CHEMICAL AND MICROBIOLOGICAL PROPERTIES OF BANANA FLOUR, AND HYGIENE KNOWLEDGE AND PRACTICE OF PROCESSORS IN MICRO AND SMALL ENTERPRISES: A CASE OF MERU COUNTY OF KENYA

BY
THUMBI FAITH WANJERA
A56/11039/2018

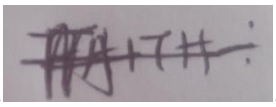
A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE IN FOOD SAFETY AND QUALITY

DEPARTMENT OF FOOD SCIENCE, NUTRITION AND TECHNOLOGY
FACULTY OF AGRICULTURE
UNIVERSITY OF NAIROBI

2020

DECLARATION

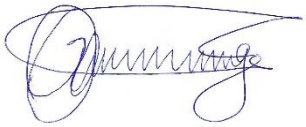
I, Faith Wanjera Thumbi hereby declare that this dissertation is my original work and it has not been presented for an award in any other institution.

Sign…  ……. Date……26/11/2020…….

This dissertation has been submitted for examination with our approval as University supervisors.

Signed  Date: 26/11/2020

Prof. Jasper K. Imungi
Department of Food Science, Nutrition and Technology
University of Nairobi

Signed:  Date: November 27, 2020

Dr. George. O. Abong'
Department of Food Science, Nutrition and Technology
University of Nairobi

UNIVERSITY OF NAIROBI

COLLEGE OF AGRICULTURE AND VETERINARY SCIENCES (CAVS)

PLAGIARISM DECLARATION FORM

Name of Student: Faith Wanjera Thumbi

Registration Number: A56/11039/2018

College: Agriculture and Veterinary Sciences

Faculty: **Agriculture**

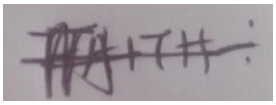
Department: Food Science, Nutrition and Technology

Course: Master of Science in Food Safety and Quality

Title of the work: Chemical and Microbiological Properties of Banana Flour, And Hygiene knowledge and Practises of Processors in Micro and Small enterprises: A Case of Meru county of Kenya

DECLARATION

1. I understand what Plagiarism is and I am aware of the University's policy in this regard
2. I declare that this dissertation is my original work and has not been submitted elsewhere for examination, award of a degree or publication. Where other people's work or my own work has been used, this has properly been acknowledged and referenced in accordance with the University of Nairobi's requirements
3. I have not sought or used the services of any professional agencies to produce this work
4. I have not allowed, and shall not allow anyone to copy my work with the intention of passing it off as his/her own work
5. I understand that any false claim in respect of this work shall result in disciplinary action, in accordance with University Plagiarism Policy

Signature;  **Date 26/11/2020**

ACKNOWLEDGEMENT

First is to thank the Almighty God for guiding and leading me during this journey. Indeed, He has been my Ebenezer.

I wish to pass my sincere gratitude to my Supervisors Prof Jasper K. Imungi and Dr. George O. Abong for sharing their wealth of knowledge, profound technical guidance, constructive criticism and assistance during this study. They spent their time to direct me from proposal writing, data collection and to the final dissertation. I thank the technical staff at Department of Food Science, Nutrition and Technology: Mrs. J. Muchiri and Mrs. E. Cheruiyot for their supervision and guidance while conducting my lab work.

I also pass my regards to all the banana flour processors in the three enterprises who agreed to take part in the study. I also thank my family for their support, prayers and financial aid while undertaking this research.

DEDICATION

I dedicate this work to my father, the late Josephat Kihono Thumbi for the great investment in my academic foundation. I also wish to pass sincere gratitude to my Mother, Beatrice Wanjiru for her support, prayers and selfless sacrifice through this study period.

A special dedication to all my siblings Edward, Margaret, Moses, Suzanne, Nahashon and Anne for their continuous motivation and prayers.

My sincere gratitude to my nephew Julius Mwendwa and niece Jedidah Tei for their thoughtfulness to cheer me on despite their young age.

ACRONYMS AND ABBREVIATIONS

RS - Resistant Starch

MSEs - Micro and Small Enterprises

VRBA - Violet Red Bile Agar

PDA - Potato Dextrose Agar

CFU - Colony Forming Unit

SPSS - Statistical Package for Social Science

GHP - Good Hygiene Practises

GMP - Good Manufacturing Practices

AOAC- Association of Analytical Chemist

ANOVA- Analysis of Variance

GDP- Gross Domestic Product

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

Banana flour processing in Kenya has gained interest among micro and small enterprises due to its nutritional properties, which comprises of high starch content, dietary fiber, rich in carbohydrate, potassium, phosphorous, iron and other food nutrient. However, there is limited information about the processing hygiene practises, chemical composition and microbial status of the flour to characterize its quality. The study was designed to determine level of hygiene knowledge and practices among banana flour processors, and the chemical and microbial quality of the flour. A cross sectional study using self-administered questionnaire was carried out among 30 banana flour processors selected from three Micro and Small enterprises and collected data on sociodemographic and socioeconomic characteristics, hygiene knowledge and practise. Twelve banana samples were collected in Kraft bags from the three enterprises. The samples were analyzed for coliforms, *E.coli*, yeast and molds counts as for chemical analysis parameters evaluated included proximate composition and selected minerals.

Majority of participants in the study were female (66.7%). Most were within age group of 18 to 37years and more than 50% had at least primary level of education. The level of education had significant ($P<0.05$) influence in hygiene knowledge and practise. Socio-economic results revealed most of the processors fall under lower class (76.3%) and few participants (proprietors) were categorized in the upper class (23.7%). Hygiene knowledge scores among the three enterprises: Ewajo, Wedo and Icobo were 80% and 70%, 62.3% whereas hygiene practise scores were 75%, 58.3% 16% for Ewajo, Wedo and Icobo enterprise respectively. The results reveal banana flour processors in Ewajo and Wedo enterprise have satisfactory level of hygiene knowledge and practise whereas processors from Icobo have low level of hygiene knowledge and poor hygienic practises. There is a strong positive association ($r=0.537$, $p=0.002$) between hygiene knowledge and practices among the three banana flour enterprises. Yeast and mold counts in

banana samples from Wedo Enterprise had highest mean count of 7.42 cfu/g whereas Icobo Enterprise had the lowest mean count 4.8cfu/g. Coliform mean count was ranging from 4.09cfu/g to 4.6cfu/g. The level of contamination with *E.coli* in the three enterprises was ranging from 1.04cfu/g to 2.9cfu/g. There was no significance difference ($P>0.05$) in microbial count among the three enterprise. Presence of Coliforms and *E.coli* in the banana sample imply poor hygiene practise in flour processing. The flour is rich in carbohydrate and fiber content ranging from 73.25% to 80.3% and 1.39% to 3.34% respectively. It was also noted a higher moisture content of 15.7% in banana flour from Icobo. Mineral analysis indicated high level of potassium ranging from 707.29mg/100g to 970.25mg/100g.

The study concludes that the level of hygiene knowledge and practise among banana flour processors is adequate in two enterprises whereas one enterprise had low performance. The levels of yeasts and moulds, coliforms and *E.coli* were high above recommended limits for microbiological safety. The levels of potassium were high showing the significant contribution of the flour to the nutrient in the diet. The study recommends food hygiene training to be carried out among the processors in banana flour enterprises for purposes of continuous improvement.

CHAPTER ONE: INTRODUCTION

1.1 Background Information

In developing countries, the food production sector comprises of Micro and Small enterprises who are significant contributors to the national economies. Micro and Small enterprises are essential in job creation and economic development (Mbuthia et al., 2018). Research shows in that they make up for 90% of firms in many countries where they contribute to Gross domestic Product (GDP), industrial development, provide products that meet local demands and on the other hand support large firms with inputs and services (Mwangi, 2016). In Kenya, many micro and small food-processing enterprises have recently been established in response to the Country's Vision 2030 strategy. These enterprises process a diversity of products in various fields of operation, where they strive to market in the existing local and even international markets. Micro and Small Enterprises have shortcoming in terms of providing quality services and products that are in line with the required compliance and regulatory standards. This is because of limited financial access, lack of skilled personnel, incapacity to conduct consistent training and inadequate research capacity (Walker et al., 2002).

Banana (*Musa Spp*) is a type of fruit that grows in the tropic and subtropics area such as Africa, Malaysia and in Indonesia. Banana is an important crop in the Eastern and Central Africa, besides being a key staple food in the region it is an important source of income for farmers (Oo & Win, 2011). Banana is highly perishable in nature and lack of proper technology, storage facilities limit market reach and which has resulted to large postharvest losses in Kenya (Mwangi, 2016). As a way of addressing the postharvest challenge banana is dried and milled into banana flour. Green banana or ripe banana may be used in preparation of banana flour, which can be processed into

different types of foods which include cakes, porridge, bread, mustard, cookies and buns (Bakare et al., 2016). Banana is easily digested therefore incorporated in diets for the infants and the elderly. The level of sodium in banana is low hence it is integrated in diets with low sodium requirement as source of the raw material (Campuzano et al., 2018). Despite the numerous uses of banana flour among the micro and small enterprises matters of good hygiene practise have not been given due priority, the level of hygiene knowledge and practise among the banana flour processors is yet to be established. There is also lack of information about microbial status of banana flour processing, in addition, there is limited research done to evaluate chemical properties of banana flour in Kenya.

The aim of the study was to evaluate sociodemographic and economic characteristic, hygiene knowledge and practices among banana flour processor, the microbial and chemical characteristics of the banana flour production in micro and small enterprises Meru, Kenya.

1.2 Problem Statement

Consumer preference for highly nutritious product has resulted to increase in banana flour production among the micro and small enterprises. Despite the increase in banana flour production there is insufficient information about the status of hygiene knowledge and practices among the banana flour processors. Implementation of good hygiene knowledge and practices remains a great concern among the micro and small enterprises. Banana flour is susceptible to contamination by spoilage microorganism along the food chain; this may ultimately reduce shelf life and affect safety of consumer. In Kenya, there is insufficient information about contaminants in banana flour as limited microbiological research has been undertaken in this area. In addition, proximate composition and mineral profiling in banana flour is yet to be determined. There is no

documentation of the same despite increase in production of banana flour not only in Meru County but also in other Counties with high production of banana such as Kisii County and Nyeri County.

1.3 Justification

In order to produce banana flour that is safe and fit for human consumption there is need to assess the prevailing level of hygiene knowledge and hygiene practises among banana flour producers. In addition to determine level of microbial contamination and chemical characteristics of the flour. This study will enhance the production process through following set standards of hygiene thus will reduce losses due to microbial spoilage. This will consequently gain confidence in consumers, attract more potential investors, and expand the market for banana flour based products. The beneficiary of the study will be the micro and small enterprises involved in banana flour processing through enhanced compliance to good hygiene practise. The information obtained from the study will contribute to formulation of policy concerning safe banana flour production in Kenya.

1.4 Objectives

1.4.1 General Objectives

To assess the chemical and microbiological properties of banana flour processed by micro and small enterprises and hygiene knowledge and practise among banana four processors in Meru County, Kenya

1.4.2 Specific Objective

i. To determine the socio-demographic and socio-economic characteristics of the banana flour processors
ii. To evaluate level of hygiene knowledge and practices among the banana flour processors

iii. To determine the level of microbial contamination in banana flour produced by Micro and Small Enterprises

iv. To determine the proximate composition, sodium and potassium level in banana flour

1.5 Hypothesis

i. Sociodemographic characteristics among processors does not significantly influence level of hygiene knowledge and practise

ii. There is significance difference in level of hygiene knowledge and practices among the Micro Small enterprises banana flour processors

iii. The level of microbial contamination in the banana flour produced by Micro and Small enterprises is above recommended limit

iv. There is significant difference in chemical characteristics in banana flour traded in Meru County Kenya.

CHAPTER TWO: LITERATURE REVIEW

2.1 Global perspective of banana production

Banana (*Musa Spp*) is a type of fruit that grows in the tropic and subtropics areas such as Malaysia, Indonesia and Africa (Rayo et al., 2015). Worldwide banana is grown in 130 countries and production stands at 71million tons (Chah et al., 2012). Countries that are considered among top 10 in banana production include India, Uganda, China, Philippines, Ecuador, Brazil, Indonesia, Colombia, Cameroon and Tanzania (Chah et al., 2012). Banana is ranked fourth after maize, wheat and rice as the world's most valuable crop (Amini et al., 2019). In 2019, the global export of banana was recorded as 20.2 million tones which increased by 5% as compared to 2018 (FAO, 2020). In Eastern and Central Africa, besides banana being a key staple food in the region it is an important source of income for small scale farmers (Oo & Win, 2011).

Banana production faces several challenges such as high incidence of pest and disease, irregular rainfall, soil erosion and unstable market price, this has led to losses and reduced yield (Mbuthia et al., 2018). In Kenya, Tanzania, Uganda, Rwanda and Burundi there has been decline in banana production in the recent past due to disease caused by pest such as banana moth, nematodes, weevils, banana aphids, among others (Chah et al., 2012). Across Africa, the scarcity of high quality seedling affects greatly the expansion of banana cultivation. Naturally, most farmers especially the smallholder farmers depend on regeneration of existing plants to obtain seedling. This process is slow therefore quite often does not yield the required amount of naturally generated suckers therefore affects the final yield (Genitha , 2014).

2.1.1 Banana production and consumption patterns in Kenya

In Kenya, an annual estimated banana production is 1.1 million metric tons where 60% is cooking variety (plantains) and 40% dessert variety (Cavendish) (FAO, 2014). Different varieties of banana exist that include Cavendish, Apple, Uganda green, Muraru. The dessert type has more demand especially in urban and peri-urban markets as compared to cooking banana varieties. The leading banana producing regions include Meru County (19%), Kirinyaga County (14%) Embu County (12%), Taita taveta County (9%), Muranga County (7%) Kisii County (5%) and Bungoma County (5%) (FAO, 2014). Banana plantation has recently replaced coffee plantation in eastern, and central region of Kenya (Mbuthia et al., 2018). Banana farming is mainly carried out by small scale farmers who are mainly women, it has also been observed that the production is gradually changing from subsistence farming to cash crop farming for small scale farmer with potential to penetrate higher value markets (Mwangi, 2016). Global climate change has affected patterns of production of various crops, as it is characterized by reduced rainfall, at times unpredictable rainfall and prolonged drought (Chah et al., 2012). This has affected food security especially for household depending subsistence farming. Banana is considered to be a crop that may aid in solving food insecurity issues (Dotto et al., 2018). If there were adequate production planning process, availability of seedling, water reservoir among other required factors then this would ensure availability of banana throughout all seasons (Chah et al., 2012).

Common forms of consumption of banana at household level include fried, boiled, roasted or pottage for green banana whereas ripe banana may be consumed in raw or fried form (Tshiunza, et al., 2001). Banana in other cases is further processed into flour, banana juice and beer (Ekesa et al., 2012). In Kenya, there is high demand for banana both in the rural and urban areas because it is a low cost staple food that is a good source of carbohydrate, mineral and vitamins (Mbuthia

et al., 2018). Counties in Kenya that are thriving in banana production are depended on to supply to most Counties that do not carry out banana production such as Mombasa, Nairobi, Laikipia, Nyandarua, Isiolo among others. For instance, Nairobi county provides ready market since it has a population of over four million, it is Projected as from 2030-2040 urban population will steadily increase thus leading to more demand (Mbuthia et al., 2018).

