Process Optimization for the production of Fufu Flour Composite Snacks

Dissertation II Report

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Section- H1731

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May, 2018

CERTIFICATE

This is to certify that **Mehak Arora** (Registration number: 11711631) has personally completed M.Sc. dissertation II entitled, **“Process optimization for the preparation of the Fufu flour Composite snacks”** under my guidance and supervision. To the best of my knowledge, the present work is the result of his original investigation and study. No part of pre-dissertation has ever been submitted for any other purpose at any University.

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INTRODUCTION

Fufu, which is a fermented Cassava product, is consumed traditionally in Nigeria and other West African country. It has a strong odor and a sour taste. The fufu acceptance and quality are determined by various significant factors that includes flavor, appearance and texture. It is said to have a good quality by the consumers if it possesses a smooth texture, a creamy-white appearance and a peculiar sour aroma. The desired colour is grey or yellow. However, the quality of fufu varies with the season and the processors and it is acceptable by the local activities of the processors. (Tomlins et al., 2007). The poor shelf life limits is rectified to enhance its suitability by traditionally selling the fufu as a wet paste.

Fufu is also called Apku in Nigeria and it is traditionally prepared by a series of several steps. Firstly, the Cassava roots are peeled, after which they are washed and cut into smaller pieces after which they are steeped for 4-5 days. The cassava pulp is detoxified by the fermentation process which helps in preservation and in flavor development. The slurring of the Fufu is done in water, it is cooked with continuous stirring and then soft elastic dough is produced. However, the detailed preparation of the fufu flour varies from locality to locality and it more adequately supplies the needed calories for the rural life than most of the Cassava products. (Sanni et al., 2006)

Cassava is as important to the African peasant farmers as the wheat and potatoes are to the European farmers and rice is to the Asian farmers. (Montagorac et al, 2009). In humid tropics it is considered to be one of the most important food crops where they are suited to the conditions of the low nutrient availability and are able to survive droughts. (Burrel, 2003).

Initially being introduced in the Central Africa from the South America by the Portuguese settlers in the latter half of the 16^{th} century (Nweke 1994), now in Africa it is considered to be the major staple food crop. (Tajudeen Adebayo Adeniji, 2013). To generate income in crop producing households and to create employment in terms of food security, cassava is considered as the major root crop in Nigeria. (Ugawa & Ukpabi, 2002).

It is the third major food source in the tropics after the cereal crops namely rice and maize. The 60% of the daily calorific needs of the Tropical and the Central American population is constituted by Cassava. (Taiwo et al., 2010).

There are various potentials for the expanding market for fufu which can improve the livelihoods of many rural small-scale cassava processors. (Tomlins et al., 2007).

Snack foods are those which are not ordinarily consumed for social or nutritive purpose and are not used in regular meal but are consumed primarily for pleasure. (Matz 1993). They satisfy short term hunger and are available in small manageable portions. (Tettweiler, 1991). The snacks are often prepared with wheat flour and also with the combination of other flours because of their convenience in preparation and their distinctive taste and are called the Composite Snacks. (Folorunso et al., 2016).

During this case of investigation, optimization of a process for the composite snacks production from fufu flour by various methods of processing such as frying and baking with or without drying of the product will be studied. The investigation will be taken up for optimization and standardization for blend preparation of fufu flour with various flours of wheat, rice and maize for the production of the Composite snacks.

PROBLEMS BACKGROUND

Snacks are famous all over the world. The Composite snacks can be obtained from Composite flours which consist of different flours mixed together in various concentrations. Snacks can also be made from various fruits and vegetables by several methods of process including frying, deep fat frying and baking with or without drying. Comparatively, fried chips contain more oil content than baked chips. Consumption of fried or deep-fried chips can lead to various health diseases like heart problems and increased cholesterols. However, the fat component contributes flavor and gives smooth texture to snacks. Over the past 10-15 years, researches have increasingly pointed fat to be the basic dietary factor which is closely associated with weight gain in individuals.

