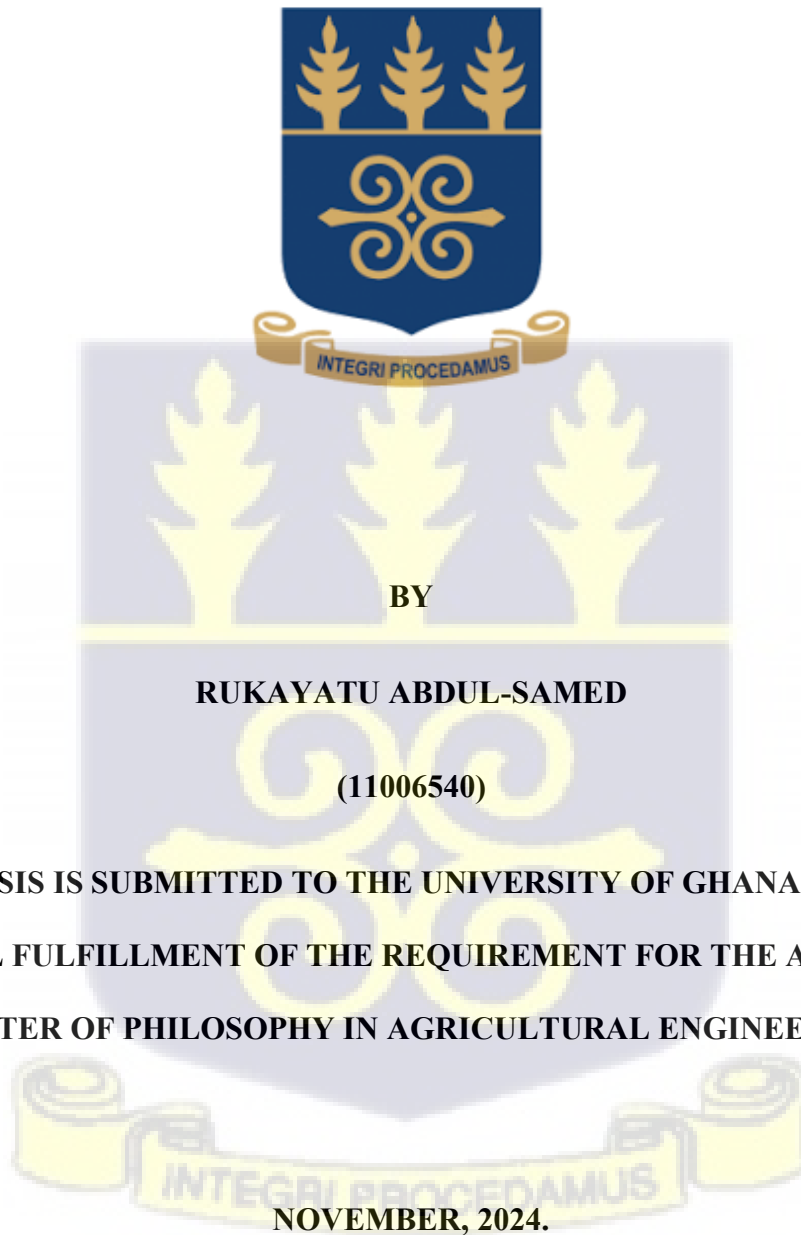


**MODELLING AND OPTIMISATION OF THE FANTI KENKEY PRODUCTION
PROCESS**



**THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON IN
PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF
MASTER OF PHILOSOPHY IN AGRICULTURAL ENGINEERING.**

DECLARATION AND CERTIFICATION

Student Declaration

I, Rukayatu Abdul-Samed, hereby declare that, except for the references cited which have been duly acknowledged, this submission is my own work towards a Master of Philosophy in Agricultural Engineering, and that to the best of my knowledge, it contains no materials previously published by another person. I also declare that this has not been presented either in whole or in part for another degree in this University or elsewhere.



