EFFECTS OF THERMAL TREATMENTS ON BOILED AND FRIED PLANTAIN (*Musa paradasiaca*)

BY

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DECLARATION

I hereby declare that this project is a record of research work that was undertaken and written by me. It has not been presented before for any degree or diploma certificate at any university or institution, information derived from personal communication, published and unpublished works were duly referenced in the text.

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CERTIFICATION

This is to certify that the project titled "Effects of Thermal Treatment on Proximate Composition of Plantain (*Musa paradasiaca*)" by Atiku, Quadri Adedigba, meets the regulations governing the award of the degree of Bachelor of Engineering (B.ENG) of the Federal University of Technology, Minna, and it is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This Project is dedicated to Almighty Allah, the most gracious, the most merciful, also to my beloved parents and siblings for their moral support and my dearest wife for giving me courage and my children.

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ABSTRACT

In this study, the effect of thermal treatments on boiled and frying plantain (Musa paradasiaca) was investigated at different stages of ripeness, sugar and mineral contents were also determined under approved standard laboratory condition and standard methods and instruments were used. The following proximate compositions were studied: moisture content, crude protein, fats (lipid), crude fibre, ash and carbohydrate. The mineral content determined were; potassium (K), Sodium (Na), Calcium (Ca), Iron (Fe), Copper (Cu), Zinc (Zn), and Magnesium (Mg). The results showed that the moisture content for raw, fried and boiled were (63.03%, 31.62%, 65.79%); (64.82%, 29.39%, 66.11%); (66.45%, 25.96%, 69.41%); (67.45%, 26.65%, 71.17%) (69.90%, 22.74%, 74.81%) and (73.39%, 18.33%, 82.14%) respectively, at different stages of ripeness from day 0 to Day5. Hence Crude protein was higher in boiled plantain but less in fried one. Plantain was very poor in lipid, when boiled the plantain was extremely low in fat compared to raw and fried. Plantain decreased in crude fibre at different stages of ripeness, crude fibre decreased from 1.10%, 0.096%, 0.91%, 0.84%, 0.51% and 0.47% for day zero (0) to five (5) respectively. Plantain is very high in carbohydrate content, the carbohydrate contents for frying increased at the different stages of ripeness. The results for mineral contents for potassium (K) and calcium (Ca) were; (7.20, 0.1571); (8.60, 0.0194); (9.30, 0.0161); (10.71, 0.1153); (11.20, 0.1702); (12.80, 0.0104) for day zero (0) to five (5) respectively. The green plantain was very low in sugar, but as it became ripe sugar content increased at different stages of ripeness. The amount of free sugar obtained in the raw sample when the plantain was green at day zero (0) to five (5) were: 15.63%, 28.13%, 40.63%, 46.88%, 59.38% and 75.00%. The result obtained for the proximate composition of plantain for the raw, fried and boiled showed that plantain is one of the healthiest fruits but fried reduced some nutritional contents and moisture content increased as the plantain was ripening.

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CHAPTER ON

1.0 INTRODUCTION

1.1 Background to the Study

Plantain (*Musa paradisiacac*) belongs to the family *musaceae* (Simmond and Shepherd, 1995). It is one of the major staple crops that contribute to the calories and subsistence economies in Africa. Alexander the great during his world conquest at about 327 B.C. came into contact with this fruit and introduced it into Europe. The long tortuous history of plantain can be traced to as far back as 500 B.C.; it is of South East Asian origin, mostly Indonesia. This now popular African food item was introduced into India by traders. Several types of plantain include "Horse", "Creole" and "Horn". The types differ in shape, size, skin color, and flavor. Plantain fruits are typically higher in starch content and lower in sugar than bananas. They are sometimes called cooking bananas and are larger and firmer than dessert bananas. Plantains are rarely eaten raw, unless completely black to ensure ripeness. Plantain and cooking bananas are very similar to unripe desert bananas (*M. cavendish* AAA) in exterior appearance, although often larger, the main differences in the former being that their flesh is starch rather than sweet, they are used unripe and require cooking (Happi *et al.,*2007). Desert bananas are consumed usually as ripe fruit; whereas ripe and unripe plantain fruits are usually consumed boiled or fried (Surga *et al.,* 1998).

Plantains maturity are less precise than they are for bananas, several different external and internal fruit characteristic can be used to determine maturity. These include fruit diameter, age of the bunch, angularity of the fruit, length of the fruit, and peel color. Plantains require about three months from the beginning of flowering until harvest. Multiple fruits are produced on a large bunch; within the bunch are clusters of double row of fruits called "hand", and individual fruit called "finger". The edible cultivars of plantains and bananas are seedless. The two obvious tissues that constitute the fruit are the pulp and the peel. The peel is ovary wall; the pulp originates from cell division of the innermost layer of the pericarp. The growth of the peel begins to slow down as the fruit matures but the growth of the pulp is continuous, consequently peel splitting often occurs in very mature green fruit (Turner, 1997). Uganda was the top producer of plantain in 2005, followed by Colombia. (FAO 2004)

Plantain is very important in the context of human nutrition. It also stands out as a very important addition to any healthy living diet plan. Plantain is one of the healthiest foods in the word in term of its nutrient content. It is rich in low GI carbohydrate, dietary fiber, vitamins and minerals. The nutritional value of plantain is even greater than that of its closet relation banana. Cooked unripe plantain is very good for diabetes, as it contains complex carbohydrate that is slowly released over time (Macdonald, 1999). Unripe plantain is traditionally processed into flour in Nigeria (Ukhum and Ukpebor, 1991). It is rich in potassium and is commonly prescribed by doctors for people who have low level of potassium in their blood. The potassium in plantain is very good for the heart and helps to prevent hypertension and heart attack (Johnston, 1997). Apart from being a source of important nutrients, plantain has also been used in making biscuits (Ngalani and Crouzet 1995). The use of plantain peel in both biogas (Methane) production and soap manufacturing has also been reported (Ogazi, 1996). They are also good sources of carbohydrate, (Marrriott, *et. al,* 1981). Plantain cultivation is attractive to farmers due to the low labour requirements for production compared with cassava, maize, rice, and yam (Marriott and Lancaster, 1983).

1.2 Statement of the Problem

Plantain is one of the major staple crops with the richest iron and other nutrient contents which make it to be one of the healthiest foods in the world. This study therefore will provide useful and meaningful data on the effect of thermal treatment (cooking and frying) on its proximate composition. There is tendency for movement of nutrients alongside the moisture from the peel to the pulps, thereby increasing the nutrient levels in the pulp. This calls for adoption of appropriate processing techniques for retention of various nutrients in foods especially vitamins and minerals. This study will therefore provide useful and meaningful data, since available information on different stages of ripeness and mineral composition of the fruit is limited and sometime unavailable.

1.3 Objective of the Study

- To determine the effect of boiling on proximate composition plantain
- To determine the effect of frying on proximate composition of plantain

1.4 Justification of the Study

The study of the effect of thermal treatment (cooking and frying) of plantain on the proximate composition of plantain attempts to provide meaningful data for engineering analysis because plantain shows extended variability in composition (mainly moisture, protein, carbohydrate, fat, ash, fiber and structure) and can be turned into even more complex composition material when heated together. The data generated will give accurate and appropriate view on the effect of these thermal treatments. Also determination of the most suitable stages for human consumption would be investigated.

1.5 Scope of the Study

The proximate composition to be determined will be limited to the following: moisture content, fat, ash, crude protein and crude fiber and sugar content. They will be determined using AOAC (2005) procedures. The following minerals would also be determined: Potassium (K), Sodium (Na), Calcium (Ca), Iron (Fe), Copper (Cu), Zinc (Zn), and Magnesium (Mg).

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 The Plantain

Plantain is a multipurpose crop because the fruit can be utilized at all stages of ripening and are a member of the banana family, they are starchy, low in sugar variety that is cooked before serving, as it is unsuitable raw. It is used in many savory dishes somewhat like how a potato would be used and is very popular in West Africa and the Caribbean countries. It is usually fried or baked. Plantains are native to India and are grown most widely in tropical climates. They are sometimes referred to as the pasta and potatoes of the Caribbean. Sold in the fresh produce section of the supermarket, they usually resemble green bananas but ripe plantain may be black in color. This vegetable-banana can be eaten and tastes different at every stage of development. The interior color of the fruit will remain creamy, yellowish or light pink. When the peel is green to yellow, the flavor of the flesh is bland and its texture is starchy. As peel changes to brown or black, it has a sweeter flavor and more of a banana aroma but still keeps a firm shape when cooked (Bishop, 1990).

Plantain averages about 65% moisture content and bananas average about 83% moisture content. Since hydrolysis, the process by which starches are converted to sugars occurs faster in bananas than it does in plantains, a banana is ready to eat "out of hand" until hydrolysis has progressed to the point where the skin is almost black. Plantains grow best in area with constant warm temperatures and Protection from strong winds. They have been grown in scattered locations. Although they look a lot like green bananas and are a close relative, plantains are very different. They are starchy, not sweet, and they are used as a vegetable in many recipes, especially in Latin America and Africa. Plantains are longer than bananas and they have thicker skins. They also have natural brown spots and rough areas. Many people confuse plantains with bananas, some of the differences are noted below.

Table 2.1: Difference between Plantain and Banana

Plantain	Banana
Starchy	Sweet
Use as a vegetable	Eaten as a fruit
Longer than banana	Shorter than plantain
Thicker skins	Thinner skin
Resemble green banana, but may be green, yellow or black	Color is green when not fully ripe, yellow when ripe

Sources: African foods (2003)

2.2 Nutritional Composition of Plantain

The processing and proximate composition of Agricultural produce dated back prehistorically to the time when man realized the need for proximate composition and analysis of food rich in nutritional value for consumption. Agricultural material involves various analyses of which proximate composition is done (Juliano, 1971).

The importance of carbohydrate, potassium, protein, fiber, and fat in human cannot be over emphasized. In the normal human diet, one fruit of plantain contains about 260 calories, it is also very rich in potassium, and it is commonly prescribed by doctors for people who have low level of potassium in their blood, thus it is good for heart and helps to prevent hypertension and heart attack. The green plantain is very low in sugar, the carbohydrate in the green unripe plantain is stored as a complex starch, slowly released after cooking and it is a good inclusion in a diabetic diet (Chandler 1995). The ripe or yellow plantain is rich in sugar and very sweet to taste. A diet of green plantain is filling, and can also be a good inclusion in a weight loss diet plan (Nelson, 1944).

From the nutritional point of view, these fruits are among the vegetables with the richest iron and other nutrient contents (Aremu and Udoessien, 1990). However, they are highly perishable and subjected to fast deterioration, as their moisture content and high metabolic activity persist after harvest (Demirel and Turhan, 2003). Plantain has commercial potential on their own or as ingredient for other foods such as baby weaning foods, puddings, soups and gravies. Gwanfogbe *et al.,* (1988) reported the usage of plantain flour at an industrial level, with full or low starch content. Plantain pulp is low in protein with estimated values of 4g per kg in green unripe finger and 9g per kg in the fully ripe finger. A higher level of about 72g per kg is found in the peels, which makes the peel a suitable feeding stuff for ruminants, especially in ripe form (Izonfuo and Omuaru, 1988).

Plantain peel is richer in minerals such as potassium, calcium, magnesium, phosphorus, copper and iron except sodium when compared to the pulp at all stages of physiological ripeness, with increasing lends of potassium, calcium and iron as the fruits ripens (Izonfuo and Omuaru, 1988). High level of potassium in plantain makes it an amendment of acidic soils (Izonfuo and Omuaru 1988). The physiological role of minerals in human diet has been documented (Ihekoronye and Ngoddy, 1985; Okaka *et al.,* 1992; Onigbinde, 2001). Rahman, (1963) reported on the utilization of flour from unpeeled green plantain on poultry feed, and concluded that no ill or toxic effects could be observed in the chicks fed with the flour.

2.3 Origin of Plantain

The plantain is thought to be a relative of the banana, as it is a fruit that resembles a large banana. Though the stories have varied somewhat, this fruit is thought to have been discovered as early as 327 B.C. regardless of its origin. The plantain was a popular trade food many years ago. In Europe 327 B.C., it is believed that Alexander the Great discovered this fruit and brought it to Europe. Plantain traveled to Madagascar from India and Malaysia through Asia and Arab trade. This fruit was popular during the Trans-Saharan trade boom. In Africa, 1500 A.D., plantains were considered a prosperous trading product. This fruit helped defined the success of the expansion of the Bantu kingdom in Southern and Central Africa (Scot 1977).

In Caribbean, 1516 A.D., a Portuguese Franciscan monk is believed to have introduced plantains to the Caribbean. He brought the plantain to Santo Domingo after discovering them in the canary Islands. Plantain probably derives from the word "koba", which is used in Sao Tomé and in the coastal zones of Southeast Africa, where that form of the name probably originated. The linking factor is clearly the Portuguese trading. Dutch, British, French and German traders also played a role in the distribution of the popular banana cultivars "Gros Michel" and the Cavendish group to West Africa, Latin America and the Caribbean. Scot, (1977).

In the Africa continent, a hundred or more different cultivars of plantain grow deep in the rainforest. In the countries bordering the Great lakes region in Africa, more than sixty different cultivars of the highland Banana also called "Mutika/ Lujugira" group, can be found in International Network for the Improvement of Banana and Plantain (INIBAP, 1993).Cultural history and tradition points to the presence of the crop in these areas since time immemorial (William *et al.,* 1989).

2.3.1 The Origin of the African Plantain

The existence of numerous plantain cultivars in the middle of African rainforest is intriguing. The plant was and still is in some remote places a key component of cultural life. (De langhe 1996) reported that plantain probably reached Africa more than 3000 years ago. However, the identity of the people responsible for growing plantain during that remote age remains a mystery. They were certainly not relatives of the inhabitants of Madagascar, who reached and colonized that Island at a much later date, about 1500 years ago. Neither are the ancestors of the Bantu- or Cushitic-speaking peoples likely to have been the growers. It is evident, however, that once the plantain spread to the more humid forest climates, it underwent an intensive diversification by the West-Bantu speaking people responsible for carrying plantain from South and /or Southeast Asia to Africa., the earliest historical traces of a cultural contact between East Africa and India data from not more than 2000 years ago, (Thompson, 1995)

Table 2.2 below shows the top 10 world producer of plantain.