The consumption of fried snacks leads to more oil absorption in the product which can lead to several health related issues. Hence, the composite snacks can be prepared with various processes and fortification can also be done in case of cassava based snacks to enhance its nutritional content and acceptability.

The present study is designed to develop composite snacks from fufu flour which is a blend of cassava and green plantain flours with a peculiar textural properties and nutrients.

REVIEW OF LITERATURE

Several food products are there such as composite snacks which are made using different frying and baking methods and are influenced commercially by increasing the commercial availability of the products because they are important for human consumption. This review focuses on the development of fufu flour chips which is a combination of cassava and plantain flour.

NUTRITIONAL COMPOSITION OF FUFU FLOUR-

Cassava is the major and cheap source of carbohydrates. From the nutritional point of view, its starch content is 80-90% on dry wet basis. The protein deficiency in cassava is because of the ignorance of food habits in the regions where cassava is consumed as a major food. It can be made nutritious if combined with other nutritional foodstuffs so that their nutritional value in terms of proteins can be enhanced. (Tajudeen Adebayo Adeniji, 2013). The geographical location, specific part of the cassava plant and the other geographical conditions are responsible for variation in the nutritional content of the cassava. (Morgan et al., 2016).

VARIABLES(gms)	RAW CASSAVA	CASSAVA ROOTS	CASSAVA LEAVES
Food energy	160	110-149	91
Moisture	59.68	45.9-85.3	64.8-88.6
Protein	1.36	0.3-3.5	1-10
Lipids	0.28	0.3-0.5	0.2-2.9
Carbohydrates	39.06	25.3-35.7	7-18.3
Dietary Fibre	1.8	0.4-1.7	0.7-4.5
VITAMINS(mgs)			
Thiamine	0.087	0.03-0.08	0.06-0.31
Riboflavin	0.048	0.03-0.06	0.021-0.7
Niacin	0.854	0.6-1.09	1.3-2.8
Vitamin C	20.6	14.9-50	60-370
Vitamin A	-	5.0-35.0	8300-11800
MINERALS(mgs)			
Phosphorus	27	6-152	27-211
Iron	0.27	1.6-5.48	0.4-8.3
Potassium	-	0.3-14	0.35-1.23
Magnesium	-	0.25-0.72	0.12-0.42
Copper	-	0.03-0.08	3-12
Zinc	-	2-6	71-249
Sodium	-	14-41	51-177
Manganese	-	3-10	72-252

Source: For standard references the values were obtained from the USDA Natl. Nutrient database. Nutrient values and weighs for the edible portion "Bradbury and Hollowey (1998). Woot- Tsuen et al., (1968), Favier (1977), Cancaster et al., (1982).

Digestibility and absorption of various nutrients are affected by the anti- nutritional compounds present in the cassava. To enhance the nutritional content of leaves and roots and to counteract the present anti-nutritional factors, various processing techniques are used. (Salvador E.M et al., 2014). Saponine, phytates, polyphenols, nitrates and oxalates are the anti-nutritional factors present. The quality is determined by the cassava's variety and the plant maturity. (Nambison and Sundareson, 1994; Montagnoc et al., 2009 ; Bandna et al., 2012-2013).

CASSAVA-

The major component of cassava roots is starch and its uses are determined by the physicochemical properties. (Ontilo et al., 2007). Preparation for the fermented cassava flours is done by the pasting in water and making it into dough, which is termed as Fufu. Supplementation of the cassava flour can be done with other cereal flours like Maize, Wheat, Rice and Sorghum or Millet during the traditional food preparation. (Osungbaro et al., 2010).

Fermentation is the most important unit operation for the processing of cassava and its consumption in Africa. (Mahingu et al., 1987). Usually fermented products are prepared from cassava in Africa. (Oyewole and Odunfa, 1992). During the traditional processing of fufu, any other processing is not subjected to it after fermentation before cooking. So, fufu is considered to be an unique product amongst the other fermented cassava products. (Sobowale et al., 2007). Significant contribution of yeast, lactic acid bacteria and other bacteria leads to acidification, development in flavor and breakdown of starch during the Fermentation of Fufu. (Oyewole, 1991).

