table 4.21).

Table 4.21: Effect of drying method on the pasting properties of „kokonte" flour

Drying Methods	Pasting temperature	Peak Viscosity (BU)	Breakdown Viscosity (BU)	Setback Viscosity (BU)
sun drying	69.2 a	519.3 a	230.9 b	7.7 a
solar drying	70.2 a	516.1 a	253.9 a	4.8 b
Lsd (0.05)	1.18	13.3	13.22	0.80

4.7.3 Effect of Holding Period on the Pasting Properties of „Kokonte" Flour From Table 4.22, holding period had a significant difference ($p<0.05$) on the pasting temperature of the „kokonte" flour for which cassava chips held for 6, 0, 4 and 2 hours before drying had 71.1^0C, 69.7^0C, 69.5^0C, and 68.4^0C respectively in decreasing order of magnitude. Holding period caused significant difference among the peak viscosities. Thus, flour produced from cassava chips not held for any period of time (0hour) had the highest influence, followed by 4, 2 and 6 hours with 539.8, 531.5, 517.9 and 481.6 BU respectively in order of decreasing peak viscosity. The means were all different ($p<0.05$) from one another significantly except 531.5 BU which was significantly similar to 539.8 and 517.9 BU (Table 4.22).

The holding period caused significant difference ($p<0.05$) to the breakdown viscosity of the cassava. Flour made from fresh cassava chips held at the various hours had breakdown viscosities significantly different from one another except 252.1 BU which was not different from 263.0 and 247.0 BU due to 2, 0 and 4 hours held respectively (Table 4.22).

The effect of the holding periods on setback viscosity was also significant and the levels increased and varied significantly ($p<0.05$) as the holding periods increase. The setback viscosities measured ranged from 4.6– 8.8 BU. Flour made from cassava held for 6hrs recorded the highest setback viscosity while the one not held for 0 hour(s) had least setback viscosity of 8.8 and 4.6BU, respectively. The impact of 2hrs (5.4 BU) was significantly not different (p>0.05) from that of 0 (4.6BU) and 4 (6.1 BU) hours hold of the cassava chips on the measure of setback viscosity (Table 4.22).

Table 4.22: Effect of holding period on the pasting properties of „kokonte" flour

Holding period (hours)	Pasting Temp. (ºC)	Peak Viscosity (BU)	Breakdown in Viscosity (BU)	Setback (BU)
0	69.7 ab	539.8 a	263.0 a	4.6 c
2	68.5 b	531.5 ab	252.1 ab	5.4 bc
4	69.4 b	517.9 b	247.0 b	6.1 b
6	71.1 a	481.6 c	207.5c	8.8 a
Lsd (0.05)	1.7	18.9	13.2	1.1

4.7.4 Interaction Effect of Cassava varieties and Drying Method on the Pasting Properties of „Kokonte" Flour

According to Table 4.23, interaction effect of the varieties and drying methods on mean peak viscosity of the sampled flours was significantly not different (p>0.05) unlike pasting temperature, of which solar dried Ankra processed flour had the highest pasting temperature of 71.5ºC and significantly different from 68.9 ºC and 67.8 ºC recorded by Afisiafi, solar and sun dried respectively. The least pasting temperature (67.8 ºC) was as well significantly different from 70.6 ºC, read for sun dried Ankra flour.

The varietal and drying methods interactions had a significant effect on the breakdown viscosity and caused a difference (p<0.05) among the means. Except for flour processed from a solar dried Ankra (242.3 BU) and sun dried Afisiafi (246.4 BU), that posed a similar effect with respect for breakdown viscosity, the rest; solar dried Afisiafi (265.5 BU) and sun dried Ankra (215.3 BU) completely showed a varied breakdown viscosities (Table 4.23).

The means on setback viscosity of the interactions showed a level of difference ($p<0.05$) though both varieties; Ankra and Afisiafi subjected to the same drying method had significantly similar effect ($p>0.05$). But the same variety exposed to a different drying method recorded significantly different setback viscosity. That is, the setback viscosity of cassava flour processed from a sun dried Ankra and Afisiafi of 7.8 and 7.6 BU respectively were significantly equal. Similarly, solar dried Ankra (4.3 BU) and Afisiafi (5.3 BU) recorded setback viscosity of a similar effect when milled into flour. However, means within the different range of the setback viscosity; 7.6 –
7.8 BU and 4.2 – 5.3 BU differed significantly from each other (Table 4.23).

Table 4.23: Effect of cassava variety and drying method interaction on the pasting properties of „kokonte‟ flour

Interaction between variety and drying method	Pasting temperature (ºC)	Peak Viscosity (BU)	Breakdown viscosity (BU)	Setback viscosity (BU)
Ankra*sun drying	70.6 ab	516.5 a	215.3 c	7.8 a
Ankra*solar drying	71.5 a	514.8 a	242.3 b	4.3 b
Afisiafi*sun drying	67.8 c	522.2 a	246.4 b	7.6 a
Afisiafi*solar drying	68.9bc	517.3 a	265.5 a	5.3 b
Lsd (0.05)	1.66	18.85	13.22	1.14

4.7.5 Interaction Effect of Cassava Varieties and Holding Period on the Pasting Properties of „Kokonte‟ Flour

From Table 4.24, pasting temperature of the interaction means were significantly not different ($p>0.05$) except flour of Ankra (72.4ºC) and Afisiafi (69.9ºC) chips held for

6hours each and Afisiafi chips held for 4hours 67.50ºC. The rest of the interacted means which fell within the ranges, 70.9 – 71.3 and 67.9 – 69.5 degree Celsius were similar and significantly not different.

