KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI

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ASSESSMENT OF PULP FLOUR QUALITY OF THREE VARIETIES OF PLANTAIN PULP PRODUCED USING SUN AND SOLAR DRYING METHODS

BY

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APRIL, 2016

ASSESSMENT OF PULP FLOUR QUALITY OF THREE VARIETIES OF PLANTAIN PULP PRODUCED USING SUN AND SOLAR DRYING METHODS

A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE (MSc. POSTHARVEST TECHNOLOGY) DEGREE

BY

BERNICE NYANTAKYI

APRIL, 2016

DECLARATION

I hereby declare that, except for specific references which have been duly acknowledged, this project is the result of my own research and it has not been submitted either in part or whole for any other degree elsewhere.

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DR. FRANCIS APPIAH ……………………… ………………...
(HEAD OF DEPARTMENT) SIGNATURE DATE

DEDICATION

I dedicate this work to my children: Ama Antwiwaa, Yaa Pomaa Payin and Yaa Pomaa Kakra

ACKNOWLEDGEMENT

I express my profound gratitude to Almighty God for the gift of life, good health and protection and for making my acquisition of this degree a reality.

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ABSTRACT

Plantain, an important staple in Ghana is known to be very perishable and efforts (including flour production) aimed at promoting its usable life and diversify its usage is imperative. This study was, therefore, conducted to assess the quality of flours produced using three plantain varieties and two different drying technologies (sun and solar). A survey was conducted in five selected communities (Hiawu Besease, Nerebehi, Asakraka, Nkotomire and Nyamebekyere) in the Atwima Nponua district in the Ashanti region using structured questionnaires to document indigenous knowledge on food uses of plantain varieties in Ghana. Laboratory analysis was conducted at Ghana Standards Authority using standard official methods to determine the physico-chemical qualities, functional properties and pasting characteristics of flour made from apem, asamienu and Apantu varieties which were either solar and sun dried. A 2X3 factorial in Completely Randomized Design was the experimental design used. The results showed that majority (99%) of the respondents indicated plantain as a staple food. The most common varieties of plantain in the study area were Apem, Apantu, Oniaba and Asamienu which were used in the preparation of fufu, ampesi, ofam and plantain chips. Moisture content, crude fat, crude fibre and ash content of both the solar and sun dried plantain flours from the varieties ranged from 10.10%- 8.87%, 1.00% -0.43%, 3.10% - 1.57% and 2.27% - 1.47% respectively. For functional properties, the sun and solar dried flours from the three varieties recorded 9.90-9.02g/g of swelling power, 45.68-9.75 of solubility, 0.86-0.84 of bulk density, 1.53-0.85g/g of water absorption, 1.14-0.80g/g of oil absorption capacity and 47.50-23.75ml of foaming capacity. Flours from both the sun and solar dried flours from Apem, Apantu and Asamienu exhibited high pasting qualities and could be used as thickening agents and also used in fufu powder preparation and other

confectionaries.

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CHAPTER ONE

1.0 INTRODUCTION

Plantains, of the *Musaceae* family, are herbaceous perennial crops (Speijer and Waela, 1997). The crop originated from South East Asia and Western Pacific regions (John and Marchal, 1995). In West and Central Africa, plantains are important staple food and a source of food energy for about 70 million people worldwide (IITA, 1992; Swennen, 1990).

In West Africa, Ghana, is the largest producer of plantain and is third in Africa (FAO, 2010). According to FAO (2004), the total domestic production of plantain in the Ghana was estimated at 2,300,000 metric tonnes.

Plantain is a good source of carbohydrates in humid tropical Africa, and has protein content of 1.2% protein appreciable amounts of vitamins A, C and K and 5minerals including iron, calcium, zinc and phosphorus (IITA, 1992; Swennen, 1990).

Plantain is a staple food, which is fried, baked, boiled or roasted and consumed alone or together with other foods (Akomea *et al.,* 1995). The green plantain can be processed into dry chips and stored or milled into powder and prepared in a thick paste-like meal known as *abetie* or *konkoti*. The main household dishes prepared from the green fruit are *fufu* and *ampesi*. Other dishes include *eto, mpotompoto, akankye, apiti, ofam, akrakuro, tatare, kalawele* and *kokoyakyea* (Akomea *et al*., 1995).

Plantain is a seasonal crop with relatively short shelf life. It is available for a limited time and thereby, increases postharvest losses (Falayan 1 and Birafin 2, 2011). It is common to find large quantities of ripe and rotten plantain during the major plantain season and Akomea *et al*. (1995) in Ghana reported postharvest loss of plantain to be about 30% of the total output during the peak period from September – March. However, plantain spoilage is scarce from May to August and causes fluctuating prices in Ghana. This presents a huge challenge and serious economic loss to farmers and the country as a whole. According to Falayan 1 and Birafin 2 (2011), the perishability of plantain makes the processing of the crop very important. However, in Ghana, processing plantain into other commercial and industrial products such as the flour seems relatively new.

Plantain flour has a good potential for use as a functional agent in a variety of pastry products on the account of its high water absorption capacity (Akubor, 2004). Yet, the flour quality and the suitability of major Musa varieties grown in Ghana for industrial food uses are relatively unknown (Dadzie and Orchard, 1997adeniji).

Plantains is a popular dietary staple due to its versatility and good nutritional value. Abioye *et al*. (2011) observed that plantain flour is gradually finding its application in the formulation of diverse foods such as weaning food for children. Researchers have found that plantain supplemented breads had comparable sensory and nutritional qualities (Folayan and Bofarin, 2011). Akubor (2004) observed that plantain flour has a good potential for use as a functional agent in a variety of pastry products on the account of its high water absorption capacity. Yet, the flour quality and the suitability of major Musa varieties grown in Ghana for industrial food uses are relatively unknown (Dadzie and Orchard, 1997). Therefore, any effort aimed at reducing the high postharvest losses of plantain through processing into flour will contribute significantly in ensuring food availability and affordability and hence a useful tool in food security initiatives.

The general objective of the study was, therefore, to assess the quality of three plantain variety flours produced using three different drying technologies.

The specific objectives of the study were to:

1. document indigenous knowledge on the food uses of plantain varieties in Ghana.
2. determine the chemical properties of the flours from the different plantain varieties.
3. determine the functional properties of the different plantain flour.

CHAPTER TWO

2.1 PLANTAIN

2.1.1 Origin and Botany of Plantain

Plantain which originated from South-East Asia is a staple in African countries and Central and South America. The plant has corms/bulbs has a central bud which is responsible for leaf production and lateral buds which eventually grows to produce suckers (Nelson *et al*., 2006).

Bananas and plantains are of the genus Musa with Family Musaceae are believed to have been obtained from *Musa acuminata* Colla and *Musa balbisiana* Colla. *Musa sapientum* refers to a plant producing horn-shaped fruit similar to the modern "French Plantain" and *Musa paradisiaca* refers to a type similar to the most popular dessert banana of the tropics. Generally, plantain described as *Musa sapientum* awhile the desert-types are known as *Musa paradisiaca* (Simmonds, 1966).

According to Simmonds (1966) ABB cultivars to possess angular, thick, near straight fruits, as against AAB plantains which are much shorter. Crossing *Musa acuminate* and *Musa balbisiana* produced three different types of plantains namely Type A (banana which contains a low starch and high sugar content when ripe), Type B (plantain, with pointed tip, which is starchy even when ripe and eaten only when cooked) and Type C (starchy banana used for cooking and is known as cooking bananas).

2.1.2 Varieties of Plantain

Ahiekpor (1996) and Hemeng *et al*. (1996), indicated that popular plantain in West Africa are French Horn Plantain (being locally known as Apempa, Oniaba and Nyeretia apem), False Horn Plantain (with local names Borodewuo, Apantu pa, Borode sebo and Osoboaso) or the True Horn Plantain (locally referred to as Asamienu and Aowin).

2.1.2.1 True horn plantain

This type of plantain has hands (one and three) and fewer fingers but are longer and shorter than those of the False Horn. It is not prolific and therefore not grown widely by farmers.

2.1.2.2 False horn plantain

This variety is distinguished by the small number of hands, usually with few fingers on a bunch that weighs about 10 kg (20 lbs).

2.1.2.3 Giant french plantain

This variety is robust, tall 70 – 75 cm (2- 2.5 ft) girth and average height of 5 m (15 ft). It has large heavy bunches 90 kg (200 lbs) and many hands but shorter fingers.

2.1.3 Economic Importance of Plantain

According to Stover and Simmonds (1987), plantain (Musa spp. AAB) is a major staple in West and Central African and estimated to provide 200 calories to about 60 million people in Africa. It is a major source of income to many farmers in Ghana

(FAO, 2010) and ranked third after yam and cassava (FAO, 2006) with a per capita annual consumption of 101.8 kg per head (FAO, 2006). It is a major contributor to Agricultural Gross Domestic Product (AGDP).

2.1.4 Nutritional and Health Benefits of Plantain

Plantain has 32% of its weight being carbohydrate making it a good source of energy. It has significant quantities of vitamins A, B_6, C, minerals and dietary fibre (Chandler, 1995). It is cholesterol-free and suitable hypertensive patients. It has lower sodium content (Adeniji *et al*., 2006). It has significant quantities of iron, potassium, calcium, vitamin A, ascorbic acid, thiamin, riboflavin and niacin, dietary fiber and resistant starch which helps to reduce the blood sugar level (Ayodele and Erema, 2011).

The pounded leaves suppresses bleeding of wounds (Ortiz and Vuylsteke, 1996) while cooked plantain bracts antidiabetic (Morton, 1987). Plantain powder is suitable flour for baking (Adeniji *et al*., 2006)

2.2 PROCESSING

Food processing is defined as the set of methods and techniques used to transform raw ingredients into food or to transform food into other forms for consumption by humans either in the home or by the food processing industry (Training manual for Food Safety Regulators, 2010).

2.2.1 Importance of Plantain Processing

Processing of plantains reduces wastages especially during the peak period of production. It also creates employment, generates income and commercialization before it reaches the market (Ekunwe & Atalor, 2007). Plantain deteriorates faster and therefore, has shorter shelf-life except when processed (Pikuda & Ilelaboye, 2009). Processing has become important to help address critical issues of glut and postharvest loss especially during the peak period so as to hold the interests of farmers and allied stakeholders in the plantain subsector. Additionally, processed products dictates higher prices due to the added value (Iyabo and Omobowale, 2013). The perishable nature of plantain like other crops gives rise to the need to preserve it and according to Whitfield (2000), drying is an excellent way to preserve food for a sustainable world.

2.3 DRYING

The process by which water is removed from a substance is known as drying. The two types of water, present in food items, are the chemically bound water and the physically held water. In drying, only the physically held water is removed. Produce are to reduce its water content to a level where it can be safely stored for future use (Bolaj and Nowicki, 2003).

At the time of harvest, most agricultural products have higher moisture content and such crops after harvest deteriorate faster due to several causes such as growth of micro-flora, particularly the aerobic of moulds. Produce are, therefore, processed for long-term storage when they are in abundance at harvesting seasons, so as to be used in the period when they are scarce (Whitfield, 2000).

2.3.1 Sun Drying

Sun-drying is based on the principle of direct exposure of the product to sun ray by spreading the product on the ground or an improvised material, after some special prior treatment. The produce is regularly turned until the produce reaches a stage considered to be satisfactory for taste, brittleness and change of colour by local standard (Alonge and Hammed, 2007).

Benefits of sun drying produce are that it requires low capital, operating costs and little expertise. The main disadvantages of the sun-drying method are that the produce gets contaminated, stolen (theft) or damage by birds, rats or insects. The drying process is slow or irregular and the products are exposed to rain or dew. This encourages mould growth and may result in a product with relatively high moisture content after drying. The temperature of the sun cannot also be regulated, therefore, low and variable quality products may be produced due to over or under drying. Sun drying also tends involves lots of physical effort since the produce must be turned regularly and moved when it rains. Additionally, since sun drying depends on uncontrolled factors, production of uniform and standard products is not expected (Alonge and Hammed, 2007),

2.3.2 Solar Drying

Solar driers are specialised devices with capacity to harness the suns energy for drying products in a chamber. They have several advantages over sun-drying in that they produce cleaner products free from insect, dust and rain.

Temperatures generated by solar driers are higher than sun drying and could be faster if relative humidity is lower (Whitfield, 2000).