Table 2.2 Top 10 Countries (% of world production) of Plantain

PLANTAIN	World Rank
Uganda (30%)	1
Colombia (9%)	2
Rwanda (8%)	3
Ghana (7%)	4
Nigeria (6%)	5
Peru (5%)	6
Cote d'Ivoire (4%)	7
Cameroon (4%)	8
Congo (4%)	9
Kenya (3%)	10

Sources: FAO (2004)

Plantains are grown as a staple food in 52 countries worldwide on about 12,800 km^2 while Banana is the fruit crop in the world in terms of production behind African oil palm. Many consider banana the fruit crop and label oil palm an "oil crop", not a fruit crop. It is grown in 130 countries worldwide, on 11,000km^2. Both banana and plantain are large, herbaceous monocots, reaching 7.5m in some cultivars, but generally 1.8-4.5m tall in cultivation. Plantains are often larger than bananas. The "trunk" or pseudostem is not a true stem, but only the clustered, cylindrical aggregation of leaf stalk bases. Leaves are among the largest of all plants, becoming up to 2.7m long and 0.6m wide. Margins are entire and venation is pinnate; leaves tear along the veins in windy conditions, giving a feathered or tattered look. There are 5-15 leaves on each plant, with 10 considered the minimum for properly maturing a bunch of fruit. The perennial portion of the plant is the rhizome, which may weigh several pounds. It is often called a corm. It produces suckers, or vegetative shoots, which are thinned to 2 per plant - one "parent" sucker for fruiting and one "follower" to take the place of the parent after it fruits and dies back. It also produces roots and serves as a storage organ for the plant (FAO, 2004).

2.3.2 Stages and Indices of maturity of Plantain

The stage of maturation at which any fruit is harvested greatly influences the fruit's green-life or ability to be stored for long periods and its final eating quality. Plantain develops its full characteristic flavors, taste and color during storage if it has been picked during an optimum period. Maturity standards for plantains are less precise than they are for bananas. Several differences in external and internal fruit characteristics can be used to determine plantain maturity. (Offem *et al.,* 1993). These include fruit diameter, age of the bunch, angularity of the fruit, length of the fruit, and peel color. The stages of maturity for harvest depend on the intended fruit, length of the fruit, and peel color. The stages of maturity for harvest depend on the intended market destination. Locally marketed plantain can be harvested at a more advanced maturity stage compared to export market fruit (John and Marchal, 1995).

Plantain maturity is related to the diameter of the fingers, this is determined by measuring the diameter of the fruit at its midpoint with a pair of calipers. Second method for estimating plantain maturity is to record the age of the bunch. The time from when the fruit bunch first becomes visible (shooting) is recorded. Bunches can be tagged with different colored ribbons at the time of shooting, and subsequently harvested after the appropriate time for particular cultivar, based on the season of the year and experience. The color of the ribbons is changed weekly to coincide with the time of shooting, subsequently the age of the bunch (NARI, 2003).

A third method used to determine harvest maturity is to observe the shape (fullness) and angularity of the fruit. Immature fruit is angular in cross-sectional shape and has distinct ridges. As fruit matures, it becomes less angular and more rounded or full. A fourth way of estimating plantain bunch maturity is to measure the length of the edible pulp portion of the fruit from the fingers in the middle hand. The length should be a minimum of 15cm for the domestic market and 18cm for the export market. Finally, peel color is another frequently used method of assessing fruit maturity. The peel remains green throughout growth and development of the fruit until it reaches physiological maturity. It then changes to a yellow color during ripening. However, plantain fruit should be harvested when the peel is green in color to withstand the rigors of handling and distribution. Changes in pulp to peel ratio during fruit maturation was one of the most significant and consistent indices of maturity in banana, cooking banana and plantain maturation were hybrid dependent (NARI, 2003).

2.3.3 Indices of Ripeness of Plantain

Plantain is eaten at all stages of ripeness from green to black. The plantain is normally eaten as a starchy staple food. It can be boiled, baked or fried and served as a vegetable or made into sweet desert, depending on the degree of ripeness of the fruit.

Green: when the plantain is green, it is quite starchy and the flavor is much like a potato or yucca root. The green fruit can be fried or boiled

Yellow: when the plantain is yellow the sugar begins to develop and impart a slight sweetness to the fruit. At this stage the fruit may show a few freckle or black.

Black: the plantain is at it is fully ripe, aromatic and sweetest once it turns black.

The color of the peel is used as an indicator of ripening. A scale of 1 to 7 is convenient where 1 is dark green, 2 is light green, 3 is more green than yellow, 4 is more yellow than green, 5 is yellow with green tips, 6 is fully yellow, and 7 is flecking (Kader, 1993).

2.4 Proximate Composition of Plantain

The determination of proximate composition in engineering is to enhance techno-scientific development with respect to food analysis. To increase the economic and nutritional importance, the proximate composition in relation to engineering standard is required. Kayisu *et al.*,(1981). Reported the Proximate compositions of plantain as follows: crude protein is 13.20%, crude fiber 2.60%, ash content 8.80% and fat 2.59%. Gwanfogbe *et al.*, (1988); and Daramola and Osanyinlusi, (2005) reported Carbohydrate contents of 74.99%. Allen *et al.*, (1984) reported that a typical average size of plantain fruits after cooking contain 50-80 grams of Carbohydrate, 2-3grams of protein, 4-6 grams of fiber and about 0.01 to 0.3 grams of fat.

2.5 Methods of Cooking of Plantain

Cooking plantain as a component of an African dish depends on the part of Africa or indeed the world. Plantain can be cooked in various ways, depending on what recipe plan to make. It can be cooked and eaten boiled, roasted, mashed, baked, grilled or even as plantain porridge.

In Nigeria, the most populous African nation, plantain is mostly eaten as *dodo* or fried plantain. In Cameroon, they are known as *missole.* This involves frying sliced ripe plantain in vegetable oil or butter till it is golden yellow to brown in color. Plantain is also cooked boiled. This is much like boiling potatoes. The peeled plantains are put in the pot and water added to it and allowed to boil for about half an hour until tender in moderate heat. This can be eaten with a soup or butter or some other sauce. Another way to cook plantain that is common in Africa is to roast it under balls of red hot charcoal until it cooked. This is called *bolae or bolle or boli* in Southern Nigeria. This can be eaten with palm oil or butter.

Plantain chips are another form in which plantain is cooked and eaten. Plantain is cooked differently in Latin American countries. One of the most popular ways plantains is prepared is as *Tostones,* (refers to thicker twice fried patties). This involves frying the slightly ripened plantain initially soaked in flavored water, mashed and then fried again until it becomes crispy.

2.6 Ripening of Plantain

Trying to ripen plantain can be frustrating, it will become delicious just like its close relative the banana, but plantain does it in their own good time. It ripens by letting them sit and then sit some more until the peel are completely black wrinkling, when poked it should yield easily to pressure. (Asiedu, 1980)

The process by which starches are converted to sugars is called Hydrolysis; it acts fastest in fruit of higher moisture content, so banana easily lap plantains (Burdon *et. al.*, 1995). It can be ripe just like ripen banana in a warm, preferably well-ventilated place. Especially if it is humid and hot in climate, throwing them in stacks should be avoided so as to prevent mold (Sankat *et al.*, 1996).

2.6.1 Humidity Management

The optimal post-harvest relative humidity (RH) for plantains is between 90 to 95% (after coloring is underway RH should be reduced to 85% to prevent peel splitting). Storage of fruit at <90%RH will result in peel desiccation and shriveling. The amount of dehydration will increase with decreasing RH. Water loss from localize skin abrasions and chafed area of the peel will be accelerated with deceasing RH, and the damaged areas will turn brown to black in color. Traditional methods for increasing the storage humidity include spraying fruit intermittently with water, storing fruit on wet sacking, and storing fruit in boxes filled with moist coir or sawdust. Although effective, these methods can cause excessive wetting, which leads to fruit splitting and reduced market quality (Scott *et al.,* 1970).

2.6.2 Artificial Ripening

Plantains may be consumed at different stages of ripeness. They are commonly prepared as fried sections or chips when the peel is still green and the pulp is high in starch. They are also consumed in the baked or fried form as a sweeter dessert fruit. Starch declines from > 30 % in green fruit at harvest to < 2 % in fully ripe yellow-brown fruit. Ripening is accomplished by holding the green harvested fruit at ambient temperatures and/or artificially ripening the fruit with ethylene gas. At ambient temperatures, the pulp of mature green harvested plantain fruit will soften and the peel will turn yellow to brown in color. A much faster rate of ripening can be obtained by putting the mature green fruit inside a sealed chamber and exposing it to ethylene gas at precisely controlled temperatures. Most commercial cultivars of plantains require 100 to 150ppm ethylene for 24 to 48 hours at 15°C to 20°C (59°F to 68°F) and 90 to 95% relative humidity to induce uniform ripening. The exact temperature chosen depends on the desired degree of ripening and the peel color. Carbon dioxide concentration should be kept below 1% to avoid its effect on delaying ethylene action. Use of a forced-air system in ripening rooms assures more uniform cooling or warming of plantains as needed and more uniform ethylene concentration throughout the ripening. After the ethylene gas treatment, the chamber is ventilated and the temperatures are gradually reduced. Ripening to a soft textured pulp high in sugars takes about 9 days at 18°C and 12 days at 14°C. If ripening temperatures are too high (>25°C), the pulp may become undesirably soft. The fruit must be kept cool (13.3 to 15.6°C) and at 90% RH after removal from the ripening chamber and during delivery to the destination market to avoid rapid spoilage (Stover and Simmonds, 1987).

2.7 Contribution to Diet

Other than fresh consumption and plantains are used in numerous ways. Dried fruit of plantain is commonly made into chips by frying slices in oil and salting. Larger slices are deep fried and eaten like French fries in many countries. *Mofongo* is fried green plantain mixed with seasoned pork. As with most fruits, the fermented juices are made into beer and wine, commonly in Africa. The young leaves and terminal inflorescence buds are edible. (U.S. FDA, 2009).

Table 2.2 below shows the dietary value of plantain per 100g edible portion.

Table 2.3: Dietary value of Plantain per 100 gram edible portion

Percentage	Plantain
Water	66
Calories	134
Protein	1.2
Fat (%)	0.4
Carbohydrates	31
Crude Fiber	2.6

Source: (U.S. FDA 2009)

2.8 Principal Diseases of Plantain

2.8.1 Crown Rot

Crown rot is a major postharvest disease of plantain fruit throughout the world. It is especially problematic in packinghouses that do not follow strict sanitation practices. Crown rot is a disease complex involving several different fungi, including *Colletotrichum musae, Fusarium* spp., and *Verticillium theobromae*. Infection occurs from plantain trash in the field, or from inoculum build-up in the packinghouse and during de-handing. Fungal spores colonize the wounded area where the hand is removed from the stalk (peduncle). Symptoms begin as a softening and blackening of the cut crown surface. Decay typically spreads from the cut surface into the crown area of the hand of plantains during transport. In severe cases, the decay may extend to the top part of the fruit. Control of crown rot is achieved by dipping the hands of fruit in a fungicide-treated wash tank and/or applying fungicide-impregnated cellulose crown pads to the cut surface of the hand. The most commonly used fungicides are thiabendazole, imazalil, and benomyl. Dipping the fruit in 50°C (122°F) water for 5 minutes is also effective in reducing deterioration from crown rot. The manner of severing the hand from the stalk also influences the amount of crown rot. Breaking the stalk near the crown rather than neatly trimming it with a knife will increase the amount of crown rot. The action of breaking will leave fragments of stalk tissue attached to the crown which are suitable microenvironments for crown rot infection. In addition, fungicide-impregnated pads will adhere better to smooth than to rough crown surfaces, allowing for more effective fungicide transfer and disease control.

Good field hygiene and elimination of sources of crown rot inoculums are additional steps useful in reducing this disease. Also, storage of the fruit at 12°C 54°F will minimize the growth of the fungi responsible for crown rot. (Stover, 1972; Wardlaw, 1972; Stover and Simmonds, 1987).

2.8.2 Anthracnose

Anthracnose peel blemish, caused by the fungus *Colletotrichum musae*, is another important postharvest plantain disease. Infection originates on immature fruit in the field, but lesions typically do not develop until the fruit ripens and the fungus can penetrate the peel. Anthracnose lesions on green fruit are generally dark brown to black with a pale margin, oval in shape, and slightly sunken. On ripening fruits the typical symptoms are numerous small dark circular spots which enlarge, coalesce, and become sunken. Salmon-pink spore masses are eventually produced. Diseased fingers mature more rapidly than healthy fingers. Anthracnose control is achieved by the same packinghouse sanitation practices, fungicide treatments, and postharvest temperature control as recommended for crown rot (Stover, 1972; Wardlaw, 1972; Stover and Simmonds, 1987).

2.8.3 Finger Rot

Finger rot, caused by the fungus *Lasiodiplodia theobromae*, is prevalent in Guyana and is most serious following heavy rains. Decay usually begins at the flower end of the fruit or in a wounded area of the peel. The decay spreads uniformly causing a brownish-black discoloration of the peel and a softening of the pulp. The affected area of the peel becomes wrinkled and covered with fungal growth. The pulp is reduced to a soft rotten mass. The disease attacks fruit of all development stages, but is more common on ripe fruit. This disease can be controlled by minimizing injury to the fruit, removing decaying banana trash in the field, spraying the plants with systemic fungicides, and maintaining a storage temperature below 20°C (68°F) (Stover, 1972; Wardlaw, 1972; Stover and Simmonds, 1987).

2.9 Postharvest Disorders of Plantain

2.9.1 Chilling Injury

Plantains are very sensitive to chilling injury (CI), which is a physiological disorder caused by exposure of the fruit to temperatures below 12°C (54°F). Symptoms include peel discoloration (dull or grayish-brown color), flesh darkening, uneven ripening, and off-flavor development. The amount of chilling injury a plantain receives depends on the temperature and the length of time exposed to the chilling temperature. Damage from chilling injury may occur after a few hours to a few days, depending on cultivar, maturity, and temperature. For example, moderate chilling injury will result from exposing mature-green plantains to several days at 10°C (50°F), but severe chilling injury will occur at 4°C (39°F). Chilled fruits are also more sensitive to mechanical injury and microbial decay (Stover, 1972; John and Marchal 1995; Turner, 1997).

