COMPARATIVE EVALUATION OF UNRIPE PLANTAIN FLOUR USING DIFFERENT DRYING TEMPERATURE

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CERTIFICATION

This is to certify that this project work titled ‘’comparative evaluation of unripe plantain flour using different drying temperature’’ was carried out by **Alao Emibue Happy** with Matriculation Number **AST/2102050040** in the Department of Food Technology, School of Applied Sciences and Technology, Auchi Polytechnic, Auchi.

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DEDICATION

This work is dedicated to Almighty God for His grace and mercy for a successful project work.

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My most special gratitude goes to the Almighty God the father in heaven for granting me strength, knowledge, wisdom and divine direction throughout this work.

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ABSTRACT

Food processing is often thought to bring about changes in nutrients content. To investigate then this research focuses on the different drying methods on unripe plantain (Musa paradisiacal) flour the flour were prepared by sun drying and over drying at 60^0c, 50^0c and 40^0c. The proximate composition focusing on ash, fat, moisture, crude protein, crude fibre and carbohydrate contents were examined where Sample C oven dried flour at 500C tend to exhibit the highest results in all the parameters examined and also coincidentally had the highest general acceptability value of the sensory attributes. Flour with both sundrying and ovendrying produced flour with similar nutritional composition. Sensory evaluation results showed that sample B (7.80 ± 1.69) had the highest score for colour. This was followed by sample D (7.10 ± 1.29) and the lowest score for colour was seen in sample C (7.40 ± 0.64) for tatse, sample A (7.10 ± 1.60) sample B (6.90 ± 1.45) and C (7.70 ± 1.34) were rated the best. The result for proximate composition showed that sample B(4.020 ± 0.02) has the lowest moisture content and was followed by sample A (4.32 ± 0.02) while the highest was sample (4.84 ± 0.02). Although sample has the highest protein content (2.88 ± 0.01).

CHAPTER ONE

1.0 INTRODUCTION

Plantain, (*Musa paradisiaca*) is cultivated in the tropics and is an important staple food in sub-saharan Africa. About 63 million tones of the crop are produced annually, of which as much as 90 % is consumed locally in the producing countries, allowing only a meager 10% for foreign financial earnings through exportation (Awodoyin, 2003; Baiyeri *et al.,* 2011). This is largely attributed to poor storage condition of the crop, worsened by poor or lack of storage facilities and processing technology (Adeniji and Empere, 2001). Certain times, processed foods are not appreciated among the populace due to textural differences, arising from the processing (Yarkwan, 2004). Plantain is a rich source of nutrients. It is well patronized as a staple food in many parts of the West and Central Africa (Adeniji *et al.,* 2006). It is a rich source of nutrients such as iron, zinc, potassium and sodium (Mepba et al., 2007; Zakpaa *et al.,* 2010; Baiyeri *et al.,* 2011). Adeniji *et al.* (2006a) reported between 14.275 to 36.500 µg/g of iron in plantain, depending on the cultivar. Plantain falls under banana and it is a monocotyledonous perennial and important crop in the tropical and sub-tropical regions of the world (Baiyeri *et al.,* 2011). In Nigeria, Cameroun, Coted' Voire, and other plantain producing countries in Africa, the entire fruit of pulp of plantain either unripe or half-ripe are roasted on hot charcoal and eaten with other delicacies such as roasted pums, avocado, roasted fish or meat, and kelat and sometimes in combination of hot stew.

In Nigeria, as well as other West African countries, the unripe plantain is traditionally processed into flour (Ukhum and Ukpebor, 2001). In other instances, unripe plantains are harvested, peeled, sliced and sundried, then pounded and ground to obtain flour. This is usually prepared by mixing the plantain flour with boiling water to an elastic pastry (amala, as fondly called among the Yorubas in Nigeria) and 'foufou' in Cameroun, and is eaten with various sauces. This tropical crop is seasonal. Its abundance is hardly contained during the harvest season, leading to spoilage, while it is insufficient during its off season periods. It is highly perishable after harvest. This makes it necessary for it to be processed within the shortest period of time following harvest to avoid postharvest losses. This compels farmers to process their harvest in order to increase the availability of the staple food produce all through the year, thereby ensuring food security and also providing for themselves a means of financial income during the off season periods.

Plantains, grouped along with tubers constitute a whopping 22.60% of the total per food commodity expenditure profile for Nigerian households (NBS, 2010). This translates to an estimated 14.62% of the total per commodity expenditure profile for Nigerian homes (NBS, 2010). The food item is of great commercial value and since tubers are not farmed in some parts of the country, such as the riverine states, where plantain is massively produced, it replaces the pounded yam produced in the yam farming communities of Nigeria (Baiyeri et al., 2011).

1.1 SIGNIFICANCE OF STUDY

This study establish the effects of three drying methods, namely sun drying, oven drying and microwave drying on the nutrient content in plantain (*Musa paradisiaca*) flour mostly vitamins A and C and proteins, in order to determine the most suitable method that will not only increase their shelf life but also retain their nutrients adequately. Since the high nutritional value of any food product is very desirable for both processing industries and consumers.

1.2 AIM OF THE STUDY

To determine the effect comparative evaluation of unripe plantain flour using different method of drying.

1.3 STATEMENT OF PROBLEM

Over 30% of produced crops in Nigeria are lost following harvest, due to poor storage facilities, poor or lack of processing technology, among others (Osagie and Eka, 2006). Traditionally, sundrying is the common method used in processing plantains. The fruit is first peeled, sliced, sundried and ground into fine powder (called in Yoruba elubo ogede, Tiv – mwem ma ayaba).

