Wolkite University

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College of Engineering and Technology

Department of Food Process Engineering

EFFECT OF DRYING TEMPERATURE ON QUALITY OF OVEN DRIED BANANA POWDER

A FINAL THESIS: SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF BACHELOR OF SCINCE IN FOOD PROCESS ENGINEERING DEPARTMENT

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June 21, 2019

Wolkite University, Ethiopia

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LIST OF ABBREVIATION&ACRONYMS

ANOVA	Analysis of Variance
AOAC	American organization analytical chemistry
B_1, B_2, B_3	Treatment of Sample Code
BD	Bulk Density
CV	Coefficient of Variance
DF	Degree of Freedom
LSD	Least significant Difference
MC	Moisture Content,
MS	Mean Square
OAC	Oil Absorption Capacity
SS	Sum Square
WAC	Water Absorption capacity

DECLARATION

This is to certify that the thesis prepared by Eyob Kolcha, Mebiratu Mengistu, and Temesgen Hoja entitled: “The effect of Drying Temperature on Quality of Oven Dried Banana Powder” summited in partial fulfillment of the requirement for the degree (Food Process Engineering) complies with the requirement of the University and meets the accepted standards with respect to originality and quality.

Signed by the Examining Committee

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ACKNOWLEDGMENT

Above all, we wish to thank the almighty God for everything. Neatly, we would like to express heartfelt appreciation and special gratitude to all persons who, in one way or the other contributed to the accomplishment of this study. Special appreciation and deepest thanks go to the bachelor thesis advisor Mr. Gashaw A (Msc), Worku A (Bsc) and laboratory assistance for their continuous guidance, inspiration, encouragement and support throughout the study period which made the completion of this study smooth and successful. Also we would like our friends that help us to sensory evaluation of the banana powder. Great deals of gratefulness and thanks go to head of Food Process Engineering and staff that support by buying raw material and other facilities to accomplish during our study.

Finally, our heartfelt gratitude goes to our all family for encouragement and endurance at all stages up to graduated studies.

ABSTRACT

This study was conducted the effect of drying temperature on quality of oven dried banana powder is to produce consumer accepted banana powder, increase shelf life of banana for long period storage and easy transportation, evaluate proximate composition of banana powders, analyze sensory analysis of banana powder. The result revealed that oven dried banana powder has like proximate composition included moisture content (17.67-24.03 %), total ash content (9.93-10.42%), Functional properties like bulk density (0.37-1.36 g/ml), oil absorption capacity (2.03-4.0%), water absorption capacity(1.4-1.65%) and Sensory quality color(2.60-4.23), aroma (3.17-3.43) appearance (3.07-3.17) texture (3.30). These indicate that some proximate composition decreased as drying temperature increased.

Key word: *Functional property, proximate composition and Oil absorption capacity.*

CHAPTER ONE

1. INTRODUCTION

Banana powder is the common name for an edible fruit produced by several kinds of large herbaceous flowering plant of the genus Musa. Banana processing, particularly drying using natural sun drying has been carried out for many centuries now. Banana processed to increase shelf life, ability to store and to be supplied when needed. Processing of green bananas into flour is of interest in view of the surplus fruits often available year round in the production areas (Suntharalingam, 1993). Most banana flour, produced from the green unripe fruit is sun dried or dried in crude ovens, under these conditions the quality of the product is very variable (Wilson, 1975). Considerable losses occur during natural sun drying; lowering the qualitative and quantitative value of the dried products. The slices of unripe fruit are normally spread out on bamboo frameworks or on bare patches of earth, roofs, stone outcrops or on sheets of corrugated iron (FAO, 1995). Dried products are subject to contamination by extraneous materials such as sand, stones, soils, tree leaves and incursion by rodents, insects, animal excreta and various forms of microorganisms (Olufayo and Ogunkule, 1996). Efforts to improve the above traditional drying methods have been going on. Drying methods have progressively improved from drying on the ground to raised racks to solar dryers, where a product is placed within an enclosed cabinet. Cabinet dryers have evolved from using solar energy alone to currently hybrid drying using both solar and other energy sources such as biomass, diesel and electric. However, these dryers have given products with inferior quality that is reduced nutritional value, collapsed structure, reduced taste and flavor deterioration and discoloration (Inglett and Chalarambous 1979; Stover and Simmonds 1987; Muranga 1998; Muyonga 2000. The discoloration during preparation and drying commonly called "browning" is caused by chemical or biochemical reactions or over heating due to difficulties in controlling, the drying conditions notably temperature and time (Anon, 1993).

In an effort to improve the quality of dried products appropriate drying temperature and drying time, have to be used (Maskan, 2000; Moreno *et al.,* 2000; Fito *et al.,* 2001; Prothon, 2003). Currently the market prefers high quality dried products with good reconstitution properties and excellent sensory attributes. In an effort to improve the quality of dried products appropriate drying temperature and drying time, have to be used.