The basic principle of operation is that air is heated in a collector by the greenhouse effect and the hot air in a drying chamber then dries the produce. Solar heating systems used to dry food and other crops helps to improve the quality of the product and also reduce wasted produce and traditional fuels (Whitfield, 2000).

2.4 FUNCTIONAL PROPERTIES

Functional property according to Matil (971) is any characteristic of flour that control the behaviour of nutrients in food during processing, storage and preparation and these affect food quality and acceptability of the product.

2.4.1 Swelling Power

According to Crosbie (1991), swelling power is as the ratio of weight of paste to the weight of dry flour. Protein content of the protein isolate when high may result in higher swelling power. Swelling power shows the water absorption index of the granules during heating (Loos *et al*., 1981) and Dengate (1984) stated that swelling power is seen as mainly the result of granule swelling allowing the release of amylose. An aqueous suspension of starch granules, when heated, hydrates and swells. King (2005) explains this principle by reporting that starch granules in suspension swell when heated and then as the temperature is raised, hydrogen bonds continue to be disrupted, water molecules become attached to free hydroxyl groups and the granules continue to swell. Usually, flours which are more soluble in a solution, is as a result of their higher swelling power.

2.4.2 Bulk density

Bulk density is determined by the ratio of weight of flour to flour volume in grammes per centimeter cube (Subramanian and Viswanathan, 2007). It measures the heaviness of a flour sample, is directly proportional to starch content of flour (Oti and

Akobundu, 2007) and increases with increase in starch content (Bhattacharya and Prakash, 1994). Knowledge of bulk density, in the food processing industries, gives an idea of the amount of starch in the food material and also how the individual particles of the flour can arrange themselves in a compact manner. Suitable packaging requirements of the flours can be determined with bulk density as it links to the load the sample could carry if allowed to rest directly on one another. Bulk density also gives a measure of the mass relative to the space occupied by the food substance. High values are indicative of high cost of packaging (Oluwatooyin *et al*., 2002) as more materials would be required. Higher bulk density products shows better packaging properties compared to those with low bulk density. Bulk density also relates to mouth feel and flavor of food. However, moisture affects bulk density and reflects particle size distribution of the flour (Etudaiye *et al.,* 2009).

2.4.3 Water Absorption Capacity

The differences in weight of the flour before and after water absorption defines water absorption capacity of flour (Abbey and Ibeh, 1988). It describes flour–water association ability under limited water supply.

Water absorption capacity is the ability of starch or flour to absorb water and swell for improved consistency in food. In food systems, it is desirable to improve yield, uniformity and body of the food. In foods such as sausages, custards and dough, absorption of water is an important functional trait (Adebowale *et al*., 2005). Water absorption capacity is specific for each type of starch, and it depends on several factors such as amylose: amylopectin ratio, intra and inter molecular forces and size of granules, (Rahman *et al.*, 1999). Smaller sizes of the granules causes higher absorption capacity (Singh *et al.,* 1991). Water absorption capacity differs with protein source, composition, previous processing, such as heating and alkali processing (Ikegwu *et al.*, 2010). It is a function of ionic strength, pH, temperature, size and shape of the protein molecules. According to

2.4.4 Oil Absorption Capacity

Giami *et al.* (1994) defines oil absorption capacity is defined as the difference in weight of flour before and after oil absorption. Oil absorption capacity is an important property in food formulations (Odoemelam, 2000) as oils improve flavor and increase the mouth feel of the food (Narayana and Narasimga, 1982).

2.4.5 Solubility

Solubility indicates the ability of water to penetrate into starch granules of flours. In the confectionery industry modified starches are used as modification of starches enhances their swelling power desirable in the industry (Ikegwu *et al.*, 2010). According to Tumaalii and Wooton (1988), when starches swell, solubilized amylose molecules leach out of starch granules resulting in increased solubility. When the associative forces in the starch granules are weak, low swelling accompanied by high solubility (Aryee *et al.,* 2006).

2.4.6 Least Gelation Property

According to Oduro *et al*. (2006) gelation is an index of water absorption capacity of flour and determines the percentage of the flour that is capable of forming a gel.

Digestibility and texture of starch containing foods is affected by gelatinization. Lawal *et al*. (2004) reported that gel forming capacity increases with increasing concentration of starch.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 INTRODUCTION

The research work was done in two parts. The first part was a survey research which involved questionnaire administration while the second part was at the laboratory where proximate analysis, functional and pasting characteristics were determined.

3.2 THE SURVEY

3.2.1 Sampling Area

A survey was conducted in five selected communities in the Atwima Nponua district in the Ashanti region. The five communities which are popularly known as plantain growing areas included Hiawu Besease, Nerebehi, Asakraka, Nkotomire and Nyamebekyere.

3.2.2 Sampling Size and Method

A sample size of 100 respondents were interviewed for the study. The respondents were made up of 20 women from each of the five communities. Random sampling methods were used to interview the respondents.

3.2.3 Questionnaire Administration

Structured questionnaires were used to collect data. Questionnaires were administered to women in five communities in the Atwima Nponua district where plantain are popularly cultivated.

3.3 LABORATORY EXPERIMENT

3.3.1 Location of Experiment

The laboratory experiment was conducted at the Department of Horticulture of KNUST and Food Research Institute in Accra, Ghana.

3.2.2 Source of Experimental Material

The plantain samples were obtained from Atwima Mponua district in the Ashanti Region of Ghana.

3.2.3 Experimental Design and Treatments

The laboratory experiment was conducted using a 3x2 factorial experiment in a completely randomized design with 3 replications. The three plantain varieties used were *Apem, Apantu* and *Asamienu* and the two drying methods used included solar dryer and sun drying.

3.2.4 Processing of Green Plantain Fruits to Flour

Green mature unripe fruits of *Apem, Apantu* and *Asamienu* varieties were obtained from farmer's field. Plantain fruits of the various varieties were hand-peeled and sliced into pieces of about 5-10mm thick. The sliced plantain were bleached in 0.03% sodium metabisulphite for 20 minutes (Abioye *et al*., 2011) and dried using solar dryer and under the sun. Temperature in the dryer and the ambient environment were monitored twice in a day until no temperature differences were observed. The dried plantain chips were milled using a domestic blender. The dried plantain was oven dried at 115^0 C to ensure complete drying. The dried slices were milled into flour and quality assessment of the flour samples was conducted.

Plantain (unripe)

↓

Peeling

↓

Slicing

↓

Drying (solar and sun)

↓

Milling

↓

Sieving

↓

Unripe Plantain flour

Figure 3.1: Flow chart on the production of ripe and unripe plantain flour (Source: Ketiku, 1978)

3.4 PARAMETERS TO BE STUDIED

Laboratory analysis of the various plantain samples was conducted on the flour to determine the following parameters:

3.4.1 Proximate Composition

3.4.1.1 Determination of Moisture Content

The procedure recommended by AOAC (2005) was used in determining moisture content. Five grams (5g) of sample was placed into an aluminum moisture and dried to constant weight at 105ºC in a conventional laboratory oven.

Percentage moisture was determined using the method:

$$\% \text{ Moisture} = \frac{M_{Initial} - M_{Dried}}{M_{Initial}} \times 100$$

Where $M_{Initial}$ and M_{Dried} are the weight of the samples before and after drying

3.4.1.2 Determination of Crude Protein

Crude protein content was determined using the Kjeldahl method as prescribed by AOAC (2005). Two (2) g of the sample of the flour were transferred into a digestion flask together with 12ml concentrated H2SO4 and 2 tablets of digestion catalyst and flask heated in digestor in a fume chamber for 45 minutes (until a clear colourless solution was obtained). The cooled digest was distilled using 4% boric acid and 20% of Sodium hydroxide solutions. The distillate was then titrated with 0.1M HCl until the formation of a violet colour indicating the end point. A blank was run under the same condition as with the sample. Total nitrogen content was then calculated according to the formula:

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

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

3.4.1.3 Determination of Crude Fat Content

Soxhlet extraction method was used for determining fat content of the samples. One gram (1g) sample was weighed into an extraction thimble and then stopped with grease-free cotton. Before extraction commenced the round bottom cans was dried, cooled and weighed. The thimble was placed in extraction chamber and 200ml of petroleum ether was added to extract the fat. The extraction was carried out at 135^0C, lasted for 1hour 40minutes after which the fat collected in the bottom cans were cooled in a desiccator. The percentage fat was calculated using the formula:

$$\%\text{Fat content} = \frac{\text{weight of ether soluble material}}{\text{Weight of sample}} \times 100$$

3.4.1.4 Determination of Crude Fiber

The residue from the fat extract was transferred into 1 litre conical flask litre. 100ml of sulphuric acid (12.5M) was heated to boiling and then introduced into the conical flask containing the sample. The contents were then boiled for 30 minutes ensuring that the level of the acid was maintained by addition of distilled water. After 30 minutes, the contents were then filtered through a muslin cloth held in a funnel. The residue was rinsed thoroughly until the water was no longer acidic to litmus. The residue was then transferred into a conical flask. 100ml of sodium hydroxide (12.5M) was then brought to boil and then introduced into the conical flask containing the sample. The contents were then boiled for 30 minutes ensuring that the level of the acid was maintained by addition of distilled water. After 30 minutes, the contents were then filtered through a muslin cloth held in a funnel. The residue was rinsed thoroughly until its washing was no longer alkali. The residue was then introduced into an already dried crucible and ashed at 600℃ ±200℃. The loss in weight was recorded as crude fibre and crude fibre was calculated as:

$$\%Crude\ \ fiber = \frac{\text{Loss in weight}}{\text{Weight of sample}} \times 100$$

3.4.1.5 Determination of Ash Content

Two (2) g of samples were weighed into well incinerated crucibles and then burnt into ash in a muffle furnace at 6000C for 3 hours. . The crucible was removed from the furnace, allowed to cool and weighed. The ash content was calculated using the formula (AOAC, 1990):

$$\%\text{Ash content} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \text{ X } 100$$

3.4.1.6 Determination of Nitrogen-Free Extract

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

% Carbohydrate (NFE) on dry matter basis= 100%- (% Ash content on DM basis+ % Crude fibre content on DM basis + % fat content on DM basis + % Protein content on DM basis)

3.4.2 Functional Properties

3.4.2.1 Bulk Density

Bulk density was determined using the method of Okaka and Potter (1979). Fifty grams (50 g) of plantain flour was placed into a 100 ml measuring cylinder and tapped on a firm table to a constant volume. Bulk density was then calculated using the formula:

$$\text{Bulk density} = \frac{\text{Weight of flour (g)}}{\text{Flour volume (cm}^3\text{)}}$$

3.4.2.2 Water and oil absorption capacities

Two (2) g of plantain flour was mixed with 10 ml distilled water or refined palm oil (frytol) in a pre-weighed 20 ml centrifuge tube. The slurry was agitated for 2 min, allowed to stand at 28°C for 30 min and then centrifuged at 500 rpm for 20 min. The clear supernatant was decanted and discarded. The adhering drops of water or oil in the centrifuge tube were removed with cotton wool and the tube weighed. The weight of water or oil absorbed by 2g of plantain flour or protein was calculated and expressed as water or fat absorption capacity (Beuchat, 1977).

3.4.2.3 Swelling power

This was determined as described by Leach *et al*. (1959). 2g of the plantain flour was mixed with 10 ml distilled water in a centrifuge tube and heated in a hot water bath at 80°C for 30 min while continuously shaking the tube. After heating, the suspension was centrifuged at 1000 g for 15minutes. The supernatant was decanted and the weight of the paste taken. The swelling power was calculated as:

$$\text{Swelling power} = \frac{\text{Weight of the paste}}{\text{Weight of dry flour.}}$$

3.4.2.4 Foaming capacity and stability

Two (2) g of plantain flour was whipped with 100 ml distilled water for 5 min in a blender at 500 rpm and poured into a 250ml graduated cylinder. The volume of foam at 30 seconds after whipping was expressed as the foam capacity and the volume of the foam after 60 minutes as the stability for the respective time periods. Foam stability was determined at 0, 30, 60 and 90 min after whipping as described by Chinma *et al*. (2008).

3.4.2.5 Gelation Capacity

Gelation capacity was dertermined by using the Coffman and Garcia (1977) method. Sample suspensions 2-20% (w/v) was prepared in 5 ml distilled water. The tubes containing the suspensions was heated in boiling water and the tubes were then cooled for 2 hours at 7^{o}C. The least gelation concentration (LCG) was determined at that concentration when the samples from the inverted tube do not fall or slip.