The present mode for sun drying in the open air exposes the product to dirt, damage from insects, bacteria infestation and the deposition of fungal spores, and a varying degree of other environmental toxicants, depending on the site/location of drying. Thus, the need for a hygienic, effective drying method is apparent. Modern methods of drying include oven and solar drying. Both of these utilize heat to remove the moisture content in the food to the barest minimum, by evaporation. These modern methods of drying are used in drying plant materials at specific temperatures over a defined period of time.

While traditional method of preservation continues, enlighten consumers tend to be skeptical over the nutritional content of the resultant flour they feed on, a factor which affects the patronage of such products. However, the local peasants enjoy the meals without bothering. There is however, scanty information available in literature over the effect of these drying methods on the nutritional composition of the resultant flour.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 PLANTAIN

Plantain (*Musa parasidiaca*) belongs to the family of plants referred to as *Musaceae*. It is an important staple crop that contributes to the calories and subsistence economies in Africa. It is a good source of carbohydrate; (Marriott *et al.*, 2010). Nigeria is one of the largest plantain producing countries in the world (FAO, 2007) but despite its prominence, Nigeria does not feature among plantain exporting nations because it produces more for local consumption than for export. The consumption of plantain has risen tremendously in Nigeria in recent years because of the rapidly increasing urbanization and the great demand for easy and convenient foods by the non-farming urban populations.

Besides being the staple for many people in more humid regions, plantain is a delicacy and favoured snack for people even in other ecologies. A growing industry, mainly plantain chips, is believed to be responsible for the high demand being experienced now in the country (FAO, 2007).

Plantain flour for “fufu” is now popular to cater for the interest of diabetics, realizing its low glycaemic index. Plantain bread and biscuit have been reported by Ogazi (2006) but like its “fufu” product, the colour of the bread have not compared well with the present commercial bread including the cassava-blend bread, even after the normal blanching process. Thus acceptable plantain bread product to serve as breakfast for diabetics is still not available. Therefore the objectives of this study are to produce plantain flour through different blanching processes, produce bread with blends of wheat and plantain flour and evaluate the acceptability of the plantain/wheat bread in comparison to normal wheat bread.

Plantain contains more starch and has sugar than dessert banana and is there cooked or otherwise processed before being eaten. They are also cooked or frizzed when eaten green (unripe). At the stage, the pulp is hard and the peel often so stiff, it has to be cut with a knife to be removed. Matured plantains can be peeled like typical dessert banana; the pulp is softer than in innovation, green fruit and some of the starch has been converted to sugar. They can be eaten raw, but not as tasted as dessert banana are usually cooked. When mature yellow plantains are frizzed, they tend to caramelize turning a golden brown Colour. They can also be baked or grilled over charcoal both peeled or still in the peel. An average has about 220 calories and is a good source of potassium and dietary fiber.

Plantains are stable food in the tropical regions of the world, the tenth most important staple food that feeds the world. Plantain are treated in much the same way as potatoes and with a similar natural flavour and texture when the unripe fruit is cooked by steaming, boiling or frying plantain fruit all fear round which makes the crops reliable, all season staple food particular in developing countries with inadequate food storage preservation and transportation technology. In Africa, plantain provides more than 25 percent of the carbohydrate requirement for over 10 million people.

2.2 GROWTH OF PLANTAIN

Plantain is widely grown in the southern state of Nigeria and it is used both in Nigeria and many Africa countries as a cheap source of calorie, esculent for weight control, slow in the release of energy after consumption with a low glycerin index high in potassium and good for diabetes patients (Akubo, 2003) plantain is also a good source of iron and B-carotene (Pro Vitamin A) (Ogazi 2006) it contain 35% carbohydrate, 10% protein, 0.02% fat, 60% water some vitamins and minerals element with the progressive increase in the consumption of bread and related baked product in Nigeria, the composite flour program, if adopted has the potential to add value to indigenous crops like plantain, and at the same time console foreign exchange agent on what importation.

Baked products produced an excellent opportunity to incorporate food, grade fractions from grains liquors on other indigenous food source that cost of wheat flour in non-wheat producing countries such as Nigeria, poses a problem to bakery industries and consumers of baked products in Nigeria present the need to further study on incorporation of indigenous food sources of baking as this will help reduce total dependence of wheat flour.

2.3 IMPORTANCE AND BENEFIT OF PLANTAIN CONSUMPTION

Plantains are among the droopiest food to produce in Nigeria. Among the staple foods, plantain holds the second highest per capital consumption after cassava, plantain is known to be low in sodium (Chandler, 2011). It contains very little fat and no cholesterol; therefore, it is useful in managing patient with high blood pressure and heart disease. They are free from substance that gives rise to uric acid, they are ideal for patients with grout or authorities. Due to the low sodium and protein content, plantain is used in special diets for kidney disease suffers. The capacity of the plantain to neutralize free hydrochloric acid suggests its use in peptic ulcer therapy.

A fully ripe plantain mixed with milla powder is specially recommended for ulcer patient. The low lipid and high palatability combination is ideal for the diet of these people. The plantain plant has some medical properties. The heart can be pounded and applied to the wound to supplies bleeding. They are also very importance sources of rural income (Awoyale *et al.*, 2020).

2.4 PROCESSING OF UNRIPE PLANTAIN FINGERS INTO UNRIPE PLANTAIN FLOUR

Fresh and healthy green bunches of the plantain fruits were detached from the peduncle. The fruits were de-fingered from the hands and washed to remove adhering dirt and possible chemical residue and latex (which may have exuded from the cut surface of the crown). The plantain fingers were peeled manually with the aid of a stainless knife and submerged in water until the peeling process was completed. The fingers were sliced longitudinally to about 15 mm thickness with a stainless steel knife to enhance dehydration. The sliced plantain was dried in a moisture extraction oven at 60 °C for about 48 h, after which it was milled and sieved to obtain the flour as described by Ndayambaje et al. (2019). The unripe plantain flour (UPF) was then prepared for the storage studies.