2.10 Optimum Storage Condition

Optimum temperatures for storage and holding of green banana are 13.3 to 14.4°C (56 to 58°F) (Thompson and Burden, 1995). Some banana cultivars can be handled at 12.8°C (55°F). Because marketing quality standards are more relaxed for plantains, and plantains are more prone to premature ripening during transit and storage, it is recommended that green plantain be held between 8.9 to 11.7°C (48 to 53°F). Plantains grown during the warmer months tend to attain physiological maturity faster than fruit grown during the winter months, consequently green life potential varies during the year. Optimum RH for holding and transporting fruit is 95%. Holding of ripe fruit should be kept to a minimum (Turner, 1997).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Materials

Samples of unripe but mature healthy plantain (*Musa paradisiaca*) variety (AAB Cultiver) were obtained directly through a local farmer from the market in Lambata, Niger State, Nigeria. The analyses were carried out at the Animal Production Research Laboratory, Food Science Laboratory and Biochemistry Laboratory, all at the Federal University of Technology Minna. Niger State, Nigeria. Plate 3.1 shows a picture of the samples of plantains used for the study.

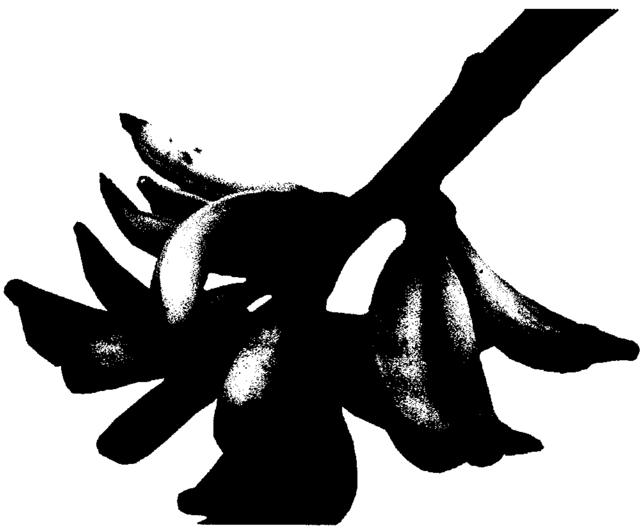

Plate 3.1: Bunch of Plantain Used

Plate 3.2 below shows the stages of ripeness of the plantains used

Plate 3.2: Stages of Ripeness of the Plantains (Day1-Day5)

3.1.1 Reagents

The reagents used are as follows:

Sodium hydroxide, tetraoxosulphate VI acid , hydrogen chloride, selenium tablet, ethanol, boric acid, petroleum ether, 1.25% sulphuric acid, 1.25% NaOH, 1M HNO3, 10% NaOH, 0.1M HCL, 1.5 sulphuric acid, 10% NaOH, dinitrosalicylic acid (DNS).

3.1.2 Apparatus

The apparatus used includes the following:

Muffle furnace (Manufactured in England-Lento, serial No. 4399)

Conical flash

Filter paper

Electronic weighing balance (Mettler PM 200, 01, 50-50Hz, 200-240volts, 45m Amps Sensitivity)

Soxhlet extractor(Model: Electrothermal, Maker: Electromantle)

Micro kjeldahl digestive block (Manufactured in England-serial No.44103)

Measuring cylinders (Pyrex; 10ml, 50ml, 100ml)

Desiccators

Electronic oven (Fisher scientific 2555 keeper, Boulevard Dubuque, lowa 25001, USA. Model number 3511-IFS, serial number 1480060997735.220, 240v, 3.3Amps, 800watts, 50/60Hz, phase1)

Tong

Crucible

Petri dish

Burette

Pipette

Pipette

Digital colorimeter (input voltage 220V, single phase 50Hz AC, Serial number; 1620/10/09)

Spatula

Knife/Slicer

Retort stand

Fume cupboard

Bunsen burner

Round bottom flask

Flat bottom flask

Boiling tube

VARIAN Atomic Spectrometer (Spectralaa-5 Model)

Atomic Absorption Spectrophotometer (Pekin- Elmar Model403, Norwalk CT, USA)

Electric Water Bath

3.2 Sample Preparation

3.2.1 Boiling

The samples were cleaned and weighed, they were placed in a pot unpeeled and 1 litre of water was added to it and covered. This was allowed to cook for 25 minutes. The plantains were not peeled because there is tendency for movement of nutrients alongside the moisture from the peel to the pulp.

3.2.2 Frying

The samples were also cleaned weighed and peeled. The plantains were difficult to peel, because they were still green, ripe plantains peel easily like banana. The end was sliced off with sharp knife and the peel was slit from tip to tip under cold running water to keep hands from becoming stained also, the peel process was done sideways in one piece. After the plantain was peeled, the pulp was sliced into a uniform thickness of 10mm by using ruler for the measurement before slices. Natural tasting oil was used for frying. The amount of oil used for frying was just enough to coat the bottom of the pan, because too much oil would cause the plantain to soak-up the oil resulting in soggy plantains.

Medium heat was used to fry the plantain, but the temperature of the vegetable oil was about 170° C. The samples were fried for four minutes. The frying process continued until plantain turned to golden colour. The heat was well regulated to prevent burning or browning too quickly. Moreover, non-stick pan was used for the frying, as this will aid in the easy release of the cooked plantain from the pan, because sugar burns quickly and sticks.

Plate 3.3 shows the picture of the fried, boiled and raw samples

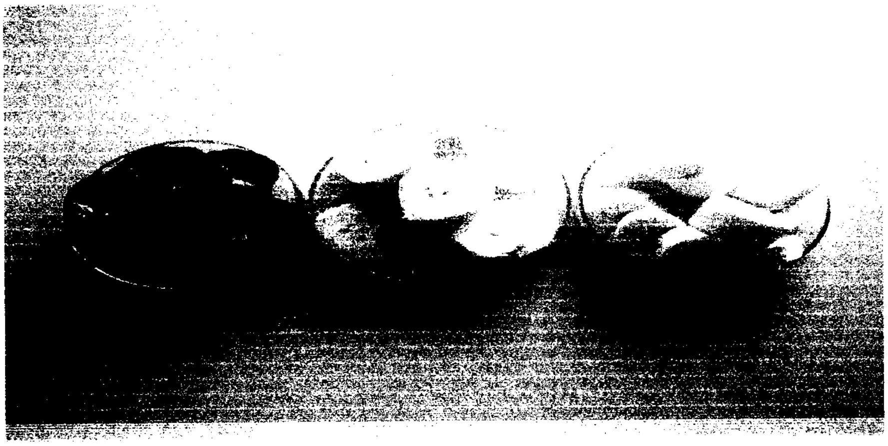

Plate 3.3: Fried, Boiled and raw samples

3.3 Experimental Procedure

The experimental procedures used in the determination of the Proximate composition were as described by AOAC (2005) Method of Analysis. Mineral and sugar contents were also determined by atomic absorption spectrophotometer and dinitrosalicylic acid (DNS) colorimetric respectively. All determinations were performed in replicates.

3.3.1 Determination of Moisture content

Moisture content of food is of great importance to every food processor as a number of biochemical reactions and physiological changes in food depend very much on the moisture content; of even greater significance is the effect of moisture on the stability and quality of foods. A clean dish was dried to a constant weight in an air oven at 110°C, cooled in desiccators and weighed (W_1). Samples of raw plantains were weighed into the previously labeled dish and reweighed (W_2). The dish containing the sample was dried in an oven to a constant weight. The dish was then transferred from the oven to the desiccators to cool for one hour and was reweighed (W_3). The percentage moisture content was calculated thus:

$$\%\, moisture\ content = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

This procedure was carried out for also the boiled and fried samples.

3.3.2 Determination of Fat (Lipid) Content

Fat is the combination of fat acid esters, compound fat neutral, sterols pseudo fat (Vitamins A, D_2, D_3, E, K) and carotene. In general, lipids are characterized by their sparing solubility in water and their considerable solubility in organic solvents and those food constituents soluble in non-polar organic solvents such as benzene and petroleum ether.

A clean dried 500ml round bottom flask containing few anti bumping granules was weighed (W_1) and 300ml of petroleum ether (40^0C-60^0C) for the extraction was poured into the flask fitted with soxhlet extraction unit. The extractor thimble containing samples folded with filter paper was fixed into the soxhlet extraction unit; the round bottom flask and a condenser were connected to the soxhlet extractor, cold water circulation was refluxing at a steady rate. The heating mantle was switched on and the heating rate adjusted until the solvent was refluxing at a steady rate. Extraction was carried out for six hours, the solvent was recovered and the oil was dried in the oven at 70°C for one hour. The round bottom flask and oil was cooled and then weighed (W_2). This procedures was carried out for all the plantain samples (raw, boiled and fried).

The lipid content was calculated thus:

$$\% \, crude\ lipid\ contentn\% = \frac{W_2 - W_1}{Wt\ of\ sample} \times 100$$

3.3.3 Determination of ash Content

Ash in food constitutes the residue remaining after all the moisture has been removed as well as organic materials (fat, protein, carbohydrates, Vitamins, organic acids e.t.c) have been burnt away by igniting at temperature of about 550°C. These results in the oxidation of organic constituents to volatile materials considered as carbon dioxide, nitrogen oxide and sulphur dioxide. Ash residue is generally taken to be a measure of the mineral content of the original food.

AOAC (2005) method was used, the porcelain crucible was dried in an oven at 100°C for 10 minutes cooled in desiccators and weighed (W_1). 2 grams of the finely ground sample was placed into the previously weighed porcelain crucible and reweighed (W_2). It was first ignited and transferred into a furnace, which was then set at 550°C. The sample was left in the furnace for eight hours to ensure proper ashing. The crucible containing the ash was then removed, cooled in the desiccators and reweighed (W_3), the percentage ash content was calculated as:

$$\% \text{ Ash content} = \frac{W3 - W1}{W2 - W1} \times 100$$

This procedure was carried out for raw, fried and boiled samples.

3.3.4 Determination of Protein Content

Amino acids are the building blocks of proteins and therefore polymers of amino acids, most of which are α-amino acids having the general formula NH_2CHR_2COOH. It is only macronutrients in foods that contain nitrogen. The nitrogen in proteins thus becomes the basis of the estimation of protein in foods.

Protein digestion

AOAC (2005) method was adopted, 1.5g of the ground defatted sample in an each less filter paper was dropped into the kjeldahl flask. 25ml of concentrated H_2SO_4 and 3g of digesting mixed catalyst $CUSO_4$ + Na_2SO_4 (1:10) were weighed separately into an ash less filter and also dropped into the kjeldahl flask. The flask was then transferred to the kjeldahl digestion apparatus. The sample was digested until a clear green colour was obtained.

Distillation of the digest

The digest was transferred into 500ml kjeldahl flask containing anti-bumping chips, 250ml of distilled water was added (rising the 300ml flask into the 500ml flask with part of the 250ml water) about 70-120ml of 40% Na_2OH was slowly added by the side of the flask and then followed by drops of 1% phenolphthalein indicator.

A 500ml conical flask containing a mixture of125ml 4% boric acid and 4 drops of mixed indicator was used to trap the ammonia being liberated.

The conical flask and the kjeldahl flask were then placed on kjeldahl distillation apparatus with the tubes inserted into the conical flask and the kjeldahl flask. The distillation was carried out until 125ml of the distillate was trapped in the boric acid solution to make a total volume of 250ml; the distillate was then titrated with 0.1M of HCl.

Calculation:

$$\% N_2 = \frac{0.014 \times M \times V}{Wt\ of\ sample} \times 100$$

% crude protein = % Nitrogen (N_2) × 6.25

Where,

M = actual molarity of acid

V = volume of HCl used

This procedure was carried out for raw, fried and boiled samples.

3.3.5 Determination of Crude fibre Content

Crude fibre is made up of cellulose and a little lignin. Crude fibre includes theoretically material that are indigestible in human and animal organism. Also, crude fibre represent the organic residue left behind after the material has been treated under standardized conditions with light petroleum, boiling dilute sulphuric acid, boiling dilute sodium hydroxide solution dilute hydrochloric acid, alcohol and ether.

From the sample, 2g of the finely ground was weighed out into a round sample bottom flask, 100ml of 0.25M sulphuric acid solution was added and the mixture boiled under reflux for 30 minutes. The hot solution was quickly filtered under suction; the insoluble matter was washed several times with hot water until it was acid free. It was quantitatively transferred into the flask and 100ml of hot 0.31M sodium hydroxide solution was added and the mixture boiled again under reflux for 30 minutes and quickly filtered under suction. The insoluble residue was washed with boiling water until it was base free, it was dried to constant weight in the oven at 100°C cooled in desiccators and weighed (C_1). The weighed sample (C_1) was then incinerated in a muffle furnace at 550°C for 2hours, cooled in the desiccators and reweighed (C_2).

Calculation:

The loss in weight on incineration = $C_1 - C_2$. The calculation was carried out thus:

$$\% \, crude\, fibre = \frac{C_1 - C_2}{weight\, of\, original\, sample} \times 100$$

This procedure was carried out for raw, fried and boiled samples.

3.3.6 Determination of Carbohydrate Content (By difference)

Carbohydrates are generally the most abundant singular food component in nature and are widely distributed. The total carbohydrate content was determined by difference, i.e. the sum of percentage of moisture, ash, crude lipid, crude protein and crude fibre was subtracted from 100.