3.4.3 Pasting Characteristics

A smooth paste was made of the prepared flours (40g) in 420ml distilled water (8.8% slurry) for viscoelastic analysis using Brabender Viscoamylograph equipped with a 1000cmg sensitivity cartridge. The smooth paste was heated at a rate of 1.5°Cmin^{-1} to 95°C and maintained for 15min. It was then cooled at 1.5°Cmin^{-1} to 50°C and maintained for 15min. Pasting properties were obtained as described by Mazurs *et al*. (1957) with slight modifications.

3.5 DATA ANALYSIS

Statistical analysis was conducted on the data obtained from the survey. The SPSS version 16 package was used for the analysis of survey data. Results were presented in tables and graphs. Data collected from the laboratory analysis was analysed using STATISTIX Version 16.0 and subjected to analysis of variance (ANOVA). The differences between treatment means was determined using least significant difference (LSD) at 1% level of significance (p=0.01).

CHAPTER FOUR

4.0 RESULTS

4.1 SURVEY DATA

4.1.1 Demographic Information

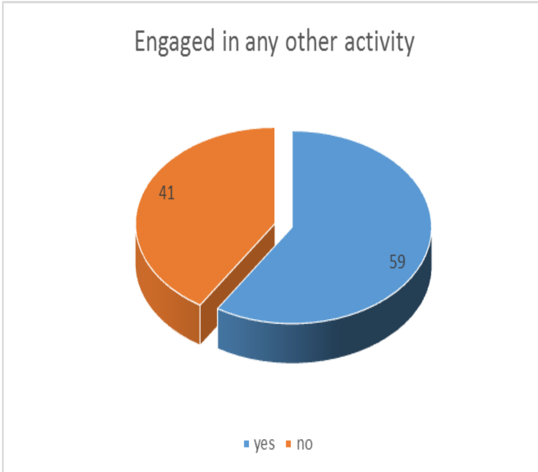
Table 4.1: Demographic characteristics of respondents

Variable	Frequency	Percent
Sex Male		
	38	38
Female	62	62
Total	100	100
Age		
20-29 yrs	19	19
30-39 yrs	27	27
40-49 yrs	34	34
50-59 yrs	20	20
Total	100	100
Marital status	Frequency	Percent
Single	12	12
Married	85	85
Widowed	3	3
Total	100	100
Educational background No		
formal Education	37	37
Primary	16	16
MSLC/JSS	30	30
SHS/Voc/Tech	9	9
Tertiary	8	8
Total	100	100
Main occupation Farming		
	63	63
Trading	19	19
Teaching	13	13
Health Assistant	5	5
Total	100	100

Table 4.1 represents demographic information of respondents. From the results, 38% of the respondents were male while 62% were female. For the age distribution, 19% of the respondents had their age ranging from 20-29 years while 27% of the respondents had their age ranging from 30-39 years. The percentage age of respondents between 40-49 and 50-59 years were 34% and 20% years respectively. Most (85%) of the respondents were married, 12% of them were unmarried while 3% of them were widowed. Their educational background showed that 16% and 30% of the respondents had Primary and MSLC/JSS education respectively while 9% and 8% of respondents had SHS/Vocational/Technical education respectively. However, 37% of respondents did not have any formal education.

4.1.2 Other Activities of Respondents

When respondents were asked if they were engaged in other activities apart from their main occupation, majority (59%) indicated that they were involved in other activities whiles 41% were not (Figure 4.1). Other activities respondents were engaged in were farming (23%), trading (14%), sales person (3%), security guard (3%), hair dressing (7%) and community sanitation (7%) (Figure 4.2).



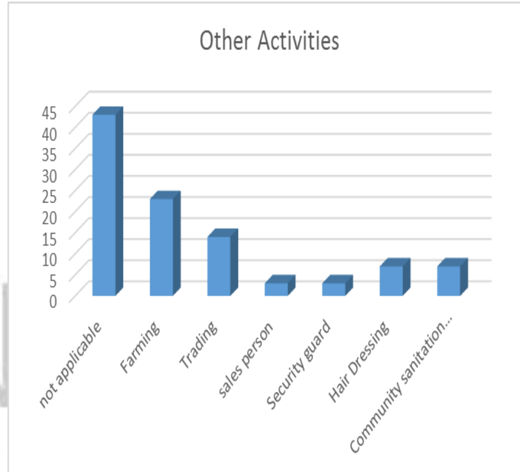


Figure 4.1: Any other activity

Figure 4.2: Other activities engaged in

4.1.3 Plantain a Staple Food

From the interview (Figure 4.3), majority (99%) of the respondents indicated plantain as a staple food while 1% did not. The varieties of plantain found in their localities were Apem (24%), Apantu (31%), Oniaba (14%), Asamienu (8%), all three varieties (62%) and other varieties (38%) (Figure 4.4).

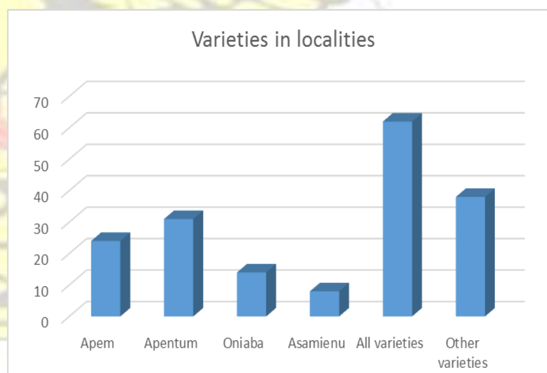


Figure 4.3: Plantain a staple food

Figure 4.4: Varieties in localities

4.1.4 Uses of Plantain

The uses of plantain in the localities varied among the respondents as presented in figure 4.5. Plantain is used as fufu (28%), ampesi (15%), ofam (2%), plantain chips (2%), all the already mentioned uses (70%) and other uses (32%) in the localities of the respondents.

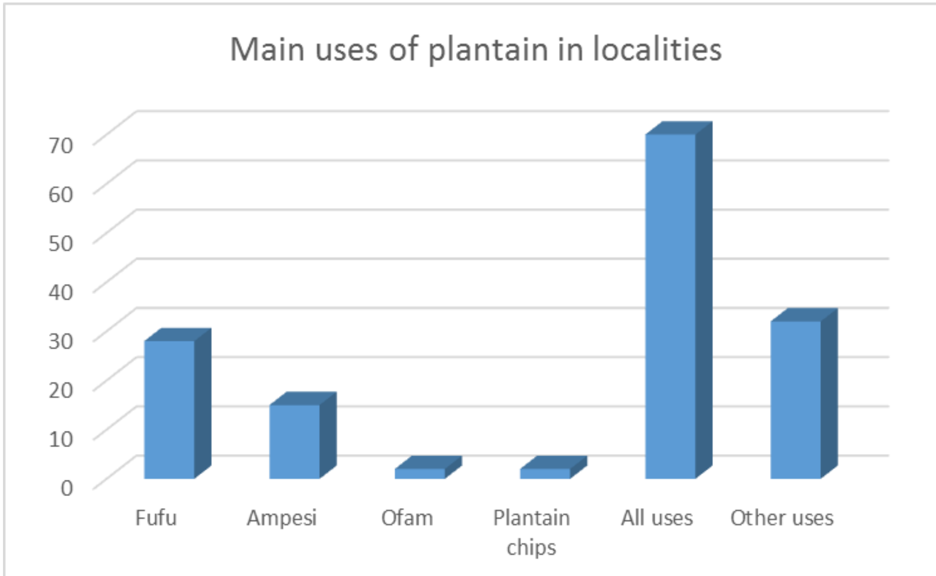


Figure 4.5: Uses of plantain in localities

4.1.5 Varieties used for Fufu

The varieties of plantain best suited for fufu were apem (8%), Apantu (90%), Oniaba (17%) and Asamienu (30%) as represented in figure 4.12. Reasons for using these varieties were that the varieties are easy to pound and have good taste (8%), the varieties have good taste (18%), there are less seeds in the varieties (2%), the varieties are easy to pound and have fine texture (31%) and also because the varieties have more bunches (5%). Other reasons were that the varieties have good gelation and is less tough (22%), the varieties easily mixes with cassava (1%) and also because the varieties are very common in the locality (3%). However, 10% had no idea why they prefer that variety for fufu.

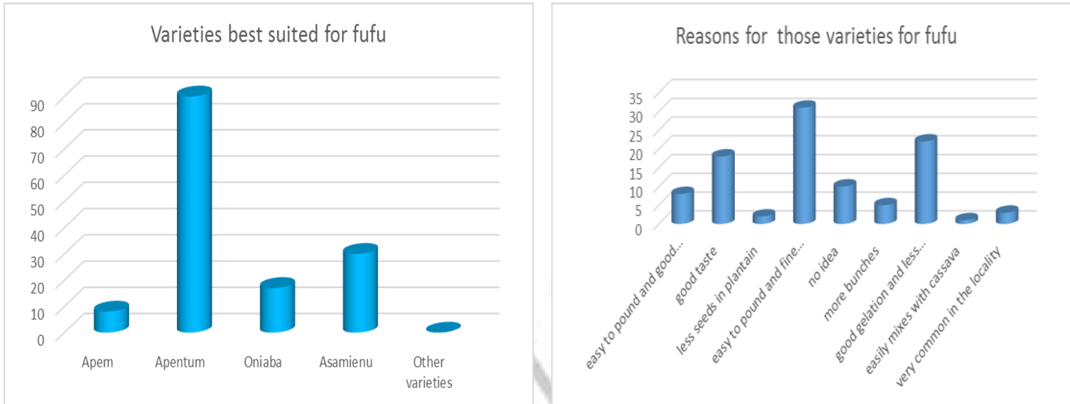
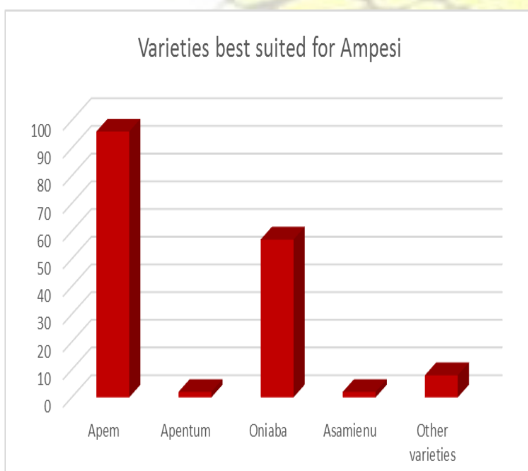


Figure 4.6: Varieties of plantain best suited for fufu and reasons for using those varieties

4.1.6 Varieties used for Ampesi

Respondents interviewed indicated that apem (96%), Apantu (2%), Oniaba (57%), Asamienu (2%) and other varieties (8%) as varieties best suited for ampesi. Reasons for using these varieties for ampesi were attributed to its texture (28%), taste (49%), size (1%), gelation (4%), taste and gelation (6%) and taste and size (12%).



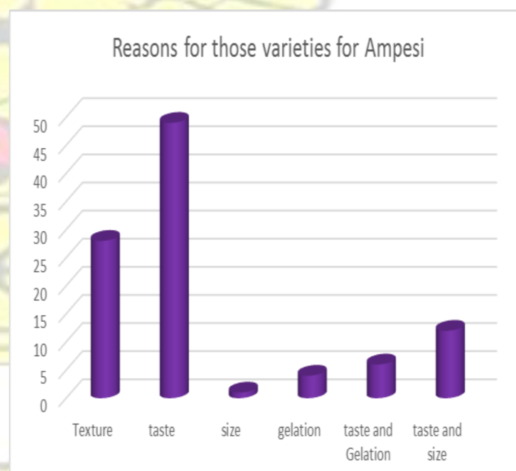


Figure 4.7: Varieties best suited for ampesi Figure 4.8: Reasons for those varieties for ampesi

4.1.7 Varieties for Plantain Chips

Figures 4.9 show the varieties best suited for plantain chips and the reasons why the respondents prefer those varieties for plantain chips. The varieties best suited for plantain chips were apem (6%), Apantu (82%), Oniaba (5%), Asamienu (27%). The reasons given for using these varieties for plantain chips were because they were big in size and could be easily sliced for slicing (59%), the varieties had good taste (7%), the varieties are big in size and had an attractive colour (2%), the varieties had more bunches (5%) and also because the varieties were the ones mostly used for plantain chips (7%). Twenty percent (20%) of the respondents, however, had no idea why they used those varieties for plantain chips.