2.5 STORAGE STUDIES OF UNRIPE PLANTAIN FLOUR

Five hundred grams (500 g) of UPF were weighed and packaged separately in PPS and properly sealed, and PVC container sealed with the lid. These packaging materials were stored at room temperature for 20-weeks. The functional and pasting properties of the UPF and the sensory attributes of the *amala* were evaluated every 4-weeks of the 20-weeks storage periods (Awoyale et al., 2020).

2.6 NUTRITIONAL VALUE OF UNRIPE PLANTAIN

Plantains may look like bananas, but they don't necessarily taste like them. In fact, unripe or green plantains may taste more like potatoes. The nutritional content of plantains varies greatly depending on their level of ripeness and how they're prepared. Plantains are a high-fiber and nutritious choice as a healthy source of carbs. Plantains are also low fat when cooked without frying in oil. Green plantains that are firm and starchy, like a potato, or yellow ones that are starchy and soft, more akin to a banana. Very ripe plantains can be quite soft and sweet.

One cup of boiled green plantains (137g) provides 166 calories, 1.5g of protein, 40g of carbohydrates, and 0.1g of fat. Plantains are an excellent source of vitamin C, fiber, and vitamin B6. The following nutrition information is provided by the U.S. Department of Agriculture (USDA, 2020).

- Calories: 166
- Fat: 0.1g
- Sodium: 2.7mg
- Carbohydrates: 40g
- Fiber: 3.5g
- Sugars: 3.1g
- Protein: 1.5g
- Vitamin C: 12.5mg
- Vitamin B6: 0.3mg

2.6.1 Carbs

Plantains provide a healthy dose of carbohydrates. One cup of boiled green plantains has 40 total grams of carbs, with nearly 4 grams of fiber and just 3 grams of natural sugar. As plantains ripen, fiber content goes down and sugar content increases. Plantains are high in resistant starch, which gives them a low glycemic index of about 38.5 (ripe, raw plantains) to 44.9 (boiled unripe plantain) (Chandler, 2011).

2.6.2 Fats

Plantains are naturally low in fat but easily absorb the oil they're cooked in. Fried plantains are a high-fat food. Try baking plantain chips with a limited amount of high-heat oil for a lighter snack (Ndayambaje *et al.*, 2019).

2.6.3 Protein

Plantains are not a significant source of protein. A medium plantain has less than 2 grams (Ndayambaje *et al.*, 2019).

2.6.4 Vitamins and Minerals

Plantains contain iron, vitamin C, vitamin B6, folate, potassium, magnesium, copper, and vitamin A.3 According to the USDA, a cup of plantains provides 12.5 milligrams of vitamin C, which is about 15% of your daily recommended intake. Plantains contain folate, which is a vital nutrient for women trying to conceive. You'll get nearly 20% of your daily recommended intake from a cup of cooked plantains (Chandler, 2011).

2.6.5 Calories

One cup of boiled green plantains (137g) provides 166 calories, 96% of which come from carbs, 3% from protein, and 1% from fat. Plantains are a carbohydrate rich source of fiber and essential vitamins and minerals such as folate, magnesium, vitamin C, potassium, and vitamin B6. Plantains are low in fat and sodium (Chandler, 2011).

2.7 HEALTH BENEFITS OF PLANTAIN

The resistant starches and micronutrients in plantains offer several health benefits, especially when plantains are consumed with minimal processing.

2.7.1 Aids Pregnancy Nutrition

Plantains contain carotenoids which convert to vitamin A. Plantains are a crucial source of carotenoids for people living in developing countries, particularly in sub-Saharan Africa. For women of childbearing age, plantain consumption contributes to preventing vitamin A deficiency (which increases the risk of preterm delivery).4 Furthermore, plantains provide folate and iron, which play key roles in maintaining a healthy pregnancy (USDA, 2020).

2.7.2 Control Blood Sugar

Plantains are high in resistant starch. Just like other types of fiber, resistant starch doesn't raise blood sugar levels. By slowing down digestion, promoting satiety, and enhancing "good" gut bacteria, the resistant starch in plantains promotes glycemic control (Ogazi, 2006).

2.7.3 Lowers Blood Pressure

Plantains are a wonderful source of potassium, an important mineral and electrolyte that reduces hypertension.6 A cup of boiled plantains has 396 milligrams of potassium. Because they are naturally low in sodium, plantains support a dietary plan for treating hypertension (as long as you don't add too much salt in preparation). Since most adults should not exceed 2,300 milligrams of sodium per day, plantains can help you stay within the recommended allowance (USDA, 2020).

2.7.4 Reduces Constipation

The fiber in plantains helps promote regularity. Plantains have both soluble and insoluble fiber (along with resistant starch), which all work together to move matter through the digestive tract. If looking to increase your daily fiber intake, give your body some time to adjust to eating more fiber by increasing slowly over time and be sure to drink plenty of water (FAO, 2007).

2.7.5 Prevent Iron-Deficiency Anemia

Plantains provide iron and vitamin C, two micronutrients that work together to optimize absorption. Although iron from plant sources is not usually as easily absorbed, vitamin C increases its bioavailability. Iron-deficiency anemia causes fatigue, difficulty concentrating, impaired immunity, and poor regulation of body temperature. Plantains can help you avoid this common condition (FAO, 2007).