% Carbohydrate= % Organic matter-% (crude protein +crude fiber+ ash +Lipid)

Where: Organic matter is the portion of samples which burnt off

3.3.7 Determination of Sugar content

Reducing sugar was determined using 3,5 Dinitrosalicylic acid (DNS) method. 0.2g grounded sample was weighed accurately into a boiling test-tube, 10ml of 1.5M sulphuric acid was added into each test tube and heated in a boiling water bath for 20minutes. The content was stirred occasionally to hydrolyze polysaccharide and other non reducing sugars, the test tube was cooled and 12ml of 10% NaOH was added carefully. The content was mixed and filtered into 100ml volumetric flash, the tube was also washed into the flask with distilled water. The volume was later made up with distilled water and mixed well by inversion: 1.0ml was pipetted into a test tube from the hydrolysate prepared, then followed by 1.0ml of DNS reagent. All the tubes were heated again in a boiling water bath for 5minutes to allow the reaction between glucose and DNS to occur, then cooled and each volume was adjusted to 20ml accurately with distilled water and pipette was used to mix well. The absorbance was read at 540mm with digital colorimeter. Standard Glucose Curve using 0.25-1.50mg/ml was used to obtain the reducing sugar content of the sample.

3.3.7.1 Analysis of Free Sugars

The methods of Joslyn (1970) and Kayisu *et al.* (1981) were used for the estimation of free sugars in plantain after separation from the starch using 95% ethanol. 5g grounded sample was weighed accurately into centrifuge tubes and wetted with 1.0 ml 95% ethanol, followed by the addition of 2.0 ml distilled water and mixed. Ten (10) ml of hot ethanol was then added and the mixture vortexed. The resultant mixture was centrifuged for 10 minutes at 2700 RPM and the supernatant decanted into a 100 ml volumetric flask, and made up to mark. An aliquot of 0.1-1.0 ml of extract was used for analysis. Each sample was diluted to 1 ml with distilled water, 0.5 ml phenol (5%) and 2.5 ml of concentrated H_2SO_4 were added and mixture vortexed. The sample was allowed to cool and absorbance was read at 490nm. D-glucose solutions were used as standards. A standard curve using 0-100μg/ml of glucose was used to obtain the sugar content of sample.

3.3.8 Determination of the Mineral Elements Composition

Minerals (both organic and inorganic compound) do occur in food. The major inorganic compounds are the carbonates, chloride, sulfates and phosphate of sodium, calcium, potassium and magnesium. Some of the nutrients essential for human nutrition include the following mineral elements: Calcium, Chlorine, Cobalt, Copper, Fluorine, Iodine, Iron, Magnesium, Manganese, Phosphorus, Sodium and Sulfur. In determination of mineral elements in food, the ash is first isolated and the relevant ash used in the determination of the individual metals. Various methods are available for the determination and estimation of mineral elements in food. Those methods are titrametric method, ion-exchange chromatography, emission spectroscopy, flame photometric, atomic absorption spectroscopy, Glass Electrodes method and host of others.

Wet ash method is one of the universally accepted techniques for isolating metals in food from their complex matrix before evaluating them with atomic absorption spectrophotometer or flame photometer. This is achieved by heating the sample with a digestion mixture containing concentrated nitric, perchloric and sulphuric acids in a kjeldahl flask for some hours. All organic matter is oxidized to water and CO_2, while metal ions are left behind as uncomplexed ions.

Mineral analyses were carried out using atomic absorption spectroscopy (AAS) following the procedures described by Allen *et al.* (1984). The analytical procedures used for sample treatment for AAS analysis are as follows: 1 gram sample was weighed into a pyrex glass conical flask.

10ml concentrated nitric acid was introduced into the flask with a straight pipette. 5ml of perchloric acid was then added. The mixture was heated on an electro-thermal heater in a fume cupboard for about 20 minutes until a clear digest was obtained. The digest was cooled to room temperature and diluted to 50ml with distilled water. The diluents were filtered into a plastic vial for AAS analysis (Techtron 1975). The filtrate was used for the determination of the mineral elements spectrophotometrically on the Bulk Scientific Atomic Absorption/Emission Spectrophotometer 205 (USA). This procedure was carried out for raw, fried and boiled samples.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

4.1 Results

The results obtained for the proximate composition, minerals and sugar contents of the samples plantain are given in Tables 4.1 – 4.7.

4.1.1 The results for the raw, fried and boiled plantain are given in Table 4.1

Table 4.1: Proximate Composition of raw, fried and boiled plantain

Treatments	Stages	Moisture	Protein	Fats	Crude Fiber	Ash	Carbohy-Drate
RAW	Day 0	63.03±0.40	13.65±0.29	12.25±0.35	1.10±0.12	5.90±0.23	64.40±1.91
	Day 1	64.82±0.10	13.30±0.12	10.65±0.17	0.96±0.12	4.10±0.23	70.99±0.21
	Day 2	66.45±0.29	14.00±0.17	10.01±0.23	0.91±0.12	4.50±0.29	70.58±.23
	Day 3	67.45±0.52	3.15±0.17	9.60±0.10	0.84±0.12	3.80±0.06	82.61±0.00
	Day 4	69.20±0.12	4.37±0.17	9.00±0.12	0.51±0.06	2.20±0.17	83.92±0.26
	Day 5	73.39±0.18	7.00±0.40	5.00±0.17	0.47±0.12	1.00±0.04	86.53±0.29
FRIED	Day 0	31.62±0.29	14.00±0.35	28.90±0.23	3.00±0.17	3.40±0.12	50.70±0.61
	Day 1	29.39±0.69	13.81±0.23	18.32±0.13	3.20±0.12	3.70±0.06	60.97±0.19
	Day 2	25.96±0.12	12.60±0.17	11.95±0.29	3.33±0.24	4.00±0.12	68.12±0.20
	Day 3	26.65±0.23	4.00±0.17	9.85±0.23	3.30±0.12	5.20±0.06	77.65±0.31
	Day 4	22.74±0.29	3.88±0.12	25.50±0.17	3.01±0.12	5.40±0.17	62.21±0.36
	Day 5	18.33±0.17	1.40±0.01	24.00±0.23	3.70±0.02	6.30±0.12	64.60±0.10
BOILED	Day 0	65.79±0.17	13.14±0.28	4.15±0.12	1.00±0.02	4.70±0.05	77.01±0.22
	Day 1	66.11±0.05	13.98±0.02	16.28±0.03	5.00±0.52	4.00±0.05	60.75±0.57
	Day 2	69.41±0.29	14.50±0.05	11.30±0.23	5.33±0.20	4.20±0.35	64.67±0.17
	Day 3	71.17±0.52	6.13±0.17	2.85±0.23	2.00±0.06	4.30±0.29	84.72±0.75
	Day 4	74.81±0.17	5.25±0.23	7.45±0.52	3.40±0.17	1.50±0.12	82.40±0.00
	Day 5	82.14±0.29	2.45±0.12	8.50±0.17	3.90±0.12	2.60±0.23	82.55±0.64

Values given are the mean of three replicates ± Standard Error of Mean

4.1.2 Result of the Mineral Analysis of Raw Plantain

Table 4.2 shows the result of the mineral analysis of raw Plantain

Table 4.2: Mineral Analysis of Raw Plantain at Different Stages of Ripeness

Minerals	Stages of Ripeness (%)					
	0	1	2	3	4	5 (Days)
K	7.20	8.60	9.30	10.71	11.20	12.80
Na	0.1268	0.2163	0.2243	0.0831	0.0436	0.0735
Ca	0.1571	0.0147	0.0161	0.1153	0.1702	0.0104
Fe	0.0047	0.0147	0.0318	0.0135	0.0094	ND
Cu	0.005	ND	0.0025	ND	0.0025	ND
Zn	0.0001	0.0001	0.0001	0.0001	0.0001	ND
Mg	ND	ND	ND	ND	ND	0.0002

ND- Not Detected

4.1.3 Result of the Mineral Analysis of Fried Plantain

Table 4.3 shows the result of the mineral analysis of fried Plantain

Table 4.3: Mineral Analysis of Fried Plantain at Different Stages of Ripeness

Minerals	Stages of Ripeness					
	0	1	2	3	4	5 (Days)
K	6.91	7.56	8.61	9.50	10.11	11.51
Na	0.1381	0.2163	0.2489	0.0279	0.0373	0.0638
Ca	0.0298	0.0199	0.0085	0.0279	0.1101	0.1421
Fe	ND	0.0032	0.0003	0.0035	ND	ND
Cu	ND	ND	ND	ND	ND	ND
Zn	ND	ND	ND	ND	ND	0.0001
Mg	0.002	ND	ND	ND	ND	0.002

ND- Not Detected

4.1.4 Result of the Mineral Analysis of Boiled Plantain

Table 4.4 shows the result of the mineral analysis of boiled Plantain

Table 4.4: Mineral Analysis of Boiled Plantain at Different Stages of Ripeness

Minerals	Stages of Ripeness					
	0	1	2	3	4	5 (Days)
K	8.21	9.01	9.91	10.11	11.85	13.50
Na	0.997	0.0956	0.0856	0.0583	0.1707	0.0644
Ca	0.2022	0.1650	0.1475	0.0251	0.0186	0.0142
Fe	0.0088	0.0041	0.0071	0.0091	0.0412	ND
Cu	0.0025	ND	0.0025	ND	0.0025	0.007
Zn	0.0001	0.0003	0.0001	ND	0.0001	ND
Mg	0.0002	0.0002	0.0002	0.0002	ND	ND

ND-Not Detected

4.1.5 Result of Reducing Sugar and free Sugar Contents of Raw Plantain

Table 4.5 shows the result of Reducing Sugar and free Sugar Contents of the Raw Plantain

Table 4.5: Sugar Content of Raw Plantain

Stages of Ripeness	Available Carbohydrate **(as glucose) (%)**	Free Sugar (%)
Day-0	78.13	15.63
Day-1	71.88	28.13
Day-2	62.50	40.63
Day-3	55.63	46.88
Day-4	40.67	59.38
Day-5	31.25	75.00

Day 0 means Harvest Day

Day 1 to 5 means Stages of Ripeness

4.1.6 Result of Reducing Sugar and free Sugar Contents of Fried Plantain

Table 4.6 shows the result of Reducing Sugar and free Sugar Contents of the Fried Plantain

Table 4.6: Sugar Content of Fried Plantain

Stages of Ripeness	Available Carbohydrate **(as glucose) (%)**	Free Sugar (%)
Day-0	75.00	18.75
Day-1	68.75	31.25
Day-2	59.00	43.73
Day-3	53.13	66.41
Day-4	34.38	68.75
Day-5	43.75	75.00

Day 0 means Harvest Day

Day 1 to 5 means Stages of Ripeness

4.1.7 Result of Reducing Sugar and free Sugar Contents of Boiled Plantain

Table 4.7 shows the result of Reducing Sugar and free Sugar Contents of the Boiled Plantain

Table 4.7: Sugar Content of Boiled Plantain

Stages of Ripeness	Available Carbohydrate **(as glucose) (%)**	Free Sugar (%)
Day-0	65.63	21.88
Day-1	75.00	37.50
Day-2	50.00	46.88
Day-3	47.00	56.25
Day-4	50.00	71.88
Day-5	50.00	81.25

Day 0 means Harvest Day

Day 1 to 5 means Stages of Ripeness

4.2 DISCUSSION

4.2.1 Moisture Content

There were differences in the moisture content between the samples for the raw, fried and boiled. The raw plantain had greater firmness and lower pulp moisture content and this may explain why the plantains were suitable for cooking or boiling. From the study, it was discovered that the moisture content of raw plantain increased as the plantain was getting ripe from one stage to another (Fig 4.1) as follow; 63.03%, 64.82%, 66.45%, 67.45%, 69.90%, and 73.39% at each stages of ripeness respectively, this may be due to the degradation activities present in the plantain as reported by (Egbebi *et al*; 2007). Also, moisture content in the pulp may have increased due to respiratory breakdown of starch and osmotic movement of water from the peel to the pulp during ripening (Loeseck, 1950). The same was also reported by (Aboua, 1991; Marriott and Lancaster, 1983). But in the case of fried plantain, the moisture content decreased (Fig 4.1), at each stages of ripeness respectively; this may have occurred as a result of loss of moisture while frying. There was also increase in moisture in the boiled sample than the raw (Fig 4.1), as follow; 65.79%, 66.11%, 69.41%, 71.17%, 74.81% and 82.14% at each stages of ripeness respectively, this may be because plantain may have absorbed moisture during boiling. Ahenkora *et al.*, (1996) reported that boiling increased the moisture content of plantain pulp, while frying decreases the moisture content. The lower the moisture contents in a product the longer the potential storage life. The moisture content increased at different stages of ripeness; the moisture content obtained at day zero (0) may be considered quite high and may not be adequate for storage since growth of micro organisms, food spoilage agents are not hindered at such moisture levels, Edelmiro *et al.*, (1977) reported that 10% moisture content in fruit is ideal for good keeping quality but the plantain's average moisture content was about 65%.

4.2.6 Carbohydrate Content

The result obtained from the study showed plantain as one of the agricultural products with high carbohydrate content as shown in Fig.4.6. The cooked unripe plantain is very good for diabetics, as it contains complex carbohydrate that is slowly released overtime FOA (2005). Fig.4.6 shows high content of carbohydrate when plantain is ripening from stages three to five, the high carbohydrates content reported in this study for frying corroborated the report of Ketiku (1973). This may be as a result of an increase due to loss of moisture resulting from frying. (Anon, 1998).