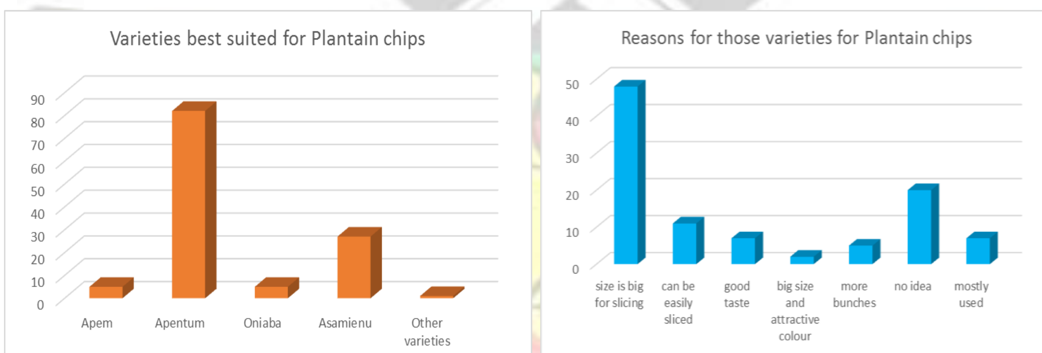


Figure 4.9: Varieties best suited for plantain chips and reasons for using those varieties

4.1.8 Other Uses of Plantain

From the results (Figure 4.10), other uses of plantain apart from fufu, ampesi and plantain chips were mpotompoto and akanchie (6%), mpotompoto only (1%), akanchie only (11%), kontonte (12%), akrakuo (11%), roasted plantain (1%), mashed plantain-"Eto" (23%) and kelewele (10%). However, 25% of respondents had no idea of other uses of plantain in their localities.

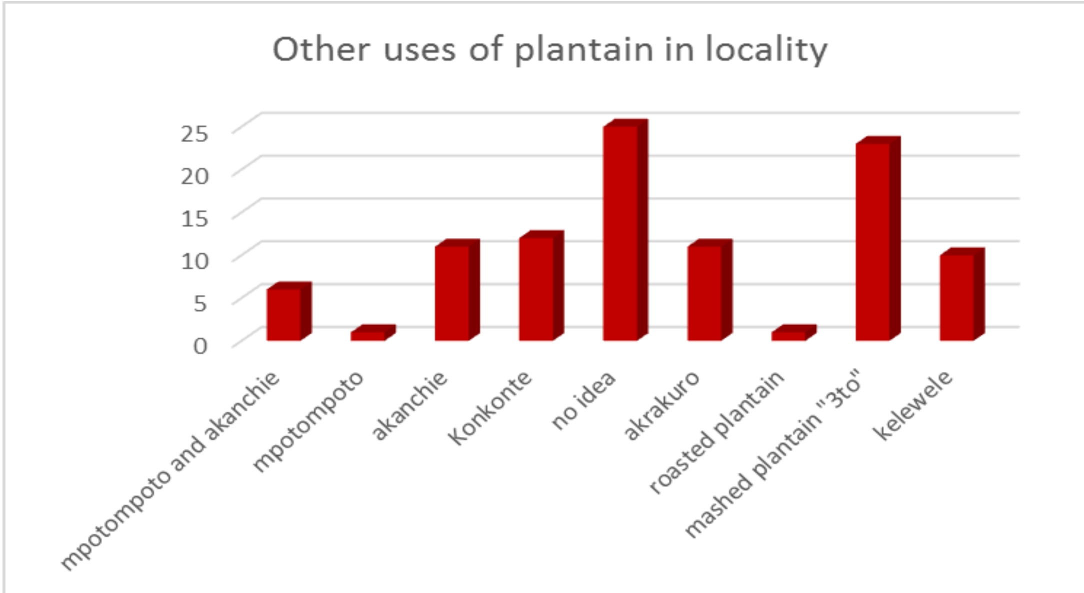


Figure 4.10: Other uses of plantain in locality

4.1.9 Storage Methods of Plantain

Respondents were asked how they stored their plantain in their localities. Figure 4.11 showed that plantain as stored in well-ventilated cool place (28%), 8% kept it in the refrigerator, 2% under trees, 5% in tents and 3% stored under water for some days. Majority (52%) had no storage methods for the plantain while 2% had no idea how to store the plantain.

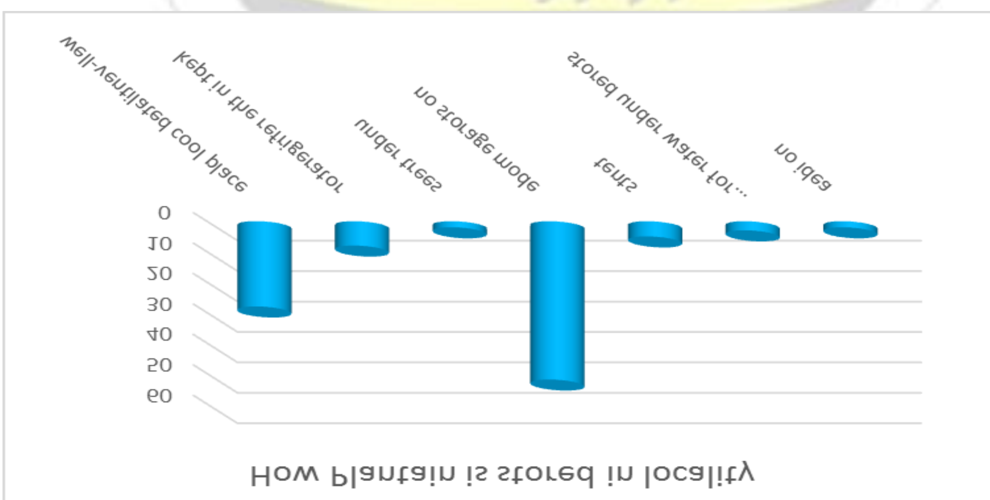


Figure 4.11: Storage mode of plantain in locality

4.1.10 Storage Duration of Plantain

Figure 4.12 shows how long respondents locally stored their plantain. Few of respondents (38%) stored their plantain for one week, 4% stored it for one month, 2% stored it for three weeks, 19% stored it for two weeks and 28% stored it for 3-5 days. Nine percent (9%) of the respondents, however, did not store their plantain.

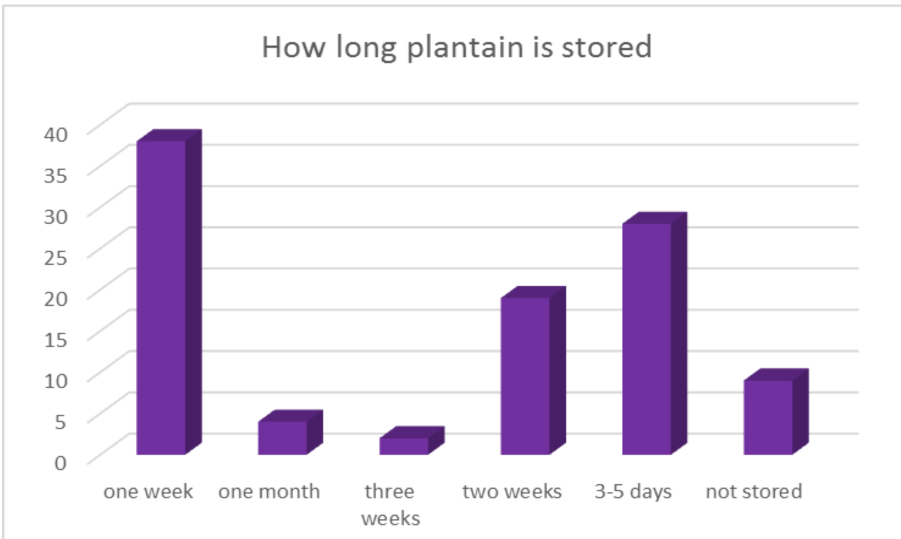


Figure 4.12: How long plantain is stored in the localities

4.1.11 Plantain Powder

Respondents interviewed were asked of their view about plantain powder for fufu and whether they would like to use the powder for fufu. 90% responded they had heard of the plantain powder while 10% had not heard of it. 86% also preferred to use the plantain powder for the fufu while 14 % did not like the idea of plantain powder for fufu.

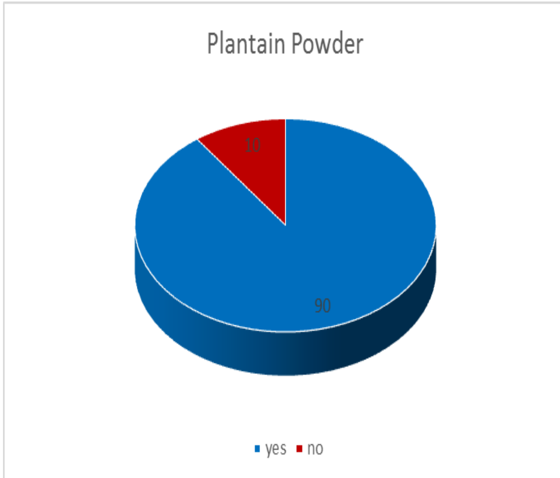


Figure 4.13: Idea about plantain powder

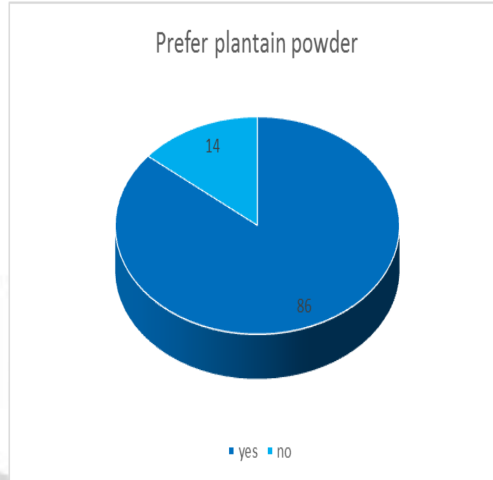


Figure 4.14: Preference for plantain powder

4.1.12 Preference for Plantain Powder

Respondents (86%) preferred to use plantain powder for fufu because the powder can be kept for a long time (2%), the powder had good taste and can be easily prepared (9%), the powder had no change in taste (24%), the powder had no change in quality (16%) and also because of food security (35%). Respondents (14%) did not prefer to use plantain powder for fufu because there was a change in taste when used for fufu (10%) and also because they did not like the chemicals used in processing the powder (4%).

Table 4.2: Reasons for preferring or not preferring plantain powder

Variable	Percentage (%)
Reasons for preferring plantain powder	
Powder can be kept for a long time	2
Powder had good taste and can be easily prepared	9
Powder has no change in taste and quality	40
Food security	35
Total	**86**

Reasons for not preferring plantain powder	
Change in taste when used for fufu	10
Dislike chemicals used in processing the powder	4
Total	**14**

4.1.13 Future Processing of Plantain

Respondents were asked their view of future processing of plantain (Figure 4.15). Most (83%) of respondents think the plantain can be changed into powder, 9% think the plantain can be stored in refrigerators, 4% think the plantain can be stored in cool places and 4% also think the plantain can be stored in a jute or rug.

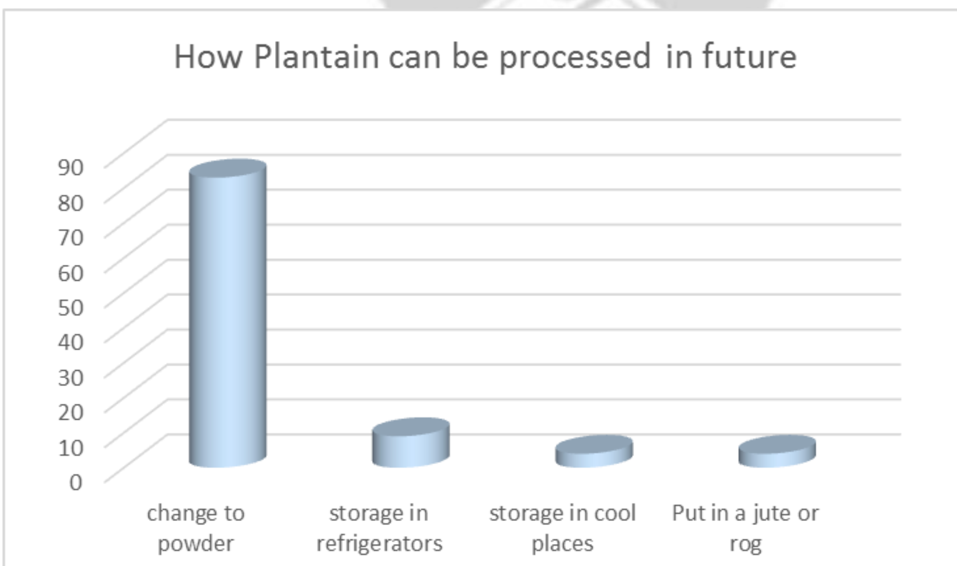


Figure 4.15: How plantain can be processed in the future

4.2 PROXIMATE COMPOSITION OF PLANTAIN FLOUR

4.2.1 Moisture content

The effect of different varieties and drying method on moisture content of plantain flour is shown in Table 4.3. From the results, moisture content of the plantain varieties were similar. Apem had moisture content of 9.50%, while had Asamienu 9.48% and Apantu 9.43%. Moisture content in the solar dried flours were significantly (P<0.05) higher (9.93%) than in the sun dried (9.01%) samples. Solar dried Asamienu plantain flour had the highest moisture content of 10.10% followed by solar dried Apem and Apantu flour (9.90%) respectively. No significant differences (P>0.05) were observed in the varieties alone and the combined effect of the variety and drying method on moisture content of the flour.