1.2 Statement of Problem

Banana is one of the largest fruit grow in sub- Sahara country like Ethiopia, Kenya and etc., even if it is one of the largest grown fruit and high nutritional content like starch, it can’t be stored for long period of time and can’t be supplied when needed. To prolong shelf life, various processing and preservation method such as drying, chemical treatment, and various packing methods are used. Drying is the major food processing operation to increase shelf life. The purpose of drying of fruit is to produce a stable and easily handled form of the product, which reconstitute rapidly to a quality product reassembling the original fruit as closely as possible. Completely dried fruit powders are often used for making many delicious food products. In Ethiopia, the number of fruit and vegetable processing industries are limited. Currently, there are only “5” fruit processing plant in the country. These plants presently process a limited variety of product; tomato paste, orange marmalade, vegetable soup, frozen vegetables and wine. Therefore, in order to prolong the shelf life of post-harvest product, processing is necessary. Processing contributes toward expansions of market of processed product in availing it during off-season and increasing its values. During processing, drying temperature is one of factor, which may affect quality of final product. The thesis mainly focuses on processing of banana powder, which is storable, and easily transport by optimizing drying temperature.

1.3. Objectives

1.3.1 General objective:

- ❖ To study the effect of drying temperature on quality of oven dried banana powder.

1.3.2 Specific objectives:

- ❖ To differentiate different drying temperature on quality of dried banana Powder
- ❖ To produce consumer accepted banana powder.
- ❖ To increase shelf life of banana for long period storage and easy transportation.
- ❖ To evaluate proximate composition of banana powders.
- ❖ To analyzes sensory analysis of banana powder

1.4. Significance of the Study

The water content of most of fruits and vegetables is higher than 80%, which limits their shelf life and makes them more susceptible to storage and transport conditions. Now days green banana powder attract attention because they can be easily produced, can be stored and transported at relatively low cost, have reduced post-harvesting loss, and their low water content avoids the development of some microorganisms responsible for deterioration of fresh food. Due to their high initial moisture content of fresh green banana, which is nearly 75 %, the energy needed for the removal of water is very high.

CHAPTER TWO

2. LITERATURE REVIEW

2.1 General Overview of Banana Fruit

Banana fruit is variable in size, color and firmness, but it is usually elongated and curved, with soft flesh rich in starch covered with a rind which may be yellow, purple or red when ripe, the fruit grow in cluster hanging from the top of the plant. Almost all modern edible bananas come from two wild species, Musa acuminate and Musa balbaisiana. Banana from two wild species, Musa acuminate and Musa balbaisiana. Banana is the second largest produced production.

Banana plant monocotyledonous perennial and important crops in the tropical and subtropical world regions (Strosse *et al.,* 2006). They include dessert banana, plantain and cooking bananas. Traded plantain (Musa paradisiacal AAB) and other cooking bananas (Musa ABB) are almost entirely derived from the AA·BB hybridization of M. acuminate (AA) and M. balbaisiana (BB) (Stover, 1987; Robinson, 1996). Plantain and cooking bananas are very similar to unripe dessert bananas (Cavendish AAA) in exterior appearance, although often larger; the main differences in the former being that their flesh is starchy rather than sweet, they are used unripe and require Cooking (Emaga *et al.*, 2007). Dessert bananas are consumed usually as ripe fruits; whereas ripe and unripe plantain fruit are usually consumed boiled or fried (Surga *et al.* 1998).

Banana is a well know source of carbohydrates and dietary fiber. Banana has long been recommended as a dietary supplement for individuals suffering from digestive disorder. According to (mota *et al,* 2000), green banana fruit contain higher hemicelluloses content (6.08%) than most fruit and vegetables. Apart from dietary fiber, green banana contains high amount of essential minerals such as potassium, and various vitamins such as A, B1, B2, and C (chandler, 1995). During processing the drying temperature, affect those nutritional compositions.

Table 2. 1. Drying temperature of banana powder

Temp (^{o}C)	**Time (min)**
30	40
40	35

2.2 General Characteristics of Banana Consumption

In culinary terms, banana cultivars can be divided into two main groups: sweet or dessert bananas, and cooking bananas, including the plantain (Champion, 1963; Lescot, 1990; Marchal, 1993; Marriott & Lancaster, 1983; Nakasone& Paul, 1999; Turner, 1994).

In terms of use and consumption, bananas are:

- Basic foodstuff consumed fresh or cooked. The mature dessert banana is primarily consumed in its natural state, raw. Unripe, it is cooked prior to consumption. Green or ripe, they represent an important part of basic alimentation for significant population groups in producer countries.
- Raw materials in a variety of domestic and regional products (Adams, 1980; Akubor, Obio, Nwadomere, & Obiomah, Carren & Aristizabal, 2003; Davies, 1993; Guerrero, Alzamora, & Guerschenson, 1994; Hammond, Egg, Diggins, & Coble, 1996): whole, peeled and dried bananas; cooked bananas (boiled, crisps, fried, pure´e); domestic preparations (fritters, jams, wines, beer); domestic and artisanal flour; green banana starch; purée; alcohol; regional beers; wine; vinegar; nectar; chunks and purees as ingredients in culinary preparations (pastries, desserts, ice-creams, sorbets and cream products).