2.2 Banana Flour Processing and Utilization

2.2.1 Banana flour processing

The green unripe banana, plantain or cooking banana can be used for preparing flour (Daniela et al., 2015). The flour production begins by first prewashing the banana, and then the bananas are hand-peeled and sliced into pieces (5-10 mm thick) using a plantain cutter (Onwuka et al., 2015). Banana slices are then pretreated in acidic solution (citric acid), pretreated banana slices are spread out on mats or bamboo framework on a roof or iron sheets for drying by sun or solar dryer (Abiodun & Falade, 2011). In other cases, oven drying is utilized basing on availability of electricity. Most small-scale processors use sun drying or solar drying as compared to oven drying due to the high cost of electricity (Ahmed et al.,2015). The slices are then dried for 24 to 48hours when sunny and 48 to 72hours or more in a cold or wet season (Ahmed et al., 2015). Once dry, the dried slices are milled into flour; it is then sieved and packed in required quantities in Kraft packaging bags. The method for banana flour processing is outlined in Figure 2.1 (Genitha , 2014).

2.2.2 Banana utilization

Banana flour can be utilized as an ingredient in preparation of different types of foods such as bread, cakes, cookies, buns, custard porridge flour (Bakare et al., 2016). In the baking sectors banana flour has caught attention due to it gluten free property and low glycemic index (Amini et al., 2019). Banana flour is also used for thickening of soups due to the high starch component and

it is also combined with other flours for fortification purposes (Tshiunza et al., 2001). It is incorporated in diets such as for the infants and the elderly to supplement for protein. In addition, the vegetarians have also benefited as banana flour is used to prepare banana custard (Tshiunza et al., 2001). The level of sodium in banana is low hence it is incorporated in low sodium diets as a ready source of raw material (Campuzano et al., 2018).

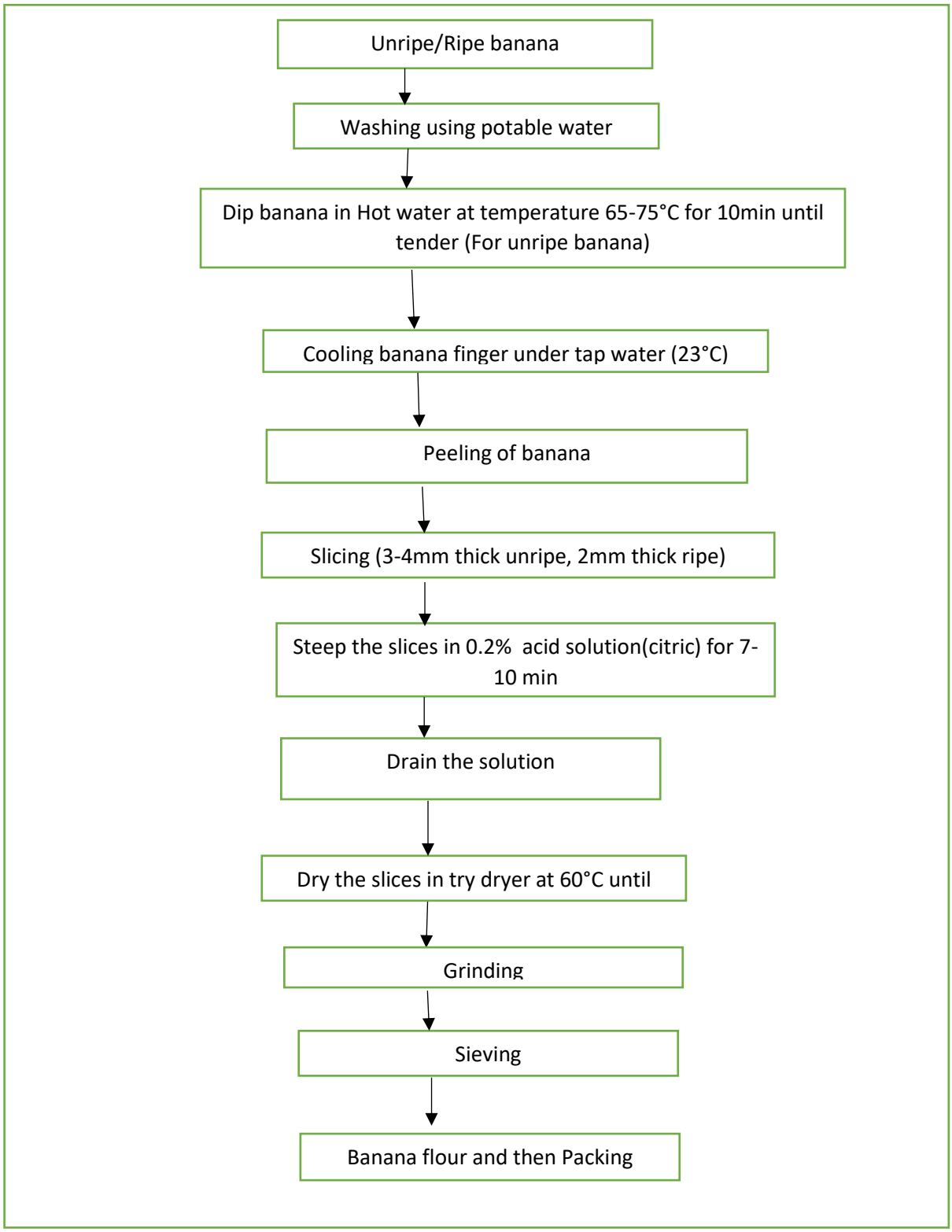


Figure 2.1: Flow chart of banana flour processing

2.3 Methods of Banana Pretreatment and Preservation

2.3.1 Pretreatment of banana

Common pretreatment methods applied include blanching, solution of salt, dip with honey, acid such as ascorbic, citric acid, sulfuring among others (Demirel & Turhan, 2003). It is essential to pretreat fruits before drying as it enhances the process and gives it better results (Dandamrongrak et al., 2003). The process of pretreating prevents fruits that are of light color from becoming dark as result of enzymatic activities (Dandamrongrak et al., 2003). This may usually occur while at drying stage and storage. Pretreatment quickens the drying process of sliced banana pieces (Bakare et al., 2016). This also reduces the effects on quality features of the banana by drying process. Research study on pretreatment process has indicated that use of acidic solution and dip of sodium metabisulfite for pretreatment is effective in destroying pathogenic microorganism such as *E.coli*, Salmonella and *Listeria monocytogenes* (Derrickson et al., 2005) .

2.3.2 Banana drying process

The high moisture content in fresh fruits make them highly susceptible to microbial contamination therefore drying act as method of preservation (Ntuli et al., 2017). Drying is a rigorous energy unit process that aids in lowering moisture content in foods to minimal level in order to prevent spoilage by microorganism such as bacteria, yeast and mold (Kendall & Sofos, 2003). Different drying techniques are used such as solar and sun drying method, spray and drum method, oven method, bed-drying method among others (Ahmed et al., 2015). The principle applied by most of the techniques mentioned is passage of hot air over the products to facilitate proper drying (Maisnam et al., 2015). Solar and sun drying methods is mainly used banana drying at household level and among the micro and small enterprises. Whereas commercially, banana is dried using various methods such as spray drying, or drum-drying, foam and oven drying (Maisnam et al., 2015).

Fruits are made up of high sugar, and high acid content (Kendall & Sofos, 2003). This quality features in fruit therefore make them suitable for drying in sun (Ahmed et al., 2015). On the other hand, certain food such as meat and vegetable are not suitable for sun drying. Vegetables are low in sugar and acid whereas meat contains high protein (Bhila et al., 2010). The high protein content creates a conducive environment for microbial growth, especially in the case when heat and humidity is not controlled therefore rises chances of susceptibility to food spoilage (Bhila et al., 2010).

2.3.2.1 Solar drying

Solar drying method is dependent on sun as source of heat to facilitate the drying process, it is classified into direct and indirect method (Vijayavenkataraman et al., 2012). Direct method is the solar drying process where fruits are exposed in open sun for several days to achieve required moisture content as shown in figure 2.2 (Demirel & Turhan, 2003). Whereas indirect method is the process where produce is dried by air flow that has been heated through solar radiation, this usually occurs in an enclosed space as shown in the figure 2.3 (Maisnam et al., 2015). The types of solar dryer include chimney type, wind ventilated and chamber solar dryer. Solar drying requires favorable condition such as when the sun is hot, humidity to be below 60%, and high temperatures (Vijayavenkataraman et al., 2012). The challenge with sun drying is that it may take a couple of days (2-5 days) for fruits to dry because weather pattern is unpredictable, other set back include exposure to dust, infestation of insects, deterioration of quality features. Therefore, indirect solar drying method is preferred (Abiodun & Falade, 2011).

Solar dryer can be made up of simply wooden box and polythene sheets (1m-2m), other categories include cabinet driers, tent driers and driers with preheating chambers (Maisnam et al., 2015). Material used in sun drying include trays of screen or wooden dowels. Fruits are placed directly

on trays therefore suitable drying materials should be used such as: stainless steel, coated fiberglass or plastic (Demirel & Turhan, 2003). Screens made from hard white cloth should be avoided as it may contain heavy metal such as cadmium or zinc since this material may be oxidize and release harmful residues on the food (Demirel & Turhan, 2003). Preferable material for outdoor sun drying of produce is wood. However not all wood can be used to make the rack for instance green wood and pine cedar, as wood traps and stains dried produce which may end up causing off flavor (Osunde, 2015). The trays are placed in block format to allow for air movement around the drying. The trays ought to be covered with cheesecloth to prevent destruction by birds or insect (Abiodun & Falade, 2011). During the night the drying produce is brought under a shelter, to avoid cool night air that condenses from making the food moist once again thus may affect the drying process (Osunde, 2015).

Figure 2.2: Open Sun Drying of banana (Direct Solar Method)

Figure 2.3: Solar drying of banana (Indirect Solar Drying)

2.4 Nutritional Value of banana

Banana has high starch content, rich in carbohydrate, resistant starch, potassium, calcium, phosphorous and iron. In food production starch is used as food additive serving as texturizers, stabilizers thickeners therefore banana starch is considered an unconventional source of starch (Tshiunza et al., 2001). Banana contains assimilable sugars in large amount that can be a suitable source of energy and thus appropriate for boosting sugar levels this make it appropriate for consumption by for athletes after exercising (Bakare et al., 2016). Banana is easy to digest hence suitable for infant consumption. Fiber content in banana aid in bowel movement and facilitates digestion process, potassium helps in regulating blood pressure. (Dotto et al., 2018).

Green banana (plantain) is made up of resistant starch type two (RSII) which aids in disease prevention such as diabetic, it has cholesterol lowering capability, modulation of glycemic index and weight management (Amini et al., 2019). The resistance starch acts as dietary fiber therefore improves digestion by hydrolyzing enzymes in the stomach. Resistance starch (RSII) is broken down into short chain fatty acids and as a result it raises pH level of large intestine which creates adverse condition for pathogenic bacteria (Yang, 2015). On the other hand, this favors the growth

of beneficial bacteria. It also promotes colon health as it increases fecal bulk and acts as rehydrating agent in cases of diarrhea. It enables slow digestion of blood glucose and insulin level (Dotto et al., 2019).

The high level of antioxidant activity is associated with the phenolic compound in banana pulp and peel which contributes to enrichment of products because of great nutrients content (Campuzano et al., 2018). They release biological effects that promote growth of probiotics. This aids in prevention of cancer and cardiac disease (Amini et al., 2019).

2.4.1 Proximate Composition Analysis

Proximate composition of food and feed consist of following parameters: moisture, ash, lipid, crude protein, crude fiber and carbohydrate (Dotto et al., 2019). It is an analysis used to used to determine closely related group of food components. Analyses used may be rapid methods for QC on the other hand more accurate standard method of association official analytical method (AOAC) (Hayder, 2016).The specific AOAC methods include 925.10 method for moisture content, 920.86 for fiber content, 920.87 method for protein, 923.03 method for ash and the difference was calculated to attain the carbohydrate content. In the food industry, this analysis is essential because it is able to evaluate the value of macronutrient in food sample, where the values obtained are reflected in the label for the final product to inform the consumer when purchasing (Odenigbo, 2013).

2.5 Microorganisms Associated with Banana Flour processing

Microorganism can affect food at any stage of the value chain for instance in banana flour production it can occur at stage of farm level due to contaminated soil, harvesting, preparation, processing and storage (Ajayi & State, 2016). In most cases, the banana flour contamination arise due to poor post-harvest handling practises. The quality of processed foods and processing

environment among other factors are assessed based on the presence and levels of indicator microorganism (Rose-monde et al., 2013). Microbial indicator microorganisms are useful in providing evidence of lack of adherence to hygiene practices and sanitary food quality. They include mainly total aerobic mesophilic bacteria, *E.coli*, total coliforms, Enterobacteriaceae, and *S. aureus* (Alum et al., 2016).

Contamination of foods by coliforms and *E.coli* may occur due to poor hygiene practices, inadequate heat treatment and post processing contamination. Coliforms and *E.coli* are consistent indicators of fecal contamination in water and food and poor hygiene in food processing environment (Dun-dery & Addo, 2016). Most strains of *E.coli* are harmless, however, there exist pathogenic strains for instance *E.coli* 0157:H7, 0104:H4 and 0121 which may release toxin that can cause food borne illness upon consumption (Alum et al., 2016). Modes of transmission of *E.coli* into food include through cross contamination from personnel, food contact surfaces or by contaminated water or presence in fresh foods produce (Sylvia et al., 2015).

Some microbes are able to grow and survive in aerobic conditions such microorganism may be grouped as aerobic mesophilic which comprise of total viable count , yeast and mold also fall under this category (Alum et al., 2016). The total viable count shows effectiveness of hygiene procedure. Occurrence of high total count in food usually results to reduced shelf life and spoilage. Yeast and molds presence in food are known to cause reduced shelf life, develop off flavors of food during storage (Waré et al., 2018) . In banana flour production lack of proper drying could results to accumulation of moisture content. Hence, this provide a conducive environment for the growth of molds such as *Aspergillus, Penicillium, Fusarium*. The species of this mold produce mycotoxin that is harmful to consumer upon consumption of the flour (Gacheru et al., 2016) .

Fungi can also serve as potential source of food contamination when they adhere to food preparation surface and rapidly grow hence cause contamination (Gacheru et al., 2016).

Enterobacteriaceae are widespread in environment, therefore they can easily contaminate food during processing and handling (Aruwa et al., 2017).Enterobacteriaceae are considered as comprising of gram negative, non-spore forming bacteria and are considered as other food quality indicators. Family Enterobacteriaceae include important food pathogen such as *Yersinia*, *Salmonella*, *E.coli*, *Shigella*, *Cronobacter* spp, *Klebsiella* among others (Alum et al., 2016).The existence of Enterobacteriaceae in food is associated with poor practise of personal hygiene, poor food handling practices, and inefficient heat treatment and cross contamination in food contact surfaces and from equipment (Waré et al., 2018).