PLANTAIN-

Two main cultivators of plantain are grown in Ghana namely, the "Apem" and "Apantu". It belongs to the genus Musa in the family Musaceae. It is said to be a giant perennial herb. The variety, maturity and the ripening degree varies along with the chemical composition of plantain and also on the soil conditions. Green plant has the water content of 61% and increases to 68% on ripening. The starch content of green plantain is within the range of 21-26%. They are highly nutritious and provide good amounts of micro and macronutrients.

The carbohydrates fraction in case of plantain is the most important. Amylose and amylopectin are the two main components of starch in the ratio of 1:5. The food powders production is increasing due to globalization and gradual urbanization. For example- the local tuber crops and cereals are used for the export of powder and are gaining the market status. Fufu is considered to be such low moisture dried product which has extended shelf life. (Zakpaa et al., 2010).

ENERGY	122 kcal
Carbohydrates	31.89 gms
Proteins	1.30 gms
Fats	0.37 gms
Dietary fiber	2.30 gms
Vitamins(mgs)	
Niacin	0.686 mg
Riboflavin	0.054 mg
Vitamin A	1127 IU
Vitamin C	18.4 mg
Vitamin E	0.14 mg
Vitamin K	0.7 mg
Sodium	4 mg
Potassium	499 mg
Calcium	3 mg
Magnesium	27 mg
Phosphorus	34 mg
Zinc	0.14 mg
Iron	0.60 mg

Source: Zakpaa et al., (2010)

PROPERTIES OF FUFU FLOUR-

Preparation of fufu flour is done from the cassava roots which are considered as the major staple food in African countries. To the African farmers, cassava is as important as the potatoes are important to the European farmers and the rice is to the Asian farmers. Cassava is a drought-tolerant crop and its nutritional value can be maintained in its mature roots. They can be stored without water for longer periods of time and in some developing countries, cassava is considered to be the future of food security. The content of fiber which is available in cassava leaves is higher than legumes and leafy legumes and is ranged between 1 and 10 g/100 g FW. Problems of constipation are reduced by dietary fiber and are an integral part of the healthy diet. Colon cancer can also be prevented by dietary fiber according to the recent evidences. The utilization of nutrients present in cassava should be optimized because the regions where cassava is considered as a staple food, nutritional deficiencies are high in them. (Montagnac et al., 2009).

Cassava is low in proteins in comparison to the other cereal grains and the protein content of cassava is of poor quality which consists of very low content of essential amino acids. (Olugbemi et al., 2010). Diets based on cassava should be supplementary with protein sources, providing adequate amounts of methionine and lysine which is expensive. Diets containing 0.2% and 0.3% methionine should be supplemented along with diets that primarily consist of cassava. (Adegbola, 1977). Cassava leaves, seeds and cake can be incorporated into the diet to overcome this problem as they are rich in protein content. (Ngiki et al., 2014) Various micronutrients present in the cassava can undergo biofortification. These nutrients include vitamin A, Zinc and Iron. (Montagnac et al., 2009; Nnadi et al., 2010). The arginine content of the proteins present in the cassava is high but it contains low amounts of methionine, cysteine, phenylalanine and proline content. (Onwueme, 1978).

The protein content of cassava can be enhanced if protein sources are added in the diet or fermentation of cassava can also be done. It consists almost entirely of starch that can be easily digestible. While comparing starches of cassava and maize, the cassava starch consists of 17% amylose, 83% amylopectin whereas maize starch contains 28% amylose and 72% amylopectin. (Gomes et al., 2005 & Promthong et al., 2005). Since, the amylopectin level is comparatively high, it shows that the digestible starch is higher in cassava in comparison to the other starches that are commonly available.

COMPOSITE FLOURS-

The mixture of various flours, starches and various ingredients that are used for replacing the wheat flour partially or completely in various product development are called the Composite flours. (Milligan et al., 1981). According to (Shittu et al., 2007), either ternary or the binary mixtures of flour makes up the composite flours constituents. Other crops are used to replace the traditional wheat flour and to enhance the essential aspects of the diet. Composite flour provides various advantages in the developing countries:

- ✓ Allows savings of the currency.
- ✓ Promotes the high yielding of the crops and the plant species belonging to the native place.
- ✓ Protein supply can be enhanced for the consumption of humans.
- ✓ The overall production of agriculture on domestic basis becomes better. (Berghofer, 2000; Bugusu et al., 2001).