Peak viscosity of the interaction means showed a significant difference ($p<0.05$). Flour processed from Afisiafi chips held for 2 hours recorded the highest peak viscosity of 557.7 BU different ($p<0.05$) from the same variety held for 6 hours, which had the least peak viscosity of 442.7 BU. Ankra held for 2 and 4 showed a similar effect with 505.3 and 502.5 respectively and were also different ($p<0.05$) from the highest and the least but not against 520.5 BU, recorded by Ankra chips held for 6 hours. The rest of the interaction means had a similar peak viscosity due to their significantly equal effect (Table 4.24).

Different significant levels ($p<0.05$) of breakdown viscosity were recorded due to the interactions of the varieties and holding period. Sample of Afisiafi variety when not held for 0hour recorded the highest breakdown in viscosity (283.2 BU). However, the least breakdown in viscosity (200.2 – 214.8 BU) was noted in samples of both cassava varieties when held for a period of 6 hours. The effect of Afisiafi held for 2 and 4 hours on breakdown viscosity compared to Ankra held for 2 and 4 hour also varied significantly (Table 4.24).

Setback viscosity varied significantly ($p<0.05$) among the interacted means. The highest (9.7 BU) and least (3.8 BU) levels were measured in flour samples made from Ankra variety held for 6 and 2 hours respectively before being dried. Both means also differed significantly from treatment means that ranged from 5.6 – 7.9 BU. The impact of the least setback in viscosity was similar to 4.2 and 5.1 BU recorded by flour samples of Afisiafi and Ankra exposed to drying without being held for any hour(s) (Table 4.24).

Table 4.24: Effect of cassava varieties and holding period on the pasting properties of „kokonte" flour

Interaction between variety and holding period (hours)	**Pasting temperature**	**Peak Viscosity (BU)**	**Breakdown viscosity (BU)**	**Setback viscosity (BU)**
Ankra*0	71.3 ab	534.3 ab	242.8 cd	5.1 de
Ankra*2	69.5 bcd	505.3 c	236.3 d	3.8 e
Ankra*4	70.9ab	502.5 c	236.0d	5.6 cd
Ankra*6	72.4 a	520.5 bc	200.2 e	9.7 a
Afisiafi*0	68.0 cd	545.3 ab	283.2 a	4.2 de
Afisiafi*2	67.5 d	557.7a	267.8ab	6.9 bc
Afisiafi*4	67.9 cd	533.3 ab	258.0 bc	6.7 bc
Afisiafi*6	69.9 bc	442.7 d	214.8 e	7.9b
Lsd (0.05)	2.35	26.66	18.69	1.61

CHAPTER FIVE

5.0 DISCUSSION

5.1 SURVEY

The outcome of the survey revealed important activities and facts about the processing and marketing of "kokonte" flour in the study area. Producers, sellers and consumers were detected as the players involved in the processing, selling and consumption of "kokonte".

The highest per cent (70%) of producers who have been in the „Kokonte" production for about ten (10) years might be a clear indication that most of the respondents are highly experienced and that the information provided was based on their several years of experience in the business. It also suggested that the results of these findings are the true reflections of what prevail in the study area.

The various indications by the respondents as how long fresh cassava chips are kept before drying showed that majority of the producers held their produce number of hours or minutes prior to drying.

The majority (90%) of the producers who processed cassava from their own farms into „kokonte" while the minority (10%) depended on the cassava sold in some major markets as source of raw material for the processing, might be a clear indication that the „Kokonte" business in the area is sustainable since the majority of the producers themselves are always cultivating cassava to feed the industry without depending solely on other source(s) which is/are likely to fail.

The fact that none of the producers depended on any Research Institution or other sources for cassava as a source of raw material for the business might be suggesting that only a very few or no Research Institutions are in the Municipality. Or it could be that the extension officers are also not doing enough to educate the farmers on the existence of these Institutions. The work of the extension officers would have helped the farmer selecting best raw materials.

The result indicating that almost all the producers use sun drying method to dry their fresh cassava chips into „Kokonte‟ might be a clear indication that majority of the producers in the study area had no or little knowledge on the existence of solar dryers and for that matter the usefulness of them. This suggested that none of the „Kokonte‟ processers used solar dryer to dry fresh cassava chips.

The confirmation by most producers (80%) that, colour of „Kokonte‟ does not change during storage might be suggesting that the production chains were being monitored closely especially any adverse change in colour which might alter the quality of the products.

The highest percent of sellers (56%) which indicated that colour amongst other sensory properties was the most single factor that influenced consumer‟s acceptability might be suggesting that most of the sellers are quality conscious by satisfying consumers with the most desired colour thus to say they maintain consistency. However, the minority who are of divergent view need education so as to help them meet the needs of their consumers so far as colour is concern.

The highest percentage of consumers (54%), showing that the appealing nature (colour) of the product motivates consumers to purchase it was a confirmation of the views of sellers that colour plays a major role in patronage.

The response to the questions as whether cooked „Kokonte‟ was more nutritious than Banku or Apkle clearly indicated that costumers had equal nutritional perception for both products; Banku / Akple and cooked „Kokonte". This perception would be serving as motivational factor for the patronage of cooked „Kokonte" hence ensuring sustainability of the business and possible expansion in future.

The higher percentage (84%) consumers who experienced no discomforts following intake of cooked „Kokonte" might be suggesting that consumers consumed high quality cooked „Kokonte" in the area. This further suggested that, steps required to process quality flour to avoid contaminations and microbial infections were being followed. However, the lower per cent (16%) who experienced discomforts but did not visit the hospital nor undergone any serious treatment before relief could be a confirmation of mere or normal reaction and not as result of contamination.