2.5.1 Analytical Method for Microbiological flour testing

There is a wide range of microorganism of interest in microbiological quality assessment of flour testing, some that are indicator microorganism others are pathogenic origin. Several techniques are utilized in microbiological assessment of flour which include pour plate and spread plate method

a) Pour plate method

This is a technique used to assay the level of microbial load in foodstuff and it used to determine the number of microbe/ml in specimen (Aruwa & Ogundare, 2017). In pour plate, a given amount of inoculum (1ml) is added to a petri-dish, and then molten agar is added to the sample (Sanders, 2012). The lid of petri-dish is placed and in circular motions, the plates are rotated to achieve an even distribution of microorganism. Pour plate is a suitable method for counting colony-forming units in liquid specimen. In addition, it is preferred over spread plate since distinct colonies are

obtained. A limitation of this method is the loss of heat sensitive microbes when they get in contact with hot agar. It is also difficult to count the embedded colonies that are on the surface and are normally smaller (Sanders, 2012).

b) Spread Plate method

It is a technique, which involves isolation and enumeration of microorganism in mixed culture and screening experiments (Hartman, 2011). In this given method, the technique used is the introduction of an inoculum onto a solidified agar on a plate then spreading the sample using a sterile glass spreader while evenly rotating (Ajayi & State, 2016). The plates are then incubated for the required period (24-72hours) depending on the microorganism being targeted based on the standard operation procedure. Spread plate is used for viable plate count where the total number of Colony Forming Units(CFU) in single plate is enumerated (Hartman, 2011). In addition is it applied in calculating concentration of cells in the tube from which sample was plated. The limitation of the technique is that colonies tend to crowd thus makes enumeration difficult (Alum et al., 2016).

2.6 Sources of Microbial Contamination in Food Processing Operations

Vectors of food contamination include food handlers, surfaces, processing conditions, water, packing materials, air, and equipment in the food processing firms (Alum et al., 2016). Presence of microbial hazards in food may result to deterioration in food quality, reduced shelf life and food borne illness incidences (Rose-monde et al., 2013). Foods can be contaminated with microorganism during processing through contaminated surfaces, use of contaminated water, food handling personnel, packaging material and environment (Sylvia et al., 2015).

Contaminated equipment and food preparation surfaces is a sign of risk factor in processing which may result in contamination of food (Akabanda et al., 2017). This majorly arises from ineffective cleaning and sanitation of equipment and other food preparation surfaces, which leads to increase in microbial load in food during processing. Cleaning and sanitation is important in minimizing microbial food contamination at all food processing stage (Nee & Sani, 2011).

In the food industry, water is essential component as it may be used in the preparation of food items or processing aid for cleaning of utensils, equipment, surfaces and hands. High Microbial load in water can contaminate food contact surfaces, personnel hands and foods (Sharif et al., 2013). It is therefore essential to verify the quality of water used in food preparation. Assessment of water quality should be done based on sources of water, method of treatment and also checking certificate of analysis for the microbial and chemical parameters if they are within acceptable limits (Malavi, 2017).

Food handlers can act as vectors of potential pathogen which include *E.coli,* S.*enterica* and *S. aureus* (Rose-monde et al., 2013). At times food handlers spread pathogen either directly or indirectly by means of protective clothing while in preparation, cross-contamination from hands to food contact surfaces. Hands represent an important vehicle for transmission of fecal and oral respiratory microorganism (Sultana et al., 2016). Inappropriate food handling practises and poor personal hygiene such as lack of washing of hands before preparation of food, spitting, chewing and tasting of food may result to food contamination along processing line (Kubde et al., 2015).

Floors are source of food contamination as they easily transfer microorganism to shoes worn by food handling personnel (Malavi et al., 2018). Through personnel movement in and out of the factory, microorganism will end up circulating to various areas of food preparation (Kubde et al., 2015). Floors can also transfer contamination to other area such as storage, holding pallets, plastic

crates and refrigerators. If cleaning and sanitation is not done appropriately, floors and drains may provide a conducive environment for growth of microorganism (Akabanda et al., 2017).

2.7 Hygiene Knowledge and Practices of Food Handlers

Food hygiene knowledge and hygiene practices is a subject that covers a broad scope. It describes all conditions and measures necessary to ensure the safety and suitability of food at all stages in the food chain (Kubde et al., 2015). Hygiene practices applied in the food industries cover areas of hand washing, food handling, waste management, use of sanitizers and disinfectant, regular medical check-up and use of hand gloves among others (Dun-dery & Addo, 2016). It is evident poor hygiene practise may lead to food poisoning and food borne outbreaks in food establishment (Nnebue et al., 2014). Hands are one of the main methods of transferring microorganism, therefore proper hand washing is one of the mechanisms of reducing food contamination, food handler are required to wash hands before handling food, in between handling raw and cooked foods, after visiting the restroom, when moving from one production area to another and after handling cleaning chemicals. A food industry should therefore have several washing points to facilitate efficient hand washing. Personal protective equipment such as gloves, hairnets, aprons or dust coats, safety shoes and face masks should be provided for food handler while at work so as to reduce the risk of exposure to food contamination (Nnebue et al., 2014). Proper waste management should be adhered to in a food firms by provision of several waste bins for different type of waste such as plastic, environment waste, recyclable, and hazardous waste. The waste bin should be well covered to prevent attracting insect such as flies or rodents which may also be vehicles of transmission of pathogenic microorganism (Dun-dery & Addo, 2016).

One of the factors influencing hygiene practices is the level of training on hygiene knowledge and practices. Equipping food handlers with comprehensive information and knowledge on food safety

and hygiene practices has an impact on food quality (Sultana et al., 2016). Previous research studies have shown that educated and trained food handling personnel are conversant with proper food hygiene knowledge and hygiene practices (Sharif et al., 2013). On the other hand studies have revealed that food handlers with poor hygiene and lack of awareness do not apply appropriate food handling practices as demonstrated by results of an intensive observation and microbial quality assessment of food (Kubde et al., 2015). It has also been noted in order to reduce the reluctance of food handlers the training should be conducted frequently and follow up internal audits to ensure application of acquired knowledge (Sultana et al., 2016).

2.8 Micro and Small Enterprises in Kenya

2.8.1 Classification of Micro and Small Enterprises

Micro and Small enterprises classification vary from country to country since it is mainly dependent on economic structure of individual countries. In the Kenyan Act of 2012 for Micro and Small Enterprises, it stipulates the regulatory and institutional framework which is based on number of employees, on annual turnover, registered capital and investment in the plant and available machinery (Indrawati, 2018). As for Micro enterprises, the Act states classification as follows: number of employees is to be less than ten, the annual turnover to be less than 4,609.2USD and plant investment to be less than 92,174USD. On the other hand, Small enterprises is categorized as follows: have 10 to 50 employees, annual turnover ranging from 4,609.2USD to 46,146USD and plant investment ranging from 46,146USD to 92,174USD.

2.8.2 Challenges to Adoption of Good Hygiene Practise and Good Manufacturing practise in Micro and Small Enterprises

Ensuring food safety through application of Good Hygiene Practise (GHP) and Good Manufacturing Practises in food processing is an essential regulatory mechanism (Walker et al.,

2002). This enhances the food production process by reducing or eliminating hazards: physical, biological and chemical hazards. However, it has been reported in previous research that among Micro and Small enterprises they have difficulty in complying to GHP and GMP, few number of the enterprises have the required food safety standards certification in place (Marais et al., 2007). Challenges that hinder implementation of food safety requirements such as HACCP, GHP and GMP in micro and small enterprise include financial constraints, lack of skilled personnel, and lack of management commitment (Rotaru et al., 2005). Ultimately, this challenges cause comprise on implementation of food safety and thus may lead to transmission food borne illness. Financial constraints may range from complication in loan application, high interest rates, lack of guarantee, difficult in obtaining assistance incentives from government and other agencies(Walker et al., 2002) . This limits the enterprises from investing in food safety matters such as training, proper machinery, testing to verify safety of product or capacity to conduct research (Hasnan et al., 2014). Most large enterprises have established laboratory or partners therefore they are able to conduct continuous quality assessment of product and undertake research to acquire new insights and innovation (Grace, 2017). Human resource is another challenge among micro and small enterprises where they lack skilled personnel, which is evident by having seasonal employees, rotation of employees in different tasks thus lack specialization and expertise (Hasnan et al., 2014). Hence may have limited knowledge and resources to identify microbial or chemical hazard, which may pause risk of food contamination in the food preparation process. In addition, most employees fail to embrace good hygiene practise due to lack of training and motivation (Marais et al., 2007). It has also been reported lack of management commitment is one of the barriers to adoption of food safety requirements and good hygiene practises (Walker et al., 2002). They are reluctant in implementation because of perception it is expensive, the returns are low as compared to the

investment made (Valeeva et al., 2004). Food safety is only of importance upon occurrence of foodborne outbreak that is when final product testing is done which is contrary to required guideline of continuous assessment of a product through the value chain (Valeeva et al., 2004). These challenges can be addressed by aid of external parties such as government agencies, food inspectors and regulators, and consumer demand for safe products (Grace, 2017).

CHAPTER THREE: STUDY DESIGN AND METHODOLOGY

3.1 Study Design

The study adopted descriptive and analytical cross-sectional design, which was conducted from May to August 2019. The descriptive component involved a survey using semi-structured questionnaire to establish the sociodemographic and socio-economic characteristics, hygiene knowledge and practises among the banana flour processors. The analytical components involved laboratory analysis to determine the microbiological status and chemical properties of banana flour.

3.2 Methodology

3.2.1 Study setting

The study was carried out in Meru County Kenya, which is made up of nine constituencies they include North Imenti, Igembe South, Tiganoa west Igembe central, Igembe North, Tigania East, Buuri, South imenti. It covers an area of 6936 square kilometers. The population estimated to be 1,365,301 as per Kenya Bureau of Statistics (2009). The specific constituencies in which study was conducted are North Imenti, Central Imenti and South Imenti. This County was selected based on the high production of banana flour among other products such as arrow root leaves, moringa leaves, pumpkin seeds which are dried to make flour. Drying of products is one of the key methods used to reduce post-harvest losses.

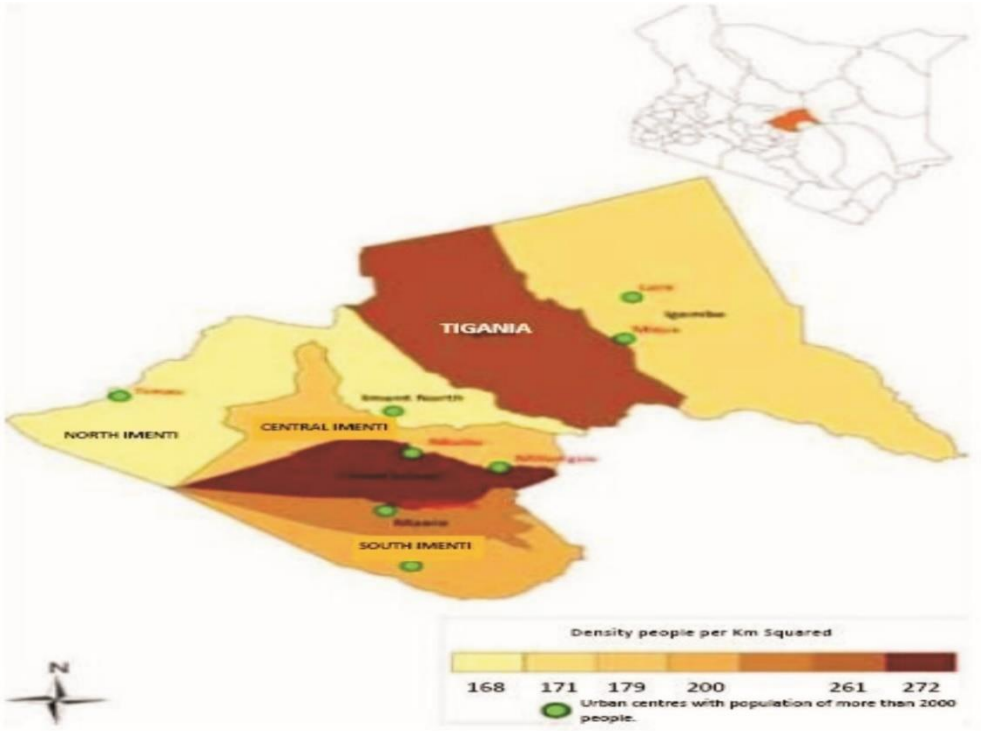


Figure 3.1: Study Site: Map of Meru County, Kenya

Source Google Maps (2020)

3.2.2 Sample Size Determination

Adjusted Fischer *et al* 1999 was used in determine the sample size for respondents (Jung, 2014).

$$N = \frac{Z^2 pq}{d^2}$$

Where N is the required sample size

Z^2 is the normal standard variation at 95% confidence Interval

p =expected proportion of the population

q = expected proportion of the population not

d = acceptable sampling error

$$N = \frac{1.96*0.5*0.5}{0.05^2}$$

N= 384.16

Since the sample size is bigger than the population, a finite correction factor is applied

$$n_a = \frac{n_r}{1+ (n_r -1)/N}$$

n_a = adjusted sample size

n_r =original required sample size

n= refers to the population size

$$n_a = \frac{384.16}{1+ (384.16 -1)/33}$$

n_a= 30 banana flour processors

3.2.2.1 Study Population

The population included thirty banana flour processors selected from three micro and small enterprises dealing with banana flour production. An enterprise with processors less than 10 was considered Micro enterprise; on the other hand, enterprise with more than 10 and less than 50 processors was considered small enterprise. In this given study, two enterprises were categorized as micro and one enterprise was small.

3.2.3 Sampling procedure

Purposive sampling was used to select Meru as the study area due to the high production of banana. Participation of all producers was upon consent to be included in the study (Appendix 1). Exhaustive sampling procedure was employed to select all processors in the three enterprises dealing with banana flour production. Simple random sampling procedure was used to select the samples collected for microbiological and chemical analysis from banana flour enterprises.

3.2.4 Data collection tools

3.2.4.1 Data collection of sociodemographic and socioeconomic characteristics, hygiene knowledge and practises of banana flour processors

Interviews were conducted using a previously pretested structured questionnaire prepared to determine socio-demographic and socioeconomic characteristics, hygiene knowledge and practices among all banana flour processors who participated in the study. The questionnaire was divided into three sections (Appendix 2). The first section of socio-demographic captured age, gender, education, marital status, socio-economic status, medical clearance and training. The second section included 22 questions which covered respondent's hygiene knowledge on food borne pathogen, temperature control, food borne illness, proper sanitation and personal hygiene whose choices being yes, no and do not know. The last section of the questionnaire consisted of 15 questions of hygiene practices in hand washing, cleaning and sanitation, protective clothing and personal hygiene practise with options of yes and no. To confirm accuracy of the responses, face-to-face interview were undertaken.