Composite flours are considered to be advantageous since the wheat flour importation is reduced and encouragement for the use of crops that are grown locally is provided. (Hugo et al., 2000;

Hasmadi et al., 2014). As the market for the confectionaries are growing rapidly the wheat flour is substituted with the locally available raw materials. (Noor Aziah & Komathi, 2009). The initiation of different programs has been encouraged in several countries that are developing for the feasibility analysis and evaluation of the alternative flours that are locally available to substitute wheat flour.

BAKED COMPOSITE SNACKS-

The baked snacks are completely different from the fried ones based on their own taste and the textural properties. It has more taste and textural properties than the fried snacks. After the production of baked snacks, the consumer's preferred more of baked goods because of its low fat content with high quality taste and textural properties. For the baking process, air-impingement ovens are used instead of conventional oven due to the faster process. (Quintero Fuentes et al., 1999). Baked snacks are comparatively new products that are found or are available in the market. Their popularity in the market is increasing because of their low fat content and the caloric content. Textural properties are influenced by the baking conditions and air cells and are cracks are formed while baking process. Simultaneous heat and mass transfer will be there during baking process and as well as deep fat frying. The optimized baking conditions for the baking process might be reduced energy consumption due to the requirement of high energy consumption (Kayacier & Singh, 2004). Some disease causing agents like cancer-causing agent has been seen in the starchy food products made by baking and frying. It is due to the formation of acrylamide in fried and baked products.

FRIED COMPOSITE SNACKS-

At commercial and household levels, the snack items are generally prepared by deep fat frying. They are the concentrated sources of energy and fats and alongside also improve the digestibility of legumes. The content of moisture in the food is reduced, shelf life is enhanced and characteristic color, flavor and texture of the product is imparted. In this case of fried foods, rancidity is the major problem which leads to food quality deterioration. It was reported by White (1991) that as a result of hydrolytic and the thermo-oxidative reactions, the quality deterioration of the fried products takes place.

The judgment of the fat oxidation content in the oil with the peroxides, aldehydes and ketones formation is done by sensory parameters including the overall appearance, texture, aroma and taste of the products. (Gray, 1978). As mentioned by (Du & Sun 2008; Zheng et al., 2006), texture is the major property of the food which strongly affects its micro-structures. The rancidity in the product can be estimated by the Peroxide value, acid value, Kreis test, panisidine test, and thiobarbituric acid test (Jensen and Risbo 2007; Jonnalagadda et al., 2001). Frying needs appreciable amounts of oil for the product to make it acceptable. (up to 40%) and also the quality of the fried product greatly depends on the quality of the oil which is used for frying. Further degradation of the oil is due to the presence of unsaturated fatty acids which can ultimately deteriorate the quality of the product as well. (Houhoula & Oreopoulou, 2004).

TECHNICAL PLAN:

PROPOSED RESEARCH OBJECTIVES

1. To optimize flours in different ratios for making fried composite snacks.
2. To optimize flours in different ratios for making baked composite snacks.
3. Shelf life evaluation of the developed composite snacks.

DETAILED PLAN OF WORK-

OBJECTIVE 1:

To optimize flours in different ratios for making fried composite snacks-

Fufu flour will be mixed with Rice, Wheat and Maize flours in different ratios as following-

FUFU FLOUR	WHEAT FLOUR
90%	10%
80%	20%
70%	30%
60%	40%
50%	50%

FUFU FLOUR	MAIZE FLOUR
90%	10%
80%	20%
70%	30%
60%	40%

50%	50%

FUFU FLOUR	RICE FLOUR
90%	10%
80%	20%
70%	30%
60%	40%
50%	50%

The optimized blend will be dried at different temperature conditions of 40, 50, 60 and 70℃ at RH 60% by using tray drier. The optimized blend will also be direct fried without drying. Fufu flour is taken as from 50-90% and preliminary trials will be used to decide the ratio of different flours such as wheat, rice and maize flours to be blended with fufu flour for the production of composite snacks using response surface methodology.