5.2 Sensory Properties of "Kokonte" Flour

Sensory characteristics such as colour, aroma, texture and taste are important quality attributes of food (Fellows, 2000) to consumers. These determine an individual"s preference for specific products and brands of similar products as well as influence level of acceptability. The sensory properties of the cassava flours based on the result revealed no significant difference ($p>0.05$) between the two cassava varieties, Ankra and Afisiafi on texture, colour, aroma and taste of the "kokonte" flour. This showed that both varieties might have exhibited the same characteristic effect on the sensory properties of the processed flour. Similarly, the drying methods employed had no significant effect ($p>0.05$) likewise the holding period. Thus, the treatments individually could not make any difference on the sensory quality of the processed flour. The interaction of varieties and the drying methods also did not cause significant change on texture, colour and taste except aroma. The effect of holding period on both varieties of cassava as result of the interaction was significant ($p<0.05$) on texture, colour and aroma. The result proved that, holding fresh cassava chips for a period of time could change the texture, colour and aroma of "kokonte" flour but not taste. This might be due to fermentation process and other reaction that occurred during the hours of holding. The taste was not different for both varieties. They might have had the same level of cyanide content which was a determining factor of sweetness in cassava.

Both processing treatments (holding period and drying method) interaction showed a significant difference ($p<0.05$) on colour and aroma but not texture and taste. Likewise, the interaction of the varietal, holding period and drying method effect caused a difference on the colour, aroma and texture. Storage and heat as result of holding and drying are factors that might have given room for chemical reaction to occur. A non-enzymatic browning reaction which affected colour might have been a possible cause for the different colour effect detected. Such a reaction normally occurs in all food in the presence of heat and during storage. It is desirable but may cause darkness of food and off-flavour. The same reaction could also affect the aroma through dehydration when a primary aroma volatile compound was released and this varies with temperature and time of heating. It is also known that fermentation, an enzymatic reaction, could improve on flavour hence, this could also be a possible cause of the difference recorded.

The difference in texture could be due to chances as the grinding may equally affect texture. Texture of a food product in particular is mostly determined by moisture content, fat content and the amount of structural carbohydrate such as cellulose, and starches (Owusu-Apenteng, 2005).

Depending on the nature of the process, they either lead to hydrolysis of cyanohydrins to release acetone and hydrogen cyanide, which are volatilized and subsequently lost.

However, the acetone release imparted on the flavour of the product (Amoa-Awua, 1996). Afisiafi solar dried 6hrs flour was the longest held sample. The longest holding period might have allowed for enough fermentation improving the taste as well as the aroma. This might have resulted in the Afisiafi solar dried 6hrs flour sample being the most accepted. In addition, varietal difference and the drying treatment might have also influenced the acetone concentration and the ease of its release respectively.

5.3 Functional Properties of "Kokonte" Flour

5.3.1 Pasting temperature

Pasting temperature is one of the pasting properties which provide an indication of the minimum temperature required for sample cooking, energy costs involved and other components stability; lower pasting temperature of starch means it is easy to cook while higher pasting temperature means the starch requires high energy to cook(Shimelis et al; 2006). However, lower pasting temperature is associated with low paste stability. Ankra, held 4 hours and sun dried had the highest (290.1ºC) pasting temperature and different from the rest of the sample. This sample resulted from the overall interactive effects of the three factors under investigation. Pasting temperature provides an indication of the minimum temperature required for sample cooking, energy costs involved and other components stability (Shimelis *et al*., 2006). The implication is that the samples with the lower pasting temperatures would require lower temperatures to cook which are associated with lower cost. Thus, the gelatinisation temperature observed for Ankra held 6hrs and solar dried has the strongest associative forces within its granules and hence difficult to cook and would require higher heat for gelatinisation.

5.3.2 Peak viscosity

The highest peak viscosity 617.00BU recorded for Afisiafi solar dried 2hrs sample therefore shows that the sample will produce the highest resistance to stirring as compared the rest of the samples with low peak viscosities during cooking. Economic benefit of low peak viscosity is cost and energy reduction. The varieties had no differences ($p>0.05$) on the peak viscosity likewise the drying methods. However, the holding period effect was significant with regards to individual effect. Hence the interaction effect recorded among the means is due to the effect of the holding period.

5.3.3 Breakdown

Breakdown viscosity measures the vulnerability or susceptibility of cooked starch to disintegration (Adebowale *et al.* (2005). Variation among the varieties, holding periods and drying methods singly had a significant effect ($p<0.05$) on breakdown of cassava flour. According to Adebowale *et al.* (2005), higher breakdown in viscosity shows decrease in ability of starch sample to withstand continuous heating and shear stress during cooking. Genotypic variation in cassava varieties (Table 4.20) might have contributed to the difference in the level of breakdown viscosity. Afisiafi had a higher breakdown in viscosity compared to Ankra which indicates that, Afisiafi is more liable to starch disintegration or has less ability to withstand heating and shear stress during cooking compared to flour from Ankra variety. Likewise, the effect of the solar drying method on flour was greater compared to sun drying. Holding period treatments showed that fresh cassava chips not held for any period tend to have a greater impact on flour's breakdown viscosity than those held for period of hour(s).

The result (Table 4.22) also indicates a decline in breakdown viscosity as period of holding increases. Thus, duration taken in processing of flour especially at preparation stage (cutting, delay in drying and mode of drying) could have a significant impact on breakdown viscosity.

5.3.4 Setback

Setback viscosity measures the recrystallization of starch during cooling. Difference in the variety as result of genetic variation of the root tuber, cassava had no significant impact ($p>0.05$) on setback of cassava flour. Thus, both varieties tested recorded setback of a similar effect. The amount and molecular weight of amylose (Loh, 1992) and inherent difference in the structure of starch (Zhang and Hamaker, 2008) are regarded as contributing factors for difference in the setback among different starches. Hence, a difference not recorded between the two cassava varieties tested may be due to similar amount and molecular weight of amylose as well as starch structure irrespective of the genetic difference which defines the varieties.