3.2.4.2 Collection of banana flour samples for chemical and microbiological analysis

Samples were collected based on their availability therefore ensuring exhaustive sampling. Banana samples were collected from the three enterprises: Ewajo, Icobo and Wedo. Twelve Samples for microbial analysis were collected from each enterprise at four different stages of the production process, which included fresh sliced banana, semi-dried, dried banana slices and banana flour. Whereas for chemical analysis only banana flour samples (six) were collected from batches produced from May to August 2019 therefore ensuring exhaustive sampling. In sterile Kraft bags, the samples were placed in cold box and transported to the Department of Food Science, Nutrition

and Technology laboratory, Upper Kabete Campus, University of Nairobi for microbiological and chemical analysis.

3.3Analytical Methods

3.3.1 Determination of microbial load

Sample preparation, Microbial analysis and Enumeration

Each Sample (25g) was weighed and homogenized with 225ml normal saline to prepare stock solution (10^{-1}). Then 1ml of stock solution was dispensed into 9ml of normal saline to make 10^{-2} dilution, the same procedure was applied to obtain 10^{-5}dilution. Aliquots of 1ml were dispensed in sterile plates and respective media were added to each plate. Plating was carried out in duplicates. Enumeration was done for plates with 30-300 colonies. All microbial counts were expressed as Log_{10} CFU/g for banana samples.

3.3.2 Determination of *E.coli*

The presence of *E.coli* was determined by pour plate technique, 1ml of each sample was dispensed into sterile plate and Hichrome (HC) media was added. After solidifying, the plates were inverted and incubated at 37 ºC for 24 hours as described by (Sylvia et al., 2015). Dark blue colonies were counted as *E.coli* colonies.

3.3.3 Determination of Coliforms

Coliforms were determined using pour plate technique as described by (Sylvia et al., 2015). Violet Red Bile Agar (VRBA) was used in detection of coliforms plates were incubated at 37 ºC for 24hours. Characteristic pink colonies were counted as member of coliform bacteria in CFU/g.

3.3.4 Determination of Yeast and molds

Yeast and molds were determined using pour plate technique. Potato dextrose Agar (PDA) supplemented with chloramphenicol (2%) was used in determination and plates were incubated at 25ºC for 48-72 hours as described by (Ajayi & State, 2016).

3.3.5 Determination of proximate composition of banana flour

Proximate composition of banana flour was determined according to AOAC methods (Hayder, 2016). The banana flour samples was analyzed for proximate analysis in triplicates. Moisture content was determined by drying 5g of the sample in an oven at 105℃ in order to achieve a constant weight. Determination of ash content was carried out by incinerating 5g of the sample in an oven at 525℃.The difference was calculated to attain the weight of the ash. Crude fiber was determined by the Wendo method. Crude protein was determined by Kjeldahl method. Crude fat was quantified by Soxhlet extraction method. Carbohydrate was calculated by difference.

3.3.6 Determination of sodium and potassium content banana flour

The selected mineral: potassium and sodium content was evaluated as described by (Joshi & Varma, 2015). Banana flour (10g) was weighed using ceramic crucible and placed in a furnace overnight and ashed at 500℃. HNO3 (10%) was used to dissolve ash obtained and to ensure complete dissolution of ash residue the solution was boiled. It was allowed to cool and filtered into volumetric flask; distilled water was added to the filtrate up to the required mark. The atomic absorption spectroscopy was used to obtain readings.

3.4 Data Analysis

a) To determine the socio-demographic and socioeconomic characteristics, hygiene knowledge and practises of the banana flour processors

The statistical analysis was carried out using Statistical Package for Social Sciences (SPSS Version 20). Frequencies and descriptive statistics were used to summarize socio-demographic data. All hygiene knowledge responses were categorized as either correct or incorrect. Each correct answer was awarded one point while incorrect answer was not awarded any point (0). Knowledge attributes were all aggregated by summing up all the correct answers to have a single summarized statistic. The minimum score to be zero or one and a maximum of 22. The data was classified by using less than 50^{th} percentile (<11) as less knowledgeable and above 50^{th} percentile (>=11) more knowledgeable. Similarly, one point was awarded for each appropriate hygiene practice while inappropriate hygienic practice was not awarded any point. All correct scores for hygiene knowledge and practices for each respondent were summed, calculated as percentage frequencies. Selected socio-demography variables: gender, age group and education level were subjected in one-way ANOVA to compare mean scores for hygiene knowledge and practice among respondents in three-banana flour enterprise. Association of the two study components: hygiene knowledge and practice was assessed by Pearson correlation.

b) To determine the level of microbial contamination in banana flour processing

Coliforms, *E.coli*, yeast and molds counts were converted into $\log_{10}$ CFU units in Microsoft Excel. The data was then transferred into SPSS (version 20) for analysis. Duplicate sample were subjected to analysis of variance and fishers test was used to determine statistical difference in microbial counts among samples at a preset p-value of 0.0.5. Results were tabulated with means and standard deviation to show level of microbial contamination.

c) To determine the chemical composition in banana flour

The chemical analysis data was analyzed in SPPS (version 20). The proximate composition and mineral concentration of banana flour was analyzed using one way analysis of variance (ANOVA). Fisher's exact test was used to determine significance difference ($P< 0.05$) between means. Data was expressed as means ± standard deviation for triplicate analysis.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Socio-demographic and Socio-economic Characteristic of Banana Flour Processors

A summary of socio-demographic and socio-economic characteristics is outlined in Table 4.1. Thirty respondents from three-banana flour processing Micro and Small Enterprises (MSE) were sampled from Meru County. Out of the 30 participants;8 (26.7%), 12 (40%) and 10(33.3%) were specifically from Wedo, Icobo, and Ewajo Enterprises respectively. This study comprised of 33.3% male, Icobo Enterprise had highest number of male (50%) whereas Ewajo Enterprise and Wedo enterprise had 20% and 25% respectively. Majority of respondents were females (66.7%) with Ewajo Enterprise recording highest females (80%) while Wedo Enterprise had lowest (25%). The ratio of females to males (20:10) respondents was not statistically different (P>0.05.Women are mostly involved in the banana drying processing as it is primarily source of income and also means for provision of food at household level in order to sustain livelihoods. In addition, bananas are dried as way of food preservation thus addressing matters of post-harvest losses. Similar finding from previous study reported majority of food handlers (91.9%) were women (Aluko et al., 2014).

Most of the respondents in the three enterprise: Wedo (62%), Icobo (50%) and Ewajo (80%) fall under youth category (18 to 37 years) as reported in this study. In Kenya, the current state of unemployment has led many youth to engage in business ventures to earn a living (Hope, 2012). The present finding concurred with study by (Aluko et al., 2014) who reported majority of food handlers (75%) were with age group (20 to 30 years). Half of respondents (50%) in both Wedo and Ewajo Enterprise had attained secondary level of education as compared to Icobo enterprise from whom majority of processors (58.3%) had attained primary education .Whereas less than a half of participants in Wedo (37.3%,), Icobo (16.7%,)and Ewajo (30%) had attained tertiary

education. The level of education among banana flour processors may attribute to the level of hygiene knowledge and practise. Contrary to present findings, a study by (Malavi, 2017) reported most of respondents (57.1%) to have attained tertiary education.

Most of respondents (90%) were employees of banana processing while the least 10% were proprietors. Concerning socio-economic status, most of the respondents (76.3%) were classified under lower class whereas only the proprietors (23.7%) were classified under upper class. Although there is no statistical significant difference among all socio-demographic characteristic, there is significant statistical difference ($P<0.05$) within socio-economic status, revealing that majority of respondents are of lower economic status.

Out the 30 banana flour processors only 10 (33.3%) had health certificates from Government Public health Department**.** Ewajo enterprise had the highest number of employees who had health certificate, however it was not statistically significant ($P>0.05$) among the enterprises. Medical examination and clearance is an important aspect in profiling the health status of food processors. This is to ensure that only healthy individuals are involved in food handling. However, in this case few respondents from the three enterprises undertook clearance. According to findings from a previous study the results showed relatively low number of employees (30%) having undertaken medical examination (Aruwa et al., 2017). Approximately less than half of participants 46.7% had undergone hygiene training. Ewajo had highest number of processors (70%) having undergone training as compared to Wedo (22%) and Icobo (8%). Micro and small enterprises experience several challenges in adopting training into their daily operations this due to financial constraints, lack of commitment from management and lack of motivation of employees thus hinders effectiveness of good manufacturing practise and good hygiene practise (Walker et al., 2002).

Table 4. 1: Socio-Demographic and Socio-economic Characteristics of the Respondents

Variable	Category	Wedo Enterprise n (%)	Icobo Enterprise n (%)	Ewajo Enterprise n (%)	P-value
Gender	Male	2(25.0)	6(50.0)	2(20)	0.344
	Female	2(25.0)	6(50.0)	8(80)	
Marital Status	Married	4(50.0)	8(66.7)	7(70.0)	0.228
	Widowed	2(25.0)	0(0.0)	2(20.0)	
	Separated	2(25.0)	4(33.3)	1(10.0)	
Educational level	College	3(37.5)	2(16.7)	3(30)	0.469
	Completed Secondary	4(50.0)	3(25.0)	5(50.0)	
	Completed primary	1(12.5)	7(58.3)	2(20.2)	
Age	18-27	2(25.0)	4(33.3)	5(50.0)	0.3160
	28-37	3(37.50)	2(16.7)	3(30.0)	
	38-47	1(12.5)	2(16.7)		
	48-57	2(25.0)	4(33.3)	2(20.)	
Socio-economic status	Upper class	1(12.5)	1(8.3)	1(10.0)	0.0
	Middle class	0.0	3(25.0)	1(10.)	
	Lower class	7(87.5)	8(66.7)	8(80.0)	
Medical Clearance		3(37.5)	2(16.7)	5(50)	0.235
Training on Hygiene	Yes	3(22)	1(8)	7(70)	
	No	5(78)	11(92)	3(30)	

n=30 banana flour processors, %= percentage of banana processors

There is need to create a culture of periodic training among the micro and small business this could be reinforced by government regulatory bodies. The findings in this study are in close agreement with what was reported by (Kubde et al., 2015) which recorded a high number of food handlers

(82.5%) who had not undergone food safety training. Conducting frequent training on food safety is important for increasing knowledge of food handler (Ansari-lari & Lakzadeh, 2019)

4.2 Level of Hygiene Knowledge among Banana Flour Processors

A summary of hygiene knowledge scores of processors among the three banana flour enterprises are outlined in figure 4.1. The respondents who were more knowledgeable scored (80%), (62.3%), (58.3%) in Ewajo, Wedo and Icobo enterprise respectively. On the other hand, those who were categorised as less knowledgeable in Wedo, Icobo and Ewajo enterprise scored 37.5%, 41.7% and 20% respectively. The overall performance shows that majority of processors (66.3%) have satisfactory score on good hygiene knowledge. The difference in hygiene knowledge score among the enterprises may be attributed to level of training or frequency of training that banana flour processors are undertaken. For instance, Ewajo had highest score in hygiene knowledge as compared to the other two enterprises. Findings stated earlier in this study indicated Ewajo had highest number of employees who had training in hygiene knowledge. A previous study has reported similar findings of generally high level of knowledge (84.8%) among food handlers(Sharif et al., 2013) .

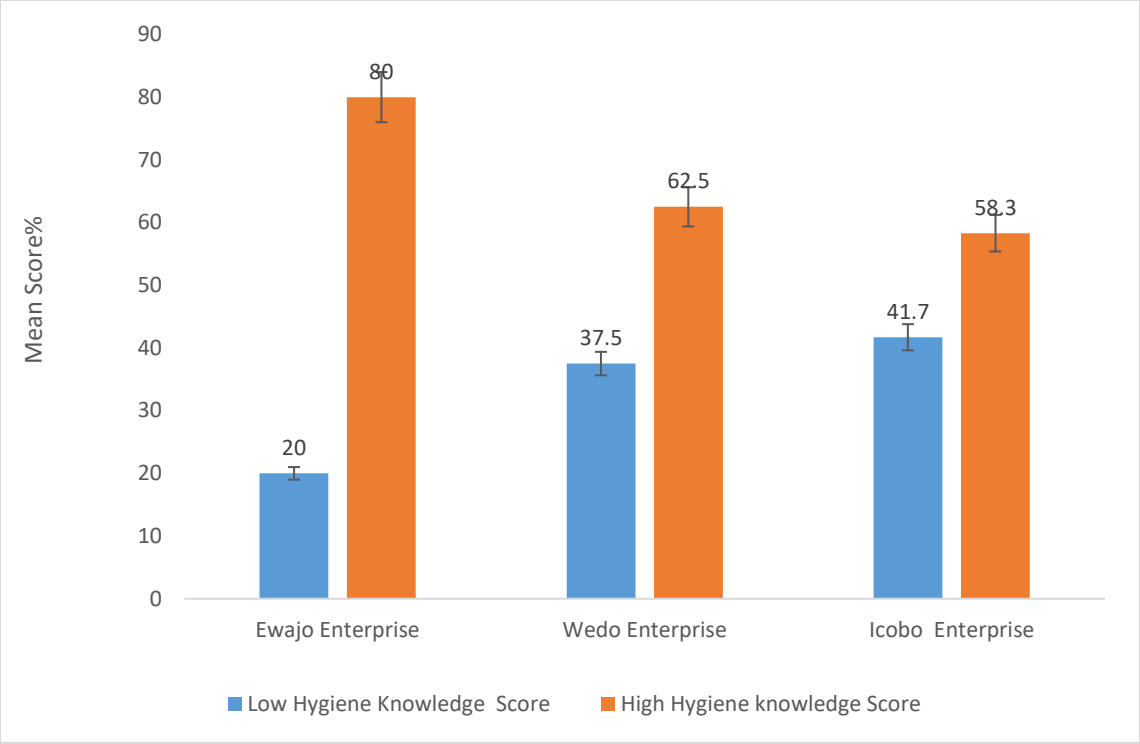


Figure 4. 1: Hygiene knowledge scores from the three banana flour enterprises

4.2.1 Comparison of Hygiene Knowledge score and socio-demographic characteristics

Results on hygiene knowledge mean scores as per sociodemographic characteristics are outlined in Table 4.2. Mean hygiene knowledge scores show that male respondents from Ewajo enterprise were more knowledgeable (14.5±0.7) than females (12.6±3.4), on the other hand female participants in Wedo enterprise had a higher knowledge mean score (13.8 ± 4.8) than male participants (12.5 ±4.9). In Icobo enterprise there was no much difference in performance between the male (11.2 ±2.8) and females (11.8±3.8).There were no statistical difference (P>0.05) in mean score of hygiene knowledge in relation to either male or female. Contrary to findings in a preceding study reported gender significantly influenced the level of hygiene knowledge (Sharif et al., 2013). Banana processors between the age category 37 to 46 years had higher hygiene knowledge mean scores in Icobo Enterprise (14.0 ±1.4) and Ewajo enterprise (14.5 ±0.7) as compared to Wedo who

registered high hygiene knowledge mean score (16.0±0.0) in the age category between 47to56 years. High hygiene knowledge means score for the older respondents could be associated with longer work experience as compared to those that are younger. The study results correlates with findings by (Nee & Sani, 2011) who reported higher knowledge score (65.8 ± 16.37and 61.4±9.2) among food handler between (31-50years). Participants at tertiary level had higher knowledge mean across the three enterprises: Wedo (17.3± 2.30), Icobo (8.6 ±2.1), Ewajo (14.66 ±1.2). This indicates that the higher level of education had an impact on hygiene knowledge. The findings ties well with the study by (Malavi, 2017) who also found food processors with higher learning perform better in food safety knowledge.