In case of this objective, the methods of processing that has to be followed are:

- The optimized blend firstly dry and then frying.
- Direct frying of optimized blend without drying.

1. Sensory properties:

Nine point hedonic scales will be used to evaluate sensory properties of the optimized fufu composite snacks. (Senthil et al., 2002)

2. Physical properties:

Texture profile analysis will be studied. (Rampersad et al., 2003)

3. Chemical properties:

Nutritional profile of the composite snacks will be analyzed viz.

- Moisture (Rampersad et al., 2003)
- Minerals (Mehrjardi et al., 2012)
- Fats (Ranganna et al., 2012)
- Proteins (Mehrjardi et al., 2012)

- Carbohydrates (Mehrjardi et al., 2012)
- Free fatty acids (Balogun et al., 2012)
- Hydroxymethylfurfural (Capuano et al, 2009)
- Thiobarbituric Acid (Robards et al., 1988)

4. Functional components:

- Antioxidant content: (Azizah et al., 2009)
  - Total Phenolic acid (Ranganna, 2012)
  - Carotenoid content (Ranganna, 2012)
  - Flavonoids (Tharasen and Lawan 2014)

- Antioxidant activity: (Azizah et al., 2009)

  -Free radical scavenging (Prakash et al., 2009)
  -Reducing power (Prakash et al., 2009)
  -Metal Chelation (Fournier et al., 2015)

- Oil absorption (Ranganna, 2012)

OBJECTIVE 2:

To optimize flours in different ratios for making baked composite snacks-

Fufu flour will be mixed with Rice, Wheat and Maize flours in different ratios.

The optimized blend will be directly baked without drying. Fufu flour is taken as from 50-90% and preliminary trials will be used to decide the ratio of different flours such as wheat, rice and maize flours to be blended with fufu flour for the production of composite snacks using response surface methodology.

In case of this objective, the method of processing that has to be followed is:

- Direct baking of optimized blend without drying.

1. Sensory properties:

Nine point hedonic scales will be used to evaluate sensory properties of the optimized fufu composite snacks. (Senthil et al., 2002)

2. Physical properties:

Texture profile analysis will be studied. (Rampersad et al, 2003).

3. Chemical properties:

Nutritional profile of the composite snacks will be analyzed viz.

- Moisture (R. Rampersad et al., 2003)
- Minerals (Mehrjardi et al., 2012)
- Fats (Ranganna, 2012)
- Proteins (Mehrjardi et al., 2012)
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- Antioxidant activity: (Azizah et al., 2009)
  -Free radical scavenging (Prakash et al., 2009)
  -Reducing power (Prakash et al., 2009)
  -Metal Chelation (Fournier et al., 2015)

OBJECTIVE 3:

Shelf life evaluation of the developed composite snacks-

The shelf of the optimized fufu flour chips will be analyzed. The optimized product will be packed in gas-impermeable and sealed LDPE and HDPE pouches and stored under accelerated conditions viz. temperatures at 10, 25 and 37℃ for shelf life evaluations.

Following responses would be studied during the shelf life analysis:

- Organoleptic evaluations:
  The colour, appearance, taste, texture and aroma, mouth feel and acceptability of the developed snacks will be evaluated using a 9 point hedonic scale.