Table 4.3: Effect of variety and drying method on moisture content (%) of plantain flour

Variety	Drying method		Mean
	Sun drying	Solar drying	
Apem	9.10 a	9.90 a	9.50 a
Asamienu	8.87 a	10.10 a	9.48 a
Apantu	9.05 a	9.90 a	9.43 a
Mean	9.01 b	9.93 a	

Lsd (p=0.05) variety	= 1.09	p= 0.98
Lsd (p=0.05) drying method	= 0.72	p= 0.02
Lsd (p=0.05) variety x drying method	= 1.95	p= 0.80

4.2.2 Crude fat content

Table 4.4 shows the effect of different varieties and drying method on crude fat content of plantain flour. No significant difference (P>0.05) was observed in the varieties. The results show that Apem plantain variety had crude fat (0.76%) while Asamienu had 0.74% and Apantu (0.71%). For the drying methods, sun dried flour had significantly (P<0.05) higher crude fat content (0.82%) than solar dried samples

(0.65%). Sun dried Apem and solar dried Asamienu plantain flour recorded significantly (P<0.05) higher crude fat content of 1.00%, respectively.

Table 4.4: Effect of variety and drying method on crude fat content (%)

Variety	Drying method		Mean
	Sun drying	Solar drying	
Apem	1.00 a	0.52 b	0.76 a
Asamienu	0.47 b	1.00 a	0.74 a
Apantu	0.98 a	0.43 b	0.71 a
Mean	0.82 a	0.65 b	

Lsd (p=0.05) variety	= 0.05	p= 0.05
Lsd (p=0.05) drying method	= 0.03	p= 0.00
Lsd (p=0.05) variety x drying method	= 0.09	p= 0.00

4.2.3 Crude Fibre

Table 4.5 shows the effect of different varieties and drying method on crude fibre content of plantain flour. The results show that Apantu plantain flour had significantly (P<0.05) more crude fibre (2.56%) than Apem (2.32%) and Asamienu (2.33%). For the drying methods, sun dried flour had significantly (P<0.05) higher crude fibre content of 2.74% than solar dried samples (2.07%). Sun dried Asamienu and Apantu plantain flours recorded significantly (P<0.05) higher crude fibre content of 3.10% and 3.09%.

Table 4.5: Effect of variety and drying method on crude fibre content

Variety	Drying method		Mean
	Sun drying	Solar drying	
Apem	2.02 c	2.63 b	2.32 b
Asamienu	3.10 a	1.57 d	2.33 b
Apantu	3.09 a	2.02 c	2.56 a
Mean	2.74 a	2.07 b	

Lsd (p=0.05) variety = 0.06 p= 0.00
Lsd (p=0.05) drying method = 0.04 p= 0.00
Lsd (p=0.05) variety x drying method = 0.11 p= 0.00

4.2.4 Ash content

The effect of different varieties and drying method on the ash content of plantain flour are presented in Table 4.6. The results show that Apem plantain flour had significantly (P<0.05) more ash content of 2.20% than the other two varieties. Sun dried flours were higher in ash content (2.02%) than solar dried samples (1.91%). Solar dried Apem flour was significantly (P<0.05) higher in ash content (2.27%). No significant difference (P>0.05) was observed in the drying methods used. Table 4.6: Effect of variety and drying method on ash content

Variety	Drying method		Mean
	Sun drying	Solar drying	
Apem	2.13 a	2.27 a	2.20 a
Asamienu	1.93 a	2.00 a	1.97 b
Apantu	2.00 a	1.47 b	1.73 c
Mean	2.02 a	1.91 a	

Lsd (p=0.05) variety = 0.19 p= 0.00
Lsd (p=0.05) drying method = 0.13 p= 0.08
Lsd (p=0.05) variety x drying method = 0.34 p= 0.00

4.3 PHYSICOCHEMICAL AND FUNCTIONAL PROPERTIES OF PLANTAIN FLOUR

4.3.1 Swelling Power (g/g)

Table 4.7 shows the effect of different varieties and drying method on swelling power of plantain flour. The results show that Apem plantain flour recorded significantly (P<0.05) higher swelling power (9.75g/g) than Apantu (9.30g/g). For the drying methods, solar dried flour had more swelling power (9.63g/g) than solar dried samples (9.52g/g). Sun dried Asamienu and solar dried Apem plantain flour variety recorded significantly (P<0.05) higher crude fibre content of 3.10% and 3.09% respectively. No significant differences were observed in the frying methods used (P>0.05).

Table 4.7: Effect of different varieties and drying methods on the swelling power of flour

Variety	Drying method		Mean
	Sun drying	Solar drying	
Apem	9.63 ab	9.87 a	9.75 a
Asamienu	9.90 a	9.44 ab	9.67 ab
Apantu	9.02 b	9.58 ab	9.30 b
Mean	9.52 a	9.63 a	

Lsd (p=0.05) variety	= 0.43	p= 0.03
Lsd (p=0.05) drying method	= 0.29	p= 0.44
Lsd (p=0.05) variety x drying method	= 0.74	p= 0.02

Table 4.8 shows the effect of different varieties and chip treatment on swelling power of plantain flour. The results show that swelling power of the flour from the treated chips (9.60) were not significantly different (P>0.05) from that of the untreated chips (9.55). Sun dried Asamienu flour recorded significantly (P<0.05) higher swelling power of 10.12.

Table 4.8: Effect of different varieties and chip treatment on the swelling power of flour

Variety	Chip treatment		Mean
	Treated	Untreated (control)	
Apem	9.58 abc	9.92 ab	9.75 a
Asamienu	10.12 a	9.22 bc	9.67 ab
Apantu	9.10 c	9.50 abc	9.30 b
Mean	9.60 a	955 a	

Lsd (p=0.05) variety	= 0.43	p= 0.03
Lsd (p=0.05) chip treatment	= 0.29	p= 0.72
Lsd (p=0.05) variety x treatment	= 0.74	p= 0.00

Table 4.9 shows the effect of different drying methods and chip treatment on swelling power of plantain flour. The results show that untreated solar dried flour (9.72) and treated sun dried flour (9.66) recorded higher swelling power. However, no significant differences were observed among the drying methods and the chip treatment (P>0.05).

Table 4.9: Effect of drying methods and chip treatment on the swelling power of flour

Drying method	Chip treatment		Mean
	Treated	Untreated (control)	
Sun	9.66 a	9.38 a	9.52 a
Solar	9.54 a	9.72 a	9.63 a
Mean	9.60 a	955 a	

Lsd (p=0.05) drying method = 0.29 p= 0.44
Lsd (p=0.05) chip treatment = 0.29 p= 0.00
Lsd (p=0.05) drying method x chip treatment = 0.54 p= 0.11

4.3.2 Solubility

Table 4.10 shows the effect of different varieties and drying method on solubility of plantain flour. The results show that the variety Apem, recorded significantly (P<0.05) higher flour solubility of 43.99 than the two other varieties. For the drying methods, solar dried flour were significantly (P<0.05) more soluble (38.69) than sun dried samples (21.03). Both the sun and solar dried Apem flours recorded significantly (P<0.05) higher solubility 42.30 and 45.68 respectively.

Table 4.10: Effect of different varieties and drying methods on the solubility of flour

Variety	Drying method		Mean
	Sun drying		
Solar drying			
Apem	42.30 b	45.68 a	43.99 a
Asamienu	9.75 f	33.50 d	21.63 c
Apantu	11.05 e	36.90 c	23.98 b
Mean	21.03 b	38.69 a	

Lsd (p=0.05) variety = 0.27 p= 0.00

Lsd (p=0.05) drying method = 0.22 p= 0.00

Lsd (p=0.05) variety x drying method = 1.19 p= 0.00

Table 4.11 shows the effect of different varieties and chip treatment on solubility of plantain flour. The results show that flour from the untreated chips had significantly (P<0.05) higher solubility of 30.43 than the treated chip flour (9.28). Untreated chips from Apem had significantly the highest flour solubility of 48.38 (P<0.05).

Table 4.11: Effect of different varieties and chip treatment on the solubility of flour

Variety	Chip treatment		Mean
	Treated	Untreated (control)	
Apem	39.60 b	48.38 a	43.99 a
Asamienu	25.53 c	17.73 e	21.63 c
Apantu	22.75 d	25.20 c	23.98 b
Mean	9.28 b	30.43 a	

Lsd (p=0.05) variety = 0.27 p= 0.00

Lsd (p=0.05) chip treatment = 0.22 p= 0.00

Lsd (p=0.05) variety x treatment = 1.19 p= 0.00

Table 4.12 shows the effect of different drying methods and chip treatment on solubility of plantain flour. The results show that both treated (38.55) and untreated solar dried flour (38.83) were high in solubility. Significant differences (P<0.05) were observed among the drying method and the chip treatment.

Table 4.12: Effect of drying methods and chip treatment on the solubility of flour

Drying methods	Chip treatment		Mean
	Treated	Untreated (control)	
Sun	20.03 c	22.03 b	21.03 b
Solar	38.55 a	38.83 a	38.69 a
Mean	9.28 b	30.43 a	

Lsd (p=0.05) drying method = 0.22 p= 0.00
Lsd (p=0.05) chip treatment = 0.22 p= 0.00
Lsd (p=0.05) drying method x chip treatment = 0.86 p= 0.00

4.3.3 Bulk Density

The effect of different varieties and drying method on bulk density of the plantain flour are shown in Table 4.13. The results show that the flour from the varieties and the drying methods were not significantly different (P>0.05) from each other and recorded a bulk density of 0.85 respectively. However, flour from sun dried Apem, solar dried Asamienu and Apantu were high in bulk density (0.86), respectively. No significant differences (P>0.05) were observed in the variety and the drying methods used.

Table 4.13: Effect of different varieties and drying methods on the bulk density of flour

Variety	Drying method		Mean
	Sun drying	Solar drying	
Apem	0.86 a	0.84 a	0.85 a
Asamienu	0.84 a	0.86 a	0.85 a
Apantu	0.84 a	0.86 a	0.85 a
Mean	0.85a	0.85 a	

Lsd (p=0.05) variety	= 0.08	p= 0.99
Lsd (p=0.05) drying method	= 0.06	p= 0.88
Lsd (p=0.05) variety x drying method	= 0.14	p= 0.88

Table 4.14 shows the effect of different varieties and chip treatment on bulk density of plantain flour. The results show that bulk density among the chip treatment did not differ (P>0.05) although flour from the treated chips were bulky (0.87) than the untreated flour (0.83). Flour from the treated Apem and Apantu chips were much bulky (0.87) than the rest. No significant differences were observed among the varieties and the chip treatment (P>0.05).

Table 4.14: Effect of different varieties and chip treatment on the bulk density of flour

Variety	Chip treatment		Mean
	Treated	Untreated (control)	
Apem	0.87 a	0.83 a	0.85 a

Asamienu	0.86 a	0.84 a	0.85 a
Apantu	0.87 a	0.83 a	0.85 a
Mean	0.87 a	0.83 a	

Lsd (p=0.05) variety = 0.08 p= 0.99
Lsd (p=0.05) chip treatment = 0.06 p= 0.16
Lsd (p=0.05) variety x treatment = 0.14 p= 0.96

Table 4.15 shows the effect of different drying methods and chip treatment on bulk density of plantain flour. The results show that treated sun dried flour and solar dried flour had higher bulk density of 0.87 and 0.86, respectively. However, no significant differences (P>0.05) were observed among the drying method and the chip treatment.