Table 4. 2: Hygiene knowledge Mean Scores by Sociodemographic Characteristics

		Wedo(N=8)		Icobo(N=12)		Ewajo (N=10)	
Demographic variable		Hygiene knowledge Mean ± SD	P-value	Hygiene Knowledge Mean ±SD	P-value	Hygiene Knowledge Mean ±SD	P-Value
Gender	Male	12.5 ±4.9	0.75	11.2 ± 2.8	0.735	14.5 ±0.7	0.48
	Female	13.8 ± 4.8		11.8 ±3.8		12.6 ±3.4	
Age	18-26	11.5 ±0.9	0.65	13.5 ±3.3	0.16	13.0 ±4.4	0.73
	27-36	14.6 ±5.5		9.5 ±2.12		12.0 ±1.0	
	37-46	9.0		14.0 ± 1.4		14.5 ±0.7	
	47-56	16.0± 0.0		9.25 ±2.2			
Education	College	17.3± 2.30	0.001	8.6 ±2.1		14.66 ±1.2	0.563
	Completed Primary	11.7±4.4		6.1 ±2.5	0.068	12.6 ±4.2	
	Completed secondary	9.0 ±2.6		6.6 +1.6		11.5 ±0.7	

All values are mean ± standard deviation, n=30 banana flour processors, P<0.05

4.2.2 Components of Hygiene Knowledge assessed among banana flour processors

Several components for hygiene knowledge were assessed in the study, which included microbial hazards, temperature control during drying, cross contamination, personal hygiene and food borne illness (figure 4.2). Results from participant's responses revealed good knowledge in the areas of personal hygiene, food borne illness, temperature control where as poor scores were recorded in microbial hazards, cleaning and sanitation and detection of food spoilage. On matters of knowledge of microbiological hazard, few respondents (10%) were aware *E.coli* was a foodborne pathogen. In addition most of the respondents (76.7%) could not distinguish whether *S.aureus* was found in contaminated foods or hands. It is through further interviews that the participants clarified they identified them as germs but were not familiar with the particular names of microorganism. Similar findings in a study by (Akabanda et al., 2017) reported that food handlers were not well informed with regards to microbial hazard and their pathogenicity. Presence of pathogenic microorganism in food could result in occurrence of foodborne illness.

Most of the participants (73.3%) recognized drying helps to remove moisture. Proper drying of banana slices before milling into flour increases shelf life and reduces chances of growth of microorganism such as moulds. In other study the findings were contrary as it was depicted most of food processors had insufficient knowledge use of temperature control (Akabanda et al., 2017).

Approximately (50.0%) of participants were aware how cross-contamination could occur whether from hands to utensils or when utensils could act as medium of transferring microbes. Contrary to this findings, previous study reported that food processors were not familiar with cross-contamination (Coutts et al., 2017). Majority of the participants (73.3%) were informed that hand washing reduces contamination of food. However, it was noted there were few designated hand washing points in the three enterprises. Hands of food handlers can act as a mode of transferring

microorganism, in the case of poor personal hygiene this may result to contamination of food. According to study by (Akabanda et al., 2017) it was also reported that hand washing is necessary in reducing risk of contamination. In the response of whether clean is same as sanitized few participants gave correct answer (36.7%). It was also observed there were no records of cleaning and sanitation available. This suggest that the banana processors lack understating of the two terms, if clean and sanitize are taken as one similar action this would result to compromise in hygiene standard. Majority of the respondents (53.3%) agreed that foodborne illness affect all people. However, through interviews some participant explained that foodborne illness mostly affects children. Most respondents (54.3%) were of the opinion foodborne illness does not cause death. It is evident from the feedback that foodborne disease is not taken seriously by most of banana flour processors. This degree of negligence among banana flour processors may result in food contamination and ultimately foodborne disease outbreaks occurrence. Half of the respondents (50%) were of the opinion there was no need to clean surfaces on daily basis but only when dirty. There was high significant difference ($P<0.05$) in this response. The implication of lack of cleaning daily is that it may result to accumulation of dirt and microorganism thus rendering the working surfaces unfit for banana preparation.

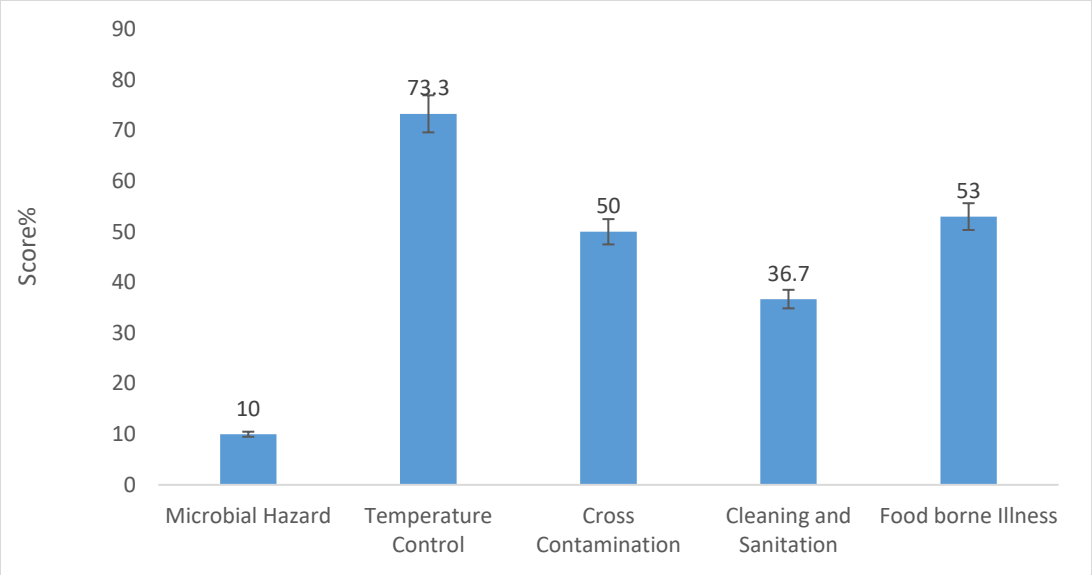


Figure 4. 2: Main Hygiene Knowledge Components Score

4.3 Hygiene Practise among Banana Flour Processors

The results for hygiene practise score of banana flour processor among the three enterprises is outlined in figure 4.3.The respondents with appropriate hygiene practise in Wedo, Ewajo and Icobo enterprise scored 75%, 70% and 16% respectively. Whereas respondents with inappropriate hygiene practice scored 83.3%, 30.0%, and 25.0% in Icobo Ewajo and Wedo Enterprise respectively. The results indicate there was an average performance in hygiene practise exhibited among the banana flour enterprises. Wedo enterprise recorded highest appropriate hygiene practise score this may have been attributed by commitment from management as result it motivated the banana flour processors towards cultivation of good hygiene practise. This finding was confirmed through further interviews conducted. Good hygiene practice is a necessity as a measure of quality control against contamination of flour. Appropriate hygiene practise was also noted in Ewajo enterprise this could be attributed to the periodic food safety trainings that processors are taken through. Icobo enterprise on the other hand had highest score in poor hygiene practice, which may

have been due to lack of carrying out training on good hygiene practise. In addition, the level of education may have influenced level of hygiene practise since most of banana flour processors in Icobo enterprise had attained only primary education. According to previous study by (Sharif et al., 2013) different findings were reported in the hygiene practise among food handlers, a mean score of 89.4% was recorded which was higher than results in present study.

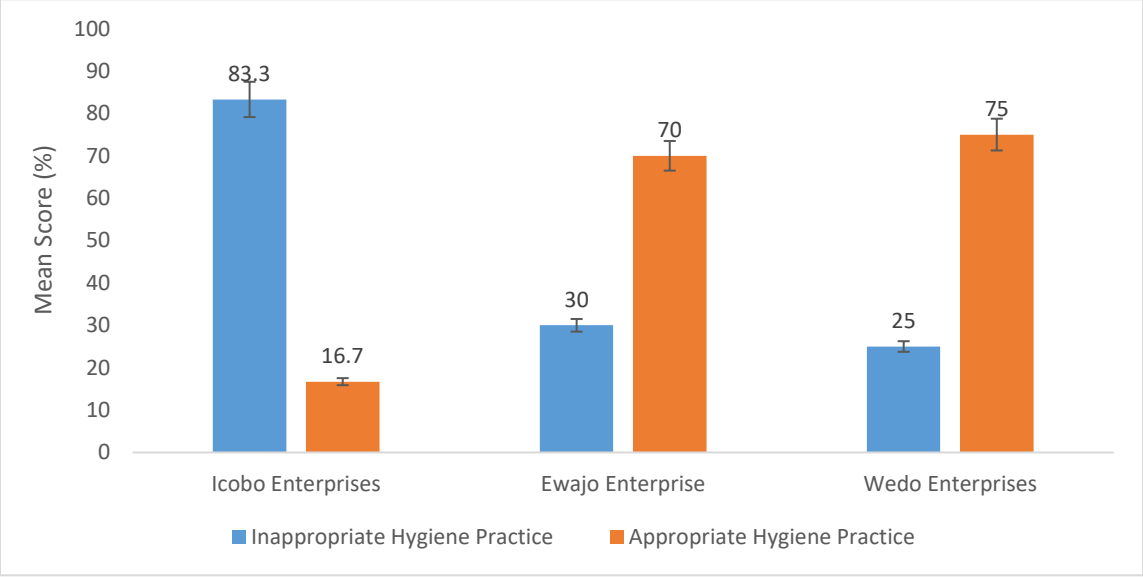


Figure 4. 3: Mean score of Hygiene practise among three banana flour enterprises

4.3.1 Comparison of Hygiene Practise and Sociodemographic Characteristics

A summary of hygiene practise mean scores as per sociodemographic characteristics are shown in Table 4.3. It is evident from the results that mean hygiene practices scores for males and females were slightly different among the three enterprises. However, the female respondents had a high hygiene practise score of means 8.2±2.48 and 8.1±1.91 in Wedo and Ewajo enterprise respectively. There was no statistical difference (P>0.05) in performance of hygiene practices between male

and female. Good hygiene practices were observed in processors within age category of 47to57 years their mean hygiene score were 9.0±1.4, 6.2±1.5, 9.0±1.4 for Wedo, Ewajo and Icobo enterprise respectively. Respondents whom had attained college and secondary education demonstrated good hygiene practise as recorded in Wedo enterprise (9.66±1.5 and 9.0), Icobo enterprise (5.5 ±0.7 and 5.8±1.21), Ewajo enterprise (9.6±0.57 and 8.0 ±0.64) respectively. On the other hand those who had primary education scored: Wedo (6.25± 2.8), Icobo (4.3 ± 2.08) Ewajo (7.2 ±2.2). Findings of this study demonstrated hygiene practices scores increased with age and level of education. Similar studies concur with the finding that participants with higher level of education display better hygiene practice (Malavi, 2017). Using Fisher exact test confirmed there was significant difference($p<0.05$) in the hygiene practices among the three banana flour processors, Icobo Enterprise demonstrated highest level of inappropriate hygiene practices methods in banana flour handling. Comparison between appropriate banana flour handling practices and social demographics status was only significant ($p<0.05$) with education level which indicated the higher the level of education the more appropriate hygiene practice.

Table 4. 3: Hygiene practices mean score as per Sociodemographic factors

Demographic variable		Wedo(N=8)		Icobo(N=12)		Ewajo (N=10)	
		Hygiene Practises Mean ±SD	P-value	Hygiene Practises Mean ±SD	P-value	Hygiene Practises Mean ±SD	P-Value
Gender	Male	7.0±4.24	0.68	5.5± 2.0	0.85	7.8 ± 2.03	0.46
	Female	8.2±2.48		5.3±0.51		8.1±1.91	
Age	18-26	7.0±4.24	0.90	4.5 ± 1.73	0.36		0.79
	27-36	7.3±3.5		5.0 ± 0.0		7.8 ±2.6	
	37-46	9.0		6.0 ± 0.0		8.0 ±0.0	
	47-56	9.0±1.4		6.2 ± 1.5		9.0 ±1.4	
Education	College	9.66±1.5	0.25	5.5±0.7	0.33	9.6±0.57	0.57
	Completed Primary	6.25± 2.8		4.3 ± 2.08		7.2 ±2.2	
	Completed secondary	9.0		5.8 +1.21		8.0 ±0.64	

All values are mean ± standard deviation, n=30 banana flour processors, P<0.05

A summary of the main components assessed in hygiene practices among three banana flour enterprises are presented in figure 4.4. The findings from this study demonstrated that half of respondents (50%) practiced washing of hands before banana flour processing. However, they did not practice the same when it came to regular washing of hands with soap. This is evidenced by the low performance in cleaning regimes, as few participants (33%) followed the required cleaning practises of hands, utensils and surfaces. Hands of food handlers are most likely means of transfer of microorganism therefore lack of proper hand washing practice would lead to risk of cross-contamination of banana flour. Study findings by (Sultana et al., 2016) were in agreement that handwashing is necessary in reducing food contamination. It was also observed less than half of participants in the study had appropriate personal hygiene practise (40%) and protective clothing (46.7%) whereas the few participants that had the protective clothing did not utilize them accordingly. As some (46.7%) wiped their hands using their aprons while working, this kind of practise suggest lack of awareness on risk of cross contamination or ignorance among the processors. This poor hygienic practise may lead to food contamination hence affect safety of consumer. A previous study confirms the same findings of inappropriate use of protective clothing such as apron and in other case hair nets (Monney et al., 2013). Findings from this study revealed poor storage practices observed at milling area, where most processors stored the packaged four on the direct floor (56.7%), some processors (26.7%) placed it on floor lined with polythene, whereas few processors (16.7%) stored appropriately on top of wooden crates. Poor storage of banana flour such as on the floor after milling may result in providing conducive moist environment for growth of microorganism such as fungi thus may end up producing mycotoxin. This may pose health risks to consumers upon consumption of contaminated flour.