- Chemical Analysis:
  - ✓ Moisture content (Mehrjardi et al., 2012)
  - ✓ Protein content (Mehrjardi et al.,2012)
  - ✓ Fat content (Ranganna, 2012)
  - ✓ Dietary fiber content (Mehrjardi et al., 2012)
  - ✓ Free fatty acid content (Sailu et al., 2017)
  - ✓ Peroxide Value (Yelboga et al., 2017)
  - ✓ Hydroxymethylfurfural (Capuano et al, 2009)
  - ✓ Thiobarbituric Acid (Robards et al., 1988)

- **Antioxidant potential:**

✓ Antioxidant Activity (Azizah et al., 2009)
✓ Free Radical Scavenging Activities (Prakash et al., 2009)
✓ Reducing Power (Prakash et al., 2009)
✓ Metal Chelation (Fournier et al., 2015)

- **Antioxidant content** (Azizah et al., 2009)
  - ✓ Total Phenolic Acid (Ranganna, 2012)
  - ✓ Carotenoid Content (Ranganna et al., 2012)
  - ✓ Flavonoids (Tharasena and Lawan, 2014)

PROPOSED RESEARCH METHODOLOGY

Fufu Flour which is a blend of cassava and green plantain is used for the preparation of the composite snacks.

Initially, the cassava was soaked which was then peeled and washed in the water for 60 hours. The tubers were completely covered with water. This is called the Submerged Fermentation Process. (Oyewole & Odunfa, 1990). For 48 hours the grated mash was soaked in water for the second time. After this the fibrous material was removed after washing it through a sieve.
After breaking the cake lump with hand it was dried in cabinet drier at 60℃ for 24 hours. An attrition mill was used for milling it after drying and was then sieved through a mesh size 212μm and then can be packed in moisture-proof polyethylene bags. (Olapade A.A. et al., 2014).

FLOWCHART FOR CASSAVA FLOUR-

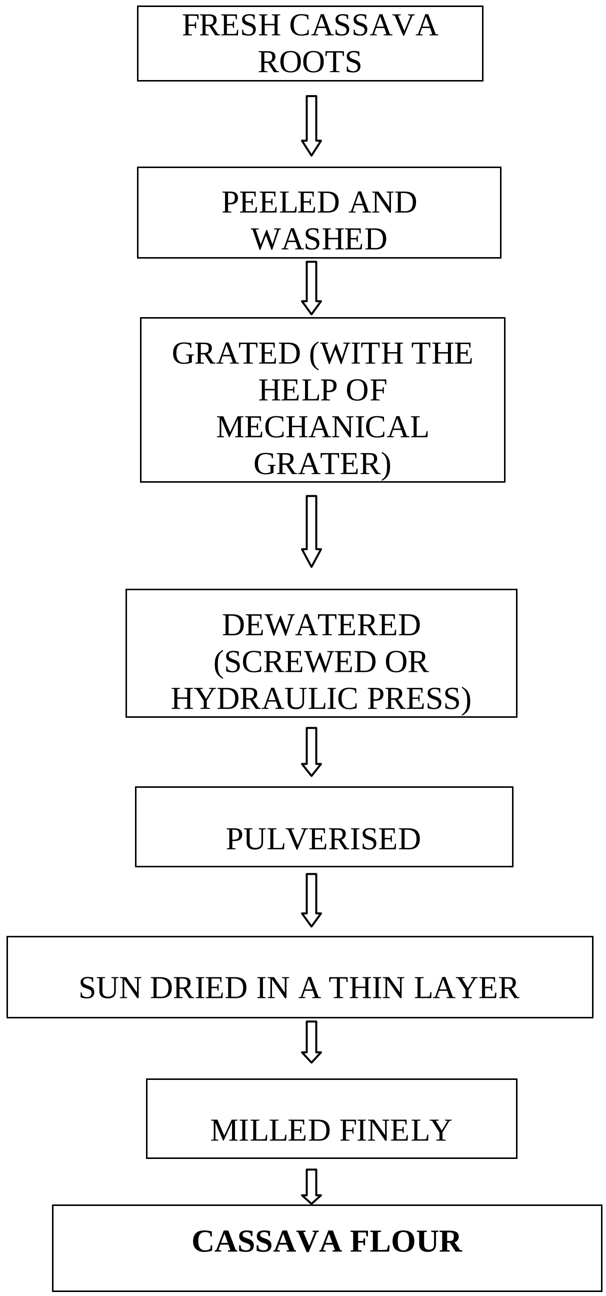


Fig 1: Flowchart for the preparation of the cassava flour (Tajudeen Adebayo Adeniji, 2013).