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ABSTRACT

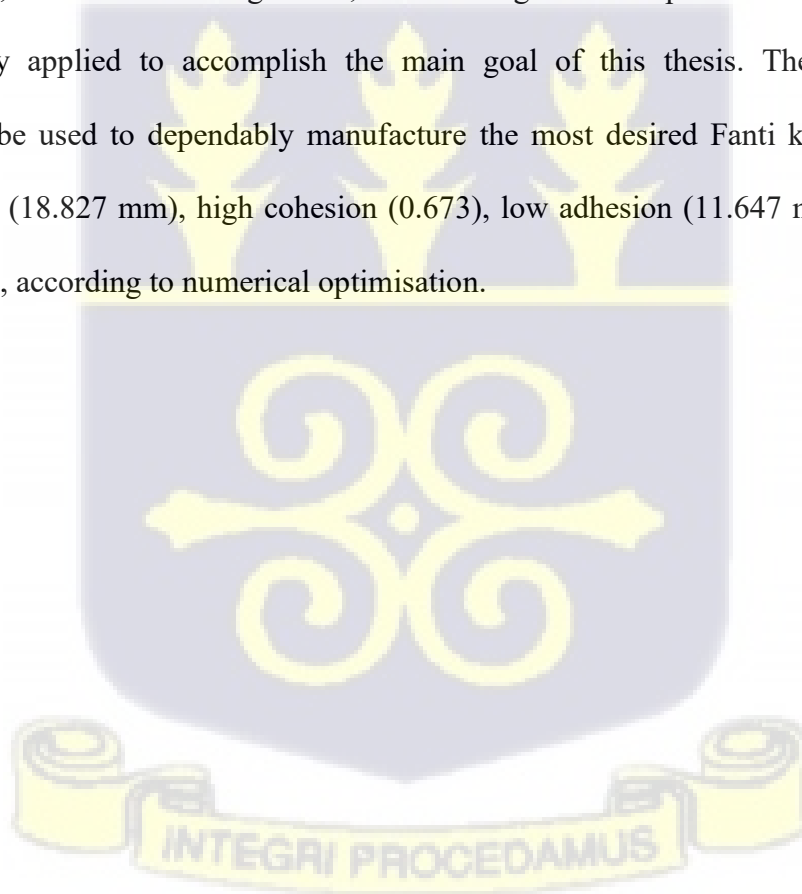
This study focused on developing and optimising the production process of Fanti kenkey, a traditional fermented maize product widely consumed in Ghana, with the goal of reducing the variability in quality due to non-standardized processing methods. The research was carried out in two phases. In the first phase, a structured survey was administered to 138 Fanti kenkey processors across the Central and Eastern regions of Ghana, covering towns such as Abura, Anomabo, Nyanyano, Kade, and Koforidua. The results showed that 99% of the respondents were females with aged between ranges from 28 to 54 years. 20 individuals or 14.5%, reported skipping some operations. Of these, 7 respondents or 5.1% skipped fermenting, 11 respondents or 8% skipped soaking, and 1 respondent or 0.7% skipped grinding. The majority, 118 respondents or 85.5%, did not skip any operations. The survey gathered information on traditional methods, key processing challenges, and common practices used by processors to maintain product quality and efficiency.

The second phase consisted of experimental trials designed to measure the effects of critical processing parameters—steeping time, mixing ratio, and cooking time—on the texture and pH of Fanti kenkey. A total of 30 experimental runs were conducted with two replications per condition. Texture analysis was performed using a texture analyser, measuring properties such as adhesion, cohesion, springiness, and hardness, while pH was assessed using a pH meter.

The statistical analysis, using response surface methodology and correlation studies, revealed that mixing ratio significantly affected all measured texture properties, while pH showed no significant correlation with texture variables or processing factors. Descriptive statistics indicated a high degree of consistency across most quality metrics, such as pH, springiness, and

cohesion, but identified variability in steeping time, hardness, and adhesion, which reflected diverse traditional practices.