2.3 History of Banana Processing

Both preservations and processing are done in order to maximize the shelf life of banana, it is the fact that only 15% of total production of banana is involved in world trade, rest of banana is consumed domestically but value added sector of the banana is yet to be developed. Both ripe and un ripe banana and plantain are peeled and sliced before drying, banana are sometimes prepared by whole ripe fruit, sun drying is the widest spread techniques of drying of banana where the climate is suitable but drying in oven or over fire is also practiced plantains are often soaked or parboiled before drying.

2.4 Industrial Processed Banana Product

In general, to obtain good quality product from ripe-banana the fruit is harvested green and ripe under controlled conditions at the processing factory. After ripening, the banana hands are washed to remove dust and any spray residue and peeled. Peeling is almost done by hands with the help of stainless steel knives, mechanical peeler to peel ripe banana are developed capable of peeling (banana bulletin, 1974). The peeling of unripe banana and plantain are facilitated by immersing the fruit in hot water. Bananas for flour production, while peeling of green bananas for freezing has-been facilitated by immersion in water at 93 ºC for 30minute.

2.5 Value Added Products of Banana

- **Banana Figs**

Fully ripe fruits with sugar content of about19.6% are used and treated with sulphorus acid after peeling, then dried as soon as possible after words, various dried system have been described using temperature between 50 to 82ºC for 10 to 24hrs to give a moisture content ranging from 8 to 18% and yield of dried figs of 12 to 17% of the fresh banana on the stem.

- **Banana Puree**

Banana puree is obtained by pulping peeled, ripe bananas and then preserving the pulp by one of three methods**:** canning aseptically, acidification followed by normal canning, or quick freezing. The bulk of the world's puree is processed by aseptic canning techniques. Peeled, ripe fruit are conveyed to a pump which forces them through plate with ¼-in. then onto a homogenizer, followed by centrifugal de-aerator, and in to a receiving tank with 29in. vacuum, where the removal of air helps prevent discoloration by oxidation. The puree is then passed through series of scraped surface heat exchangers where it is sterilized by steam, partially cooked and finally brought to filling temperature. The sterilized puree is then packed aseptically into steam-sterilized can, which are closed in a steam atmosphere.

- **Banana slices**

Several methods for canning of banana slices in syrup are used. Best quality slices are obtained from fruit at an early stage of ripeness. The slices are processed in syrup of 25deg Brix with $_P{}^H$ about 4.2, and in some processes calcium chloride (0.2%) or calcium lactate (0.5%) are added as firming agents. A method for producing an intermediate-moisture banana product for sale in flexible laminate pouches has been Banana slices are blanched and equilibrated in solution containing glycerol (42.5%), sucrose (14.85%), potassium sorbet (0.45%), and potassium meta developed. bisulphate (0.2%) at 90 ºC for 3 min to give moisture content of 30.2%.

- **Banana flour**

Production has been carried out by peeling and slicing green fruit, exposure to Sulphur dioxide gas, then drying in counter-current tunnel dryer for 7 to 8 hr with an inlet temperature of 75 ^{0}C and outlet temperature of 45ºC, to a moisture content of 8 % and finally milling.

❖ Banana Chips (Crisp)

Typically, unripe peeled bananas are thinly sliced, immersed in a sodium and potassium metabisulphite solution, fired in hydrogenated oil at 180 to 200ºC.and dusted with salt and an antioxidant. Alternatively, slices may be dried before frying and the antioxidant and the salt added with oil. Similar processes for producing plantains chips have been developed.

❖ Banana Beverages

In a typical process, peeled ripped fruit is cut in to pieces, blanched for 2 min in steam, pulped and pectolytic enzymes added at the concentration of 2 g per 1 kg pulp then held at 60 to 65º and 2.7 to 5.5 P^H for 30 minutes. In a simpler method, lime is used to eliminate pectin. Calcium dioxide (0.5%) is added to the pulp and after standing for 15 min. This is neutralized giving a yield up to 80% of a clear attractive juice. In other process banana, pulp is acidified, and steam blanched in AAa28-in Hg in a vacuum, which ensures distingeration and enzymes inactivation. The pulp is then conveyed to a screw press, the resulting puree diluted in the ratio1:3 in water and the P^H adjusted by further addition of citric acid 4.2 to 4.3 which yield an attractive drink when it is centrifuged and sweeten.

❖ Banana Jam

A small amount of jam is prepared commercially by boiling equal quantities of fruit and sugar together with water and lemon juice, lime juice or citric acid, until setting point is reached.