FLOWCHART FOR GREEN PLANTAIN FLOUR-

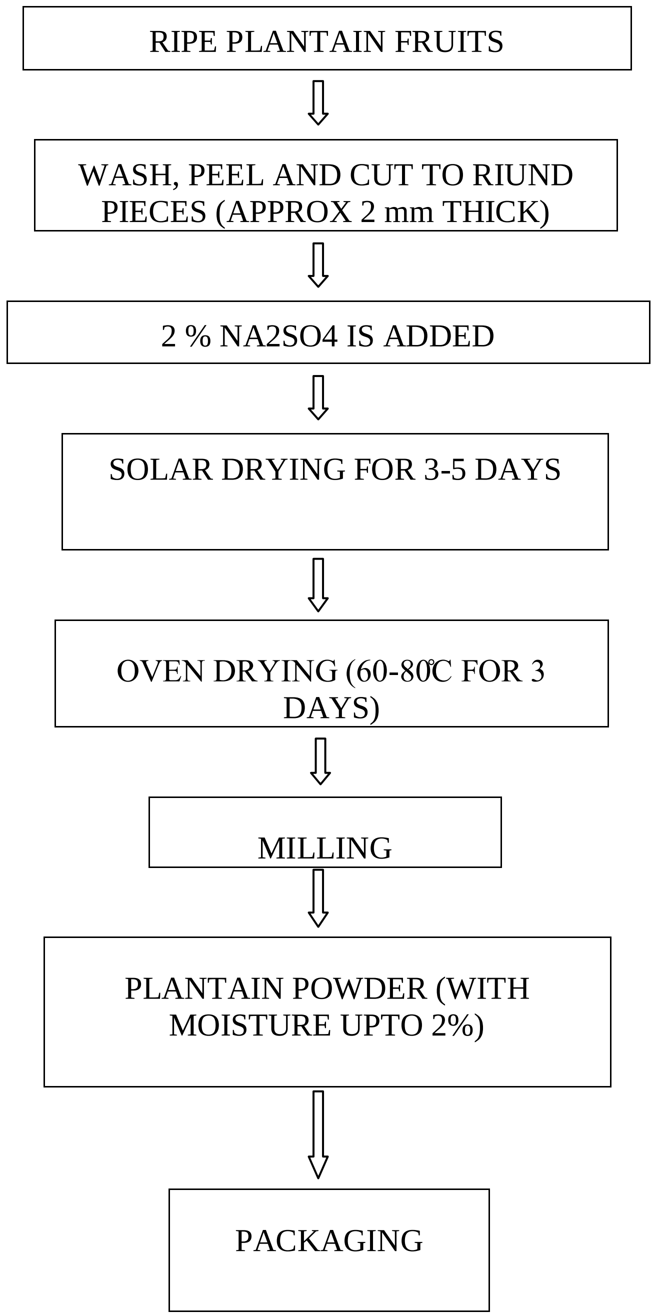
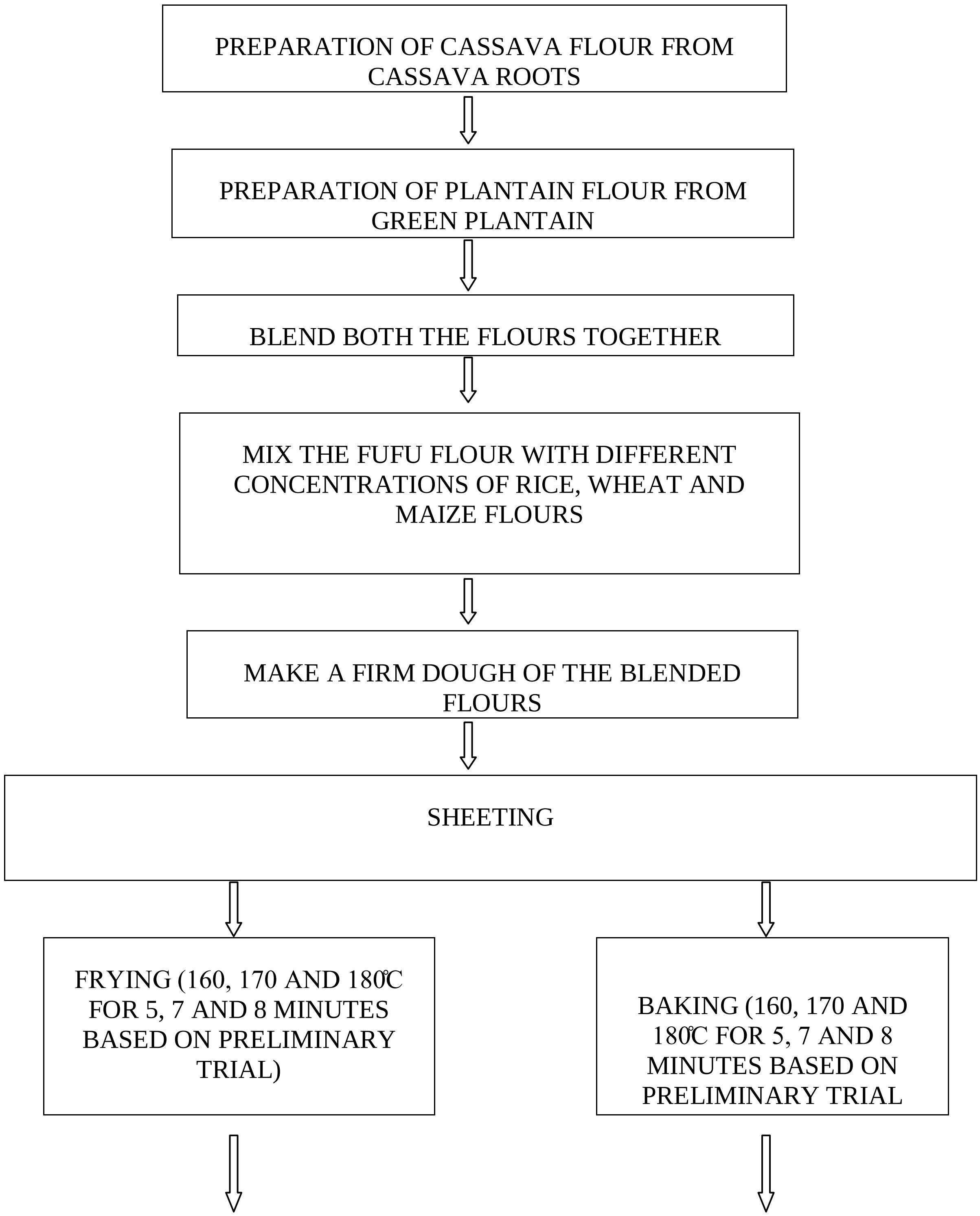


Fig 2: Flowchart for the preparation of green plantain flour (Zakpaa et al., 2010).

FLOWCHART FOR THE PREARATION OF FUFU FLOUR COMPOSITE SNACKS-



SPICING AND FLAVOURING (SPRINKLE CHILLY POWDER AND SALT, PEPPER POWDER AND SALT)

↓

PACKING (LDPE & HDPE POUCHES FOR 25 gms AND 50 gms OF 50-150 MICRONS THICKNESS)

↓

STORAGE (20,25 AND 35℃ FOR 3 MONTHS)

SPICING AND FLAVORING (SPRINKLE CHILLY POWDER AND SALT, PEPPER POWDER AND SALT)

↓

PACKING (LDPE & HDPE POUCHES FOR 25 gms AND 50 gms OF 50-150 MICRONS THICKNESS)

↓

STORAGE (20,25 AND 35℃ FOR 3 MONTHS)

Fig 3: Flowchart for the preparation of fufu flour composite snacks.

EXPECTED RESEARCH OUTCOMES

1. Optimized process for the production of fried composite snacks from fufu flour.
2. Optimized process for the production of baked composite snacks from fufu flour.
3. The obtained final product will be having good sensory characteristics and high shelf life.

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