The results emphasize the cultural and socioeconomic importance of Fanti kenkey production, which not only provides a staple food for a large segment of the Ghanaian population but also supports local economies by offering job opportunities in maize processing and street vending. The findings underscore the potential benefits of optimising critical unit operations to improve the consistency and quality of Fanti kenkey. By verifying that the final textural characteristics and pH of the product are significantly and predictably impacted by the standard processing steps of steeping time, aflata to raw dough ratio, and cooking time. Response Surface Methodology was successfully applied to accomplish the main goal of this thesis. The following ideal parameters can be used to dependably manufacture the most desired Fanti kenkey, which has high springiness (18.827 mm), high cohesion (0.673), low adhesion (11.647 mJ), and moderate hardness (175 g), according to numerical optimisation.



DEDICATION

I dedicate this work to the Almighty God and my husband for the love and support he gave me throughout my study.



ACKNOWLEDGEMENT

First, my profound gratitude goes to the Almighty God for giving me the strength, guidance and protection throughout the programme successfully.

My next sincere appreciation goes to my supervisors Dr. Essien and Prof. Bani for their advice, ideas, criticisms and suggestions that contributed greatly towards the preparation of this work. I also express my gratitude to Dr. Ing. Peace K. Amoatey and Prof. Saalia, for their support and encouragement. To my dear husband, I acknowledge his support, encouragement and love for seeing me from the beginning of my programme to the end. I also thank my colleagues at work that helped me in diverse ways towards the successful completion of my programme.

Finally, my sincerest thanks go to my family for their support, prayers, sacrifices, patience and encouragement throughout this period.