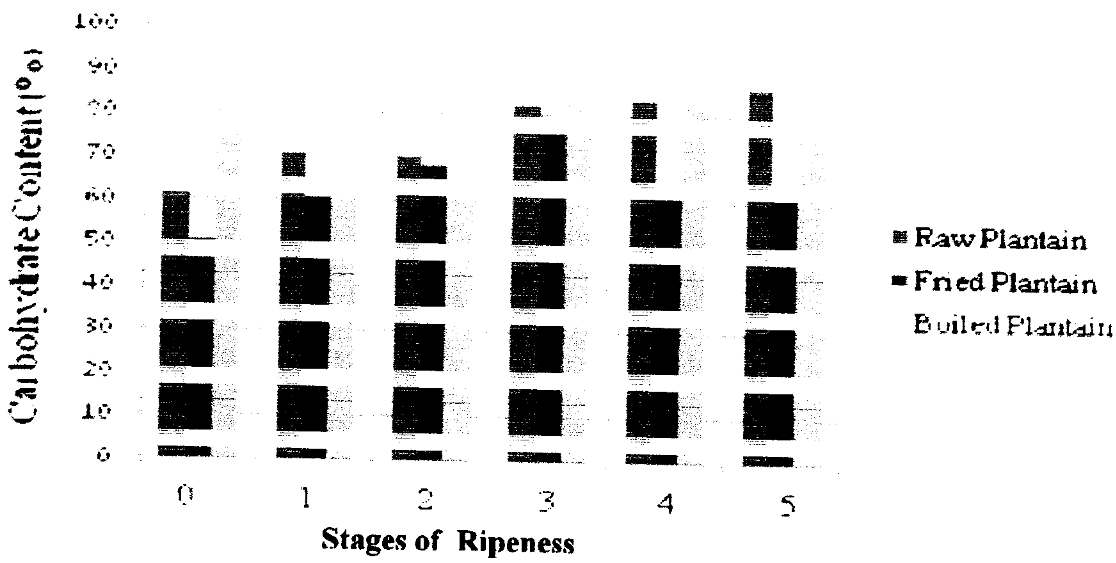

Figure 4.6: Carbohydrate content of Raw, Fried and Boiled at different stages of ripeness

4.2.7 Mineral Contents

The mineral analyses of plantain at different stages of ripeness (day 0 to day5) for raw, fried and boiled samples revealed that plantain is very rich in potassium, and increased at the different stages of ripeness while calcium content was decreasing. This agreed with the work of Izonfuo and Omuaru (1988), their Iron content was low in the raw sample in all the stages of ripeness. Iron was not detected in the fried plantain, this may be due to heat denature. But in the boiled plantain, iron was detected and higher at some stages, may be as a result of micronutrient moves from the peel into the pulp during the boiling. Magnesium was very small and not consistent with the stages of ripeness as a result of cooking. Ebuelu (2003) reported significant losses in various minerals including calcium, magnesium, iron and sodium as a result of boiling.

Boiling and frying has also been implicated in the reduction of certain micronutrients in plantain pulp including iron, copper and zinc (Ahenkora *et al.*, 1996). The result obtained in this study showed that fruits at any ripening stage (stage zero – five) can be a potential source of mineral supplement in the diet. Increased utilization of ripe plantain could offer significant intake of certain micronutrient, as ripening significantly increased the level of these nutrients in plantain (Ahenkora *et al.*, 1996). Boiled plantain also had higher contents of copper compared to fried and raw. (Fig.4.10)

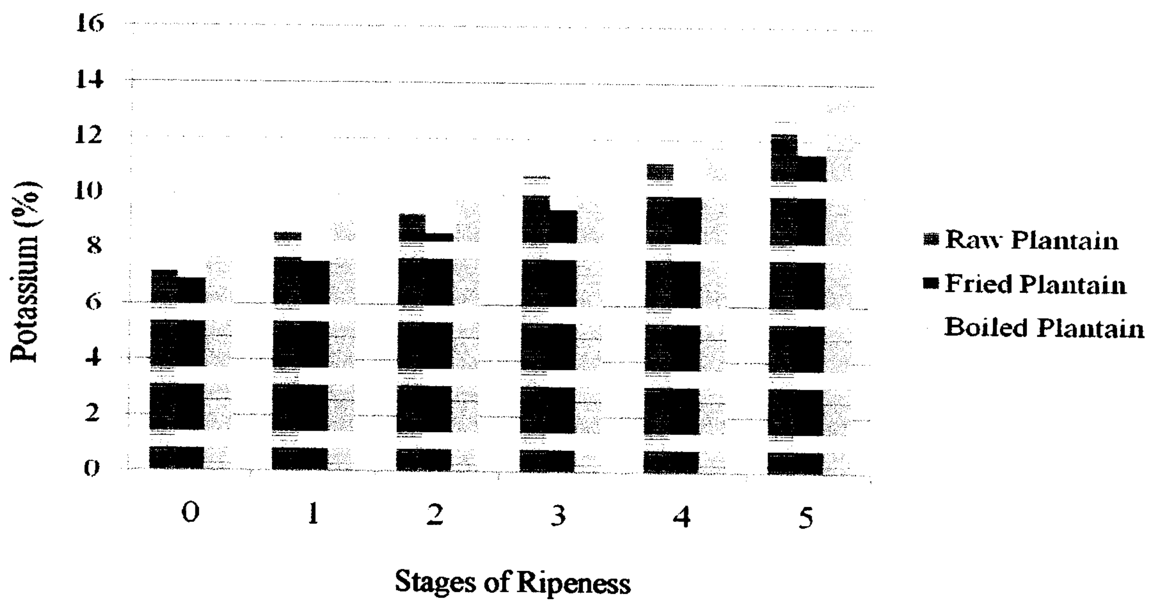

Figure 4.7: Potassium content of Raw, Fried and Boiled Plantain at different stages of ripeness

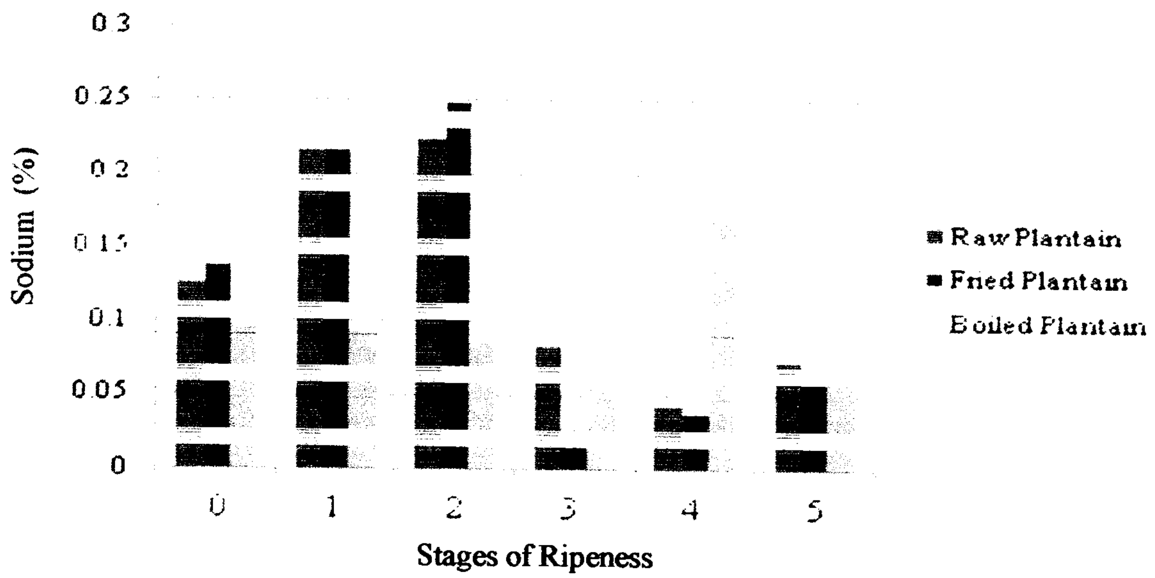

Figure 4.8: Sodium content of Raw, Fried and Boiled Plantain at different stages of ripeness

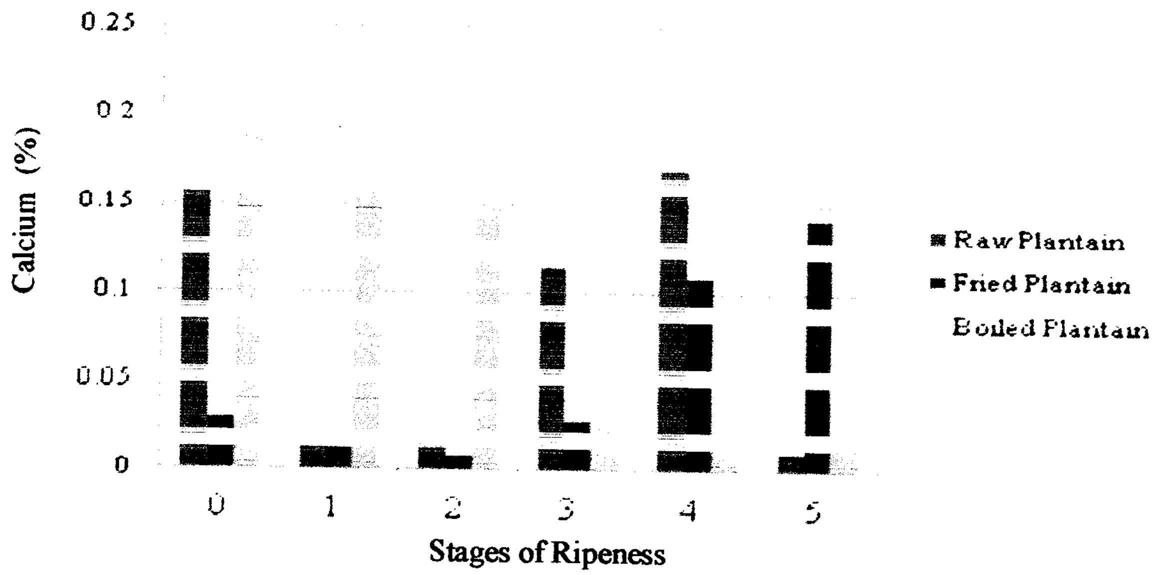

Figure 4.9: Calcium content of Raw, Fried and Boiled at different stages of ripeness

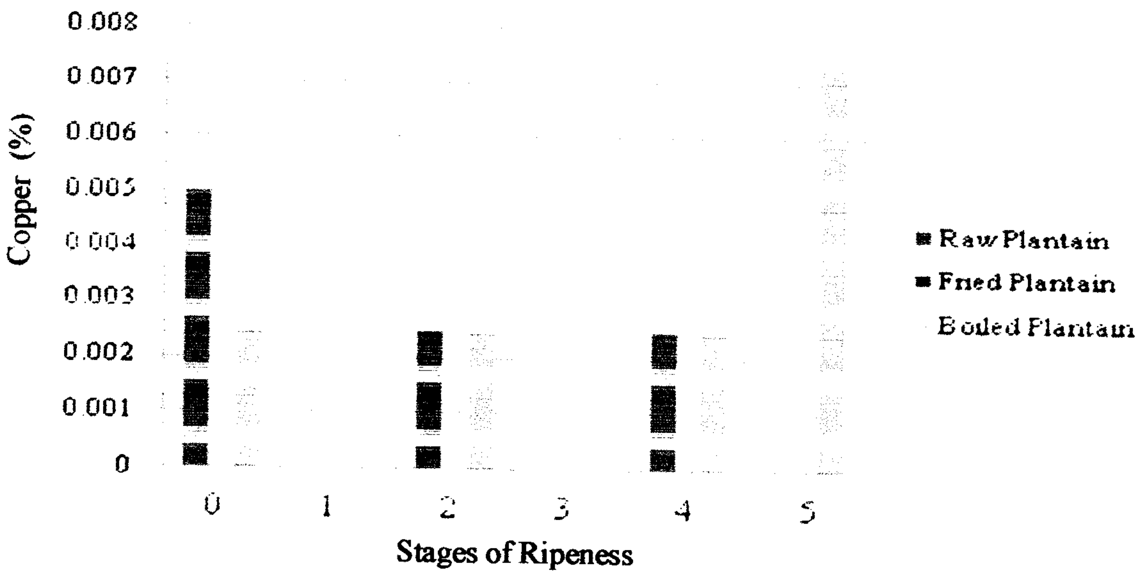

Figure 4.10: Copper content of Raw, Fried and Boiled Plantain at different stages of ripeness

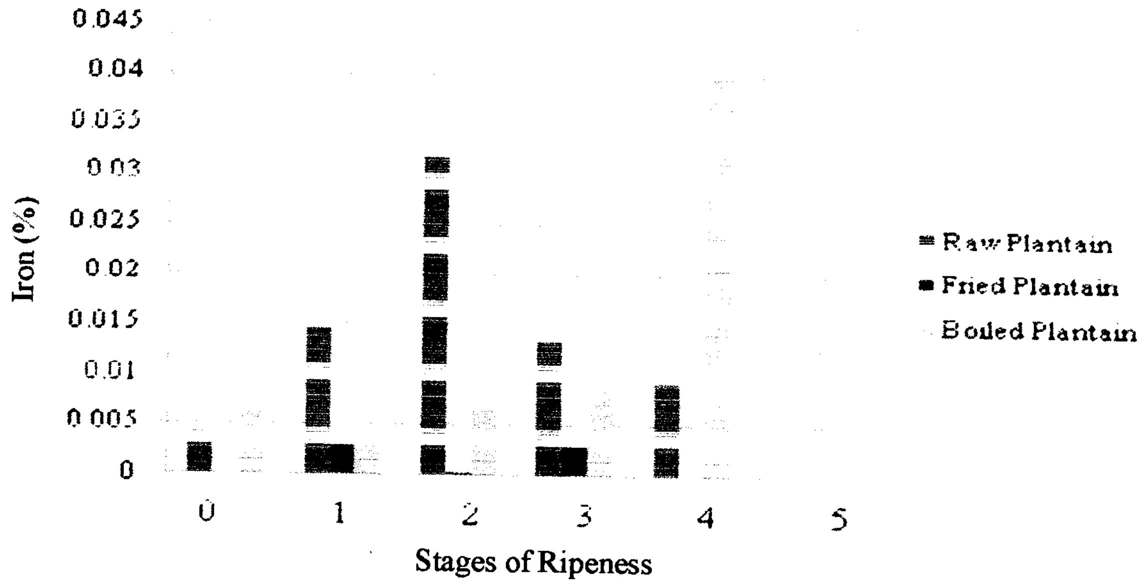

Figure 4.11: Iron content of Raw, Fried and Boiled at different stages of ripeness