Difference in setback as a result of the holding periods impact, was significant ($p<0.05$). The result (Table 4.22) showed setback viscosity increases with an increase in hours of holding. Thus, length of holding could alter a change in setback viscosity of cassava flour. The drying methods also had a significant influence ($p<0.05$) as a difference was seen in the mean setback viscosities measured. Flour of a sun dried cassava showed a higher setback viscosity than the solar dried treated. The outcome also shows that mode of drying could inflict variation in the level of setback viscosity. Sun drying tend to increase the level of setback viscosity in cassava milled into flour and according to Adeniji *et al.* (2010) it is significant in domestic products like pounded yam, which requires high setback, high viscosity and high paste stability.

Variation in the level of setback viscosity values (Table 4.23) was significantly influenced ($p<0.05$) by the interaction of the varieties and drying methods. That is, any variety according to the result could have different setback viscosities if mode of drying is varied. But it is likely to have setback viscosity values of a similar effect if cassava (regardless of the variety) is subjected to the same mode of drying or drying method. And the varieties when exposed to sun drying recorded a higher setback viscosity values. According to Oduro *et al.* (2000), high setback values are associated with a cohesive paste. And flour made from cassava variety exposed to sun drying recorded higher setback value which indicates a lower potential for retro-gradation in such treatment sample. Also, the impact of the interaction of varieties and holding period was significant ($p<0.05$) among some of means and any difference was mainly due to the effect of the holding period and not the genotypic variation. That is, the way cassava flour is made (preparatory procedures followed), could greatly have an impact on the level of setback viscosity measured in cassava paste. Likewise, different degree of interactions and its associated compounds during pasting as by Zhang and Hamaker (2008) may possibly cause the difference.

5.4 PROTEIN AND CARBOHYDRATE CONTENTS

Starch, the main plant carbohydrate is the most important plant derivative used by man. It has an unlimited importance in industry and food and can be modified to suit various applications using inexpensive methods making it ideal for a number of uses (Satin, 2006). Generally, the processed flours had carbohydrate contents not less than 84%. This value is however lower than the concentration (level) in fresh cassava samples; Afisiafi (84.5%) and Ankra (84.4%). It was observed that there was often a trend of decreasing initial percentage of the nutritional composition (carbohydrate and protein) of fresh samples as compared to their respective products over time. It could be argued that, the processing involved in changing food from one state to another and persistent respiration of the fresh sample might have had an impact on the compositions.

In line with the argument, holding period and drying method had a significant impact on the carbohydrate (Table 4.15 and 4.16) but not the protein though percentage loss might have occurred.

The interaction of the varieties, holding period and drying method had a significant influence ($p<0.05$) on the protein as well as the carbohydrate. High temperatures increases physiological activities especially with respiration and transpiration (Passam *et al.,* 1978) and fluctuation in the temperatures during drying and holding could have caused the difference. Complexes of proteins with tannins (Osunde and Orhevba, 2009) may be responsible for the relatively low of proteins found in cassava.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

6.1 CONCLUSION

„Kokonte‟ producers in the study area used or depended solely on sun drying to dry their fresh cassava chips. Majority (90%) of the producers processed cassava from their own farms into „kokonte‟ while the minority (10%) depended on the cassava sold in some major markets as source of raw material for the processing which was clear indication that the „Kokonte‟ business in the area is sustainable.

The solar dryer did not improve upon the sensory qualities of the flour samples as well as their overall acceptability as anticipated. It meant that, producers had equal chances of their final products being accepted by consumers.

In terms of nutrition, sun drying retained higher carbohydrate content than the solar dryer which was investigated. Irrespective of the method used, the same level of protein was maintained in the flour.

The solar dryer caused a significant variation in breakdown in viscosity. This meant that „Kokonte" produced using the solar dryer has less ability to withstand heating and shear stress.

„Kokonte" processed from Ankra variety will incur higher cost of preparation as compared to that of Afisiafi due to the higher pasting temperature associated with it (70.0°C). At the same time this product cannot withstand continual heating and sheer stress when compared to Afisiafi.

Holding fresh cassava chips between the hours of zero and six prior to drying had no influence on „Kokonte" sensory qualities for consumers in the Hohoe Municipality of the volta Region. This meant that irrespective of the holding period (0hour, 2hours, 4hours and 6hours) consumers had the same level of acceptability. In addition, regardless of these holding periods, the same level of protein was retained in the final product (Kokonte) except carbohydrate when held for 4hours. „Kokonte" held for this period (4hours) prior to drying retained significantly higher carbohydrate level in the flour sample and was therefore of the best quality.

6.2 RECOMMENDATION

Cyanide concentrations as well as harmful microbial contaminations are the possible sources of toxicity in cassava products. Further analyses on microbial contamination and cyanide toxicity should be carried out to determine the safety of cassava flour processed by similar methods as in this study. Other component apart from carbohydrate and protein could be investigated in future.

The effect of mixed cassava varieties and single varieties on the investigated physicochemical properties of cassava flour could be taken by another researcher.

In future studies, the solar dryer should be equipped with openings to provide adequate ventilation in order to reduce mold growth as observed during drying.

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APPENDICES

Appendix I: Sample of processed cassava flour and solar dryer chamber used

Plate 1: Ankra flours that were subjected to drying solar drying

Plate 2: Afisiafi flours that subjected to sun

Plate 3: Flour samples from Ankra and Afisiafi

Plate 4: Solar dryer used to dry samples chips

Appendix II: Questionnaire Administered

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

DEPARTMENT OF HORTICULTURE

This questionnaire is designed to evaluate the quality of „Kokonte" being produced and sold in some major markets in the Hohoe Municipality of the Volta Region of Ghana and sustainability of business. All information provided will be treated confidentially. Please be as objective as possible.