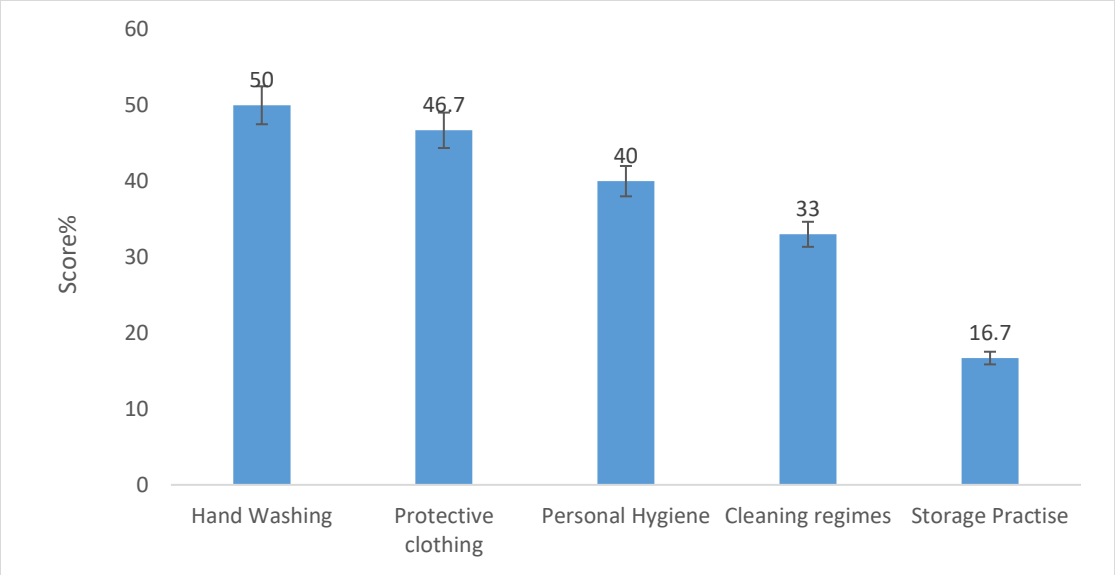


Figure 4.4: Main Hygiene Practise components of banana flour processors

4.3.2 Association between hygiene knowledge and practices

The level of food hygiene knowledge may influence the level of good hygiene practise. However this may not always be the case, as reported in previous studies increased knowledge of safety does not always result in practical application (Ansari-lari & Lakzadeh, 2019). The findings in this study reveal a strong positive association between hygiene knowledge and practices within the three banana flour enterprises (Table 4.4). The association is highly demonstrated in Ewajo enterprise and least in Icobo Enterprise. Although the association is positive and strong in the three enterprises, it is only significant in Ewajo Enterprise. Overall there is also positive association ($r=0.537$, $p=0.002$) which is significant ($p<0.05$).

Table 4. 4: Hygiene Knowledge and Practice association

Banana Flour Enterprise		Mean	Std. Deviation	Correlation Coefficient (r)	P-value
Wedo Enterprise	Knowledge score	13.5	4.57	0.570	0.140
	Practice Score	8.5	3.07		
Icobo Enterprise	Knowledge score	11.5	3.17	0.186	0.564
	Practice Score	6.17	1.85		
Ewajo Enterprise	Knowledge score	13.0	3.16	0.700	0.024
	Practice Score	8.0	2.10		
All				0.537	0.002

All values are mean**,** standard deviation, n=30, Coefficient factor (r) significant level P<0.05,

4.4 Microbiological Quality of Banana Flour Processing

A summary of results from microbial assessment of banana samples is outlined in table 4.5. The results gives an overview of microbial status of banana samples collected from four different stages of banana flour processing which include fresh banana slices, semi dried banana slices, dried banana slices and banana flour. The results for microbiological examinations were compared to the guideline for microbiological specification according to (Centre for Food Safety, 2014) and (Gilbert et al., 2000). The level considered satisfactory in ready to eat (RTE) foods for yeast and molds is (<10CFU/g or 1.0 log CFU/g) , coliforms and *E.coli* (<20 CFU/g or 1.30 log CFU/g) (Centre for Food Safety, 2014).

Fresh banana slices recorded highest contamination in yeast and mold with mean values of 7.82± 0.63 CFU/g whereas least contamination in *E.coli* with mean value 1.33±1.15 CFU/g. On the other hand coliform level of contamination was 4.32±0.3670 CFU/g.The microbial load for fresh banana slices were above recommended limit according to (Centre for Food Safety, 2014). The high

microbial load may be due to inappropriate hygiene practices when preparing the banana slices during peeling, washing, or shredding. In the preparation step some procedures to which fresh banana is subjected to may increase or decrease microbial load. For instance, washing may remove surface microbes on the other hand peeling, cutting or slicing may contaminate banana slices through the hands of banana processors or preparation utensils and surfaces. Similar findings of high microbial contamination in green banana has been reported by (Jahan et al., 2019). Therefore there is need for fresh banana slices to go through pre-treatment with salt solution, ascorbic acid, citric acid, sodium metabisulfite and blanching as described by (Demirel & Turhan, 2003) before proceeding to drying the banana, this will serve as control method. Findings form previous studies have demonstrated pre-treatment with sodium metabisulfite or acidic solution dip enhances the destruction of potentially pathogenic bacteria during drying (Derrickson-Tharrington et al., 2005). In addition pre-treatment aids in prevention of browning during drying and storage of light colour fruits. It also speeds up drying of fruits and minimize effect of drying operation on some quality parameters. Research on use of blanching technique was carried out and results highlighted it is an efficient method of control for inactivating heat sensitive microorganism (Dandamrongrak et al., 2003).

Semi dried slices were obtained from the solar dryer area. Findings in this current study recorded higher mean values in coliforms 4.6±0.14 CFU/g and yeast and molds 4.2± 3.68 CFU/g while mean values for *E.coli* were 3.1±.42 CFU/g. Coliforms and *E.coli* counts were within borderline limit which is outlined as from 10^2 to $<10^4$ CFU/g and 20 to $<10^2$ CFU/g for coliforms and *E.coli* respectively (Centre for Food Safety, 2014). Presence of yeast and molds may be attributed to existing microbes in dryer area or drying surfaces, on the other hand *E.coli* and coliform served as indicators of lack of proper cleaning and maintenance of the solar dryer area. When cleaning and

sanitation is not carried out appropriately, this may provide a favourable environment for microbial growth that could result to biofilm. Formation of biofilm is serious concern in food industry as pathogenic microorganism are capable of attaching and growing on food surface and surfaces of other processing equipment (Malavi et al., 2018). Therefore, routine cleaning and maintenance of sanitary surroundings in dryer will aid in prevention of proliferation and spread of microbial contamination.

Dried banana slices recorded highest mean counts in yeast and molds 4.95±4.28 CFU/g as compared to *E.coli* that had lowest mean count values 1.0 ±1.75CFU/g. The level of *E.coli* and Coliforms in dried banana slices was within acceptable limits whereas yeast and mold was at border limit according to (Gilbert et al., 2000). Presence of yeast and mold may be due to lack of proper drying or the packaging material (polythene bag) used could have accumulated moisture providing a suitable environment for microbial growth. Molds are potential spoilage agent that produce secondary metabolites such as aflatoxin, occurrence of this toxic substance may render the flour harmful for consumption as they remain in food even after processing due their resistance nature to heat or acid treatment. In addition, molds cause off flavours upon storage (Gacheru et al., 2016). During the interviews with the banana processors, they acknowledged challenges in assessing whether banana slices had dried and it was difficult to determine the right moisture content. Banana flour processors highlighted they used physical means such as pressing to check whether banana slices are dry, if no moisture was left on the hand and pieces spring apart when released, this is a sign they are dry. The required technique of moisture determination is by use of moisture meter (Vera et al., 2019), which most banana processors stated they were not aware of and could not afford. Another challenge was the variation in weather, during cold season the banana slices would take longer period to dry. In this given times, the processors may compromise

quality as way of meeting requirement or demand in market. Previous studies on dried fruits demonstrated high microbial contamination with possible pathogens of the genus Salmonella, Bacillus and other Enterobacteriaceae were isolated from home dried samples, faecal coliforms were detected in 55% of the home dried fruits and vegetables (Ntuli et al., 2017) .

Table 4. 5: Microbial mean counts of banana samples (log Mean CFU/g)

Sample	N	E.coli CFU/g	Coliform CFU/g	Yeast and mold CFU/g
Fresh banana slices	3	1.33 ±1.15	4.32 ±.367	7.83± 0.64
Semi-dried sample	3	3.10±.417	4.65± 0.15	4.23± 3.68
Dried sample	3	1.01 ±1.76	4.01±0.85	4.95±4.28
Banana flour	3	3.03 ±1.66	4.46 ± 0.39	6.65+1.43

All Values are Mean ± Standard Deviations, ($P<0.05$), n=12

Microbial level of contamination in banana flour was recorded highest in yeast and mold with mean values of 6.6±1.4 CFU/g, while coliforms and *E.coli* had mean values: 4.45±0.39 CFU/g and 3.0348 ±1.66 CFU/g respectively. *E.coli* and coliforms counts were within acceptable limit, yeast and mold mean count exceeded acceptable limit (Gilbert et al., 2000) and (Centre for Food Safety, 2014). The implication of high yeast and mold level in the flour it may lead to spoilage upon storage, in addition this may cause off flavours in flour and thus result to deterioration in quality and short shelf life of banana flour. Presence of *E.coli* and coliforms may have been attributed to poor personal hygiene practices of banana flour processors while handling the flour for instance in the packaging stage due to contaminated equipment, packaging bags or cross-contamination from hands to the flour. Some strains of *E.coli* such as Escherichia coli O157 and other Shiga toxin-producing *E. coli* (STEC) are pathogenic in nature therefore their presence in food may

pause risk of food borne illness**.** Similar finding of a study carried out in plantain flour showed high microbial load of 3.0×10^4 cfu/ml and 3.1×10^4 cfu/ml reported by .(Aruwa & Ogundare, 2017). Microbiological quality of banana flour is important is mostly consumed product by children and elderly who are immunocompromised (Waré et al., 2018).

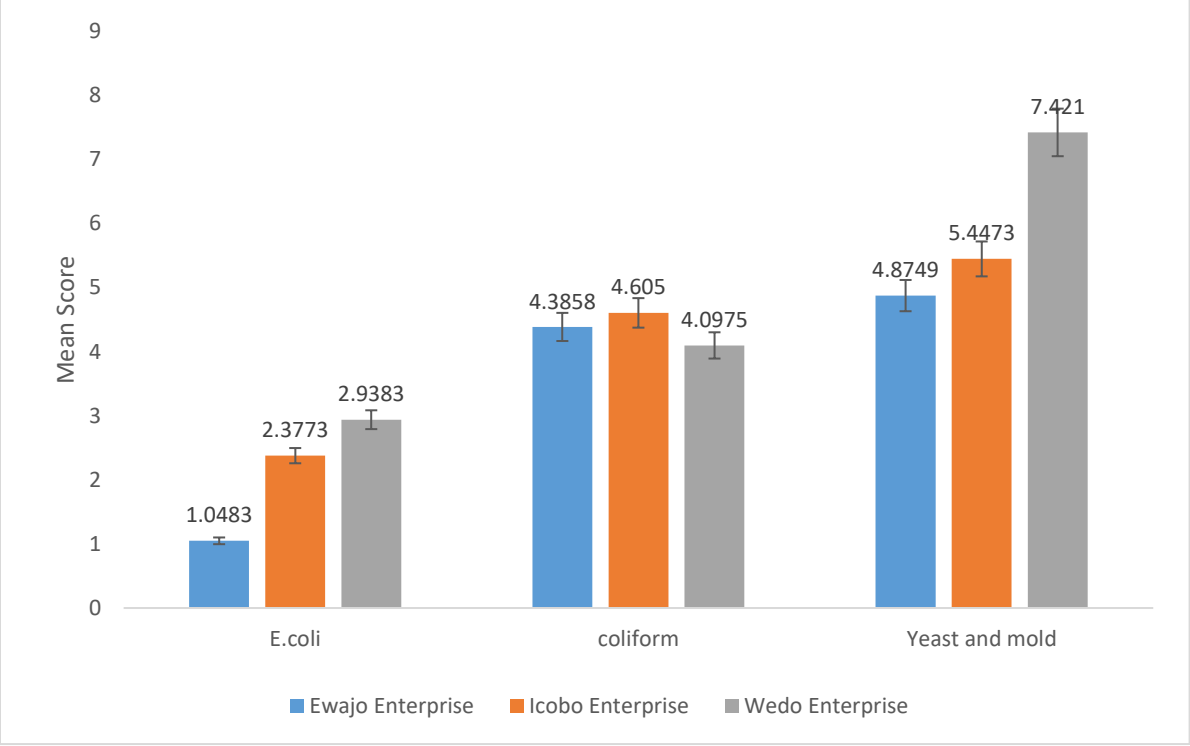


Figure 4. 5: Mean counts of microbial load among the three banana flour enterprise

The figure 4.5 represents microbiological status of banana samples examined from the three banana flour enterprises: Wedo, Ewajo and Icobo. It is evident microbial load in yeast and mold had highest mean values in the three enterprises with Wedo enterprise having highest mean count 7.4± 1.5 CFU/g whereas Icobo had the lowest mean count 4.87±3.4 CFU/g. The high level of yeast and mold contamination was above acceptable limits according (Centre for Food Safety, 2014).Occurrence of Yeast and molds may have been attributed to poor post-harvest handling in

terms of banana preparation process, drying and milling thus facilitating proliferation of microbes. The consequence of their presence could result in deterioration of flour, in other case release of mycotoxin hence result to food poisoning. The findings were contrary to a previous study in microbial assessment of flour which reported lower mean counts of 1.00 to 3.86 cfu/ g and 1.00-6.73 cfu/g in yeast and mold contamination (Gacheru et al., 2016).

Among the three enterprises, prevalence of coliform was ranging from 4.09±0.80 CFU/g to 4.60±0.11CFU/g. There was no significance difference (P>0.05). Coliforms were within acceptable limits according (Gilbert et al., 2000). The level of contamination with *E.coli* in the three enterprises ranged from 1.05±1.45 CFU/g to 2.93±0.83 CFU/g. Coliforms and *E.coli* are used to assess the microbiological quality of food processing plants (Malavi et al., 2018).They serve as indicators of fecal contamination, hygiene practises and level of sanitation in food establishment. The findings in this study suggest that presence of *E.coli* and coliform may have been attributed to poor personal hygiene practise by banana flour processors and lack of adherence to good manufacturing practises. In addition, it was observed among the three enterprises there were no documented cleaning procedures or sanitary program. Inefficient cleaning and sanitation of banana preparation area, equipment or utensil may lead to cross contamination of banana flour.

4.4 Chemical Properties of Banana Flour

4.4.1 Proximate Composition of Banana Flour

The proximate composition properties of banana flour samples obtained from the three enterprises: Wedo, Icobo and Ewajo are presented in table 4.6. There were significant differences ($P<0.05$) in all parameters in proximate composition except for the fat content. The results in this current study recorded highest moisture content of 15.77% in Banana flour obtained from Icobo enterprise whereas the lowest moisture content (9.3%) in banana flour sampled from Ewajo enterprise. The recommended moisture limit in banana flour is 11% according to Uganda Standard for banana flour (Edition, 2013). Banana flour from Icobo enterprise exceeded the expected limits this could suggest the flour may not have long shelf life. In addition high moisture content level may make the flour more susceptible to microbial contamination. General acceptability and shelf life of a product is determined by moisture level (Anggraeni & Saputra, 2018). Low moisture content is important for flour to maintain long shelf life and adaptability for further use as an ingredient in food production. As compared to other studies low moisture content in flour were reported as: 10.43% and 12.91% according to (Onwuka et al., 2015) and (Anggraeni & Saputra, 2018).