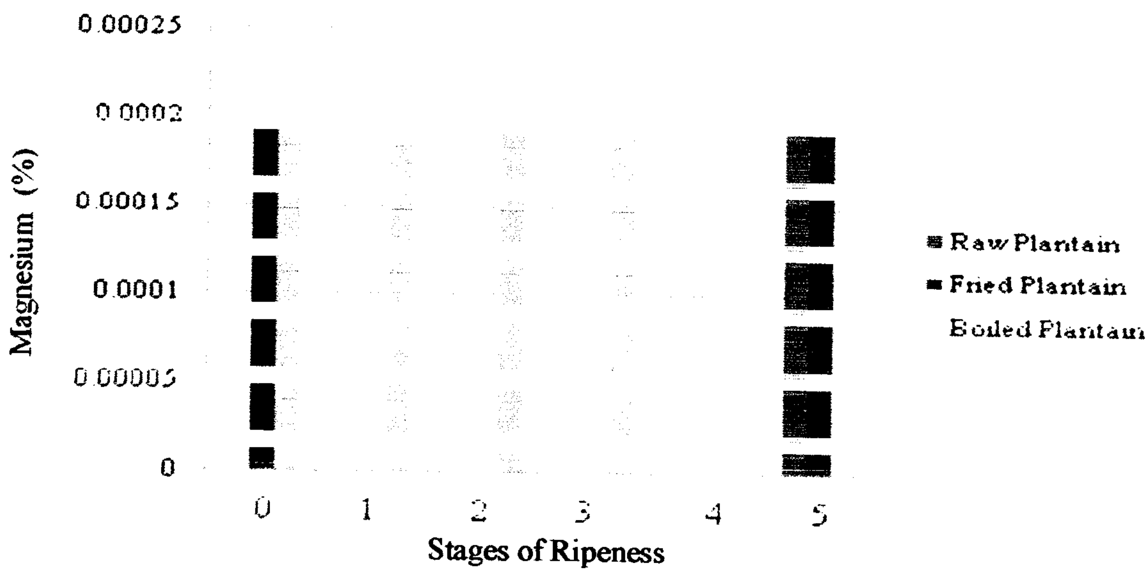

Figure 4.12: Magnesium content of Raw, Fried and Boiled at different stages of ripeness

4.2.8 Sugar Contents

The green plantain is very low in sugar, but when plantain is getting ripe the sugar content is increasing, the results revealed that the sugar content is increasing at different stages of ripeness, it may be due to hydrolysis process, which convert starch into sugar as plantain is getting ripe from stage zero (0) to five (5). (Fig 4.13) show that the free sugar in plantain is increasing while the available carbohydrate (as glucose) i.e. reducing sugar is decreasing at different stages both raw, fried and boiled because the carbohydrate was hydrolyzed by sulphuric acid to reducing sugar by heating while the free sugar is not hydrolyzed.

The amount of free sugar obtained in the raw sample when the plantain is green at day zero (0) to five are 19.63%, 28.13%, 40.63%, 46.88%, 59.38% and 75.00% respectively. In fried plantain the percentages of available carbohydrate (as glucose) is always less than raw sample at stages of ripeness, this may be as a result of heat. But boiling sample is not consistent at different stages of ripeness but in a case of free sugar there is increase in fried and boiled samples than raw at each different stages of ripeness.

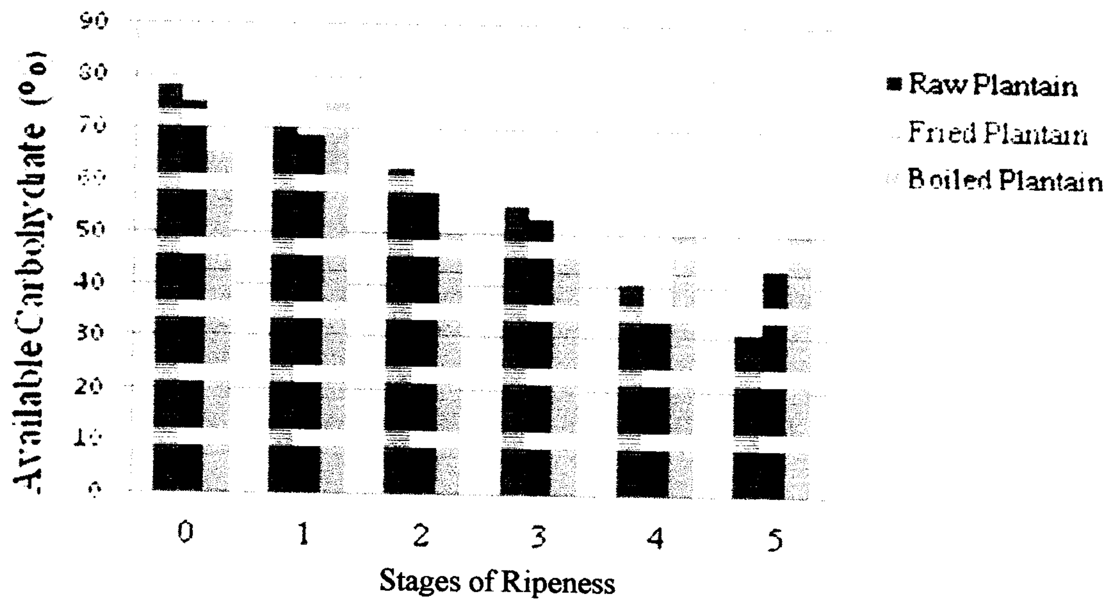

Figure 4.13: Reducing Sugar content of Raw, Fried and Boiled Plantain at different stages of ripeness

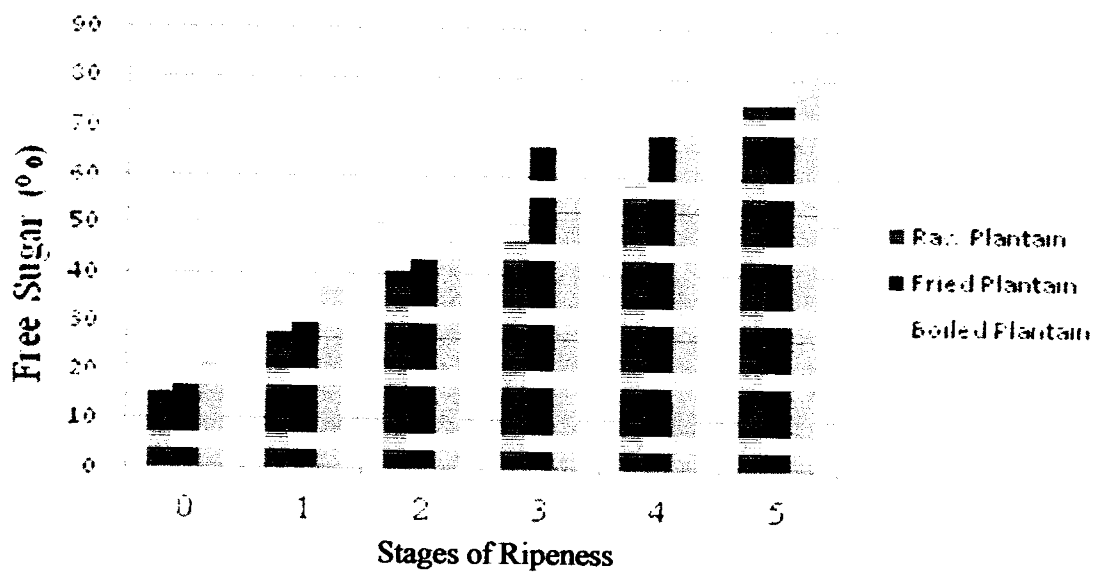

Figure 4.14: Free Sugar content of Raw, Fried and Boiled Plantain at different stages of ripeness

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This study was carried out to determine the effect of thermal treatments on boiled and fried plantain. The result obtained for the proximate composition of plantain for the raw, fried and boiled showed that plantain is one of the healthiest fruits but cooking reduced some nutritional contents and moisture content increased as the plantain was ripening.

The results obtained for the mineral content showed that plantain is very rich in potassium (K), calcium (Ca) and sodium (Na) which is very good for the health while copper (Cu) and Mg were very small. Sugar content increased at different stages of ripeness and was very sweet to taste. The result obtained in this study showed that fruits at any ripening stage (stage zero – five) can be a potential source of mineral supplement in the diet. Increased utilization of ripe plantain could offer significant intake of certain micronutrient, as ripening significantly increased the level of these nutrients in plantain. Boiled plantain also had higher contents of copper compared to fried and raw. In this study it concluded that boiled plantain is preferred to be taking compared to raw and fried, because it gave the best results in terms of retention of nutrients

5.2 Recommendation

From the studies, the following recommendation were made

1. It is recommended that plantain being a fruit with high nutrition value and one of the healthiest fruits in the world with high potassium content can be consumed by people who have low level of potassium in their blood.
2. It is also recommended that plantain being a fruit with high contents of carbohydrate can be consumed by people because carbohydrate cannot be over emphasized in human diet.
3. This new data therefore suggest that boiled plantain is preferred compared to raw and fried, because it gave the best results in terms of retention of nutrients.