Town………………………………………………………………………….

BIODATA (producers, sellers and consumers)

1. Sex of respondent a. male [ ] b. female [ ]
2. Age of respondent a.Below 20 [ ] b.20-29 [ ] c. 30-39 [ ] d. 40-49 [ ] e. 50-59 [ ]f. 60 and above [ ]
3. Marital status a. single [ ] b. married [ ] c. divorced [ ] d. widowed [ ]
4. Educational background a. informal education [ ] b. primary [ ] c .MSLC/JHS [ ] d. SHS/Voc./Tech. [ ] e. tertiary [ ]
5. Religious background a. Christian [ ] b. Muslim [ ] c. Traditionalist [ ] d. other [ ] specify…………………………………………………
6. Number of dependents(s) a.1-3[ ] b.4-6 [ ] c. 7-10 [ ] d. 11 and above [ ] e. Other [ ] specify…………………………….
7. Main occupation……………………………….

<u>PRODUCTION RECORD (Mainly by producers)</u>

8. How long have you been in the „Kokonte" production business? a. About one to two years [ ] b. About three to five years [ ] c. About six to ten years [ ] d. Above ten years [ ]

9. Which of the following ways of processing „Kokonte" do you use? a. Peel, wash and dry immediately [ ] b. Peel, wash and dry after few days [ ] c. Peel and dry immediately without washing [ ]

10. What volume of „Kokonte" do you produce weekly? a. About 1/2 a maxi bag [ ] b. about 2 maxi. Bag [ ] c. 3 and above maxi. Bags [ ]

11. On what scale is your production? a. Small scale [ ] b. Commercial scale [ ]

12. What is the source of cassava used for producing your „Kokonte"? a. The market [ ] b. Own farm. [ ] c. Crop Research Institute [ ]. d. Other [ ] Specify…………

13. What is the average age of the cassava used for producing „„Kokonte""? a. Six month old [ ] b.One year old [ ] c. Two years old [ ] d. More than two years old [ ] d. Can"t tell [ ]

14. Do you think „Kokonte" production is more challenging as compared to other products from cassava? a. Yes [ ] b. No [ ]

If yes, what are the challenges? ....

15. Apart from „Kokonte", do you process cassava into any other useful product(s)? a. Yes [ ] b. No [ ]

If yes state………………………………………………………..

16. Do you use a specific variety of cassava in your production? a. Yes [ ] b. No [ ].

If yes state the variety and give reason…………………………………………………………………………………… ……………………………………………………………………………………

…………………

17. (a) Which of the following do you mostly employ in the drying of „„Kokonte""?

a. Sun drying [ ] b. Solar drying [ ] c. Electric drying [ ] d. Other………………………….

b. State the reason for your choice above:

……………………………………..………

18. Which of the drying methods below do you think produces the quality of „„Kokonte"" that is often in high demand by potential consumers? a. Sun drying [ ] b. Solar drying [ ] c. Electric drying [ ] d. Other…………….

19. Which stage of „„Kokonte"" processing is most challenging a. Peeling and washing [ ] b. Cutting into chips [ ] c. Drying [ ] d. Milling into flour [ ]

20. Which of the following serves as a temporal storage facility for fresh cassava chips before drying? a. A metal container with lid [ ] b. A metal container without a lid [ ] c. A basket with a lid [ ] d. A basket without a lid

21. How long do you hold fresh cassava chips before drying? a. 0hour [ ] b. 2 hours [ ] c. 6 hours [ ] d.12 hours [ ] e. Other [ ] specify……………..

22. Where do you dry your cassava chips? a. On bare floor [ ] b. On covered floor [ ] c. On covered mat above the ground [ ] d .On uncovered mat above the ground [ ]

23. Do you have any knowledge about solar dryer? a. Yes [ ] b. No

If yes, what do you know about solar dryer?

....

24. Does your method of production differ from those of the neighbouring districts/ Municipalities? a. Yes [ ] b. No [ ] If yes, state the

difference(s)……………………………………………………………………………

………..………………………………………………………………………………

…………………………………………………………………………………………

25. Which of the following techniques do you employ in the storage of dried „Kokonte" chips? a. Storage in air-tight container [ ] b. Storage in well ventilated containers [ ]

26. Do you experience colour change(s) during storage? a. Yes b. No

If yes, is it desirable? a. No [ ] b. Yes [ ]

27. Which of these techniques give the desirable change(s)? a. Storage in air-tight containers [ ] b. In well ventilated containers [ ]

28. Which of the following colours of „Kokonte" do you produce? a. light brown [ ] b. brown [ ] c. light dark [ ] d. dark [ ] e. white [ ]

29. Why do you often supply the colour, above to your customers? Because a. of customer demand [ ] b. it is relatively cheaper to produce [ ] c. no special skill is required for production [ ]

30. Do you have challenge(s) in preserving the „Kokonte" flour? Yes [ ] No [ ]. If yes what is/are the challenge(s)?

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………

RATE OF CONSUPTION (Mainly Consumers)

31 How often do you eat „Kokonte" in a week a. Once [ ] b. twice [ ] c. thrice [ ] d. four times and above [ ]

32 What is the main source of the „Kokonte" you often eat? a. Self [ ] b. Sellers [ ]

33 Do you think „Kokonte" is more nutritious than Banku/Akple a. Yes [ ] b. No [ ]

34 As a consumer, do you think „Kokonte" provides more energy as compared to other products from cassava? a. Yes [ ] b. No [ ]