Table 4.15: Effect of drying methods and chip treatment on the bulk density of flour

Drying method	Chip treatment		Mean
	Treated	Untreated (control)	
Sun	0.87 a	0.82 a	0.85 a
Solar	0.86 a	0.84 a	0.85 a
Mean	0.87 a	0.83 a	

Lsd (p=0.05) drying method = 0.06 p= 0.88
Lsd (p=0.05) chip treatment = 0.06 p= 0.16
Lsd (p=0.05) drying method x chip treatment = 0.10 p= 0.58

4.3.4 Water Absorption Capacity (g/g)

Table 4.16 shows the effect of different varieties and drying method on water absorption capacity of plantain flour. The results show that the Apem plantain flour had significantly higher (P<0.05) water absorption capacity of 1.34 than Asamienu (1.20) and Apantu (0.93). For the drying methods, no significant differences were seen in the sun and solar dried flour (P>0.05), although water absorption capacity of the solar dried flour were higher (1.16). Both sun dried Apem and Solar dried Asamienu flours recorded significantly (P<0.05) higher water absorption capacity of 1.53 and 1.48.

Table 4.16: Effect of different varieties and drying methods on the water absorption capacity of flour

Variety	Drying method		Mean
	Sun drying	Solar drying	
Apem	1.53 a	1.15 b	1.34 a
Asamienu	0.93 cd	1.48 a	1.20 b
Apantu	1.00 c	0.85 d	0.93 c
Mean	1.15 a	1.16 a	

Lsd (p=0.05) variety = 0.07 p= 0.00
Lsd (p=0.05) drying method = 0.05 p= 0.73
Lsd (p=0.05) variety x drying method = 0.13 p= 0.00

Table 4. 17 shows the effect of different varieties and chip treatment on water absorption capacity of plantain flour. The results show that no differences exist between the chip treatments (P>0.05) with the control having higher water absorption capacity (1.18). Flour from the treated Apem chips recorded high water absorption capacity of 1.38. Significant differences were observed among the varieties and the chip treatment (P<0.05).

Table 4.17: Effect of different varieties and chip treatment on the water absorption capacity of flour

Variety	Chip treatment		Mean
	Treated	Untreated (control)	
Apem	1.38 a	1.30 ab	1.34 a
Asamienu	1.20 b	1.20 b	1.20 b
Apantu	0.83 d	1.03 c	0.93 c
Mean	1.13 a	1.18 a	

Lsd (p=0.05) variety = 0.07 p= 0.00
Lsd (p=0.05) chip treatment = 0.05 p= 0.10
Lsd (p=0.05) variety x treatment = 0.13 p= 0.00

Table 4.18 shows the effect of different drying methods and chip treatment on water absorption capacity of plantain flour. The results show that untreated solar dried flour had higher water absorbing capacity (1.18), followed by treated sun dried flour (1.17). No significant differences were observed among the drying method and the chip treatment (P>0.05).

Table 4.18: Effect of drying methods and chip treatment on the water absorption capacity of flour

Drying method	Chip treatment		Mean
	Treated	Untreated (control)	
Sun	1.13 a	1.17 a	1.15 a
Solar	1.13 a	1.18 a	1.16 a

Mean	1.13 a	1.18 a	

Lsd (p=0.05) drying method	= 0.05	p= 0.73
Lsd (p=0.05) chip treatment	= 0.05	p= 0.10
Lsd (p=0.05) drying method x chip treatment	= 0.09	p= 0.73

4.3.5 Oil Absorption Capacity (g/g)

Table 4.19 shows the effect of different varieties and drying method on oil absorption capacity of plantain flour. The results show that the Apantu plantain flour had significantly higher (P<0.05) oil absorption capacity of 1.07 than Apem (1.01) and Asamienu (0.82). For the drying methods, no significant differences were seen in the sun and solar dried flour (P>0.05), although oil absorption capacity of the sun dried flour were higher (0.99). Sun dried Apantu flours recorded significantly (P<0.05) higher oil absorption capacity of 1.14.

Table 4.19: Effect of different varieties and drying methods on the oil absorption capacity of flour

Variety	Drying method		Mean
	Sun drying	Solar drying	
Apem	1.00 b	1.02 ab	1.01 a
Asamienu	0.84 c	0.80 c	0.82 b
Apantu	1.14 a	1.02 ab	1.07 a
Mean	0.99 a	0.95 a	

Lsd (p=0.05) variety = 0.06 p= 0.00
Lsd (p=0.05) drying method = 0.04 p= 0.08
Lsd (p=0.05) variety x drying method = 0.11 p= 0.10

Table 4.20 shows the effect of different varieties and chip treatment on oil absorption capacity of plantain flour. The results show that no differences exist between the chip treatments (P>0.05) although the control had higher oil absorption capacity (0.99). Flour from the untreated Apantu however, recorded high oil absorption capacity of 1.25. Significant differences (P<0.05) were observed among the varieties and the chip treatment.

Table 4.20: Effect of different varieties and chip treatment on the oil absorption capacity of flour

Variety	Chip treatment		Mean
	Treated	Untreated (control)	
Apem	1.05 b	0.98 bc	1.01 a
Asamienu	0.91 c	0.72 d	0.82 b
Apantu	0.89 c	1.25 a	1.07 a
Mean	0.95 a	0.99 a	

Lsd (p=0.05) variety = 0.06 p= 0.00
Lsd (p=0.05) chip treatment = 0.04 p= 0.08

Lsd (p=0.05) variety x treatment = 0.11 p= 0.00

Table 4.21 shows the effect of different drying methods and chip treatment on oil absorption capacity of plantain flour. The results show that untreated sun dried flour had higher oil absorption capacity (1.05), followed by treated solar dried flour (0.97). Significant differences were observed among the drying method and the chip treatment (P<0.05).

Table 4.21: Effect of drying methods and chip treatment on the oil absorption capacity of flour

Drying method	Chip treatment		Mean
	Treated	Untreated (control)	
Sun	0.92 b	1.05 a	0.99 a
Solar	0.97 ab	0.92 b	0.95 a
Mean	0.95 a	0.99 a	

Lsd (p=0.05) drying method = 0.04 p= 0.08

Lsd (p=0.05) chip treatment = 0.04 p= 0.80

Lsd (p=0.05) drying method x chip treatment = 0.08 p= 0.00

4.3.6 Foaming Capacity (ml)

The effect of different varieties and drying method on foaming capacity of the plantain flour are shown in Table 4.22. The results show that the flour from Apantu recorded significantly ($P<0.05$) higher foaming capacity of 40.62. The solar drying method were not significantly different ($P>0.05$) from each other with solar dried flour having high foaming capacity (32.08). Significant differences ($P<0.05$) were observed in the foaming capacity among the varieties and drying methods. Solar dried Apantu recorded high foaming capacity of 47.50.

Table 4.22: Effect of different varieties and drying methods on the foaming capacity of flour

Variety	Drying method		Mean
	Sun drying	Solar drying	
Apem	38.33 b	25.00 c	31.67 b
Asamienu	23.75 c	23.75 c	23.75 c
Apantu	33.75 b	47.50 a	40.62 a
Mean	31.95 a	32.08 a	

Lsd (p=0.05) variety = 4.00 p= 0.00
Lsd (p=0.05) drying method = 2.70 p= 0.91
Lsd (p=0.05) variety x drying method = 0.22 p= 0.10

Table 4.23 shows the effect of different varieties and chip treatment on foaming capacity of plantain flour. The results show that no differences ($P>0.05$) exist between the chip treatments although the control had higher foaming capacity (32.36). Flour from the untreated Apantu however, recorded high foaming capacity of 42.50. Significant differences (P<0.05) were observed among the varieties and the chip treatment.

Table 4.23: Effect of different varieties and chip treatment on the foaming capacity of flour

Variety	Chip treatment		Mean
	Treated	Untreated (control)	
Apem	35.00 bc	28.33 cd	31.67 b
Asamienu	21.25 e	26.25 de	23.75 c
Apantu	38.75 ab	42.50 a	40.62 a
Mean	31.67 a	32.36 a	

Lsd (p=0.05) variety = 2.70 p= 0.00
Lsd (p=0.05) chip treatment = 2.70 p= 0.60
Lsd (p=0.05) variety x treatment = 7.02 p= 0.00

Table 4. 24 shows the effect of different drying methods and chip treatment on foaming capacity of plantain flour. The results show that untreated sun dried flour had higher foaming capacity (33.06), followed by treated solar dried flour (32.50).

However, no significant differences (P>0.05) were observed among the drying methods and the chip treatment.

Table 4.24: Effect of drying methods and chip treatment on the foaming capacity of flour

Drying method	Chip treatment		Mean
	Treated	Untreated (control)	
Sun	30.83 a	33.06 a	31.95 a
Solar	32.50 a	31.67 a	32.08 a
Mean	31.67 a	32.36 a	

Lsd (p=0.05) drying method = 2.70 p= 0.92
Lsd (p=0.05) chip treatment = 2.70 p= 0.60
Lsd (p=0.05) drying method x chip treatment = 5.11 p= 0.25

4.4 PASTING CHARACTISTICS OF PLANTAIN FLOUR

4.4.1 Beginning of Gelatinization

Table 4.25 shows the effect of different varieties and drying methods on the beginning of gelatinization of plantain flour. There were significant differences (P≤0.05) among the flour from the varieties. Apantu variety recorded the highest value for beginning of gelatinization (11.83 BU), statistically similar to flour from the Apem variety (10.83 BU). The least value for beginning of gelatinization (10.17 BU) was recorded in Asamienu variety which was also not statistically different from flour from Apem variety (10.83 BU). However, sun dried flour (10.67 BU) and solar dried flour (11.22 BU) were not significant (P≥0.05) from each other.

Significant differences (P≤0.05) were observed among the different varieties dried in either the sun or solar. The highest value for beginning of gelatinization was recorded in solar dried apem (12.00 BU) and sun dried Apantu flours (12.00 BU) while the least was recorded in sun dried apem flour (9.67 BU).

Table 4.25: Effect of different varieties and drying methods on the beginning of gelatinization of the plantain flour

	Drying Methods		
Varieties	Sun	Solar	Mean
Apem	9.67c	12.00a	10.83ab
Asamienu	10.33abc	10.00bc	10.17b
Apantu	12.00a	11.67ab	11.83a
Mean	10.67a	11.22a	

Lsd (p=0.05) drying method = 1.15 p= 0.31
Lsd (p=0.05) varieties = 1.40 p= 0.07
Lsd (p=0.05) drying method x varieties = 1.98 p= 0.10

4.4.2 Maximum Viscosity

Table 4.26 shows maximum viscosities for different varieties and drying methods used for processing plantain flour. Significant differences were not observed (P>0.05) among the varieties and drying methods. Apem, Asamienu and Apantu varieties recorded 368.50 BU, 377.67 BU and 442.67 BU, respectively. Sun dried flour had maximum viscosity of 389.33 BU while solar dried flour had 403.2 BU.

However, significant variations (P≤0.05) were observed with interactions between varieties and drying methods. The highest maximum viscosity was recorded in sun dried Apantu flour (458.67 BU) which was statistically different (P≤0.05) from the sun dried Apem flour which recorded the least (291.00 BU).

Table 4.26: Effect of different varieties and drying methods on the maximum viscosity of the plantain flour

	Drying Methods		
Varieties	Sun	Solar	Mean
Apem	291.00c	446.00ab	368.50a
Asamienu	418.33ab	337.00bc	377.67a
Apantu	458.67a	426.67ab	442.67a
Mean	389.33a	403.22a	

Lsd (p=0.05) drying method	= 68.09	p= 0.66
Lsd (p=0.05) varieties	= 83.40	p= 0.15
Lsd (p=0.05) drying method x varieties	= 117.94	p= 0.02

4.4.3 Start of Holding Period

For start of holding period, no significant differences were recorded for both the varieties and drying methods. Apem, Asamineu and Apantu varieties recorded 356.60 BU, 363.33 BU and 427.33 BU values for start of holding period of the flour. Sun dried flour and solar dried flours also recorded 377.11 BU and 387.67 BU values for start of holding period of the flour.

The effect of different varieties and drying methods on start of holding period showed significant differences (P≤0.05). The highest value for start of holding period was recorded in sun dried Apantu Flour (456.67 BU) while the least was recorded in sun dried apem flour (282.00 BU).