2.8 HEALTH BENEFITS OF UNRIPE PLANTAIN FLOUR

According to the United States Department of Agriculture (USDA), 1 large raw, green unripe plantain (100 g) will provide you with:

- Energy kcal/100 g
- Moisture 59.4 g
- Crude protein 7.7 g
- Carbohydrate 24.4
- Crude fiber 1.4 g
- Ash 1.5 g
- Potassium 120 mg

- Magnesium 275 mg
- Phosphorus 195 mg
- Iron 2.53 mg
- Sodium 80 mg
- Calcium 66.6 mg
- Zinc 3.7 mg
- Vitamin C 23 mg
- Vitamin A 63 ug
- Vitamin B-6 0.29 mg

Source: (USDA, 2020)

100 g of plantain products can provide 6.3 to 15.3 percent energy, 5.9 to 30.2 percent protein, 7.8 to 16 percent calcium, 9.2 to 23.3 percent iron, and 28.5 to 33.7 percent zinc to consumers Recommended Dietary Allowances (percent RDAs).

2.8.1 Antioxidant-rich

Plantains contain a high concentration of antioxidants. Antioxidants are substances that aid in the fight against free radicals, which cause oxidative damage in the body. According to one study, the peels and flesh of plantains contain flavonoids and polyphenols, both essential antioxidants. Antioxidants are vital because they aid in treating metabolic illnesses such as diabetes, cancer, and heart disease (Akubo, 2003).

2.8.2 Excellent diabetic food

When boiled, unripe plantains have a low glycemic index (GI) of 45 due to their high resistant starch content. Resistant starch is a form of carbohydrate that does not break down into sugar in the small intestine but instead goes into the large intestine, where fermentation occurs. Resistant starch does not elevate blood glucose levels since it is not digested in the small intestine, making it suitable for managing diabetes. Fermentation in the large intestine also helps glycemic management by encouraging the growth of "good" gut flora. It's a good meal for managing diabetes because it has minimal sugar; their low carbohydrate content combined with relatively high energy content makes them suitable for managing this disease. It makes it a good choice, especially if you add other fiber and protein-rich foods like green vegetables, hence an excellent choice if you want to avoid diabetes (FAO, 2007).

2.8.3 Maintains blood pressure control

Plantains are high in potassium, a mineral that aids in the treatment of hypertension. One large green plantain can give you around 44 percent of your daily potassium requirement. Unripe plantain's low sodium level makes them ideal for hypertensive people (FAO, 2007).

2.8.4 Enhances intestinal health

Plantains' fiber and resistant starch both aid digestive regularity. Its high fiber content aids in moving materials through the digestive tract, hence reducing constipation and colon cancer. Its resistant starch content encourages the growth of beneficial bacteria that keep the gut healthy (Akubo, 2003).

2.8.5 Weight Loss

Plantains' high resistant starch content is ideal for weight loss. It promotes a sense of fullness and encourages you to eat less. Load up on nutritious carbs like unripe plantain if you're attempting to lose weight (Akubo, 2003).

2.8.6 Prevent Anemia

Plantains are high in iron, a mineral essential for the proper function of hemoglobin, a protein that transports oxygen in the blood. Iron contributes to numerous physiological processes in the body and aids in preventing iron-deficient anemia and neuritis, among many other things. It has vitamin B6, which can help treat neuritis (nerve inflammation). As part of your meal plan, It can keep you from getting sick (Akubo, 2003).

2.8.7 Beneficial During Pregnancy

Plantains are incredibly high in folate (folic acid) and iron. Folates are required for a healthy pregnancy. During pregnancy, folic acid is essential to avoid fetal malformations such as Spina bifida, whereas iron aids in preventing anemia. Folate is a water-soluble B vitamin naturally found in some foods and a dietary supplement (Akubo, 2003).

Plantains are also high in vitamin C, vitamin B-6, calcium, phosphorus, and magnesium, which help the baby's growth and development (Von Loesecke 2013)

2.8.8 Excellent Baby Weaning Food

Plantains are also an excellent weaning food for newborns. They are easy on the stomach and mixed with millet, sorghum, and soybeans; This combination delivers all the nutrients necessary for a baby's development and growth (Von Loesecke 2013).

2.8.9 It Can Stop Ulcers.

Many studies have shown that unripe plantain has phytochemical properties like leucocyanidin that can help prevent ulcers. In holistic medicine, unripe plantain is used to prevent or alleviate ulcer discomfort. It is thought to provide an antacid-like effect on those suffering from stomach ulcers, reducing pain and preventing additional damage (Akubo, 2003).

2.8.10 Improves Sexual Health

Unripe plantains are loaded with vitamins and nutrients that may improve your sexual performance by increasing libido, increasing male fertility, making sperm thicker, and increasing the amount of sperm you have. Africans believe that regularly eating unripe plantains energizes men sexually and increases fertility (Akubo, 2003).

2.8.11 It Makes the Heart Stay Healthy

Unripe plantain has a small amount of serotonin, which opens up the arteries, improves blood flow, and lowers homocysteine (which causes coronary artery disease and stroke). It has a lot of potassium, making it suitable for your heart because it can keep your blood pressure and heart rate under control in your body and cells. Because it contains a lot of fiber, it helps keep cholesterol levels down, lowering the risk of getting heart disease (Ogazi, 2006).

2.8.12 Build Strong Bones and Keeps Them Strong

Plantain that hasn't ripened is full of calcium, which is vital for strong bones, muscles, nails, and teeth. People who eat a healthy meal with unripe plantain can avoid diseases like osteoporosis, which weakens bones and causes fractures (Von Loesecke 2013).