35 Do you often experience any stomach discomfort following intake of „Kokonte"? Yes [ ] No [ ]

36 Which of the following colours of the „Kokonte" do you like most? a. light brown [ ] b. brown [ ] c. light dark [ ] d. very dark [ ]

37 What is the reason for the choice of colour in 37 above? a. Because it is the most hygienic [ ] b. Because most people patronize this colour [ ]. c. Because it is relatively cheaper [ ] d. Because it is attractive [ ]

38 Which of the following soups best goes with cooked „„Kokonte""? a. Okra soup [ ] b. Ground nut soup [ ] c. Light soup [ ] d. Palm nut soup [ ]

<u>ACCEPTABILITY AND PATRONAGE (Sellers only)</u>

39 Which colour of „Kokonte" do you often cook? a. Light brown [ ] b. Brown [ ] c. Light dark [ ] d. Dark [ ].

40 Do you think acceptability of cooked „Kokonte" is influenced by colour? a. Yes [ ] b. No [ ] c. No idea

41 What is the level of patronage of the „Kokonte" a. Very high [ ] b. high [ ] c. low [ ] d. very low [ ]

42 What is the patronage level of the „Kokonte" as compared to banku/akple? a. Higher [ ] b. Lower [ ] c. At par [ ]

43 As „Kokonte" seller, what are the common reasons why some people don"t patronize it?

…………………………………………………………………………………

…………………………………………………………………………………

……………………………………………………………….....................................

....

44 Which time of the day is patronage high? a. Morning [ ] b. Afternoon [ ] c. Evening [ ]

45 Which of the following is a possible reason for your choice above? a. It is safer to eat „Kokonte" at this time [ ] b. No reason [ ] c. Doctor"s advice [ ].d .Other [ ] specify……..…………………………………………

46 Is the "Kokonte" business viable? a. Yes [ ] b. No [ ]

If yes in Q46, what is the fate of the „Kokonte" business in the municipality? a. It is expected to increase but not significantly [ ] b. It is expected to increase significantly [ ] c. No idea. [ ]

47 How much percentage increase in the business are you expecting? a. 10 [ ] b. 20 [ ] c. 30 [ ] d. Other [ ] specify…………………………………

48 Which of the following characteristics do you think mostly influence consumer acceptability? a. Taste [ ] b. Colour [ ] c. Smell. [ ]

Appendix III: Analysis of Variance Tables

SENSORY PROPERTIES

Analysis of Variance Table for Aroma

Source	DF	SS	MS	F	P
Reps	2	3.957	1.93287		

variety	1	1.6913	1.69125	3.19	0.0842
drying_me	1	1.3906	1.39060	2.62	0.1158
holdng_pe	3	1.7350	0.57832	1.09	0.3682
variety*drying_me	1	0.1530	0.15300	0.29	0.5951
variety*holdng_pe	3	2.1346	0.71155	1.3	0.2794
drying_me*holdng_pe	3	2.7521	0.91735	1.73	0.1820
variety*drying_me*holdng_pe	3	2.7122	0.90407	1.70	0.1871
Error	30	15.9077	0.53026		
Total	47	32.3421			

Grand Mean 3.7819   CV 19.25

Analysis of Variance Table for Colour

Source	DF	SS	MS	F	P
Reps	2	1.0530	0.52650		
variety	1	0.0019	0.00187	0.00	0.9672
drying_me	1	0.1704	0.17041	0.16	0.6953
holdng_pe	3	4.8503	1.61676	1.5	0.2390
variety*drying_me	1	0.0261	0.02613	0.02	0.8780
variety*holdng_pe	3	14.1094	4.70312	4.32	0.0121
drying_me*holdng_pe	3	3.5373	1.17911	1.08	0.3717
variety*drying_me*holdng_pe	3	3.8533	1.28445	1.18	0.3344
Error	30	32.6962	1.08987		
Total	47	60.2980			

Grand Mean 3.4692   CV 30.09

Analysis of Variance Table for Taste

Source	DF	SS	MS	F	P
Reps	2	14.7770	7.38851		
variety	1	0.0180	0.01802	0.03	0.8723
drying_me	1	0.0945	0.09452	0.14	0.7129
holdng_pe	3	0.3655	0.12184	0.18	0.9106
variety*drying_me	1	0.0581	0.05810	0.08	0.7729
variety*holdng_pe	3	0.2908	0.09694	0.14	0.9343
drying_me*holdng_pe	3	0.5800	0.19332	0.28	0.8379
variety*drying_me*holdng_pe	3	4.5648	1.52160	2.22	0.1062
Error	30	20.5564	0.68521		
Total	47	41.3051			

Grand Mean 3.773 CV 22.33

Analysis of Variance Table for Texture

Source	DF	SS	MS	F	P
Reps	2	7.0579	3.5896		
variety	1	1.1470	1.14701	3.76	0.0619
drying_me	1	0.0602	0.06021	0.20	0.6600
holdng_pe	3	0.3058	0.10194	0.33	0.8006
variety*drying_me	1	0.0140	0.01401	0.05	0.8317
variety*holdng_pe	3	0.8772	0.29241	0.96	0.4249
drying_me*holdng_pe	3	1.4244	0.47481	1.56	0.2203
variety*drying_me*holdng_pe	3	6.0660	2.02199	6.63	0.0014
Error	30	9.1490	0.30497		
Total	47	26.1016			

Grand Mean 3.596 CV 15.65

Analysis of Variance Table for Overall acceptability

Source	DF	SS	MS	F	P
Reps	2	2.1107	1.05535		
variety	1	2.5346	2.53460	6.58	0.0156
drying_me	1	1.0296	1.02960	2.67	0.1125
holdng_pe	3	2.4861	0.82870	2.15	0.1145
variety*drying_me	1	0.3153	0.31525	0.82	0.3728
variety*holdng_pe	3	1.7981	0.59937	1.56	0.2205
drying_me*holdng_pe	3	0.7089	0.23631	0.61	0.6116
variety*drying_me*holdng_pe	3	3.8515	1.28384	3.3	0.0325
Error	30	11.5552	0.38517		
Total	47	26.3900			