2.6 Drying Technology

Drying is defined as the application of heat under controlled conditions to remove the majority of Water normally present in a food by evaporation. The main purpose of drying is to extend the shelf life of foods by a reduction in water activity. This inhibits microbial growth and enzyme activity, but the processing temperature is usually insufficient to inactivate. Drying causes deterioration of both the eating quality and the nutritional value of food. The design and operation of dehydration equipment aim to minimize these changes by selection of appropriate drying conditions for individual food items (Elias, 2007).

2.6.1 Drying Techniques

The drying of materials whether solids, liquids or slurries to improve storage life or reduce transportation costs is one of the oldest and most commonly used unit operations. Drying of fruit, meat and various building and craft materials date back before the discovery of fire. The physical laws governing drying remain the same, even though the machinery to accomplish it has improved considerably. Today, dryers are in operation in most manufacturing industries including chemical, pharmaceutical, process and food. Products that are dried range from organic pigments to proteins, as well as minerals to dairy products. Because of the spectrum of duties required, there is a great variety of dryers available. The correct choice depends on the properties of the feed material and the desired characteristics of the final product. Several types of dryers and drying methods, each better suited for a particular situation, are commercially used to remove moisture from a wide variety of food products including fruit and vegetables. While sun drying of fruit crops is still practiced for certain fruit such as prunes, figs, apricots, grapes and dates, atmospheric dehydration processes are used for apples, prunes, and several vegetables; continuous processes as tunnel, belt trough, fluidized bed and foam-mat drying are mainly used for vegetables.

Factors on which the selection of a particular dryer/ drying method depends include:

- Form of raw material and its properties
- Desired physical form and characteristics of dried product
- Necessary operating conditions;
- operating costs

2.6.2 Oven drying

Everyone who has an oven has a dehydrator. By combining the factors of heat, low humidity and airflow, an oven can be used as a dehydrator. An oven is ideal for occasional drying of meat jerkies, fruit leathers, and banana chips or for preserving excess produce like celery or mushrooms (Harrison, 1999). Because the oven is needed for every day cooking, it may not be satisfactory for preserving abundant garden produce.

2.6.3 Sun drying:

Sun drying is used to denote the exposure of the food material to direct solar radiation.

2.6.4 Spray drying

Spray drying is suitable for fruit juice concentrates and vacuum dehydration processes are useful for low moisture / high sugar fruits like peaches, pears and apricots.

2.7 Product Description

Banana Powder is a free flowing product made from fresh bananas ripened to full flavor. This product is 100% natural without any preservatives or additives. Chiquita banana powder is easily used in diverse applications to enhance flavor whenever low moisture is necessary. It can be reconstituted in hot or cold liquid with a weight relation of 3:1 (water to banana powder) (Chiquita, 2005). Banana powder has a great potential for commercialization.

It has a high sugar and low starch content and can be used as a substitute for fresh banana in making traditional cakes or their premixes as well as in the processing of banana snacks, crackers or crisps. The quality of banana powder is determined by the color, flavor, texture and moisture content. These are affected by the varieties of bananas and processing operations specially blanching process. Good quality powder is produced from the bananas of right variety and degree of ripeness. The dry powder can be used as an additive in confectioneries, milkshakes and baby foods. Banana powder, because of its high concentration of banana essence, has been found to be a major source of carbohydrate and calories. While it is generally low as a source of protein, the beneficial ingredients of the powder are still markedly superior to that of other fruits. Product characteristics Particle size - Below 100 mesh. Appearance - Free flowing powder Advantage - Major source of carbohydrate and calories Shelf life -1-Year State -Solid, Divided solid Applications. The powder has been found to be useful as a general treatment for dyspepsia (indigestion). Fights Anemia by stimulating the production of hemoglobin. Helping regulate blood pressure because of high potassium and low salt levels. Reducing constipation because of high amounts of fiber, assisting learning & alertness by bringing more oxygen to the brain. A banana powder has a mild laxative property and hence is very useful in children’s diseases. Banana powder is helpful to combat diarrhea and dysentery. Used for the treatment of stomach ulcers.