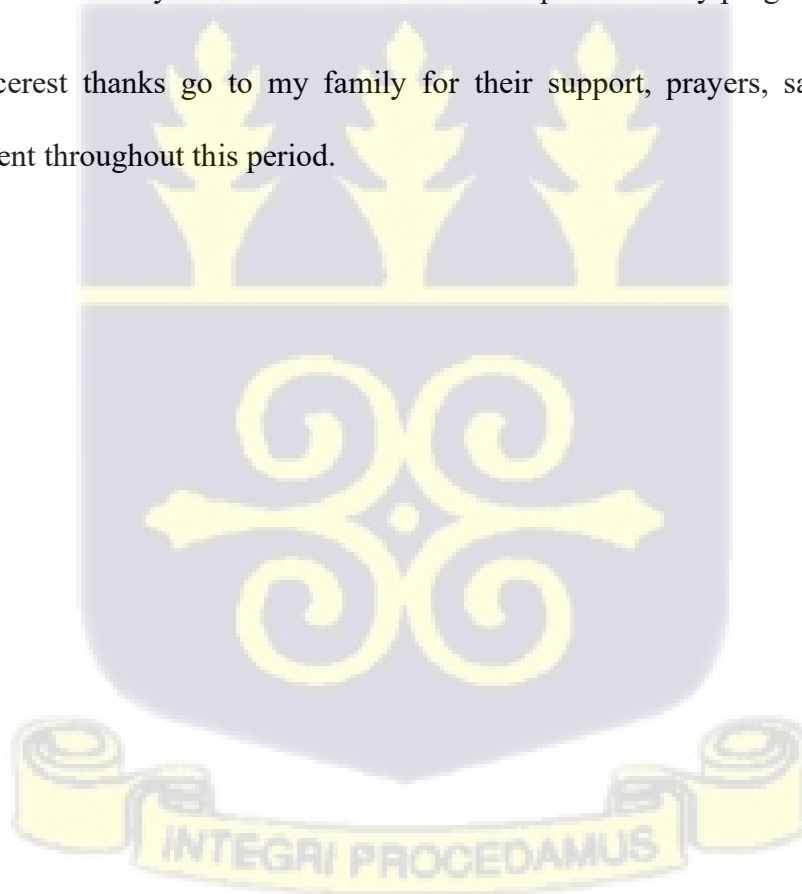


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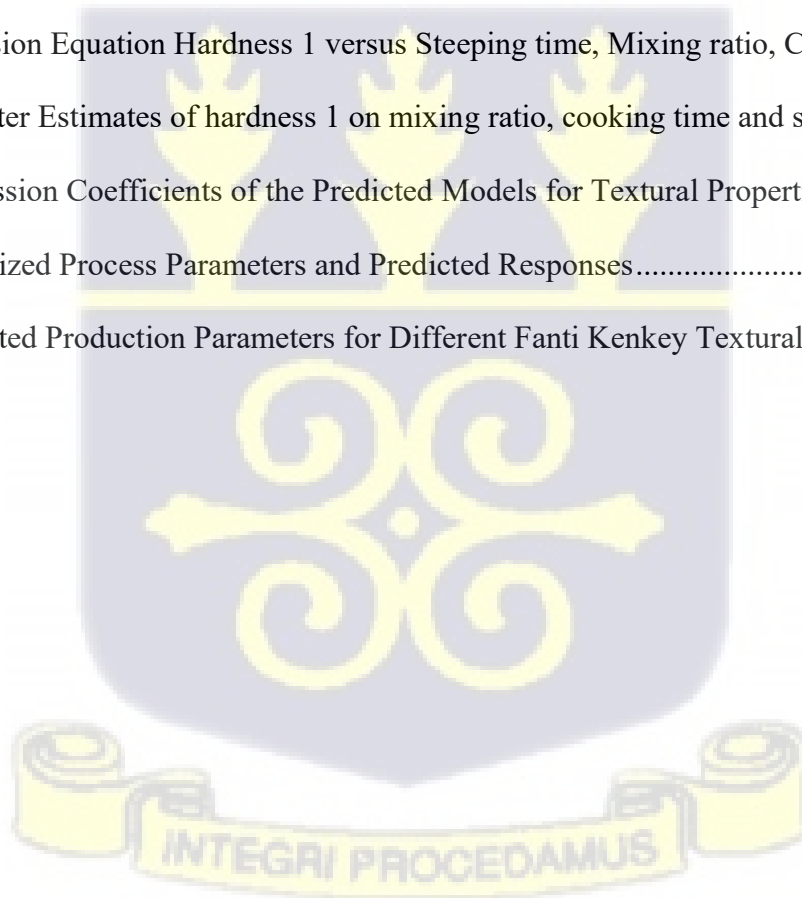
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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

Zea mays, commonly known as maize, is an annual graminaceous plant with American roots that was first brought to Europe in the sixteenth century. It subsequently spread outside of the continent, throughout Africa and Far East Asia, and thanks to its remarkable ability to adapt to various climates, it is now regarded as one of the world's most significant cereals. Although it has low protein content, maize is regarded as an essential food grain in many nations, particularly in Africa, Asia, Central America, and Southern America (Chaves-López et al, 2020).

Asante et al. (2011) found that kenkey, a traditional fermented corn meal product native to Ghana's coastal regions, including the capital Accra, has a moisture content of 52–55 percent, a pH of about 3.7, and a shelf life of 3–4 days. Kenkey is a popular staple food in Ghana made from fermented maize dough (Halm et al., 2004a).

It is known to be produced in Ghana by two ethnic groups: the Fanti in the Central and Western areas and the Ga in the Greater Accra area. "Fanti kenkey" has socioeconomic significance since it provides an economical main meal that is frequently consumed by a sizable portion of the Ghanaian population, as well as a means of subsistence for several families involved in its manufacture and distribution. For those with limited resources, it is an essential diet that offers a substantial, reasonably priced meal that makes them feel full (Halm et al., 2004).

"Fanti-kenkey" is moulded into cubic shape and covered with a polyethylene bag and then wrapped with banana leaves. Many of the people who create "Fanti kenkey" rely on the commercial production and street selling of it for their livelihood. The "Fanti kenkey" sellers in Ghana contribute significantly to the country's economy since their products are reasonably

priced and accessible for middle-class consumers. It gives households additional income and job chances for the unorganized sector (Tortoe et al., 2008).