2.8.13 Good for Kidney

According to Hajiya Jummai Abdul, a Nutritionist in Nigeria, eating unripe plantain could help with bladder and kidney disorders. It provides potassium, a vital component of cell and body fluids that aid in blood pressure control. Eating unripe plantain can also help with menstruation cramps. Plantain is a good source of minerals, including iron, phosphorus, and magnesium, essential for bone health and a cardiac-protective agent. The high vitamin C and A nutrients assist the body to establish resilience to illnesses and hunt down toxic oxygen. Aside from being a potent antioxidant, vitamin A is essential for the visual cycle, keeping healthy mucous membranes, and improving skin color (Madamba, Driscoll, & Buckle, 2006).

2.9 USES OF UNRIPE PLANTAIN

2.9.1 Cooking

Boil the plantains by peeling them first, covering them with water and cooking them for 20 minutes. Boiled, sweet plantains nutrition makes it a nutrient powerhouses, filled with vitamins A and C, minerals such as potassium and a healthy helping of fiber. As the plantain ripens, it develops a sweet flavor. The same way you may use over-ripe bananas for baking, over-ripe plantains can be boiled and mashed for a sweet treat. Plantains are often cooked and eaten as a breakfast food in tropical regions, and you can add spices such as cinnamon, cloves, vanilla and even honey if you like (Akubo, 2003).

Boiled, sweet plantains contain numerous essential vitamins, but two stand out from the others. A 1-cup serving of mashed, boiled plantains contains 21.6 milligrams of vitamin C, which is 29 percent of the recommended daily intake of 75 milligrams for women and 24 percent of the RDI of 90 milligrams for men.

Vitamin C plays a major role in several body processes, including the formation and maintenance of bones, tissues, skin, blood vessels and teeth. Vitamin C is an antioxidant vitamin, which may help slow the aging process and prevent cancer and heart disease, reports MedlinePlus. Another antioxidant vitamin found in significant amounts in boiled, sweet plantains is vitamin A, with a 1-cup serving containing 90 micrograms of vitamin A, more than 50 percent of the recommended intake of 2,333 international units for women and the 3,000 international units recommended for men. Vitamin A helps boost your immune system, supports eye health, aids in physical growth and development and helps prevent various cancers and skin diseases (Ogazi, 2006).

2.9.2 Plantain Flour

Plantain flour has advantage over other starchy foods because it contains protein, mineral and vitamins. Medically, plantain can be used to cure a lot of ailments including diabetes, sore throat, tonsillitis, diarrhoea, vomiting and it is said to be a major diet in the production of *soya-musa* which can be used in the treatment of kwashiorkor (Von Loesecke 2013; Idachaba, 2005).

Plantain flour is the product of dried and pulverized unripe plantain pulp. It is called "*elubo agbagba*" in Yoruba-speaking areas of Nigeria, where it is normally made into a dough called "*amala*", having being reconstituted in boiling water (Frison and Sharrock, 2008; Ibrahim, 2013; Ukhum and Ukpebor, 2003). The processes involved in plantain flour production are separation into fingers from bunch, peeling, washing, slicing, drying, milling and packaging (Adeboye, Iyanda, Yusuf, Olaniyan, and Oje, 2014; Adeniji, Sanni, Barimalaa, and Hart, 2006; Madamba, Driscoll, & Buckle, 2006). The present processing of plantain into flour takes a lot of time, requires a lot of energy and attention from one stage to the other. Thus, the quality and quantity of the flour produced are usually adversely affected (Ogazi, 2006).

2.9.3 Industrial Purposes

There are so many different things you can use plantain flour for. It’s a perfect substitute for regular flour when baking, and easy to incorporate into your recipes. Plantain can be eaten raw when ripe, processed into flour to make 'elubo', a local meal consumed in Nigeria with soup, and also serves as industrial raw material in firms producing sanitary pads, fabrics and also for the food and beverage industry for making baby foods, biscuits, bread and cakes (Madamba, Driscoll, & Buckle, 2006).

CHAPTER THREE

3.0 MATERIAL AND METHOD

3.1 MATERIAL

3.1.1 MATERIAL/EQUIPMENT/APPARATUS

Unripe Plantain, Portable water, Bowl, Knife, Tray, Sieve, Oven dryer

3.1.2 COLLECTION OF MATERIALS

Unripe plantain was purchased from Uchi market Auchi, Edo state Nigeria. It was then transferred to the Department of Technology, Auchi Polytechnic Auchi, food processing workshop where it was processed and stored before transferring to the lab for analysis. All the material used were obtained from the workshop and reagents and equipments were of analysis grade.

3.2 METHOD

3.2.1 PREPARATION OF SAMPLE

Plantain were picked and washed in a bowl of portable water to remove the later and avoid darkening of the pulp during peeling. And the plantain was randomly divided into three part or group. Then each group was peeled, sliced in thin slices of about 5.0mm thick using a stainless steel knife. The washed plantain were then divided to be sun drying. Oven drying at low temperate, oven drying at high temperature.

Sun drying: sluices in this group were dried on a non-adsorbent surface directly under the sun, in a manner similar to what the farmers do in their houses. This was removed and kept in the workshop in the evening and resumed drying during the day. This continued till the slices were crispy dried.

Oven drying: An electrically heated oven was turned on, with a thermometer fitted to monitor the temperature at 40^0c, 50^0c and 60^0c and the plantain was removed after 24hours, cooled and then mill with a hammer mill machine. This was sieved into fine flour using a mash net of about 0.2 mash size. Sodium metabissuphite was used. Since browing was going to be a limiting factor. The second portion of the sliced plantain was oven dried at different temperature at 40^0, 50^0c and 60^0c.