Banana powder with milk and sugar can be an excellent supplementary or weaning food for children; it is used in the diets of children for treating malnutrition. Experiments have shown that intake of banana powder helps children to retain many mineral nutrients. Global demand National Scenario India is the fruit and vegetable basket of the world. India produces 54% of world's mango, 23% banana, 24% cashew nuts, 36% green peas and 10% onion production. India is the largest producer of banana in the world. Maharashtra accounts for 25% of banana production in India, followed by Tamil Nadu (20%), Gujarat (15%), Karnataka (10%) and Andhra Pradesh (10%). The major banana producing states of India are Tamilnadu, Maharashtra, Karnataka, Gujarat, Andhra Pradesh, Assam and Madhya Pradesh. In India, Banana is available all through the year all over the country. If it is converted into powder or other form with the help of technology, then not only a massive wastage of this fruit could prevented but more demand for the fruit could also be generated, because demand for individual products can be increased if they are offered before or after the season. International scenarios Bananas are the fifth largest agricultural commodity in world trade after cereals, sugar, coffee and cocoa. India, Ecuador, Brazil and China alone produce half of total bananas of the world. The advantage of this fruit is its availability round the year. The present scenario the productivity of World is 115.20 T/ha where as that of India is 30.63 T/ha. Banana powder and pulp is largely used in the baking and confectionery, and baby food industries. The Indian food industry is estimated to be worth over US$ 200 billion and is expected to grow to US$ 310 billion. By 2015 India is one of the world's major food producers but accounts for only 1.7 per cent (valued at US$ 7.5 billion) of world trade in this sector this share is slated to increase to 3 per cent (US$ 20 billion) by 2015. Since the applications and demand of banana powder is immense therefore the potential of the product is excellent. It is one of the imperative fields to endeavor (cheirsilPb, 2008). In the manufacture of banana powder, full ripe banana pulp is converted into a paste by passing through a chopper followed by a colloid mill or 1 to 2% of sodium Metabisulphite solution is added to improve the color of final product. Spray or drum drying may be used; the latter being favored as all the solids are recovered. A typical spray dryer can have produced 70kg powder per hour to give yields of 8 to 10 % of fresh fruit, while drum drying gives final yield 13% of fresh fruit in the latter method moisture content is reduced to 8 to 12% and then further decreased to 2% by drying in a tunnel or cabinet dryer 60^{o}C.

2.8 Nutritional value (composition) of Banana

Banana is highly nutritious and easily digestible than many other fruit. Digestion time of banana fruit is less (105min) than apple (210min) (Sharrock and Lustry, 2000). Banana are popular for aroma, texture, and easy to peel and eat, besides rich in potassium and calcium and low in sodium content (Anhwange, 2008). Nutritional content of banana are Carbohydrates, fats, protein,

CHAPTER THREE

3. MATERIALS AND METHODS

3.1 Experimental Site

The experiment was conducted at Wolkite University College of Engineering and Technology in Food Process Engineering Laboratory.

3.2. Experimental Materials

The basic raw material, only unripe banana. The banana was obtaining from the local market in nearby Wolkite University in Gubre town.

3.3. Sample Preparation

- **Determination of Moisture Content (AOAC 2000, 925.05)**

A dish was dried at 130 ^{o} C for one hour and was placed in desiccators for about 15-20 minutes. The mass of the dish was measured (Wa). About 2-3g of the sample was weighed into the moisture dish (Wi). The sample was dried at 60^{o}C, 85^{o}C, and 105^{o}C for three hour. After drying was completed, it was measured as Wf.

$$MC\ (\%) = \frac{Wi - Wf}{Wi} * 100$$

Where: MC Wb is the moisture content in wet basis (%)

Wi is the initial weight of samples before drying plus aluminum dish (g).

Wf is the final weight of dried samples plus aluminum dish (g).

- **Total Ash Content Determination (AOAC 2000, 925.05)**

The porcelain dish, used for the analysis, and cleaned by drying at 120 ^{o}C and igniting at 550 ^{o}C in furnace for three hours. Then the dish was removed from the furnace and cooled in desiccators. The mass of the dish was measured by analytical balance.

$$\text{Ash Content}\ (\%) = \frac{W2 - W1}{W3} * 100$$

Where: W_1= Weight of the dish (g)

W_2=Weight of fresh sample and dish (g)

W_3=Weight of ash and dish (g)