The moisture content range for “Fanti-Kenkey” is 52–55%, and its pH is 3.7. According to Halm et al. (2004a), its shelf life is expected to be within 3–4 days. Fanti-Kenkey has a 6–10-day shelf life, according to studies by Mensah et al. (2012).

Despite being an essential component of the local economy and diet, the production of Fanti Kenkey is still mostly an artisanal craft, using non-standardized techniques that have been passed down through the centuries. There is a great deal of variation in the end result because of this dependence on arbitrary metrics and conventional methods. Important processing variables include the amount of time maize takes to steep, the proportion of raw to cooked dough, and the length of time it takes to cook can vary from producer to producer and even batch to batch. As a result, customers encounter irregularities in important quality characteristics such as taste, texture, shelf life, and even safety. In addition to lowering consumer satisfaction and confidence, this fluctuation restricts Fanti kenkey's financial potential by making it more difficult for producers to expand their businesses, reach new markets, or ensure a steady export product.

A number of scholars have looked into particular facets of kenkey manufacture in response to these difficulties. For example, research has concentrated on the chemical and microbiological alterations that occur during fermentation in order to pinpoint the main organisms that give it its distinct flavour and preservation properties (Halm et al., 2004; Annan et al., 2003).

Amoa-Awua et al. (2007) investigated how semi-commercial manufacturing environments might be made safer by implementing quality management systems such as HACCP. Additionally, studies have looked at the possibility of reducing wastewater (Asante et al., 2011) and the impact of various packaging materials on shelf life (Mensah et al., 2012). Nevertheless, a sizable gap in

the process's overall modelling and optimisation still exists in spite of these important contributions. The final textural qualities of Fanti kenkey, which are crucial for customer acceptance, are influenced by a number of significant processing variables, including steeping time, mixing ratio, and cooking time. However, few researches have thoroughly examined these interactions.

Therefore, this work is crucial because it goes beyond evaluating individual processes to create a prediction model for the complete production process of Fanti Kenkey. This study intends to give manufacturers a useful, scientifically supported framework for lowering product variability by modelling and optimising the important variables. The consequences are significant for the Fanti Kenkey company. A standardised procedure might provide a consistently high-quality product that would increase brand loyalty and fetch higher costs. Additionally, reduced production time, increased shelf life, and improved resource efficiency could all result from optimised parameters, creating new business opportunities including supermarket retail distribution and export markets. Finally, this project aims to promote the economic viability of Ghana's informal food sector, empower local producers, and upgrade a traditional staple meal.

1.2 Problem Statement

The issues of variability and non-standardized processing methods used in Fanti kenkey production sometimes affect the product quality in terms of nutrients, texture, etc.