Protein content mean value ranged from 3.22±0.19 to 6.235±0.007%. Banana flour sample from Wedo enterprise had lowest protein content whereas Ewajo enterprise had highest protein content.The difference could have risen from the variety of banana used in preparation of flour. Approximately 6% of recommended daily allowance (RDA) of protein may be supplied by 100g of cooking banana (Dotto et al., 2019).The protein of green banana flour is considered of low biological value, this can be increased by combining banana flour with other food that are rich in protein source. Similar findings from previous study reported protein content ranging from 4.11 to 4.47% according to (Abbas et al., 2009) .

Banana flour from Ewajo enterprise had highest mean of fat content 2.205±0.89% where as Icobo enterprise had lowest mean value of fat content 1.0350±0.021%. The high level of fat content in banana flour may result into oxidation of fats therefore lead to rancidity and off flavours in flour thus renders it unsuitable for consumption. The present findings are higher than what was observed in previous studies ranging from 0.78±0.03 to 0.84±0.05 by (Onwuka et al., 2015) and 0.25±0.28 to 0.70±0.01 by (Odenigbo, 2013)

The ash content mean ranged from 2.575± 0.07 to 3.5± 0.38%. Banana flour sampled from Ewajo and Icobo enterprise had higher ash content this may imply it has high mineral content as compared to banana flour from Wedo enterprise, which had lower ash content. The ash content was within acceptable limits according to Uganda Standard for banana flour (Edition, 2013) which outlines a limit of 4%. Ash content portrays the quality of flour thus corresponds to high mineral content especially sodium .Ash is a an organic residue in any food substance which directly denotes the mineral content (Dotto et al., 2019). Findings from previous study depicted lower mean value of ash content of 1.7% (by (Anggraeni & Saputra, 2018) and similar findings reported ash content of 3.8% by (Onwuka et al., 2015)

Fiber content in banana flour ranged from 1.73±0.66 to 3.34±0.035%. The recommended daily fiber intake is between 25 and 30g, 100g of banana may deliver 12% of recommended allowance for dietary fiber (Bezerra et al., 2013).In human nutrition, fiber aids in digestion as it maintains bowel health, it helps control blood sugar level and lowering cholesterol. Therefore, it suggests from findings of this current study the banana flour from Ewajo enterprise is more suitable in providing for fiber in meals. According to previous studies by (Anggraeni & Saputra, 2018)and (Dotto et al., 2019) it was reported that fiber content was 1.36% and 2.79% respectively, which was in same range as with the current study.

The carbohydrate level ranged from 73.23±0.30% to 80.30±0.24%. Results reveal that carbohydrate content had significance difference ($p<0.05$) in the flours among the three enterprises .The findings suggest carbohydrate in banana flour was sufficient since 100g of banana may provide 17% of the recommended daily absorption for carbohydrate (Dotto et al., 2019). Banana flour is considered a rich source of carbohydrate because of high content of carbohydrate. This suggest it can be utilized in addressing malnutrition and food insecurity issues. A similar pattern of results was reported by (Abbas et al., 2009) who found CHO was ranging from 80.80 to 82.78% in banana flour. Contrary to present findings, previous study obtained higher carbohydrate content ranging from 89.66 to 92.31% reported by (Odenigbo, 2013).

Table 4. 6: Mean Values of Proximate Composition of Banana Flour (g/100g)

Chemical Components	Banana flour Sample		
	Wedo enterprise	Ewajo enterprise	Icobo Enterprise
Moisture	10.705±0.68	9.315±0.12	15.77±0.81
Protein	3.220± 0.19	6.235± 0.00	4.565 ±0.18
Fat	1.470 ±0.14	2.205 ±0.89	1.035 ± 0.02
Ash	2.575 ± 0.08	3.530± 0.38	3.49±0.11
Fiber	1.730 ±0 .66	3.345± 0.03	1.39±0.08
Carbohydrate	80.30±0.24	74.51±0.22	73.24±0.30

Values reported are means ± standard deviation of replicate determination, n=6 banana flour samples

4.4.2 Sodium and potassium contents of banana flour

Results for mineral analysis are summarized in Table 4.7. The mean value for sodium (Na) content was ranging from 86.80±0.705 to 106.85±1.06% with Icobo banana flour sample having lowest whereas Wedo Enterprise had highest mean. There were significant difference ($p<0.05$) in the banana flour samples collected from the three enterprise. Banana is considered low in sodium content therefore useful in supplementing diets for with low sodium requirement. Contrary to previous study the Na content was slightly lower (76.64 ± 30.0%) as reported by(Abbas et al., 2009). The potassium (K) content in the banana flour ranged from 707.285±1.06 to 970.25 ± 1.90919mg/100g. The difference across the three enterprises could have risen from varying type of banana used in the banana flour production. Banana is a rich source of potassium that can be of nutritive value when incorporated into meals especially for infants. Minerals such as potassium, calcium and sodium are essential in muscle function, regulating fluid balance and maintaining normal heart beat. The findings in this current study recorded higher K content as compared to a previous study where results of K ranged from 679.71 to 699.56 mg/100g reported by (Abbas et al., 2009).

Table 4. 7: Mean values of Sodium and Potassium content in banana flour (mg/100g)

Mineral Content	Wedo Enterprise	Ewajo enterprise	Icobo Enterprise
Na	106.85 ± 1.0606	103.10 ±1.27279	86.80 ± .70711
K	707.285 ± 1.0606	928.29± 2.26274	970.25±1.90919

Values reported are means ± standard deviation of replicate determination, n=6

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.1 Conclusion

It is evident that women and youth mainly carry out banana flour processing; therefore, this may be a propelling factor for increasing source of income and improving living standards. The level of education had impact on the hygiene knowledge and practise.

The study reveals that banana flour processors in Ewajo and Wedo enterprise have adequate level of good hygiene knowledge and appropriate hygiene practise whereas banana flour processors in Icobo demonstrated low level of hygiene knowledge and poor hygiene practises. There is a close association in level of hygiene knowledge and performance in hygiene practice among the three-banana flour enterprise.

The assessment of microbial quality in banana samples revealed prevalence of microorganisms in higher counts than recommended limits. Yeast and mold was most prevalent in the banana sample among the three enterprise. Presence of *E.coli* and coliforms indicate poor hygiene practises among the banana flour processors.

Based on the findings from this study it is also evident banana flour is of nutritive value due to its high carbohydrate and fiber content. In addition, potassium was also found in abundant supply in banana flour. This suggest that nutritional potential in banana flour to be utilized as an ingredient food production.

5.2 Recommendation

The findings in the current study suggest there is need to conduct continuous training on good hygiene knowledge and practises among banana flour processors in Micro and Small Enterprises. There is need also for further studies to be conducted to identify the sources of microbial

contamination in the banana flour processing. In addition, there is need for Kenya Bureau of Standards (KEBS) to develop a Kenyan standard for microbiological assessment in banana flour.

REFERENCES

Abbas, F., Saifullah, R., & Azhar, M. E. (2009). Differentiation of ripe banana flour using mineral composition and logistic regression model. *International Food Research Journal*, *87*(16), 83–87.

Abiodun-Solanke, A., & Falade, K. (2011). A review of the uses and methods of processing banana and plantain (Musa spp.) into storable food products. *Journal of Agricultural Research and Development*, *9*(2). https://doi.org/10.4314/jard.v9i2.66815

Ahmed, N., Singh, J., Chauhan, H., Anjum, P. G. A., & Kour, H. (2015). Different Drying Methods : Their Applications and Recent Advances Different Drying Methods : Their Applications and Recent Advances. *Researchgate*, *5*(January 2013), 33–42.

Ajayi, A. O., & State, O. (2016). Microbiological Quality of Plantain (Musa paradisiacal). *Nigerian Journal of Microbiology*, *30*(2), 3962–3969.

Akabanda, F., Hlortsi, E. H., & Owusu-Kwarteng, J. (2017). Food safety knowledge, attitudes and practices of institutional food-handlers in Ghana. *BMC Public Health*, *17*(1), 1–9. https://doi.org/10.1186/s12889-016-3986-9

Aluko, O. O., Ojeremi, T. T., Olaleke, D. A., & Ajidagba, E. B. (2014). Evaluation of food safety and sanitary practices among food vendors at car parks in Ile Ife, southwestern Nigeria. *Food Control*, *40*(1), 165–171. https://doi.org/10.1016/j.foodcont.2013.11.049

Alum, Akanele, E., Chukwu, S., & Ahudie, C. (2016). Microbiological Contamination Of Food: The Mechanisms, Impacts And Prevention. *International Journal of Scientific & Technology Research*, *5*(3), 65–78. Retrieved from www.ijstr.org

Amini Khoozani, A., Birch, J., & Bekhit, A. E. D. A. (2019). Production, application and health effects of banana pulp and peel flour in the food industry. *Journal of Food Science and Technology*, Vol. 56, pp. 548–559. https://doi.org/10.1007/s13197-018-03562-z

Anggraeni, R., & Saputra, D. (2018). Physicochemical characteristics and sensorial properties of dry noodle supplemented with unripe banana flour. *Food Research*, *2*(3), 270–278. https://doi.org/10.26656/fr.2017.2(3).061

Ansari-lari, M., & Lakzadeh, L. (2019). Knowledge , attitudes and practices of workers on food hygienic practices in meat processing plants in Fars , Iran. (October). https://doi.org/10.1016/j.foodcont.2009.06.003

Aruwa, C. E., & Ogundare, O. (2017). Microbiological Quality Assessment of Pupuru and Plantain Flours in an Urban Market in Akure, Ondo State, South Western Nigeria. *OALib*, *04*(08), 1–11. https://doi.org/10.4236/oalib.1103783

Aruwa, C, Akindusoye, A., & Awala, S. (2017). Socio-demographic Characteristics and Food Hygiene Level Assessment of Food Handlers in Cafeterias around a Federal University in Nigeria. *Journal of Scientific Research and Reports*, *14*(4), 1–9. https://doi.org/10.9734/jsrr/2017/33273

Aruwa, Christiana, Akindusoye, A., & Awala, S. (2017). Socio-demographic Characteristics and Food Hygiene Level Assessment of Food Handlers in Cafeterias around a Federal

University in Nigeria. *Journal of Scientific Research and Reports*, *14*(4), 1–9. https://doi.org/10.9734/jsrr/2017/33273

Bakare, A. H., Ogunbowale, O. D., Adegunwa, M. O., & Olusanya, J. O. (2016). *Effects of pretreatments of banana (Musa AAA , Omini) on the composition , rheological properties , and baking quality of its flour and composite blends with wheat flour*. https://doi.org/10.1002/fsn3.378

Bezerra, C. V., Rodrigues, A. M. da C., Amante, E. R., & da Silva, L. H. M. (2013). Nutritional Potential of Green Banana Flour Obtained by Drying in Spouted Bed. *Revista Brasileira de Fruticultura*, *35*(4), 1140–1146. https://doi.org/10.1590/S0100-29452013000400025

Bhila, T. E., Ratsaka, M. M., Kanengoni, A., & Siebrits, F. K. (2010). Effect of sun drying on microbes in non-conventional agricultural by-products. *South African Journal of Animal Sciences*, *40*(5SUPPL.1), 484–487.

Campuzano, A., Rosell, C. M., & Cornejo, F. (2018). Physicochemical and nutritional characteristics of banana flour during ripening. *Food Chemistry*, *256*(February), 11–17. https://doi.org/10.1016/j.foodchem.2018.02.113

Centre for Food Safety. (2014). *Microbiological Guidelines for Food*. *2014*(August), 1–38. Retrieved from https://www.cfs.gov.hk/english/food_leg/files/food_leg_Microbiological_Guidelines_for_Food_e.pdf

Chah, J. M., Ani, N. A., Irohibe, J. I., & Agwu, A. . (2012). Involvement of Farm Households in Banana and Plantain Production in Aguata Agricultural Zone of Anambra State, Nigeria. *Journal of Agricultural Extension*, *18*(2), 10–20. https://doi.org/10.4314/jae.v20i2.10

Coutts, S. P., Sturge, K., Lalor, K., Marshall, J. A., Bruggink, L. D., Subasinghe, N., & Easton, M. (2017). An outbreak of foodborne norovirus gastroenteritis linked to a restaurant in Melbourne, Australia, 2014. *Western Pacific Surveillance and Response Journal : WPSAR*, *8*(2), 12–16. https://doi.org/10.5365/WPSAR.2017.8.1.008

Dandamrongrak, R., Mason, R., & Young, G. (2003). The effect of pretreatments on the drying rate and quality of dried bananas. *International Journal of Food Science and Technology*, *38*(8), 877–882. https://doi.org/10.1046/j.0950-5423.2003.00753.x

Daniela, B., Porciuncula, A., & Segura, L. A. (2015). Processes for Controlling the Structure and Texture of Dehydrated Banana. (July). https://doi.org/10.1080/07373937.2015.1014911

Demirel, D., & Turhan, M. (2003). Air-drying behavior of Dwarf Cavendish and Gros Michel banana slices. *Journal of Food Engineering*, *59*(1), 1–11. https://doi.org/10.1016/S0260-8774(02)00423-5

Derrickson-Tharrington, E., Kendall, P. A., & Sofos, J. N. (2005). Inactivation of Escherichia coli O157:H7 during storage or drying of apple slices pretreated with acidic solutions. *International Journal of Food Microbiology*, *99*(1), 79–89. https://doi.org/10.1016/j.ijfoodmicro.2004.07.015

Dotto, J., Matemu, A. O., & Ndakidemi, P. A. (2018). Potential of cooking bananas in addressing food security in East Africa International Journal of Biosciences | IJB |. *Int. J. Biosci*, *13*(4),

278–294. https://doi.org/10.12692/ijb/13.4.278-294

Dotto, J., Matemu, A. O., & Ndakidemi, P. A. (2019). Nutrient composition and selected physicochemical properties of fifteen Mchare cooking bananas: A study conducted in northern Tanzania. *Scientific African*, *6*, e00150. https://doi.org/10.1016/j.sciaf.2019.e00150

Dun-dery, E. J., & Addo, H. O. (2016). Food Hygiene Awareness , Processing and Practice among Street Food Vendors in Ghana. *Journal of Food and Public Health*, *6*(3), 65–74. https://doi.org/10.5923/j.fph.20160603.02

Edition, F. (2013). *Final Draft Uganda Standard*.

Ekesa, B., Kimiywe, J., Davey, M., Dhuique-Mayer, C., Van Den Bergh, I., & Karamura, D. (2012). Banana and Plantain (Musa spp.) Cultivar preference, Local processing Techniques and Consumption Patterns in Eastern Democratic Republic of Congo. *International Journal of Agriculture Sciences*, *4*(8), 312–319. https://doi.org/10.9735/0975-3710.4.8.312-319

FAO. (2014). *FOOD LOSS ASSESSMENTS : Causes and Solutions. Case studies in Small-scale Agriculture and Fisheries Subsectors*.