3.4 Oven Dried Banana Powder Production Process

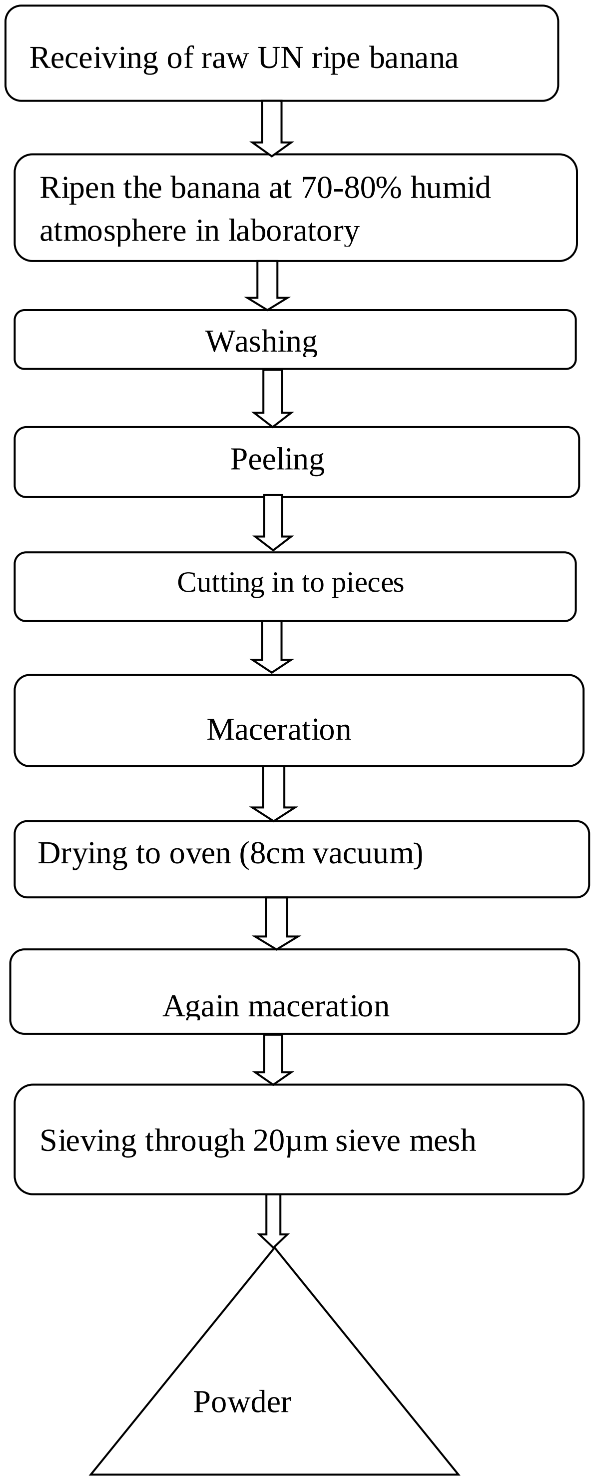

Figure3. 1. Oven Dried Banana Powder, Production Process

3.5 Quality Parameters of Banana Powder

- **Moisture content**

Moisture content in pulp increases during ripening process due to respiratory break down of starches into sugar, and migration of moisture from peel to pulp (Marriott *etal*, 1981). However, in AAB variety, moisture content could be (68%) due to presence of starchier balbaisianagenome and incomplete conversion of starch into sugar: even when banana is fully ripe, still some starch is left in pulp tissue (Yang SF and HoftmanNE, 1984).

- **Carbohydrate**

During ripening process, starch is converted into sugar through enzymatic break down process .in AAB group starch content decline from 20-30% to1- 2%, but starch amount could be as high as 11% depending on variety. Sugar content of fully matured banana is quite high that makes it an ideal substrate for wine making (Cheirsil, 2008). Carbohydrate type in is resistance starch and non-starch poly saccharine, which have low glycemic index or low digestibility (Lehmann U, 2007). This property makes it an excellent ingredient for different functional and convenience foods like cookies (Say ago, 2007) and chips (Agunbiade, 2006).

- **Ash content**

The organic matter is burned off at low temperature and the inorganic materials remaining are cooled and weighed. Heating is carried out in stages, first to derive the water, then to char the product thoroughly and finally to ash at 550oC in a muffle furnace (AOAC, 1984).

3.6 Quality Determination of Functional Properties Banana Powder

Oil absorption capacity: 10 ml-refined olive oil was added to 1 g of the banana powder in a weighed 15 ml centrifuge tube. The tube was agitated on a vertex mixer for 2 min. It was centrifuged at 3000 rpm for 30 min. The volume of free oil was recorded and decanted. Oil absorption capacity was expressed as ml/g.

$$\text{Oil absorption Capacity}\left(\frac{\text{ml}}{\text{g}}\right) = \frac{\text{V1} - \text{V2}}{\text{W}}$$

Where: V1=Volume of oil added to sample

V2=Volume of oil separated as supernatant

W=Weight of the sample

Determination of water absorption capacity

Water absorption capacity was determined with the method reported by (sosulski, 1988). 10 ml of distilled water was added to a sample of 1g banana powder (W_1) in a weighed centrifuge tube (W_2) and stirred six times for 1 minute to 10 minutes' intervals.

$$\mathrm{WAC}\frac{g}{g} = \frac{w_3 - (w_2 + w_1)}{w_1} * 100$$

W_3=weight of empty tube with sample after centrifuged and decanted

W_2=weight of empty tube with sample before centrifuged and decanted

W_1=weight of sample

Bulk density: 3g banana powder sample put into a 10 ml measuring cylinder. The cylinder was tapped several times on a laboratory bench to a constant volume. The volume of sample is recorded.

$$\text{Bulk density}\frac{g}{ml} = \frac{w_2 - w_1}{v}$$

W1=cylinder mass (g)

W2= untapped cylinder with sample (g)

V= volume (ml)

3.7 Sensory Analysis

Sensory evaluation was conducted for each banana powders dried at different temperature. The evaluation was carried out by ten semi-trained panelists of whom three are female and seven are male comprised of students of the Food Process Engineering Department. Panelists were asked to give acceptance score for four attributes: color, aroma, appearance and texture using the five-point hedonic scale, in which 1 represent dislike very much, 2 represent dislike, 3 represent moderate, 4 represent like, 5 represent very much like. The powder was diluted with warm water placed in glasses and coded. The powder samples were served to each panelist in a random order.