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APPENDIX A

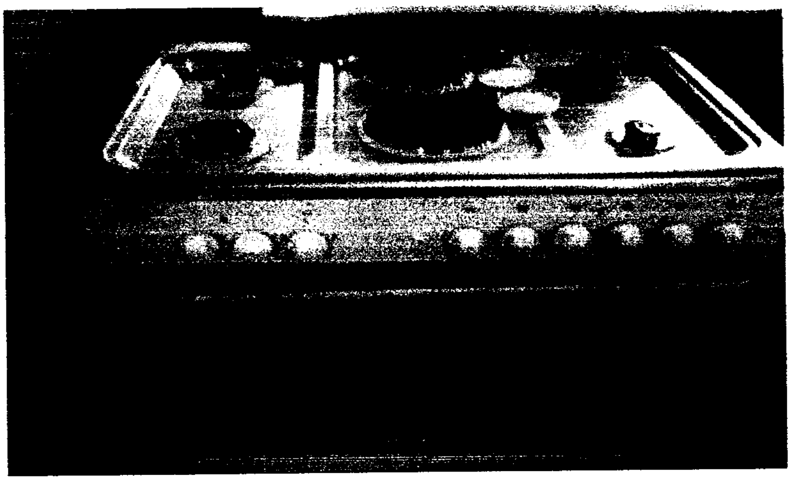

Plate 3.4: Gas and Hot Plate cooker

Plate 3.5: Tong

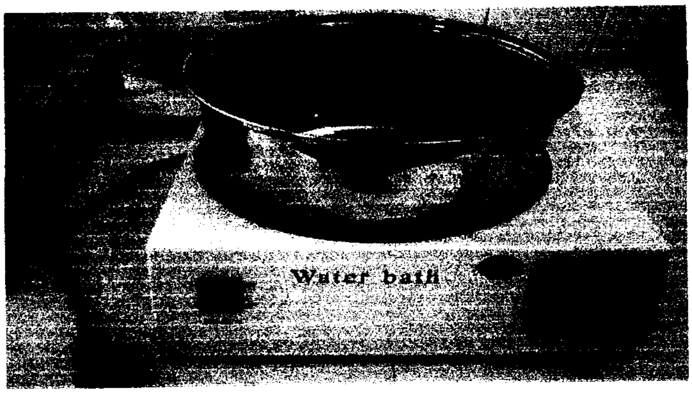

Plate 3.6: Electric Water bath

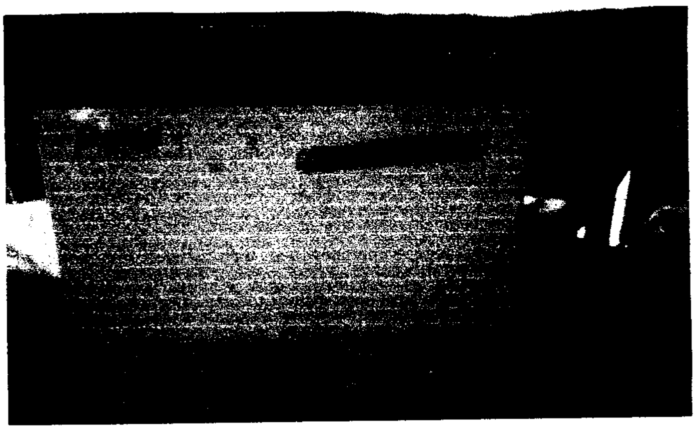

Plate 3.7: Muffle Furnace

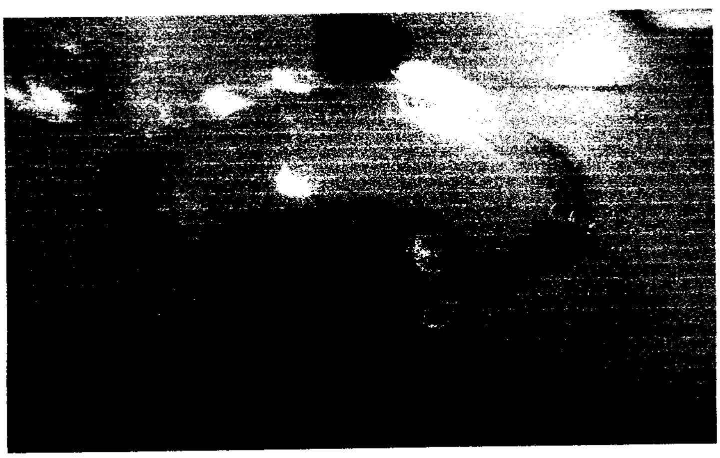

Plate 3.8: Desiccators

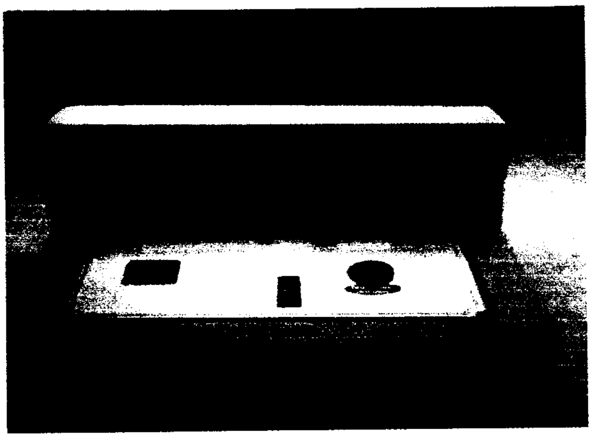

Plate 3.9: Digital Colorimeter

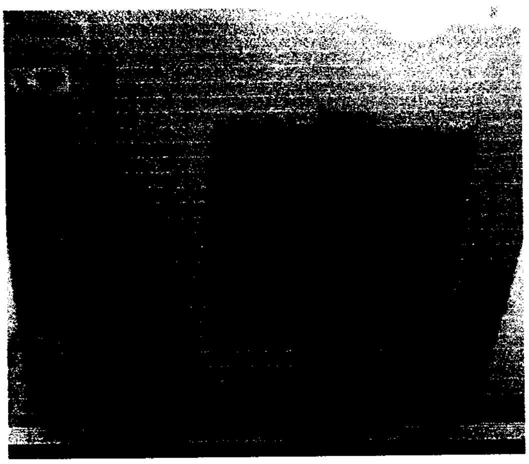

Plate 3.10: Electric Oven

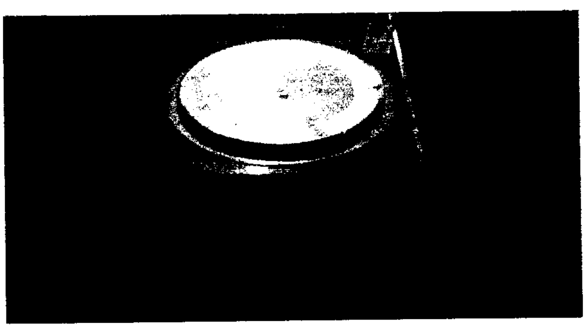

Plate 3.11 Electronic weighing balance

Plate 3.12: Soxhlet extractor

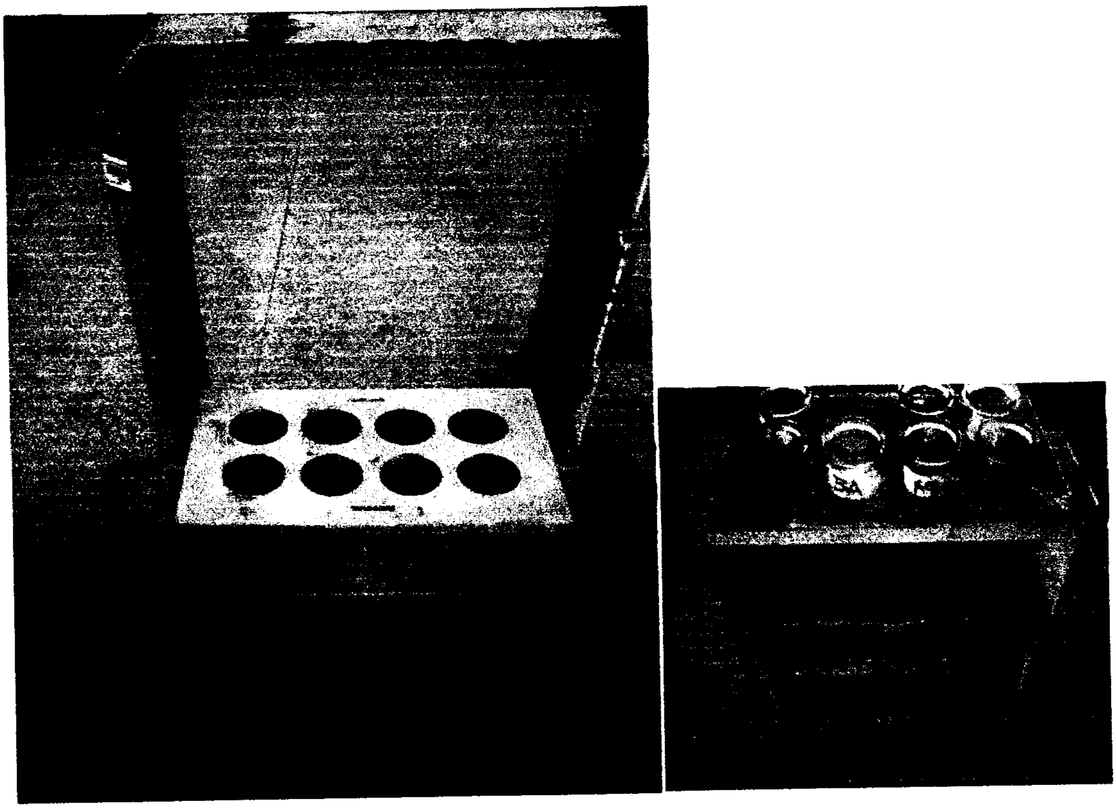

Plate 3.13: Micro Kjeldahl Digestion Unit and Kjeldahl flask

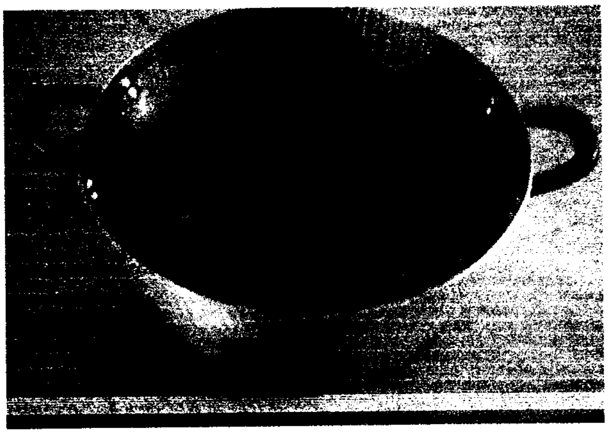

Plate 3.14: Boiling Sample

Plate 3.15: Frying Sample

APPENDIX B

Table4.8: Proximate composition of raw, fried and boiled plantain at different stages of ripeness from Day 0-5.

Name of sample	Moisture (%)	Protein (%)	Fat (%)	Crude fiber (%)	Ash (%)	Carbohydrates (%)
T_0^0 (Raw)						
R1	63.03	13.65	12.25	1.10	5.90	67.10
R2	62.33	13.15	11.65	0.90	5.50	60.70
R3	63.73	14.15	12.85	1.30	6.30	65.40
Mean	63.03	13.65	12.15	1.10	5.90	67.10
T_0^1						
R1	65.02	13.30	10.95	0.96	4.10	70.69
R2	64.72	13.10	10.35	1.16	4.50	70.89
R3	64.72	13.50	10.65	0.76	3.70	71.39
Mean	64.72	13.30	10.65	0.96	4.10	70.99
T_0^2						
R1	66.45	14.00	10.01	0.91	4.50	70.58
R2	66.95	14.30	10.41	1.11	4.00	70.18
R3	65.95	13.70	9.61	0.71	5.00	70.98
Mean	66.45	14.00	10.01	0.91	4.50	70.58
T_0^3						
R1	67.45	3.45	9.50	0.64	3.80	82.61
R2	66.55	3.15	9.50	0.84	3.90	82.61
R3	68.35	2.85	9.80	1.04	3.70	82.61
Mean	67.45	3.15	9.50	0.84	3.80	82.71
T_0^4						
R1	69.00	4.37	9.00	0.41	2.20	84.02
R2	69.20	4.07	9.20	0.51	1.90	84.32
R3	69.40	4.67	8.80	0.61	2.50	83.42
Mean	69.20	4.37	9.00	0.51	2.20	83.92
T_0^5						
R1	73.32	7.00	4.70	0.47	0.93	86.90
R2	73.72	6.30	5.30	0.67	1.00	86.73
R3	73.12	7.70	5.00	0.27	1.07	85.96
Mean	73.72	7.00	5.00	0.47	1.00	86.53
T_1^0(Fried)						
R1	31.62	13.40	28.50	3.00	3.40	51.70
R2	31.12	14.00	29.30	2.70	3.20	50.80
R3	32.12	14.60	28.90	3.30	3.60	49.60
Mean	31.62	14.00	28.90	3.00	3.40	50.70
T_1^1						
R1	29.39	13.81	18.45	3.20	3.70	60.84
R2	28.19	14.21	18.45	3.00	3.60	60.74
R3	30.59	13.41	18.05	3.40	3.80	61.34

	Mean	29.39	13.81	18.45	3.20	3.70	60.84
T_1^2							
	R1	26.16	12.90	11.95	3.20	4.20	67.75
	R2	25.76	12.30	11.45	3.80	4.00	68.45
	R3	25.96	12.60	12.45	3.00	3.80	68.15
	Mean	25.96	12.60	11.95	3.00	4.00	68.45
T_1^3							
	R1	27.05	4.00	10.25	3.10	5.20	77.45
	R2	26.65	4.30	9.85	3.50	5.10	77.25
	R3	26.25	3.70	9.45	3.30	5.30	78.25
	Mean	26.65	4.00	9.85	3.30	5.20	77.75
T_1^4							
	R1	22.74	3.88	25.20	2.81	5.40	62.71
	R2	22.24	4.08	25.50	3.21	5.70	61.51
	R3	23.24	3.68	25.80	3.01	5.10	62.41
	Mean	22.74	3.88	25.50	3.01	5.40	62.21
T_1^5							
	R1	18.33	1.41	24.00	3.70	6.30	64.59
	R2	18.03	1.40	24.40	3.67	6.10	64.43
	R3	18.63	1.39	23.60	3.73	6.50	64.78
	Mean	18.33	1.40	24.00	3.70	6.30	64.60
T_2^0(Boiled)							
	R1	65.79	13.13	4.15	1.00	4.61	77.11
	R2	65.49	12.65	4.35	0.97	4.70	77.33
	R3	66.09	13.63	3.95	1.03	4.79	76.60
	Mean	65.79	13.13	4.15	1.00	4.70	77.03
T_2^1							
	R1	66.11	14.00	16.25	5.00	4.00	60.75
	R2	66.02	13.93	16.33	4.10	3.91	61.73
	R3	66.20	14.00	16.25	5.90	4.09	59.76
	Mean	66.11	14.00	16.25	5.00	4.00	60.75
T_2^2							
	R1	68.91	14.50	11.70	5.00	4.20	64.60
	R2	69.41	14.42	11.30	5.70	3.60	64.98
	R3	69.91	14.58	10.90	5.30	4.80	64.42
	Mean	69.41	14.50	11.30	5.00	4.20	66.00
T_2^3							
	R1	70.27	6.13	2.85	2.00	4.30	84.72
	R2	72.07	6.43	3.25	2.10	4.80	83.42
	R3	71.17	5.83	2.45	1.90	3.80	86.02
	Mean	71.17	6.13	2.85	2.00	4.30	84.59
T_2^4							
	R1	75.11	5.25	7.45	3.40	1.50	82.40
	R2	74.51	5.65	6.55	3.70	1.70	82.40
	R3	74.81	4.85	8.35	3.10	1.30	82.40
	Mean	74.81	5.25	7.45	3.40	1.50	82.40

T_2^5						
R1	81.64	2.45	8.50	3.90	2.60	82.55
R2	82.64	2.65	8.80	4.10	3.00	81.45
R3	82.14	2.25	8.20	3.70	2.20	83.65
Mean	82.14	2.45	8.20	3.90	2.60	82.76

T_0 T_1 T_2 = Sample Treatment for Raw, Frying and Boiling respectively, i.e. the subscript is for the Treatment while superscript is for the Stages of Ripeness (0-5)

R1 - Replicate one

R2- Replicate two

R3- Replicate three

Mean – total mean of the replicate

Table 4.9: Proximate composition of Raw Plantain at different Stages of ripeness

Mean result.

Stages of Ripeness	Parameters (%) Moisture Content	Protein	Fate	Ash	Crude Fiber	Carbohydrate
Day-0	63.03	13.65	12.25	5.90	1.10	67.10
Day-1	64.72	13.30	10.65	4.10	0.96	70.99
Day-2	66.45	14.00	10.01	4.50	0.91	70.58
Day-3	67.45	3.15	9.50	3.80	0.84	82.71
Day-4	69.20	4.37	9.00	2.20	0.51	83.92
Day-5	73.72	7.00	5.00	1.00	0.47	86.53

Day 0 means Harvest Day

Day 1 to 5 means Stages of Ripeness

Table 4.10: Proximate composition of Fried Plantain at different Stages of ripeness

Mean result.

Stages of Ripeness	Parameters (%)					
	Moisture Content	Protein	Fate	Ash	Crude Fiber	Carbohydrate
Day-0	31.62	14.00	28.90	3.40	3.00	50.70
Day-1	29.39	13.81	18.45	3.70	3.20	60.84
Day-2	25.96	12.60	11.95	4.00	3.00	68.45
Day-3	26.65	4.00	9.85	5.20	3.20	77.75
Day-4	22.74	3.88	25.5	5.40	3.01	62.21
Day-5	18.33	1.40	24.00	6.30	3.70	64.60

Day 0 means Harvest Day

Day 1 to 5 means Stages of Ripeness

Table4.11: Proximate composition of Boiled Plantain at different Stages of ripeness

Mean result.

Stages of Ripeness	Parameters (%)					
	Moisture Content	Protein	Fate	Ash	Crude Fiber	Carbohydrate
Day-0	65.79	13.13	4.14	4.70	1.00	77.03
Day-1	66.11	14.00	16.25	4.00	5.00	60.75
Day-2	69.41	14.50	11.30	4.20	4.00	66.00
Day-3	71.17	6.13	2.85	4.43	2.00	84.59
Day-4	74.81	5.25	7.45	3.40	1.50	82.40
Day-5	82.14	2.24	8.50	2.60	3.90	82.76

Day 0 means Harvest Day

Day 1 to 5 means Stages of Ripeness

Table 4.12 Statistic for Standard Error of Mean

Statistics

R DAY O

		M.C	Protein	fats	Crude fibre	Ash	CHO
N	Valid	3	3	3	3	3	
	Missing	0	0	0	0	0	
Mean		63.0300	13.6500	12.2500	1.1000	5.9000	64.40(
Std. Error of Mean		.40415	.28868	.34641	.11547	.23094	1.913!
Std. Deviation		.70000	.50000	.60000	.20000	.40000	3.315'

Raw of day zero

Statistics

R D1

		M.C	Protein	fats	Crude fibre	Ash	CHO
N	Valid	3	3	3	3	3	
	Missing	0	0	0	0	0	
Mean		64.8200	13.3000	10.6500	.9600	4.1000	70.99(
Std. Error of Mean		.10000	.11547	.17321	.11547	.23094	.208'
Std. Deviation		.17321	.20000	.30000	.20000	.40000	.360!