Samples

A = Sundried

B = Oven dried (40^0c)

C = Oven dried (50^0c)

D = Oven dried (60^0c)

Unripe Plantain
↓
Washing
↓
Peeling
↓
Slicing
↓
Soaking (balanced and Sulphite)
↓
Sun drying
↓
Chips
↓
Cooling
↓
Milling
↓
Sieving

Fig 3.1 Flow chart for the production of sundried unripe plantain flour

Unripe plantain
↓
Washing
↓
Peeling
↓
Slicing
↓
Soaking (5mins) (balanced and sulphited)
↓
Oven-drying (40, 50, and 60^0c)
↓
Dry milling (Hammer mill)
↓
Screening (0.25mm)
↓
Plantain Flour

Fig 3.2 Flow chart for the production of oven-dried unripe plantain flour

3.3 SENSORY EVALUATION

The sample were evaluated on the basis of texture, flavor, colour, crispasses and general acceptability. Questionnaires were given to 10 member trained panelist who were randomly selected from both students and staffs of Auchi Polytechnic, Department of Food Technology. They were asked to rate the degree of likes or dislikes of the plantain using the parameters. They were asked to rate the sample using 9-point hedonic scale where 9 is like extremely, 5 is neither like or disliked 1 is dislike extremely.

3.4 PROXIMATE ANALYSIS

The proximate composition of the prepared sample was determined using the standard method of associated of official analytical chemists (AOAC, 1990).

3.4.1 Moisture content Determination

5.0g of each sample was weighed and spread in washed, dried and weighed pertri-dish. The was place in an oven and dried at temperature of $105c^0$ of 3hours. The sample was removed and cooked in desiccators and weighed. This was until constant weight was attained. The percentage moisture content was calculated by computing the loss in weight of sample used a fraction of the initial weight of sample used and multiplied by 100 mathematically expressed this.

$$\% \text{ Moisture content} = \frac{W_1 - W_2}{W_2} \times \frac{100}{1}$$

Where:

W_1 = weight of sample and petri-dish before drying

W_2 = weight of sample

W_3 = weight of sample and petri-dish after drying

3.4.2 Ash Content Determination

The crucibles was thoroughly washed and dried. 2g of each sample was weighed from the oven dried sample used in moisture determination into the dried, cooled was weighed crucible. The crucible was reweighed, placed in the cold furnace and the temperature. After ashing the crucible was removed from the furnace, allowed to cool in a desiccator, and weighed. The percentage ash content is content is calculated using the formula.

$$\% \text{ Total Ash} = \frac{M_1}{M_2} \times 100$$

Where:

M_1 = weight of Ash (g)

M_2 = weight of sample used (g)

3.4.3 Crude Fibre Determination

2 – 3g of each sample were weighed (W1), oven dried and transfer into a conical flask where 200mil of boiling 1.25% H_2SO_4 was added to each of the sample and brought to boiling within one minute, then allow to boil gently for 30mins maintaining constant volume and rotating the flask every 5minutes for proper mixture of content. The side of conical flask were scraped into the flask as well as to prevent foaming leading to spillage. At the expiration of 30minutes, the acid mixture was filtered immediately with muslin cloth. The insoluble matter was free of acid. The washed sample was scrape back into the flask with spatula: 200ml of boiling 1.25% NaOH was added and allowed to boil for 30minutes. It was filtered with muslin cloth, the residue was washed thoroughly. First with boiled distilled water and twice with ethanol hexane, finally with

boiled distilled water. The treated sample was scrapped into crucible and oven dry at temperature of 105c, cooled in a dessicator and weighed (w_2). The sample was finally ashed in a muffle furnace at about 300^0c for 2hours. The ash sample were cooled and reweighed.

Calculation

$$\% \text{ Crude fiber} = \frac{W_2 - W_3}{W_1} \times \frac{100}{1}$$

Where:

W_1 = weight of sample

W_2 = weight of sample and crucible before ashing

W_3 = weight of sample and crucible after ashing

3.4.4 Fat Determination

Fat content was determined using soxhlet apparatus as described by AOAC (2005). About 1 – 2g of the sample each was weighted into filter paper tied and fixed into the soxhlet extractor (w_1). The solvent hexane was poured into a round bottom flask and placed on the heating mantle. The extraction continued for 3hours after which the flask was cooled and disconnected. The defatted sample were removed and dried to a constant weight in air oven at 10500c (W_2). The difference between the weighed of the filter paper before and after drying was recorded to obtain the fat extracted. The percentage fat content was then calculated on dry basis as;

$$\% \text{ fat content} = \frac{W_2 - W_3}{W_1} \times \frac{100}{1}$$

Where:

W1 = weight of sample (g)

W2 = weight of sample and filter paper before defating.

W3 = weight of sample and filter paper after defating

3.4.5 Protein Determination

Crude was done by determining the total organic nitrogen using the macro-kejeldhel method. The involve digestion, distillation and titration. 0.5g of each sample was weighed and poured into digestion flask respectively. A spatula full of copper catalyst mixture (97%) anhydrous sodium sulphate, 3.5% copper sulphate and 0.5 selenium dioxide) was added to each of the flask containing the sample. Digestion was then commenced by adding to each flask 10ml of concentrated H_2SO_4 and heated on a heating mantle. During digestion oxidation took place all the carbons present were converted to CO_2 Nitrogen to Ammonium Sulphate (NH_4) SO_4. Digestion was continued until a clear solution was obtained and flask was allowed to cool. The digest was made up to 50ml with distilled water. 5ml of the diluted digest was pipette and used in the distillation step.

Distillation

This involves steam distillation of the dilute digest with 10ml of 40% NaOH. 5ml of 2% boric acid (H_3BO_3) was pipette into 100ml conical flask, 3 drops of mixed indicator (bromocresol green + alcohol) was added. The conical flask was placed in such a way that the delivery tube touches the boric acid level inside the flask to trap the librated ammonia. The distillation continued until the solution turned cloudy thus indicating that the solution has become alkaline. The pink color of boric acid solution in the receiver flask turned greenish blue which indicate presence of ammonia. Distillation was continued until about 50ml of distillate was collected.