3.8 Experimental Design

The experiment was conducted in a completely randomized design. Samples were analyzed in triplicate

Table3. 1. Drying Temperature

Time		**Drying temperature**	
T	**T_1**	**T_2**	**T_3**
t_1	T_1t_1	T_2t_1	T_3t_1
t_2	T_1t_2	T_2t_2	T_3t_2

3.9. Data Analysis

Data was analyzed by the analysis of variance (ANOVA) procedures using statically analysis of software (SAS) for windows version 9.0. Least significant differences (LSD) are using for Fisher mean comparison tests. Significance is accepting at ($P < 0.05$).

CHAPTER FOUR

4. RESULT AND DISCUSSION

In this section, the main results of the studies and the general discussions are presented. The tables and figures in this section refer to the figures and tables of each particular study where specified. Banana powder samples were evaluated for their proximate composition, functional properties and sensory evaluation.

4.1 Proximate Composition of Dried Banana Powder

- ✓ **Moisture Content**

The measured moisture content of banana powder is shown in Table 4.1. The moisture content values were B1, B_2 and B_3 24.03, 20.75 and 16.7 respectively. There is significant difference among the treatment with in (P<0.05). The highest moisture content was recorded at B_1 (24.03 %) and the lowest value was recorded at B_3 (16.7%). The lower the banana powder moisture content B_3, the better its storage stability and important for the shelf life. When the moisture level exceeds 23%, the shelf life of the flour is greatly reduced. Generally, the moisture should be 14% to 23%, which when stored under appropriate conditions (relatively cool, dry, and aerated) will provide a long shelf life (Yang and Hoftman, 1984).

- ✓ **Ash Content**

The measured total ash content of banana powders is presented in Table4.1. The values were B1, B_2 and B_3 9.93, 10.28 and 10.42 %, respectively. There is significant difference among the treatment with in (P<0.05). The highest ash content was recorded at B_3 (10.42%) and the lowest value was recorded at B_1 (9.93 %.) At the highest ash, content (B_3) has high mineral and the lowest ash content (B_1) has low mineral. Drying temperature of the ash content of the dried banana samples must have been greatly increased, depending on the value of temperature (AOAC, 1984).

Table 4. 1. Proximate analysis of dried banana powder

Treatment	M.C (%)	Ash (%)
B_1	24.03 ± 0.03^a	9.93 ± 0.06^c
B_2	20.75 ± 0.01^b	10.28 ± 0.02^b
B_3	17.67 ± 0.01^c	10.42 ± 0.03^a
LSD	0.04	0.08
CV	0.09	0.37

Note, M.C= Moisture Content, LSD= Least Significant Difference, CV=Coefficient of VarianceB_1, B_2, B_3=Treatment of Sample Code.

Values within the same column with different superscript letters have significant ($P<0.05$) differences.

4.2 Functional Property of Dried Banana Powder

- **Bulk Density**

The measured bulk density of banana powder is shown in Table 4.2. There is no significant difference among the treatment with in ($P>0.05$). The bulk densities of banana powder ranged from 0.37 - 1.3600 g/ml. The highest bulk density was observed B_1 (1.36 g/ml) and lowest value was observed B_2 (0.37 g/ml). The present study revealed that bulk density depends on the particle size and initial moisture content of banana powder. The high bulk density of powder suggests their suitability for use in food preparations. On contrast, low bulk density would be an advantage in the formulation of complementary foods. Generally, higher bulk density is desirable for the greater ease of dispersibility and reduction of paste thickness (Edema, 2005).

- **Oil Absorption Capacity**

The measured oil absorption capacities of banana powder are presented in Table 4.2. There is significant difference among the treatment with in ($P<0.05$). The ranged between (2.03-4.0 ml/g) among the banana powder the highest value had highest B_3 (4.0 ml/g) and the lowest value was recorded B_1 (2.03). It is clear that the highest (B_3) increased with increase in the proportion of the powder. The presence of high fat content (B_3) increases the composition of powder. However, the highest fat content (B_3) is potentially useful in structural interaction in food especially in flavor retention, improvement of palatability and extension of shelf life particularly in bakery. (Wainwright *et,al* 1989).