1.3 Justification

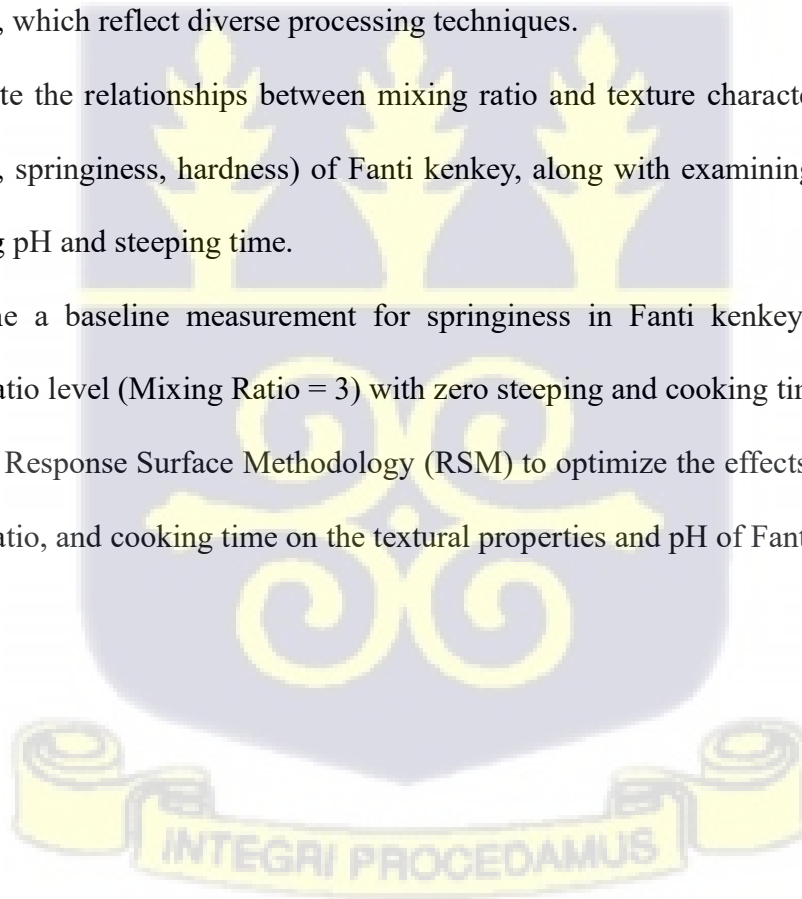
This study aims to optimize processing models to reduce quality variation and enhance consistency in Fanti kenkey production.

1.4 Objectives

The aim of the research study was to develop and optimize the production of “Fanti kenkey”.

The specific objectives for the proposed research were:

- a) Explore the cultural importance and economic sustainability of traditional maize processing trades, focusing on how practitioners incorporate minor innovations within established methods to enhance product quality and operational efficiency.
- b) Use descriptive statistics to evaluate consistency across variables such as pH, springiness, and cohesion, while identifying notable variations in steeping time, hardness, and adhesion, which reflect diverse processing techniques.
- c) Investigate the relationships between mixing ratio and texture characteristics (adhesion, cohesion, springiness, hardness) of Fanti kenkey, along with examining any correlations involving pH and steeping time.
- d) Determine a baseline measurement for springiness in Fanti kenkey at the reference mixing ratio level (Mixing Ratio = 3) with zero steeping and cooking times.
- e) To apply Response Surface Methodology (RSM) to optimize the effects of steeping time, mixing ratio, and cooking time on the textural properties and pH of Fanti kenkey.



CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Maize (*Zea mays*)

In central Mexico, maize (*Zea mays*) first appeared about 5,000 BC. In the sixteenth century, the crop was brought to Europe, from which it migrated to Asia and Africa. It is currently one of the most extensively cultivated crops in both temperate and tropical climates worldwide. When it comes to both production and consumption, maize is the most significant cereal in Ghana. 3% of the Agricultural Gross Domestic Product was accounted for by the 2 billion metric tons of maize produced worldwide in 2012 (SRID, 2013).

Over half of all cereals produced in Ghana are made from maize, making it a significant food crop. The crop thrives across the majority of Ghana's ecological zones, including the northern savannah, because to its good adaptation. In many places of Ghana, it's a substantial source of calories. Compared to a projected possible output of roughly 6.0 t/ha, the average yield of maize grains on farmers' fields is approximately 1.7 t/ha (MoFA, 2011).

The most well-known traditional dish made with fermented maize dough is kenkey, a sour, stiff dumpling that is wrapped in leaves and cooked. Other traditional dishes made with maize include banku, koko, and abolloo (Johnson and Halm, 1998).

2.2 Kenkey

Ghana, West Africa is home to the indigenous fermented product known as kenkey, which is primarily made along the coast. There are numerous varieties of kenkey, and they differ based on the ethnic background, type of packaging, and appearance. Two ethnic groups, the Gas in the Greater Accra region and the Fantis in the Central and Western regions, have historically produced it.

Ghana produces two varieties of Kenkey: "Ga-Kenkey," also known as Komi, and "Fanti kenkey," also known as dokono among the Fantis. The Ga-kenkey is often shaped like a sphere and enveloped with corn sheaths, whereas the Fanti-kenkey is shaped like a cylinder and enveloped in plantain or banana leaves.