Grand Mean 3.2952   CV 18.83

PROXIMATE ANALYSIS

Analysis of Variance Table for Carbohydrate

Source	DF	SS	MS	F	P
Reps	2	0.00345	0.00173		
variety	1	0.52292	0.52292	1526.15	0.0000
drying_me	1	0.04502	0.04502	131.39	0.0000
holdng_pe	3	0.03132	0.01044	30.47	0.0000
variety*drying_me	1	0.01725	0.01725	50.35	0.0000
variety*holdng_pe	3	0.04057	0.01352	39.47	0.0000
drying_me*holdng_pe	3	0.01441	0.00480	14.01	0.0000
variety*drying_me*holdng_pe	3	0.00707	0.00236	6.88	0.0012

Error	30	0.01028	0.00034		
Total	47	0.69230			

Grand Mean 84.226 CV 0.02

Analysis of Variance Table for Protein

Source	DF	SS	MS	F	P
Reps	2	0.05188	0.02594		
variety	1	0.27301	0.27301	13.28	0.0010
drying_me	1	0.02253	0.02253	1.10	0.3035
holdng_pe	3	0.07328	0.02443	1.19	0.3308
variety*drying_me	1	0.04441	0.04441	2.16	0.1520
variety*holdng_pe	3	0.08528	0.02843	1.4	0.2670
drying_me*holdng_pe	3	0.06888	0.02296	1.12	0.3577
variety*drying_me*holdng_pe	3	0.06454	0.02151	1.05	0.3863
Error	30	0.61665	0.02056		
Total	47	1.30047			

Grand Mean 1.467 CV 10.12

PASTING PROPERTIES

Analysis of Variance Table for Pasting Temperature

Source	DF	SS	MS	F	P
Reps	2	4.788	2.3940		
variety	1	87.750	87.7502	22.09	0.0001
drying_me	1	13.547	13.5469	3.4	0.0747
holdng_pe	3	43.32	14.4374	3.6	0.0239
variety*drying_me	1	0.092	0.0919	0.02	0.8801

variety*holdng_pe	3	3.427	1.1424	0.29	0.8340
drying_me*holdng_pe	3	58.657	19.5524	4.92	0.0067
variety*drying_me*holdng_pe	3	15.006	5.0019	1.26	0.3061
Error	30	119.185	3.9728		
Total	47	345.765			

Grand Mean 69.77 CV 2.86

Analysis of Variance Table for peak viscosity

Source	DF	SS	MS	F	P
Reps	2	101	50.6		
variety	1	200	200.1	0.39	0.5363
drying_me	1	127	126.8	0.25	0.6221
holdng_pe	3	23817	7939.1	15.53	0.0000
variety*drying_me	1	30	30.1	0.06	0.8100
variety*holdng_pe	3	29405	9801.8	19.18	0.0000
drying_me*holdng_pe	3	40282	13427.5	26.27	0.0000
variety*drying_me*holdng_pe	3	19522	6507.2	12.73	0.0000
Error	30	15333	511.1		
Total	47	128818			

Grand Mean 517.71 CV 4.37

Analysis of Variance Table for Breakdown Viscosity

Source	DF	SS	MS	F	P
Reps	2	15	7.3		
variety	1	8829	8829.2	35.15	0.0000
drying_me	1	6371	6371.0	25.36	0.0000
holdng_pe	3	21088	7029.2	27.98	0.0000
variety*drying_me	1	188	188.0	0.75	0.3938
variety*holdng_pe	3	1125	375.1	1.5	0.2364
drying_me*holdng_pe	3	55903	18634.4	74.18	0.0000
variety*drying_me*holdng_pe	3	7729	2576.2	10.26	0.0001

Error	30	7536	251.2
Total	47	108783	

Grand Mean 242.40 CV 6.54

Analysis of Variance Table for Setback Viscosity

Source	DF	SS	MS	F	P
Reps	2	2.764	1.49		
variety	1	1.780	1.7801	0.96	0.3352
drying_method	1	97.114	97.1143	52.33	0.0000
holdng_period	3	119.822	39.9407	21.52	0.0000
variety*drying_me	1	4.374	4.3739	2.36	0.1352
variety*holdng_pe	3	43.100	14.3667	7.74	0.0006
drying_me*holdng_pe	3	41.863	14.042	7.52	0.0007
variety*drying_me*holdng_pe	3	62.592	20.8639	11.24	0.0000
Error	30	55.673	1.8558		
Total	47	429.082			