FAO, F. and A. O. of the U. N. (2020). *Banana market review: Preliminary results 2019*. 1–16. Retrieved from http://www.fao.org/economic/est/est-commodities/bananas/it/

Gacheru, P. K., Abong, G. O., Okoth, M. W., Lamuka, P. O., & Shibairo, S. A. (2016). Microbiological Safety and Quality of Dried Cassava Chips and Flour Sold In The Nairobi and Coastal Regions of Kenya Cassava (Manihot esculenta Crantz) significantly contributes to food security , incomes and employment opportunities in the rural areas. *African Crop Science Journal*, *24*, 137–143.

Genitha I, S. P. (2014). Comparative Study of Ripe and Unripe Banana Flour during Storage. *Journal of Food Processing & Technology*, *5*(11). https://doi.org/10.4172/2157-7110.1000384

Gilbert, R., Louvois, J., Donovan, T., Little, C., Nye, K., Ribeiro, C., … Bolton, F. (2000). Guidelines for the microbiological quality of some ready-to-eat foods sampled at the point of sale. *Communicable Disease and Public Health / PHLS*, *3*(3), 163–167.

Grace, D. (2017). Food safety in developing countries: research gaps and opportunities. In *White paper, Nairobi, Kenya: ILRI*. Retrieved from https://cgspace.cgiar.org/bitstream/handle/10568/81515/White paper food safety.pdf?sequence=1

Hartman, D. (2011). Perfecting Your Spread Plate Technique. *Journal of Microbiology & Biology Education*, *12*(2), 204–205. https://doi.org/10.1128/jmbe.v12i2.324

Hasnan, N. Z. N., Aziz, N. A., Zulkifli, N., & Taip, F. S. (2014). Food Factory Design: Reality and Challenges Faced by Malaysian SMEs. *Agriculture and Agricultural Science Procedia*, *2*, 328–336. https://doi.org/10.1016/j.aaspro.2014.11.046

Hayder, N. A.-M. (2016). Official Methods of Analysis of AOAC INTERNATIONAL. *AOAC International*, (February), 3172. Retrieved from

https://www.techstreet.com/standards/official-methods-of-analysis-of-aoac-international-20th-edition-2016?product_id=1937367

Hope, K. R. (2012). Engaging the youth in Kenya: Empowerment, education, and employment. *International Journal of Adolescence and Youth*, *17*(4), 221–236. https://doi.org/10.1080/02673843.2012.657657

Indrawati, H. (2018). *Micro and Small Enterprises (MSEs):* (55), 309–314. https://doi.org/10.5220/0006885203090314

Jahan, N., Noor, R., & Munshi, S. K. (2019). Microbiological analysis and determination of antimicrobial traits of green banana (Musa spp.) and papaya (Carica papaya). *Stamford Journal of Microbiology*, *8*(1), 41–45. https://doi.org/10.3329/sjm.v8i1.42439

Joshi, P., & Varma, K. (2015). Assessment of Nutritional and Physiochemical properties of Banana Flour. *Research Journal of Family, Community and Consumer Sciences*, *3*(5), 3–4.

Jung, S. (2014). *Stratified Fisher ' s exact test and its sample size calculation*. *56*, 129–140. https://doi.org/10.1002/bimj.201300048

Kendall, P., & Sofos, J. (2003). Drying Fruits. *Colorado State University*, *9.309*(9), 8–11.

Kubde, S., Pattankar, J., & Kokiwar, P. (2015). Knowledge and food hygiene practices among food handlers in food establishments. *International Journal of Community Medicine and Public Health*, *3*(1), 251–256. https://doi.org/10.18203/2394-6040.ijcmph20151572

Maisnam, D., Rasane, P., Dey, A., Kaur, S., & Sarma, C. (2015). Recent advances in conventional drying of foods. *Journal of Food Technology and Preservation*, *1*(1), 25–34.

Malavi, D. N. (2017). Food Safety Knowledge, Attitude and Practices of Orange-Fleshed Sweetpotato Puree handlers in Kenya. *Food Science and Quality Management*, *67*(April 2018), 54–63. Retrieved from http://iiste.org/Journals/index.php/FSQM/article/view/38648

Malavi, D. N., Muzhingi, T., & Abong, G. O. (2018). Good manufacturing practices and microbial contamination sources in orange fleshed sweet potato puree processing plant in Kenya. *International Journal of Food Science*, *2018*. https://doi.org/10.1155/2018/4093161

Marais, M., Conradie, N., & Labadarios, D. (2007). Small and micro enterprises - Aspects of knowledge, attitudes and practices of manager's and food handlers' knowledge of food safety in the proximity of Tygerberg Academic Hospital, Western Cape. *South African Journal of Clinical Nutrition*, *20*(2), 50–61. https://doi.org/10.1080/16070658.2007.11734124

Mbuthia, S. W., Kayi, C., & Wambugu, S. K. (2018). Constraints to Profitable Participation in Agri-food Value Chains: A Case of Small-scale Banana Farmers in Meru County, Kenya. *International Journal of Scientific and Research Publications (IJSRP)*, *8*(7). https://doi.org/10.29322/ijsrp.8.7.2018.p7912

Monney, I., Agyei, D., & Owusu, W. (2013). Hygienic Practices among Food Vendors in Educational Institutions in Ghana: The Case of Konongo. 282–294. https://doi.org/10.3390/foods2030282

Mwangi, M. (2016). Preferred banana varieties and their seed systems in Eastern and Central provinces of Kenya. (May).

Nee, S. O., & Sani, N. A. (2011). Assessment of Knowledge, Attitudes and Practices (KAP) Among food handlers at residential colleges and canteen regarding food safety. *Sains Malaysiana*, *40*(4), 403–410.

Nnebue, C., Adogu, P. U., Ifeadike, C., & Ironkwe, O. (2014). Assessment of the food hygiene practices of food handlers in the Federal Capital Territory of Nigeria. *Tropical Journal of Medical Research*, *17*(1), 10. https://doi.org/10.4103/1119-0388.130175

Ntuli, V., Chatanga, P., Kwiri, R., Gadaga, H. T., Gere, J., Matsepo, T., & Potloane, R. P. (2017). Microbiological quality of selected dried fruits and vegetables in Maseru, Lesotho. *African Journal of Microbiology Research*, *11*(5), 185–193. https://doi.org/10.5897/ajmr2016.8130

Odenigbo, M. (2013). Proximate Composition and Consumption Pattern of Plantain and Cooking-Banana. *British Journal of Applied Science & Technology*, *3*(4), 1035–1043. https://doi.org/10.9734/bjast/2014/4943

Onwuka, G. I., Onyemachi, A. D., & David-Chukwu, N. . (2015). Comparative Evaluation of Proximate Composition and Functional Properties of Two Varieties of Cooking Banana\n. *IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)*, *9*(1), 01–04. https://doi.org/10.9790/2402-09130104

Oo, K. S., & Win, Y. Y. (2011). Study on the Preparation of Banana Chips and Banana Powder. 4(3).

Osunde, Z. D. (2015). Quality o f Dried Banana Fruit Under Different Pretreatments a nd Drying Quality of Dried Banana Fruit Under Different Pretreatments and Drying Methods. *Australian Journal of Engineering Research*, (January), 1–7.

Rayo, L. M., Chaguri e Carvalho, L., Sardá, F. A. H., Dacanal, G. C., Menezes, E. W., & Tadini, C. C. (2015). Production of instant green banana flour (Musa cavendischii, var. Nanicão) by a pulsed-fluidized bed agglomeration. *LWT - Food Science and Technology*, *63*(1), 461–469. https://doi.org/10.1016/j.lwt.2015.03.059

Rose-monde, M., Kouassi, K., Séverin, A., Lessoy, Z., Edwige, A., & Sébastien, N. L. (2013). *Microbiological safety and quality assessment of a very appreciate traditional ready to eat plantain food , sold in retails markets*. *7*(32), 4123–4129. https://doi.org/10.5897/AJMR12.1282

Rotaru, G., Sava, N., Borda, D., & Stanciu, S. (2005). Food Quality and Safety Management Systems: a Brief Analysis of the Individual and Integrated Approaches. *Agroalimentary Processes and Technologies*, *XI*(1), 229–236.

Sanders, E. R. (2012). Aseptic laboratory techniques: Plating methods. *Journal of Visualized Experiments*, (63), 1–18. https://doi.org/10.3791/3064

Sharif, L., Obaidat, M. M., & Al-Dalalah, M.-R. (2013). Food Hygiene Knowledge, Attitudes and Practices of the Food Handlers in the Military Hospitals. *Food and Nutrition Sciences*, *04*(03), 245–251. https://doi.org/10.4236/fns.2013.43033

Sultana, M., Alam Mahumud, R., Razzaque Sarker, A., & Mahmud Hossain, S. (2016). Hand hygiene knowledge and practice among university students: Evidence from private universities of Bangladesh. *Risk Management and Healthcare Policy*, *9*, 13–20. https://doi.org/10.2147/RMHP.S98311

Sylvia, A. B., RoseAnn, M., & John, B. K. (2015). Hygiene practices and food contamination in managed food service facilities in Uganda. *African Journal of Food Science*, *9*(1), 31–42. https://doi.org/10.5897/ajfs2014.1170

Tshiunza, M., Lemchi, J., Onyeka, U., & Tenkouano, A. (2001). Cooking Banana Consumption Patterns in the Plantain-growing Area of Southeastern Nigeria. *Tropicultura*, Vol. 19, pp. 135–140.

Valeeva, N. I., Meuwissen, M. P. M., & Huirne, R. B. M. (2004). Economics of food safety in chains: A review of general principles. *NJAS - Wageningen Journal of Life Sciences*, *51*(4), 369–390. https://doi.org/10.1016/S1573-5214(04)80003-4

Vera Zambrano, M., Dutta, B., Mercer, D. G., MacLean, H. L., & Touchie, M. F. (2019). Assessment of moisture content measurement methods of dried food products in small-scale operations in developing countries: A review. *Trends in Food Science and Technology*, *88*(July 2018), 484–496. https://doi.org/10.1016/j.tifs.2019.04.006

Vijayavenkataraman, S., Iniyan, S., & Goic, R. (2012). A review of solar drying technologies. *Renewable and Sustainable Energy Reviews*, Vol. 16, pp. 2652–2670. https://doi.org/10.1016/j.rser.2012.01.007

Walker, E., Pritchard, C., & Forsythe, S. (2002). Hazard analysis critical control point and prerequisite programme implementation in small and medium size food businesses. *Food Control*, *14*(3), 169–174. https://doi.org/10.1016/S0956-7135(02)00061-0

Y. Waré, L., P. Nikièma, A., C. Meile, J., Kaboré, S., Fontana, A., Durand, N., … Barro, N. (2018). Microbiological safety of flours used in follow up for infant formulas produced in Ouagadougou, Burkina Faso. *AIMS Microbiology*, *4*(2), 347–361. https://doi.org/10.3934/microbiol.2018.2.347

Yang, F. (2015). Effects of Green Banana Flour on the Physical , Chemical and Sensory Properties of Ice Cream. *53*(3), 315–323.

APPENDICIES

Appendix 1: **Consent Form**

Title: Chemical and Microbial Characteristics of Banana flour From Micro and Small Enterprises in Meru County, Kenya

University of Nairobi, Department of Food Science, Nutrition and Technology, Food Safety and Quality Program

Faith Wanjera is a student from the University of Nairobi studying MSc. in Food safety and Quality Assurance. She is conducting a study on the Chemical and Microbiological Characteristics in banana flour produces from Micro and Small Enterprises in Meru County. In order to get this information, I am pleased to have you take part in this study.

The study involves answering of a few questions with the responses you give being filled in a questionnaire. The information you will provide will help in instituting measures for hygienic practices among banana flour producers.

The information you will provide is confidential and in as much as a report of the same will be made, no names will be included. There is no way any information will be directly associated with you. I encourage you to participate in the study and your cooperation is highly appreciated.

Please sign below if you accept to be part of the study

Name of Interviewee……..

Signature of interviewee……

Date……..

In case of any problem,

Contact: Faith Thumbi

Phone Number: 0727411137

Appendix 2: Questionnaire

Section A: Socio-Demographic and Economic information

Respondent's Details

Residence	**Sex** **1=Male** **2=Female**	**Age** **Yrs.** **(Codes**	**Marital** **Status** **(codes)**	**Education** **(codes)**	**Income status**

Marital status	**Education**	**Age**	**Occupation**
1=Married 2=Separated 3=Widowed 4=Single	1=College/University 2=Completed Secondary 3=Completed primary 4= 10= Others (specify)	1) 18-27 2) 27-37 3)38-47 4) 48-57	=Salaried employee 2=Farmer 3=Self employment 4=Casual laborer 5=Student 6=Housewife 7=Unemployed 8=Others (specify) 9=N/A

1. Do you have any orientation in hygiene knowledge and practise?

1=Yes [ ] 2=No [ ]

2. Do you have medical clearance from public health department?

1=Yes [ ] 2=No [ ]

Section B: Assessment on Hygiene Knowledge

Questions	**1=YES**	**2=NO**	**3= DO NOT KNOW**
1. Microbe are on skin of healthy banana flour			
2. Banana do not spoil easily even without proper drying.			
3. *E.coli* is one food borne pathogen			
4. *S.aureus* can't be found in hands of food handler but only in food.			
5. No need for medical clearance if handler is not sick			
6. Drying eliminate moisture, reduce yeast and molds in flour			
7. High temperature or freezing is safe method to destroy bacteria			
8. Health status of workers evaluated before employment			
9. Take leave from work when sick			
10. Improper handling of bananas pose health hazard to consumers.			
11. Food borne illness are not serious to cause death			
12. Bad odour in food is a sign of food spoilage,			
13. Cross contamination transfer microbes to hands and to utensils			
14. Utensils handling can results into cross contamination of foods			
15. Hand washing reduces chances of contamination of food.			
16. All food borne illnesses have same symptoms as TB and AIDS			
17. Food contact surfaces not be cleaned everyday but only when dirty			

18. Cleaning is the same as sanitizing			
19. Foods from the supermarket are very clean and can be taken without washing.			
20. Water is an agent of food contamination			
21. Using sterilized gloves help prevent food contamination			
22. Food borne illnesses can affect all people			

Section C: Assessment on Hygiene Practise

Questions	**1=YES**	**2=NO**	**3= DO NOT KNOW**
1. Do you daily clean working area before banana flour processing?			
2. Do you eat or drink at work place?			
3. Do you wash hands with soap?			
4. Do you handle bananas when you have bruises or injuries?			
5. Do you use detergent in cleaning utensils?			
6. Do you use protective clothing in banana flour preparation?			
7. Do you use protective clothing in banana flour preparation?			
8. Do you wear jewelry while working?			
9. Do you clean storage area before storing banana flour?			
10. Do you rub face, hands, face and hair while working?			
11. Do you wipe hands with protective clothing?			
12. Do you store on the floor?			
13. Do you store on the floor lined with sack?			

14. Do you store on the top of wooden crates?			
15. . Do you package in polythene sack?			
16. Do you packaged sealed container?			