According to Halm et al. (2004), it has a pH of roughly 3.7 and a moisture content of 52–55%. With a low protein and fat content and a high fibre and carbohydrate content, it is highly healthy. Minerals and vitamins including riboflavin, thiamine, niacin, and folates are also present, along with vitamins A, C, E, K, and B (Amoa-Awua et al., 2007).

One of the most popular dishes made in conventional food processors is kenkey, a sour dumpling. The traditional method of making kenkey involves soaking maize for one to two days at room temperature, grinding it, and allowing it to spontaneously ferment for two to four days. It is made by cooking the fermented, sour meal that is made from maize.

Due to its dual role as a primary meal that is routinely consumed by a significant portion of the population and a source of income for several families involved in its manufacture and distribution, kenkey has significant socioeconomic significance. The importance of kenkey in the diets of low-income workers has been highlighted by Halm et al. (2003). It is an economical, filling, and reasonably priced hefty supper that makes you feel full.

2.3 Types of Kenkey Produced in Ghana

There are two primary varieties of kenkey known as Ga and Fanti kenkey, which are predominant in various regions of the nation and have their origins there (Halm et al., 2004). The two types of kenkey have been the subject of extensive research, and a wealth of scientific information about them can be found in international literature. Some of the topics covered include the aroma of kenkey (Annan et al., 2003), starter cultures that can be used for their

production (Fadahunsi et al., 2012), and the use of GMP and HACCP as quality management systems to ensure the safety of kenkey (Amoa-Awua et al., 2007).

Other kenkey varieties exist, however they are less well-known, than Ga and Fanti kenkey. Still, these items are significant in certain regions of the nation. Nsiho, also known as akporhie, is a type of kenkey made from dehulled or degermed maize grains, giving it a whiter hue. Nsiho, or white kenkey, has a less sour flavour (thus blander) and a less sticky texture when compared to Ga and Fanti kenkey (Obodai et al, 2014).

2.4 Process flow of kenkey

In the process of kenkey processing, whole maize is ground, steeped for one to two days at room temperature, and then dough is formed (Nche et al., 1994, Amponsah, 2010, Dzigbor, 2012). Depending on the type of kenkey being produced, the dough is left to naturally ferment for a few days at room temperature. Following the fermentation process, the dough is split into two portions, with one portion being combined with water to create thin slurry.

Aflata is the thick, sticky paste made from the cooked slurry, which may or may not include salt depending on the type of kenkey. The raw part of the dough is well combined with the *aflata*. When part of the dough is cooked and combined with raw dough, it acts as a moisturizing agent and binding agent (Sefa-Dedeh and Plange, 1989).

Kenkey is made by moulding the mixture, wrapping it in plantain or corn husks, and cooking it. Firewood serves as the primary cooking fuel and is typically cooked in aluminium pots.

2.5 Fanti Kenkey

Fanti kenkey is a delectable dish that is highly favoured in the Fanti communities and has gained popularity across numerous other ethnic groups, nearly turning it into a national staple in Ghana. Maize serves as the primary basic material for Fanti kenkey. Because it ferments lactic acid, the

fermented food known as Fanti Kenkey, which is native to the area, has several inherent qualities, including antimicrobial activity.

2.5.1 Cleaning

To make kenkey, maize must be thoroughly cleansed to get rid of any foreign objects. This is accomplished by one or more of the following methods: winnowing, handpicking, sieving, and sedimentation. These procedures clear away waste such as stones, chaff, dust, and grains ruined by insects.

2.5.2 Steeping

This entails steeping the maize grains in clean water for one to three days, depending on the hardness and initial moisture content of the grains. According to Nout (1980), soaking stimulates natural enzymes including proteases and amylases.