Table 4.27: Effect of different varieties and drying methods on start of holding period of plantain flour

	Drying Methods		
Varieties	Sun	Solar	Mean
Apem	282.00c	431.00ab	356.60a
Asamienu	392.67abc	334.00bc	363.33a
Apantu	456.67a	398.00abc	427.33a
Mean	377.11a	387.67a	

Lsd (p=0.05) drying method = 67.47 p= 0.73

Lsd (p=0.05) varieties = 82.63 p= 0.16

Lsd (p=0.05) drying method x varieties = 116.85 p= 0.03

4.4.4 Start of Cooling Period

From Table 4.28, Apem, Asamienu and Apantu varieties were not statistically different and had 284.50 BU, 296.17 BU and 344.17 BU values of start of cooling period respectively. Sun dried flours also had 322.78 which was not statistically different ($P \geq 0.05$) from solar dried flour (293.78 BU).

The effect of different varieties and drying methods showed significance ($P \leq 0.05$) in start of cooling period. Sun dried Apantu flour (386.67 BU) recorded the highest value for start of cooling period. Sun dried apem flour (244.00 BU) which had the least value for start of cooling period was not statistically different ($P \geq 0.05$) from solar dried asamienu (254.67 BU).

Table 4.28: Effect of different varieties and drying methods on Start of Cooling Period of Plantain flour

	Drying Methods		
Varieties	Sun	Solar	Mean
Apem	244.00b	325.00ab	284.50a
Asamienu	337.67ab	254.67b	296.17a
Apantu	386.67a	301.67ab	344.17a
Mean	322.78a	293.78a	

Lsd (p=0.05) drying method	= 58.40	p= 0.29
Lsd (p=0.05) varieties	= 71.52	p= 0.19
Lsd (p=0.05) drying method x varieties	= 101.14	p= 0.04

4.4.5 End of Cooling Period

Table 4.29 shows the effect of different varieties and drying methods on end of cooling period of plantain flour. Flour from Apem (181.67 BU), Asamienu (188.00 BU) and Apantu (264.17 BU) varieties were not significantly different (P≥0.05) from one another. Sun dried flour (210.78 BU) was also not significantly different (P≥0.05) from solar dried flour (211.78 BU).

There were significant differences (P≤0.05) between the interaction of the different varieties and drying methods for end of cooling period of the flour. Sun dried Apantu variety (285.33 BU) recorded significantly the highest value for end of cooling period while the least value was recorded in sun dried apem flour (130.67 BU) which was not statistically different (P≥0.05) from solar dried asamienu flour (159.67 BU).

Table 4.29: Effect of different varieties and drying methods on End of cooling period of plantain flour

Varieties	Drying Methods Sun	Solar	Mean
Apem	130.67b	232.67ab	181.67a
Asamienu	216.33ab	159.67b	188.00a
Apantu	285.33a	243.00ab	264.17a
Mean	210.78a	211.78a	

Lsd (p=0.05) drying method = 68.30 p= 0.97
Lsd (p=0.05) varieties = 83.65 p= 0.10
Lsd (p=0.05) drying method x varieties = 118.29 p= 0.11

4.4.6 End of Final Holding Period

From the results (Table 4.30), there was no significant difference between the sun dried flour (187.67 BU) and solar dried flour (191.11 BU). The highest value for end of final holding period was recorded in Apantu variety (240.83) while the least was recorded in Apem flour (160.67 BU).

For effect of different varieties and drying methods on end of final holding period of flour, significant differences (P≤0.05) were observed. The highest value for end of the final holding period of flour was recorded in sun dried Apantu (260.67 BU) while the least value for the end of the final holding was recorded in sun dried apem flour (113.67 BU).

Table 4.30: Effect of different varieties and drying methods on the end of final holding period of flour

Varieties	Drying Methods Sun	Solar	Mean
Apem	113.67b	207.67ab	160.67b
Asamienu	188.67ab	144.67b	166.67ab

Apantu	260.67a	221.00ab	240.83a
Mean	187.67a	191.11a	

Lsd (p=0.05) drying method	= 63.09	p= 0.91
Lsd (p=0.05) varieties	= 77.27	p= 0.08
Lsd (p=0.05) drying method x varieties	= 109.27	p= 0.13

4.4.7 Breakdown

Table 4.31 shows the effect of different varieties and drying of methods on the breakdown of plantain flour. Solar dried flour (109.22 BU) recorded significantly higher ($P<0.05$) value of breakdown than sun dried flour (66.22 BU) which recorded the least. However, Apem (84.00 BU), Asamienu (81.17 BU) and Apantu (98.00 BU) varieties were not significantly different from each one other.

As regards the interaction between the different varieties and drying methods, solar dried Apantu flour (124.67 BU) recorded the highest value of breakdown while the least was recorded in sun dried Apem flour (47.00 BU).

Table 4.31: Effect of different varieties and drying methods on the Breakdown of plantain flour

	Drying Methods		
Varieties	Sun	Solar	Mean
Apem	47.00c	121.00ab	84.00a
Asamienu	80.33abc	82.00abc	81.17a
Apantu	71.33bc	124.67a	98.00a
Mean	66.22b	109.22a	

Lsd (p=0.05) drying method	= 29.05	p= 0.01

Lsd (p=0.05) varieties = 35.58 p= 0.55

Lsd (p=0.05) drying method x varieties = 50.32 p= 0.11

4.4.8 Setback

From the results (Table 4.32), there were no significant differences (P≥0.05) between the varieties and drying methods. Apem, Asamienu and Apantu varieties recorded setback values of -64.50 BU, -107.33 BU and -79.50 BU, respectively. Sun dried flour had -86.11 BU value for setback while solar dried flour had -81.44 BU value for setback.

The effect of different varieties and drying methods on setback also showed no significance (P≥0.05). The setback value of the interactions ranged between 120.00 BU to 58.00 BU.

Table 4.32: Effect of different varieties and drying methods on setback of plantain flour

	Drying Methods		
Varieties	Sun	Solar	Mean
Apem	-37.33a	-91.67a	-64.50a
Asamienu	-120.00a	-94.67a	-107.33a
Apantu	-101.00a	-58.00a	-79.50a
Mean	-86.11a	-81.44a	

Lsd (p=0.05) drying method = 59.95 p= 0.87

Lsd (p=0.05) varieties	= 73.42	p= 0.45
Lsd (p=0.05) drying method x varieties	= 103.83	p= 0.33

CHAPTER FIVE

5.0 DISCUSSION

5.1 SURVEY INFORMATION

From the results, females (62%) dominated in the plantain industry as compared to males. This could be due to the fact that, traditionally, women are involved in marketing and trading of food crops while the men are involved in their production as it is labour-intensive.

Most (54%) of the traders were observed to be between the ages of 40-59years. This shows the older women were active in the plantain business and this could be because trading was capital intensive and also required some form of experience. The youth were not be interested in trading of plantain as a profession.

The study showed that majority of the traders (83%) had basic or no formal education. This could be attributed to the fact that most of these traders learnt the trade from their parents who were involved in the trading of plantain. Root and tuber crops trading has been in existence for a long time and has been observed not to require educated people to participate in that trade.

The plantain traders were also involved in other forms of occupation such as farming and trading of other crops or vegetables to help them source enough income. Trading of plantain might not have been on a large scale and therefore selling of plantain solely would not generate enough income or profit.

Respondents (99%) confirmed plantain to be a staple food as reported by Akomea *et al.* (1995). Varieties common in their localities were Apem, Apantu, Oniaba and Asamienu. According to Ampofo *et al.* (2013), false horn plantain, true horn and french plantain are common groups of plantain in Ghana. Apem and Oniaba are the local names for the French horn plantain while Apantu and Asamienu are the local names for the false horn plantain and true horn plantain respectively (Ampofo *et al*., 2013).

Plantain in the locality were used for *fufu, ampesi, ofam* and *plantain chips*. These are common household foods in Ghana produced from plantain and corroborates a report from Akomeah *et al*. (1995) which stated that *fufu* which involves a mixture of boiled green plantain and cassava, pounded into a thick dough and *ampesi,* boiled plantain, are the main household dishes in Ghana, usually eaten with soup or stew.

The most common plantain variety used for preparation of fufu was "Apantu" (90%) because it was easy to pound, had good taste, had less seeds and also had fine texture when pounded. The respondents also indicated "Apantu" to be best suited for *fufu* because it had good gelation, was less tough and easily mixes with cassava when pounded together. Apem (96%) was the most common plantain variety used for preparation of *ampesi* by people in the locality. The taste, texture and size of the variety made it suitable for preparation of *ampesi*. "Apantu" was the most preferred variety for making plantain chips because the hands of the variety was big in size and easy for slicing, the variety had good taste and was also attractive in colour. From the study, majority of the respondents (52%) had no specific place for storage of plantain. However, some of them stored in a well-ventilated cool place, in refrigerators and under water. This may be due to the fact that these storage methods were the commonest and known methods in Ghana. The longest period plantain could be stored was between 3-7 days.

Majority of the respondents (90%) were aware of plantain flour and were willing to use the plantain flour for preparation of fufu. This could be because processing of plantain has become essential to address critical issues of glut and postharvest loss, especially, during the peak period (Iyabo and Omobowale, 2013). Plantain flour was also preferred by consumers because they indicated there was no change in the taste and quality of plantain when made into the flour form.

5.2 PROXIMATE COMPOSTION OF THE PLANTAIN FLOUR

5.2.1 Moisture Content

The moisture content of both the solar and sun dried plantain flours ranged from 10.10%- 8.87% and showed no significance ($p>0.05$) in each other. It was observed that the moisture content of the plantain flour had significantly been reduced compared to the moisture content of the fresh plantain (60%) as reported by Agoreyo *et al*. (2011). According to Abulude (2006), the low moisture content of samples prevents the growth of micro-organisms and increases the storage life of the sample. High amount of moisture in the plantain flour would allow fungal growth and cause the flour to grow mouldy, thereby, reducing the shelf-life of the flour. Reduction in moisture content also decreases the perishable nature of food crops, adds value and extends the shelf-life making them available throughout the year (Emperatriz *et al*., 2008). Therefore, irrespective of the plantain varieties used for production of the flour and the drying method used (solar and sun dried), the plantain flour could be stored for a longer period than the fresh plantain as its moisture content had been reduced.

5.2.2 Crude Fat

Crude fat determines the free fatty lipids of a product. From the results, both the solar and sun dried Asamienu and Apem varieties made into plantain flours had significantly the highest fat content (1.00%). The crude fat contents recorded in these plantain flours (1.00%) were lower than the 1.38% reported by Agoreyo *et al*. (2011) to be present in plantain flours. Decrease in the crude fat content of these plantain flours could be as a result of the heat applied. However, their low fat content could help increase the storage shelf-life of the flour by reducing the chances of becoming rancid during storage. Thus, processing of fresh plantain into plantain flour using either solar or sun dryer, although reduces the fat content of the flour, it increases the shelf-life as its ability to become rancid is reduced.

5.2.3 Crude Fibre

The highest crude fibre recorded in sun-dried plantain flours (3.10%) from the study was high in crude fibre, comparably higher than the value (0.7%) obtained for plantain flour worked on by Egbebi and Bademosi (2012). It was observed that the drying methods increased the fibre content in the varieties (2.56%- 2.32%) and this corroborates with a report from Hassan *et al*. (2007). The increase in fibre content may be attributed to the removal of moisture which tends to increase the availability of nutrients (Morris *et al*., 2004). According to Ng and Fong (2000) plantain contains high fibre content and thus has the ability to lower cholesterol and help to relieve constipation, hence prevention of colon cancer. Therefore, consumption of processed plantain flour would be of benefit to consumers.

5.2.4 Ash Content

Ash is the inorganic residue remaining after the water and inorganic matter have been removed by heating in a food. The ash content also measures the total amount of minerals present in a food. The ash content of both the solar and sun-dried plantain flour ranged between 2.27% and 1.47% with solar dried Apem variety made into plantain flour recording the highest (2.27%) ash content. Agoreyo *et al*. (2011) and Egbebi and Bademosi (2012) reported higher ash content of 5.5% - 4.8% and 3.8% respectively. The differences might be due to varietal and climatic differences.

5.3 FUNCTIONAL PROPERTIES OF PLANTAIN FLOUR

Swelling power is an indication of the water absorption index of the granules during heating (Loos *et al*., 1981). The swelling power of the plantain varieties dried using both solar and sun dryer into plantain flour ranged from 9.02g/g to 9.92g/g. The higher swelling power of the plantain flours could be attributed to the smaller particle size of the plantain starch (Ojinnaka *et al*., 2009). Higher swelling power of the flour is also an indication of higher solubility which makes it suitable for noodle-quality flours (Morris *et al*., 2006). The results showed the plantain flours had higher swelling power and therefore makes it suitable for noodle production as well as some confectionaries.