Titration

50ml of distillate collected was titrated with 0.0M of HCL until end point was obtained from green to pink the chemical reaction involved is as follow;

Distillation

$(NH_4)2SO4 + 2NaOH \longrightarrow 2Na_2SO_4 + NH_3 + 2H_2O$

$NH_3 + H_3 BO_3 \longrightarrow NH_4 + H_2BO_3$

Titration

$NH_4 + H_2BO_3 \longrightarrow NH_4 + H_3BO_3$

Calculation

$$\% \text{ Nitrogen} = \frac{TV \times M \times 0.014 \times DF}{\text{Weight of sample}} \times \frac{100}{1}$$

Where;

TV = titre value

DF = dilution factor

M = molarity of acid

0.014 = standard value

% Crude protein = Nitrogen

3.4.6 Carbohydrate Content Determination

Carbohydrate content of each sample was estimated by difference that is the sum of the percentage of all other proximate was subtracted from 100.

% carbohydrate = 100 – (% moisture + % crude protein + %fat crude fiber + % ash)

CHAPTER FOUR

4.0 RESULT AND DISCUSSION

4.1 RESULT

4.1 Sensory Evaluation

Table 4.1: Sensory Evaluation of unripe plantain flour

	Parameters				
Samples	Colour	Texture	Taste	Flavor	general acceptability
Sun drying A	7.90 ±1.73[a]	7.10 ± 1.60[a]	7.20 ± 1.99[a]	7.30 ± 1.77[a]	7.44 ± 2.01[a]
Oven drying B	7.80 ± 1.69[a]	6.90 ± 1.45[a]	5.90 ±1.68[a]	7.70 ± 1.34[a]	7.10 ± 1.66[a]
Oven drying C	7.40 ± 0.64[a]	7.70 ± 1.34[a]	6.50 ±2.17[a]	7.60 ± 1.07[a]	7.70 ± 1.83[a]
Oven drying D	7.10 ± 1.29[a]	7.00 ± 1.63[a]	6.50 ± 2.27[a]	6.70 ±1.42[a]	7.50 ± 0.97[a]

- Values with the same superscript in the same column are not significant different ($p \leq 0.05$).

Table 4.2: Proximate Composition of Unripe Plantain

	Samples			
Parameters %	**A**	**B**	**C**	**D**
Moisture	4.320 ± 0.02^{c}	4.02 ± 0.02^{d}	4.62 ± 0.00^{b}	4.84 ± 0.02^{a}
Ash	1.81± 0.01^{a}	1.71 ± 0.02^{d}	1.77 ± 0.02^{b}	1.74 ± 0.01^{c}
Crude fibre	2.06 ± 0.02^{d}	2.16 ± 0.02^{c}	2.43 ± 0.02^{a}	2.37 ± 0.02^{b}
Fat	1.92 ± 0.02^{a}	2.82 ± 0.02^{b}	1.76 ± 0.02^{c}	1.73 ± 0.01^{b}
Protein	2.83 ± 0.02^{a}	2.81± 0.01^{a}	2.87± 0.02^{b}	2.88 ± 0.01^{b}
CHO	87.23 ± 0.02^{d}	88.43 ± 0.02^{c}	89.31 ± 0.01^{b}	89.92 ± 0.02^{a}

- Values with the same superscript in the same row are not significantly different ($p \leq 0.05$).
- Values are expressed as mean ± standard deviation

Key: A = Sun drying

B = Oven drying at 600c temperature

C = Oven drying at 500c temperature

D = Oven drying at 400c temperature

4.2 Discussion

4.2.1 Sensory Evaluation

Table 4.1 shows the result of the values of mean and standard deviation computed from the data obtained from panel's scores. Response on colour, texture, taste, flavor and the general acceptability show no significant difference ($p \leq 0.05$). Sample B has the lowest value in the response of taste with 5.90± 2.68 and the highest were generally acceptable with scores in the same trend ranging from 7.10 ± 1.66 in sample B to 7.70 ± 1.83 in sample C.

4.2.2 Proximate Composition

Table 4.2 shows the result of the proximate composition of the samples. The results showed appreciation low moisture content for all the samples ranging from 4.02 ± 0.02% to 4.48 ± 0.02. Application to heat can be both beneficial and detrimental promotes palatability and also improves the keeping quality of food, making them safe to eat, also results in nutrient losses by including biochemical and nutritional variation in food composition (Enanfom and Umoh, 2004).

The apparent increase in the ash and fat content observed in this study following drying treatment in higher than those reported by Baturh and Uvir (2015) and this could be as a result of removal of moisture of nutrients (Morris et al., 2004). Processing has been reported to increase carbohydrate availability in a more digestible from (Emperatries et al, 2008). This could explain the significant difference ($p<0.05$) observed in the carbohydrate content of the processed sample. (Oven – dried and sundried plantain flour).

The % crude protein and crude fibre were all in the same trend ranging from 3.81± 0.01% to 2.88 ± 0.01% and 2.06 ± 0.02 to 2.43 ± 0.02% respectively.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Based on the results obtained from the study on the sensory an proximate composition the two drying methods were all goods as they yielded nutritional constituents with minimal differences from sundried and oven dried samples To obtain a fast drying, conserve nutrients the sample C at 500C oven drying tends to exhibit higher % of results in the proximate parameters and the higher over all general acceptability of the sensory attributes was also the highest in sample C.

Though, oven drying may seems expensive while the sun drying is cheaper but prone to contaminations from micro organism due to unhygienic exposures.