- **Water Absorption Capacity**

The water absorption capacity of banana powder given in Table 4.2. The water absorption capacity value ranged between 1.40 - 1.65 % for banana powder. The water absorption capacity value was observed the highest in B_3 (1.65) and the lowest value B1 (1.40 %.) There is significant difference among the treatment with in ($P<0.05$). The powder with high water absorption (B_3) may have more hydrophilic constituents such as polysaccharides. Protein has both hydrophilic and hydrophobic nature and therefore they can interact with water in foods. The good water absorption capacity of composite banana powder (B_3) may prove useful in products where good viscosity (Chandra, 2013)

Table 4. 2. Functional Property of Dried Banana Powder

Treatment	**BD (g/ml)**	**OAC (ml/g)**	**WAC (%)**
B_1	1.36 ± 1.77^{a}	2.03 ± 0.06^{c}	1.40 ± 0.06^{a}
B_2	0.37 ± 0.006^{a}	3.07 ± 0.12^{b}	1.45 ± 0^{b}
B_3	0.42 ± 0.023^{a}	4.0 ± 0.02^{a}	1.65 ± 0^{a}
LSD	2.04	0.15	0.07
CV	141.7	2.47	0.22

Note: BD= Bulk Density, OAC= Oil Absorption Capacity, WAC= Water Absorption capacity, LSD= Least significant difference, CV=Coefficient of variance and B_1, B_2, B_3=Treatment of sample code values within the same column with different superscript letters have significant ($P<0.05$) differences.

4.3 Sensory Evaluation of Dried Banana Powder

Sensory quality is the ultimate measure of product quality and success. Sensory analysis comprises a variety of powerful and sensitive tools to measure human responses to foods and other products. Selection of the appropriate test, test conditions, and data analysis result in reproducible, powerful, and relevant manner. Appropriate application of these tests enables specific product and consumer insights and interpretation of volatile compound analyses to flavor perception. Since temperature has effect on nutritional value, color, aroma, appearance and texture sensory evaluation was conducted on the product produced a temperature 60 ^{0}C, 85 $^{0\ C}$ and 105 ^{0}C of dried banana powder.

Table 4. 3. Sensory Evaluation for Dried Banana Powder

Treatment	Color	Aroma	Appearance	Texture
B_1	4.23 ± 0.11^{a}	3.43 ± 0.06^{ba}	3.17 ± 0.06^{a}	3.3 ± 0.1^{a}
B_2	3.33 ± 0.06^{b}	3.9 ± 0.52^{a}	3.07 ± 0.06^{a}	3.3 ± 0.1^{a}
B_3	2.6 ± 0.1^{c}	3.17 ± 0.06^{b}	3.1 ± 0.1^{a}	3.3 ± 0^{a}
LSD	0.19	0.61	0.15	0.16
CV	2.78	8.68	2.34	2.47

LSD= Least significant difference, CV=Coefficient of variance B_1, B_2, B_3=Treatment of sample code Values within the same column with different superscript letters have significant ($P<0.05$) differences.

❖ **Color**

Color is very significant parameter in judging well oven dried banana powder. It does not only reflect the suitable raw material used for the preparation but also provides information about the formulation and quality of the product (Mepba *et al,* 2007). The mean score of banana powder was decreased from (4.23 to 2.6) because as temperature increase dark in color as table 4.3 shows). This indicates that at 60 ^{o} c of banana powder was acceptable with respect to color.

❖ **Aroma**

The mean aroma score of the was significantly affected by different temperature, the result shows that the aroma score between (3.17-3.9),then this indicates that at 85^{o}C of dried banana powder was better acceptance with respect to other (Prothon, 2003).

❖ **Appreance**

The appearance is also a significant parameter of banana powder, which is significantly affected by variety of temperature. The recorded value was (3.07-3.17), indicates that the higher the recorded value of dried banana powder was better acceptance and the lower recorded value of dried banana powder was lower acceptance.

❖ **Texture**

There is no difference among oven dried banana powder on texture at three different temperatures. Because of the measured value of the sample B1, B2 and B3 = (3.3) were the same. The similarity of the recorded sample value indicates that the absence of significant difference among them.

CHAPTER FIVE

CONCLUSIONS AND RECOMMEDATIONS

Now days in Ethiopia many agro- processing industries are emerging in an alarming rate due to the current opportunity. These industries are initiating the private sector to involve in the area of fruit processing. A study aimed at development of banana powder. The results showed that the operating parameters such as drying temperature affect the powder quality properties significantly. The investigation indicated that increasing the drying temperature within increase yield of banana powder. In general drying temperature affect product quality attributes. The best conditions to produce lower moisture content; higher yield and best quality banana powder were at temperature of 85 °C, as we observed from the investigation.

RECOMMENDATION

Future studies are recommended on:

- Banana powder production by using different drying technology for reducing darkness problem.
- Banana powder production by using value added product (i.e. fortification and the like) in order to increase nutritional composition further.

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APPENDX I: ANOVA TABLE

ANOVA for water absorption capacity of flour

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	1.26	0.21	1.48	<.0001
Error	14	1.99	0.14		
Corrected total	20	3.26			

Significant (P<0.05) differences, DF=Degree of Freedom

ANOVA for Ash analysis of flour

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	26.35	4.39	122.27	<.0001
Error	14	0.5	0.04		
Corrected total	20	26.85			

Significant (P<0.05) differences, DF=Degree of Freedom

APPENDX II: PICTURE

Sliced banana for maceration

dried banana powder

Sensory analysis for dried banana