Raw of day 1

Statistics

R D2

		M.C	Protein	fats	Crude fibre	Ash	CHO
N	Valid	3	3	3	3	3	
	Missing	0	0	0	0	0	
Mean		66.4500	14.0000	10.0100	.9100	4.5000	70.58(
Std. Error of Mean		.28868	.17321	.23094	.11547	.28868	.230(
Std. Deviation		.50000	.30000	.40000	.20000	.50000	.400(

Raw of day 2

Statistics

R D3

		M.C	Protein	fats	Crude fibre	Ash	CHO
N	Valid	3	3	3	3	3	
	Missing	0	0	0	0	0	
Mean		67.4500	3.1500	9.6000	.8400	3.8000	82.61(
Std. Error of Mean		.51962	.17321	.10000	.11547	.05774	.000(
Std. Deviation		.90000	.30000	.17321	.20000	.10000	.000(

Raw of day 3

Statistics

R D4

		M.C	Protein	fats	Crude fibre	Ash	CHO
N	Valid	3	3	3	3	3	
	Missing	0	0	0	0	0	
Mean		69.2000	4.3700	9.0000	.5100	2.2000	83.92(
Std. Error of Mean		.11547	.17321	.11547	.05774	.17321	.264[illegible]
Std. Deviation		.20000	.30000	.20000	.10000	.30000	.458[illegible]

Raw of day 4

Statistics

R D5

		M.C	Protein	fats	Crude fibre	Ash	CHO
N	Valid	3	3	3	3	3	
	Missing	0	0	0	0	0	
Mean		73.3867	7.0000	5.0000	.4700	1.0000	86.53(
Std. Error of Mean		.17638	.40415	.17321	.11547	.04041	.2891
Std. Deviation		.30551	.70000	.30000	.20000	.07000	.500[illegible]

Raw of day 5

Statistics

F D0

		M.C	Protein	fats	Crudefibre	Ash	CHO
N	Valid	3	3	3	3	3	
	Missing	0	0	0	0	0	
Mean		31.6200	14.0000	28.9000	3.0000	3.4000	50.70(
Std. Error of Mean		.28868	.34641	.23094	.17321	.11547	.608[illegible]
Std. Deviation		.50000	.60000	.40000	.30000	.20000	1.053[illegible]

Fried of day zero

Statistics

F D1

		M.C	Protein	fats	Crudefibre	Ash	CHO
N	Valid	3	3	3	3	3	
	Missing	0	0	0	0	0	
Mean		29.3900	13.8100	18.3167	3.2000	3.7000	60.97[illegible]
Std. Error of Mean		.69282	.23094	.13333	.11547	.05774	.185[illegible]
Std. Deviation		1.20000	.40000	.23094	.20000	.10000	.3214

Fried of day 1

Statistics

F D2

		M.C	Protein	fats	Crudefibre	Ash	CHO
N	Valid	3	3	3	3	3	
	Missing	0	0	0	0	0	
Mean		25.9600	12.6000	11.9500	3.3333	4.0000	68.11
Std. Error of Mean		.11547	.17321	.28868	.24037	.11547	.202
Std. Deviation		.20000	.30000	.50000	.41633	.20000	.351

Fried of day 2

Statistics

F D3

		M.C	Protein	fats	Crudefibre	Ash	CHO
N	Valid	3	3	3	3	3	
	Missing	0	0	0	0	0	
Mean		26.6500	4.0000	9.8500	3.3000	5.2000	77.65
Std. Error of Mean		.23094	.17321	.23094	.11547	.05774	.305
Std. Deviation		.40000	.30000	.40000	.20000	.10000	.529

Fried of day 3

Statistics

F D4

		M.C	Protein	fats	Crudefibre	Ash	CHO
N	Valid	3	3	3	3	3	
	Missing	0	0	0	0	0	
Mean		22.7400	3.8800	25.5000	3.0100	5.4000	62.21
Std. Error of Mean		.28868	.11547	.17321	.11547	.17321	.360
Std. Deviation		.50000	.20000	.30000	.20000	.30000	.624

Fried of day 4

Statistics

F D5

		M.C	Protein	fats	Crudefibre	Ash	CHO
N	Valid	3	3	3	3	3	
	Missing	0	0	0	0	0	
Mean		18.3300	1.4000	24.0000	3.7000	6.3000	64.60
Std. Error of Mean		.17321	.00577	.23094	.01732	.11547	.101
Std. Deviation		.30000	.01000	.40000	.03000	.20000	.175

Fried of day 5

Statistics

B D0

		M.C	Protein	fats	Crudefibre	Ash	CHO
N	Valid	3	3	3	3	3	
	Missing	0	0	0	0	0	
Mean		65.7900	13.1367	4.1500	1.0000	4.7000	77.01
Std. Error of Mean		.17321	.28292	.11547	.01732	.05196	.216
Std. Deviation		.30000	.49003	.20000	.03000	.09000	.374

Boiled of day zero

Statistics

B D1

		M.C	Protein	fats	Crudefibre	Ash	CHO
N	Valid	3	3	3	3	3	
	Missing	0	0	0	0	0	
Mean		66.1100	13.9767	16.2767	5.0000	4.0000	60.74
Std. Error of Mean		.05196	.02333	.02667	.51962	.05196	.568
Std. Deviation		.09000	.04041	.04619	.90000	.09000	.985

Boiled of day 1

Statistics

B D 2

		M.C	Protein	fats	Crudefibre	Ash	CHO
N	Valid	3	3	3	3	3	
	Missing	0	0	0	0	0	
Mean		69.4100	14.5000	11.3000	5.3333	4.2000	64.66
Std. Error of Mean		.28868	.04619	.23094	.20276	.34641	.165
Std. Deviation		.50000	.08000	.40000	.35119	.60000	.285

Boiled of day 2

Statistics

B D3

		M.C	Protein	fats	Crudefibre	Ash	CHO
N	Valid	3	3	3	3	3	
	Missing	0	0	0	0	0	
Mean		71.1700	6.1300	2.8500	2.0000	4.3000	84.72
Std. Error of Mean		.51962	.17321	.23094	.05774	.28868	.750
Std. Deviation		.90000	.30000	.40000	.10000	.50000	1.300

Boiled of day 3

Statistics

B D4

		M.C	Protein	fats	Crudefibre	Ash	CHC
N	Valid	3	3	3	3	3	
	Missing	0	0	0	0	0	
Mean		74.8100	5.2500	7.4500	3.4000	1.5000	82.4
Std. Error of Mean		.17321	.23094	.51962	.17321	.11547	.00
Std. Deviation		.30000	.40000	.90000	.30000	.20000	.00

Boiled of day 4

Statistics

B D5

		M.C	Protein	fats	Crudefibre	Ash	CHC
N	Valid	3	3	3	3	3	
	Missing	0	0	0	0	0	
Mean		82.1400	2.4500	8.5000	3.9000	2.6000	82.5
Std. Error of Mean		.28868	.11547	.17321	.11547	.23094	.63
Std. Deviation		.50000	.20000	.30000	.20000	.40000	1.10

Boiled of day 5

APPENDIX B

Table 4.13: Determination of available carbohydrate in plantain (as glucose)

Name of sample		Absorbance (Mean)	Concentration (mg/ml)	Available carbohydrate (%)
T_0^0 (Raw)				
	R1	0.24	1.54	78.10
	R2	0.26	1.58	78.16
	R3	0.25	1.56	78.13
	Mean	0.25	1.56	78.13
T_0^1				
	R1	0.22	1.44	71.90
	R2	0.23	1.44	71.86
	R3	0.24	1.43	71.88
	Mean	0.23	1.44	71.88
T_0^2				
	R1	0.18	1.28	62.50
	R2	0.19	1.23	62.50
	R3	0.23	1.24	62.50
	Mean	0.20	1.25	62.50
T_0^3	R1	0.19	1.11	55.64
	R2	0.17	1.11	55.62
	R3	0.18	1.11	55.63
	Mean	0.18	1.11	55.63
T_0^4				
	R1	0.10	0.80	40.65
	R2	0.12	0.79	39.60
	R3	0.17	0.84	41.64
	Mean		0.81	40.63
T_0^5				
	R1	0.10	0.64	32.00
	R2	0.11	0.63	30.00
	R3	0.10	0.60	31.75
	Mean	0.10	0.63	31.25
T_1^0(Fried)				
	R1	0.23	1.60	75.00
	R2	0.25	1.50	74.99
	R3	0.24	1.40	75.01

Mean	0.24	1.50	75.00
T_1^1			
R1	0.26	1.35	68.75
R2	0.18	1.38	68.75
R3	0.22	1.41	68.75
Mean	0.22	1.38	68.75
T_1^2			
R1	0.19	1.19	56.00
R2	0.22	1.16	59.00
R3	0.16	1.19	62.00
Mean	0.19	1.18	59.00
T_1^3			
R1	0.18	1.06	53.10
R2	0.16	1.03	53.19
R3	0.17	1.03	53.10
Mean	0.17	1.06	53.13
T_1^4			
R1	0.11	0.68	34.38
R2	0.12	0.69	34.38
R3	0.11	0.69	34.38
Mean	0.11	0.69	34.38
T_1^5			
R1	0.14	0.85	43.65
R2	0.14	0.88	43.85
R3	0.13	0.91	43.75
Mean	0.14	0.88	43.75
T_2^0(Boiled)			
R1	0.21	1.30	65.65
R2	0.21	1.31	65.61
R3	0.21	1.32	65.63
Mean	0.21	1.31	65.63
T_2^1			
R1	0.22	1.50	75.03
R2	0.23	1.52	75.00
R3	0.26	1.48	74.97
Mean	0.24	1.50	75.00
T_2^2			
R1	0.09	0.65	50.00

	R2	0.11	0.64	50.00
	R3	0.10	0.60	50.00
	Mean	0.10	0.63	50.00
T_2^3				
	R1	0.17	0.96	49.00
	R2	0.13	0.96	49.00
	R3	0.15	0.90	43.00
	Mean	0.15	0.94	47.00
T_2^4				
	R1	0.15	10.00	48.25
	R2	0.16	10.00	50.25
	R3	0.16	10.00	51.50
	Mean	0.16	10.00	50.00
T_2^5				
	R1	0.19	9.40	51.30
	R2	0.14	9.40	49.50
	R3	0.15	11.20	49.20
	Mean	0.16	10.00	50.00

T_0 T_1 T_2 = Sample Treatment for Raw, Frying and Boiling respectively, i.e. the subscript is for the Treatment while superscript is for the Stages of Ripeness (0-5)

Table 4.14: Determination of Free Sugar at different stages of Ripeness

Name of sample		Absorbance (Mean)	Concentration (mg/ml)	Free sugar (%)
T_0^0 (Raw)				
	R1	0.06	0.32	15.63
	R2	0.04	0.31	15.62
	R3	0.05	0.30	15.64
	Mean	0.05	0.31	15.63
T_0^1	R1	0.10	0.56	28.16
	R2	0.09	0.56	28.13
	R3	0.08	0.56	28.10
	Mean	0.09	0.56	28.13
T_0^2	R1	0.12	0.80	40.65
	R2	0.11	0.80	40.64
	R3	0.16	0.83	40.60
	Mean	0.13	0.81	40.63
T_0^3	R1	0.15	0.93	46.84
	R2	0.15	0.93	46.89
	R3	0.15	0.96	46.92
	Mean	0.15	0.94	46.88
T_0^4	R1	0.18	1.18	59.40
	R2	0.17	1.17	59.38
	R3	0.22	1.22	59.36
	Mean	0.19	1.19	59.38
T_0^5	R1	0.22	1.50	75.05
	R2	0.25	1.45	75.05
	R3	0.25	1.55	74.00
	Mean	0.24	1.50	75.00
T_1^0(Fried)				
	R1	0.06	0.43	18.72
	R2	0.02	0.42	18.73
	R3	0.10	0.35	18.80
	Mean	0.06	0.40	18.75
T_1^1	R1	0.10	0.62	31.23
	R2	0.11	0.61	31.24
	R3	0.09	0.66	31.28
	Mean	0.10	0.63	31.25

T_1^2	R1	0.14	0.94	43.73
	R2	0.15	0.92	43.73
	R3	0.13	0.84	43.72
	Mean	0.14	0.90	43.73
T_1^3	R1	0.19	1.03	66.40
	R2	0.17	1.08	66.41
	R3	0.15	1.07	66.41
	Mean	0.17	1.06	66.41
T_1^4	R1	0.22	1.44	68.76
	R2	0.21	1.38	68.74
	R3	0.23	1.38	68.75
	Mean	0.22	1.40	68.75
T_1^5	R1	0.21	1.45	75.05
	R2	0.25	1.50	75.01
	R3	0.26	1.55	74.94
	Mean	0.24	1.50	75.00
T_2^0(Boiled)				
	R1	0.07	4.15	21.89
	R2	0.07	4.85	21.83
	R3	0.06	4.20	21.92
	Mean	0.07	4.40	21.88
T_2^1	R1	0.12	0.85	37.45
	R2	0.12	0.73	37.55
	R3	0.13	0.77	37.50
	Mean	0.12	0.75	37.50
T_2^2	R1	0.15	0.90	46.83
	R2	0.14	0.91	46.92
	R3	0.16	1.01	46.89
	Mean	0.15	0.94	46.88
T_2^3	R1	0.18	1.09	56.20
	R2	0.19	1.21	56.30
	R3	0.17	1.09	56.25
	Mean	0.18	1.13	56.25
T_2^4	R1	0.21	1.42	71.88
	R2	0.22	1.41	71.86
	R3	0.26	1.49	72.90
	Mean	0.23	1.44	71.88
T_2^5	R1	0.22	1.63	81.45

R2	0.29	1.63	81.15
R3	0.27	1.63	81.15
Mean	0.26	1.63	81.25

T_0 T_1 T_2 = Sample Treatment for Raw, Frying and Boiling respectively, i.e. the subscript is for the Treatment while superscript is for the Stages of Ripeness (0-5)