5.2 Recommendation

Further studies could be focused on the microbial contamination amino acid profile, mineral, antinutrient, antioxidant and the % resistance starch of the samples. The reducing sugar content and the glucemic index of flours needs to be examined. The will provide the necessary information to adopt this food sample as a dietary source for special functional cares.

REFERENCES

Adeboye, M. O., Iyanda, E. O., Yusuf, A. A., Olaniyan, H. A., and Oje, E. O. (2014). Evaluation of nutritional and functional properties of plantain (Musa paradisiaca L.) and tiger nut (Cyperus esculentus L.) flour blends for food formulations. *Cogent Chemistry*, *3*(1), 1–15.

Adeniji, V.F. and Empere, M.K. (2001). Effect of Soy Flour Fractions on some Functional and Physicochemical Properties of Plantain Flour In: (Ebuehi OAT, (Ed) pp. 142-143.

Adeniji, V. F., Lelisa, A., & Geleta, B. (2007). Complementary feeding: Review of recommendations, feeding practices, and adequacy of homemade complementary food preparations in developing countries-lessons from Ethiopia. *Frontiers in Nutrition*, *3*(41), 1–9.

Adeniji, V.F., Sanni, L. O., Barimalaa, E. and Hart, L. (2006). Functional, and pasting properties of cassava-sweet potato starch blends. A research article. *AJRTC*, *9*(1), 6–10.

Akubo, J. O. (2003). Functional properties of wheat and sweet potato flour blends. *Pakistan Journal of Nutrition*, *9*(6), 535–538.

AOAC, (1990). Official methods of analysis. 18th Edition Washington, D.C. Association official Analytical chemists.

Awoyale, W., Oyedele, H. A., and Maziya-Dixon, B. (2020). Correlation of the sensory attributes of thick yam paste (*amala*) and the functional and pasting properties of the flour as affected by storage periods and packaging materials. *Journal Food Processing and Preservation*, e14732.

Baiyeril, E. O., Budu, A., Asiedu, S., Chiwona-Karltun, C., & Nyirenda, D. B. (2011). Viscoelastic properties and physico-functional characterization of six high yielding cassava mosaic disease-resistant cassava (Manihot esculenta Crantz) genotypes. *Journal of Nutrition and Food Science*, *2*(2), 129.

Baturh, Y. and Uviri, R.H. (2015). Effect of Drying Methods on the nutritional composition of unripe plantain flour. *Food Science and Quality Management* 41:5-10 ISSN2224 – 6088 (paper) ISSN 2225 – 0557(online).

Chandler, M. (2011). Relationship between Polyphenols and Browning in Avacado Mesocarp-Comparison between the Fuerte and Lerman Cultivars. *Journal Agricultural Food Chemistry*, 25: pp. 1253-1259.

Emperatriz, P.D., Ronald, M., Elvina, P., and Mily, S. (2008). Production and characterization of unripe plantain (Musa paradisiacal) flour, Interciencia, 33:290-296.

Enonfon–Akpan, J. and Umoh, I.B. (2004). Effect of heat and tetracycline treatments on the food quality and acridity factors in cocoyam Xanthosoma sagittifoliun (L) Schott. *Pakistan Journal of nutrition*, 3:240 – 243.

FAO (2007). Statistics Series No 95 FAO, Rome.

Frison, H. and Sharrock, E. Y. (2008). Functional and rheological properties of composite flour from sweet potato, maize, soybean, and xanthan gum. *Journal of Saudi Society of Agricultural Science*, *16*(2), 171– 177.

Ibrahim, S. F. (2013). Effect of drying methods on the chemical, pasting, and functional properties of unripe plantain (Musa paradisiaca) flour. *British Journal of Applied Science Technology*, *14*(3), 1–7.

Madamba, K. D., Driscoll, D. N., and Buckle, U. M. (2006). Sorghum malt–based weaning food formulations. Awoyale et al., *Cogent Food & Agriculture* (2020), 6: 1823595.

Mepba, H.D., Eboh, L., and Nwaojigwa, S.U. (2007). Chemical Composition, Functional and Baking Properties of Wheat – Plantain Composite Flours, 7(1): 4-5.

Morris, A.A and Barnett, B. (2004). Effects of processing on nutrient content of foods Cajarticles 37:160 – 164.

Ndayambaje, J. P., Dusengemungu, L., and Bahati, P. (2019). Nutritional composition of plantain flour (Musa paradisiaca): The effect of various drying methods in Rwanda. *American Journal of Food Science and Technology*, *7*(3), 99–103.

Ogazi, P.O. (2006). Quality Assessment of Plantain Fruits for Dehydration. Niger. Food J., 4(1): 125-130.

Osagie, S.and Eka, O. (2013).Quality attributes of weevils (Callosobruchus maculatus) infested cowpea (Vigna unguiculata) products. *Nigeria Journal of Agriculture, Food, and Environment*, *9*(3), 16–22.

Ukhum, M. E. and Ukpebor, I. E. (2001). Production of instant plantain flour, sensory evaluation and physico-chemical changes during storage. Food Chem. 42(3):287-299.

USDA (2020). Expert Consultation. Energy and Protein Requirements. World Health Organization, Geneva.

Von-Loesecke, M. (2013). Effect of fat-replacement through rice milling by-products on the rheological and baking behaviour of paste. *African Journal of Agricultural Research*, *7*(44), 5898–5904. https://doi.org/10.5897/ AJAR12.1052.

Yarkwan, J. (2004). Functionality and Nutritive Value of Composite Plantain (*Musa paradisiaca*) Flours. Tropic Sci., 28: 51-66.

Zakpaa, K. S., Singh, N., and Malhi, N. S. (2007). Some properties of corn grains and their flour I: Physicochemical, functional and chapatti- making properties of flour. *Food Chemistry*, *101*(3), 938–946.