From the results, significant solubility differences ($p<0.05$) were observed for the plantain flours produced from the two drying methods. The solar dried plantain varieties, especially the apem variety (45.68%), had higher solubility than the sun dried plantain varieties. Solubility indicates the ability of water to penetrate into starch granules of flours (Ikegwu *et al.*, 2010). Higher solubility increases the swelling power and indicates better digestibility of the plantain flours (Johnson *et al*., 2001). Thus, solar dried apem varieties would have better digestibility and would be more palatable and suitable for infant foods.

Bulk density measures the heaviness of a sample of a flour and is directly proportional to starch content of the flour (Oti and Akobundu, 2007). The bulk density of the plantain flours ranged between 0.82 g/cm^3 to 0.87 g/cm^3 and showed no significant differences. The high bulk density of the plantain flours could be attributed to the high carbohydrate content of the flours. High bulk density is suitable in the processing industries as it gives greater packaging advantage due to the greater quantity of flour that can be packaged within a constant volume (Ijarotimi and Ashipa, 2005). Therefore, plantain flours from the three varieties, either solar or sun dried would exhibit better packaging properties.

The results showed that the apem variety which was sun dried (1.53 g/g) had the highest water absorption capacity similar to asamienu solar dried (1.48 g/g), whereas, the solar dried Apantu had the least (0.85 g/g). Water absorption capacity is the ability of starch or flour to absorb water and swell for improved consistency in food and imbibition of water is an important functional trait in foods such as sausages, custards and doughs (Adebowale *et al*., 2005). The relatively high bulk density of the apem sun dried indicates it could be useful in paste formation and suitable for thickening of soups.

From the study, the plantain flours had the oil absorption capacity ranging from 0.72 g/g to 1.25 g/g for the various treatments. Oil absorption capacity aids food formulations (Odoemelam, 2000) and gives an indication of flavor-retaining capacity of flour (Narayana and Narasimga, 1982). Flours with lower oil absorption capacity have higher flavor retention abilities (Oladele and Aina, 2007). Therefore, the

Asamienu solar dried plantain flour could have a high potential of retaining flavour which makes it desirable for food product formulation. Plantain flours such as sun dried Apantu with high absorption capacities could be useful in food formulations such as sausage making, cakes and soups where high oil holding capacity is necessary.

Foaming capacity is the ability of a flour sample in a solution to produce foam after shaking vigorously or stirring. Foaming capacity is as a result of the protein content available in the flour and its solubility since foam ability is a function of solubilized proteins (Narayana and Narasimga, 1982). From the study, the highest foaming capacity was recorded in Apantu solar dried (47.50%) while the least was recorded in Asamienu solar and sun dried (23.75%) which was similar to Apem solar dried (25.00%). High foaming capacity improves the texture, consistency and appearance of foods. Hence, the solar dried Apantu plantain flours are more suitable for foods such as koose preparation where foaming is desirable

5.4 PASTING CHARACTERISTICS OF PLANTAIN FLOURS

Beginning of gelatinization signifies the initial stages of starch getting cooked in wet flours during cooking. The study indicated that starch in Apantu cooked at higher viscosity than Asamienu. This suggests that during cooking Apantu would require stirring at the beginning in order not to get burnt due to thickening.

Generally, all the varieties had similar maximum viscosities. Again, no differences were found in drying methods with respect to maximum viscosity. The findings indicate that the three varieties of plantain cooked to similar maximum viscosities and that if maximum viscosity was the parameter of interest, any of the varieties would do for use in food processing operations. Similarly, the plantain varieties did not show different maximum viscosities when dried using different drying technologies in this study. Consequently, any drying method could be used for similar maximum viscosity.

However, in the interaction study, sun drying of Apantu resulted in the highest maximum viscosity suggesting it would be the variety and method of choice for food systems where plantain flour with higher maximum viscosities are required.

Maximum viscosity reflects a starch-type's ability to swell upon cooking forming thicker pastes. Sundried Apantu could be useful in foods which require higher maximum viscosities. According to Zhou *et al.* (1999) such flours would need frequent stirring during cooking to reduce burning.

Maximum viscosity of 458 BU recorded in this study is lower than the 677 BU reported for false horn plantain flour by Zakpaa *et al.* (2010), Cassava (966 BU) and Potato (3000 BU) but higher than Maize (77.5 BU) and Wheat (300 BU) (Ciacco *et al.,* 1997). Characteristic differences in variety and crop types as observed in starch granule size and amylose content could be responsible for the observed variations.

Sun-dried Apantu could consequently be used in foods where thickening is required (Kim *et al.,* (1995).

Breakdown is a quality attribute of starch and establishes the difference between maximum and minimum viscosities during cooking. It provides an estimation of extent of reduction in viscosity when wet starch is heated. It is indicative of starch granule disintegration (Adebowale *et al.,* 2005). Starches which have lower breakdown withstands heating and shear stresses consequently yielding more stable cooked paste (Zobel, 1984). Sun-dried Apem was consequently, once it formed paste was more stable than the rest and could be used where cooked paste stability is of interest.

Setback a measure of post-cooking paste stability is indicative of the difference between the hot paste viscosity or trough and the final viscosity. It shows the extent of retrogradation or reordering of starch molecules during heating. According to Etudaiye *et al.* (2009) and Sanni *et al.* (2004), lower setback of starches indicate high stability of paste and greater resistance to retrogradation and syneresis. This is attributable to the low amylose content of some starches (Peroni *et al*., 2006). Noncohesive paste formation is an indicative of low setback (Kim *et al*., 1995). Setback values are important as food quality for starches used as food ingredient in the processing and preservation industries and physical properties are negatively affected by retrogradation with the lapse of time after cooking. Since the study showed that no differences existed in setback values, irrespective of variety or drying method, any of the varieties and drying methods could be used without significant variation to

Breakdown.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

6.1 CONCLUSION

From the study, females (62%) dominated in the plantain industry as compared to males. Most (54%) of the traders were observed to be between the ages of 40-59years and had basic or no formal education (83%). Plantain varieties reported by respondents to be common in their localities were Apem, Apantu, Oniaba and Asamienu and were used for preparation of fufu*, ampesi, ofam* and *plantain chips*.

The most common plantain variety used for preparation of fufu (90%) was "Apantu" while Apem was the most common plantain variety used for preparation of *ampesi* (96%). Storage of plantain in the localities was a problem and therefore, most of the respondents (52%) had no specific place to store their plantain. Majority of the respondents (90%) were aware of plantain flour and were willing to use the plantain flour for preparation of fufu.

The moisture content of both the solar and sun dried plantain flours ranged from 10.10%- 8.87% and showed no significance ($p>0.05$) in each other. The solar and sun dried Asamienu and Apem varieties made into plantain flours had significantly the highest fat content (1.00%) while the least was recorded in solar dried Apantu flour. The drying methods also increased the fibre content in the varieties. Sun dried Asamienu and Apantu plantain flours recorded significantly ($P<0.05$) higher crude fibre content of 3.10% and 3.09% while solar dried Apantu and sun dried apem recorded the least (2.02%). The ash content of both the solar and sun-dried plantain flours ranged between 2.27% and 1.47% with solar dried Apem flour recording the highest (2.27%) ash content.

For the functional properties, the results showed that solar dried plantain varieties, especially, the apem variety (45.68%), had higher solubility than the sun dried plantain varieties. The bulk density of the plantain flours ranged between 0.82 g/cm^3 to 0.87 g/cm^3 and showed no significant differences ($p>0.05$). The sun-dried apem flour (1.53 g/g) had the highest water absorption capacity and was statistically similar to asamienu solar dried (1.48 g/g), whereas, the solar dried Apantu had the least (0.85 g/g). The results showed that the oil absorption capacity of the plantain flours ranged between 0.72 g/g and 1.25 g/g for the various treatments. The highest foaming capacity was also recorded in Apantu solar dried flour (47.50%) while the least was recorded in asamienu solar and sun dried flours (23.75%) which were similar to apem solar dried flours (25.00%).

As regards the pasting characteristics of the plantain flour, the solar dried apem flour had significantly the highest value for beginning of gelatinization (12.00 BU) while the least was recorded in sun dried apem flour (9.67 BU). The highest maximum viscosity was recorded in sun dried Apantu flour (458.67 BU) which was statistically different ($P\leq0.05$) from the sun dried Apem flour which recorded the least (291.00 BU). Apantu variety sun dried had the highest value for start of holding period (456.67 BU), start of cooling period (386.67 BU), end of cooling period (285.33 BU) and end of final holding period (260.67 BU). The least values for start of holding period (282.00 BU), start of cooling period (244.00 BU), end of cooling period

(130.67 BU) and end of final holding period (113.67 BU) was recorded in sun-dried apem variety. For value of breakdown, solar dried Apantu flour (124.67 BU) recorded the highest value of breakdown while the least was recorded in sun dried Apem flour (47.00 BU). The setback value of the flours showed no significance ($P \geq 0.05$) and ranged between 120.00 BU to 58.00 BU.

6.2 RECOMMENDATION

It is recommended that flours from the various treatments be used for formulations of different products for assessment.

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APPENDICES

Student Edition of Statistix 9.0 22/03/2016, 11:06:07

Analysis of Variance Table for Beginning

Source DF SS MS F P rep

2 4.1111 2.05556

DM 1 1.3889 1.38889 1.17 0.3051 trt

2 8.4444 4.22222 3.55 0.0683 DM*trt 2

7.1111 3.55556 2.99 0.0959

Error 10 11.8889 1.18889

Total 17 32.9444

Grand Mean 10.944 CV 9.96

Analysis of Variance Table for Maximum

Source	DF	SS	MS	F	P
rep	2	1536	768.1		
DM	1	868	868.1	0.21	0.6592
trt	2	19619	9809.7	2.33	0.1473
DM*trt	2	46628	23314.1	5.55	0.0239
Error	10	42028	4202.8		
Total	17	110680			

Grand Mean 396.28 CV 16.36

Analysis of Variance Table for breakdown

Source	DF	SS	MS	F	P
rep	2	2144.8	1072.39		
DM	1	8320.5	8320.50	10.87	0.0080
trt	2	974.8	487.39	0.64	0.5490
DM*trt	2	4164.3	2082.17	2.72	0.1139
Error	10	7651.2	765.12		
Total	17	23255.6			

Grand Mean 87.722 CV 31.53

Analysis of Variance Table for endcoolin

Source DF SS MS F P rep

2 201.4 100.7 DM 1 4.5 4.5

0.00 0.9746 trt 2 25295.4 12647.7 2.99

0.0959 DM*trt 2 23106.3 11553.2 2.73

0.1130

Error 10 42279.9 4228.0

Total 17 90887.6

Grand Mean 211.28 CV 30.78

Analysis of Variance Table for endfinal

Source DF SS MS F P rep

2 536.8 268.4 DM 1 53.4 53.4

0.01 0.9056 trt 2 23926.8 11963.4 3.32

0.0786 DM*trt 2 18464.8 9232.4 2.56

0.1266

Error 10 36076.6 3607.7

Total 17 79058.3

Grand Mean 189.39 CV 31.71

Analysis of Variance Table for setback

Source DF SS MS F P rep
2 14295.4 7147.72 DM 1 98.0 98.00
0.03 0.8658 trt 2 5668.8 2834.39 0.87
0.4483 DM*trt 2 8066.3 4033.17 1.24
0.3308
Error 10 32572.6 3257.26
Total 17 60701.1

Grand Mean -83.778 CV -68.12

Analysis of Variance Table for start

Source DF SS MS F P rep
2 1774.1 887.1 DM 1 3784.5 3784.5
1.22 0.2944 trt 2 12000.4 6000.2 1.94
0.1939 DM*trt 2 27228.0 13614.0 4.40
0.0425
Error 10 30908.6 3090.9
Total 17 75695.6
Grand Mean 308.28 CV 18.03

Analysis of Variance Table for starthold
Source DF SS MS F P rep

2 1119 559.7 DM 1 501 501.4

0.12 0.7346 trt 2 18320 9160.1 2.22

0.1592 DM*trt 2 43125 21562.7 5.23

0.0279

Error 10 41256 4125.6

Total 17 104322

Grand Mean 382.39 CV 16.80