Grand Mean 6.2332 CV 21.86

Appendix IV : Laboratory Analysis for pasting properties

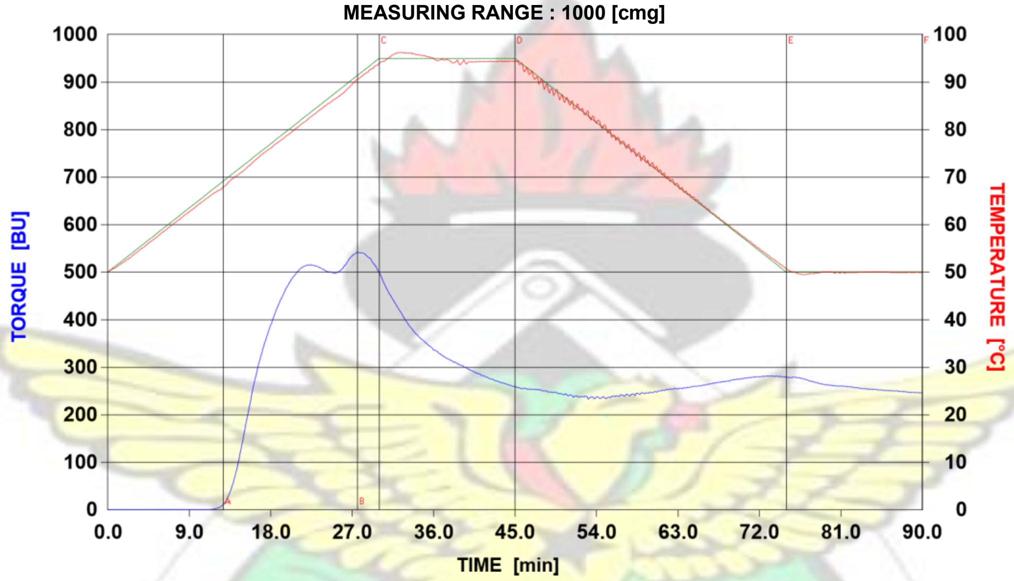
BRABENDER VISCOGRAPH

Parameter

Operator	:	Nii Nortey	Date	:	3/27/2013
Sample	:	SO 1(B)	Method	:	
Moisture	:	11.67 [%]	Correction	:	12.76 [%]
Sample weight	:	40 [g]	Corr. to 12.76%	:	39.5 [g]

Water	:	420 [ml]	Corr. to 12.76%	:	420.5 [ml]
Note	:				
Note	:				

Speed	:	75 [1/min]	Meas. range	:	1000 [cmg]
Start temperature	:	50 [°C]	Heat./Cool. rate	:	1.5 [°C/min]
Max. temperature	:	95 [°C]	Upp. hold. time	:	15 [min]
End temperature	:	50 [°C]	Fin. hold. time	:	15 [min]



Evaluation

Point	Name	Time [HH:MM:SS]	Torque [BU]	Temperature [°C]
A	Beginning of gelatinization	00:12:45	11	67.9
B	Maximum viscosity	00:27:35	542	90.6
C	Start of holding period	00:30:00	499	93.9
D	Start of cooling period	00:45:00	259	94.3
E	End of cooling period	01:15:00	279	50.7
F	End of final holding period	01:30:00	245	49.9
B-D	Breakdown		283	
E-D	Setback		21	

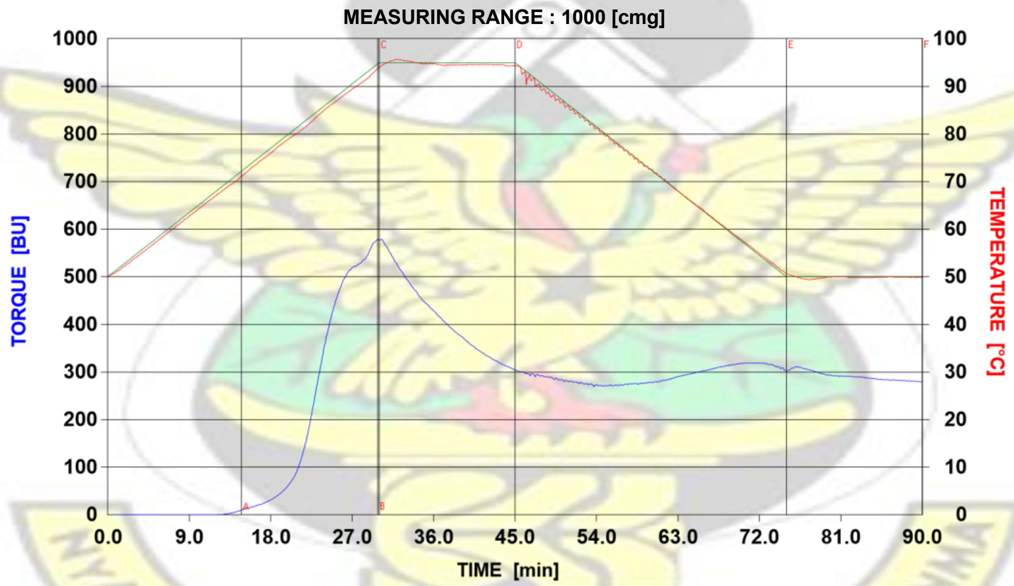
File : Measurement V: 2.3.16

BRABENDER VISCOGRAPH

Parameter

Operator	:	Nii Nortey	Date	:	4/2/2013
Sample	:	Ansu 5 (A)	Method	:	
Moisture	:	12.32 [%]	Correction	:	12.76 [%]
Sample weight	:	40 [g]	Corr. to 12.76%	:	39.7 [g]
Water	:	420 [ml]	Corr. to 12.76%	:	420.2 [ml]
Note	:				
Note	:				

Speed	:	75 [1/min]	Meas. range	:	1000 [cmg]
Start temperature	:	50 [°C]	Heat./Cool. rate	:	1.5 [°C/min]
Max. temperature	:	95 [°C]	Upp. hold. time	:	15 [min]
End temperature	:	50 [°C]	Fin. hold. time	:	15 [min]



Evaluation

Point	Name	Time [HH:MM:SS]	Torque [BU]	Temperature [°C]
A	Beginning of gelatinization	00:14:45	10	71.0
B	Maximum viscosity	00:29:50	579	93.7
C	Start of holding period	00:30:00	577	94.0
D	Start of cooling period	00:45:00	304	94.4
E	End of cooling period	01:15:00	303	50.6
F	End of final holding period	01:30:00	279	49.8
B-D	Breakdown		274	

E-D	Setback		-2	

File : Measurement V: 2.3.16