The softening action that results from steeping is significant since it determines the efficiency of the milling operation with respect to the recovery of components. May (1987) reports that during steeping the maize kernel reaches a maximum moisture content of approximately 45% within 8-10hr. Ingbian and Agwu (2010) also observed water uptake of maize grains as a relatively fast process.

2.5.3 Milling and Doughing (Kneading)

After being steeped, the maize is ground in a plate mill, also called a "corn mill" in Ghana, into a very smooth meal that is combined with water to create dough that has 50–55% moisture content. It is crucial to use the right amount of water when forming the dough since it influences not only the dough's quality and shelf life but also its pace of fermentation.

This was followed by fine-milling fermented dough from coarsely milled grits at a rotor speed of 20,000 rpm using a 24-tooth rotor in conjunction with a 1 mm or 0.5 mm screen (Nche et al., 1995). A 12-tooth rotor and a 4 mm screen were used to mill soaked maize into course.

2.5.4 Fermentation

In many nations, fermented cereal dough and porridges are traditional staple foods. As the starch in the cereal is broken down by fermentation, it becomes more digestible. It also imparts a unique sour taste to the food and lowers the pH, which helps to preserve the dough.

For up to three days at room temperature, the dough is packed firmly into wooden vats, aluminium pots, enamel or aluminium basins, or plastic containers and let to ferment naturally.

According to reports, *Lactobacillus fermentum* is primarily responsible for the fermentation of maize dough (Sefa-Dedeh, 1993; Halm et al., 1993). Yeasts, in addition to lactic acid bacteria, are among the microbiological flora that is present in fermented maize (Jespersen et al., 1994; Halm et al., 1993; Hounhouigan et al., 1993). When nitrogen is plentiful, yeasts like *Saccharomyces cerevisiae* excrete amino acids and vitamins like B-vitamins, which are necessary growth factors for auxotrophic LAB (bacteria that are unable to manufacture their own critical chemicals). According to Ponomarova et al. (2017), yeast produces a nutritional niche for LAB through the "overflow" of amino acids, allowing the bacteria to flourish in conditions in which they would not otherwise be able to.

2.5.5 Preparation and Mixing Dough (*Aflata*)

After adding two or three parts water to a portion of the fermented dough, the mixture is cooked while being constantly stirred, resulting in a sticky, gelatinous paste called aflata. The processors rely more on subjective than on empirical measurements for control when combining the cooked dough (aflata) with the uncooked dough. Rather than using measures for managing and

determining mixing homogeneity that are derived empirically, the degree of mixing is decided by visual examination and experience. According to Amponsah (2010), the ultimate quality of kenkey is influenced by the extent to which aflata is mixed with uncooked dough.

When making Ga-kenkey, salt is added during this process; however, salt is not included when making Fanti-kenkey. Using wooden ladles mix the aflata completely with some of the uncooked fermented dough, then set aside to chill. When a portion of the dough is cooked and combined with raw dough, it acts as a moisturizing agent and binding agent (Sefa-Dedeh and Plange, 1989). When deciding on the appropriate textural characteristics for the finished product, aflata quality plays a critical role.

2.5.6 Moulding and Packaging

According to Halm et al. (2003), plantain leaves are used to encase the rectangular forms of Fanti-kenkey, which are then sealed within a polyethylene bag. Wrapping the kenkey ball in a polyethylene sheet before the plantain leaves is a recent invention in Fanti-kenkey packaging. The leaves still have an impact on the kenkey's flavour and scent even after this prolongs its shelf life (Obodai et al., 2014). Plastic is impermeable, which traps all moisture inside. While this can make the kenkey softer and smoother, it alters the traditional texture that results from the slight moisture loss allowed by leaves. Mensah et al. (2012) identified that plastic-wrapped kenkey had higher levels of heavy metals and chemical contaminants compared to leaf-wrapped controls.

2.5.7 Cooking

Fanti kenkey typically requires a prolonged boiling time (ranging from 6 to 12 hours, depending on batch size). To keep the kenkey balls from adhering to the pots while cooking, some clean maize husks or plantain leaves are placed at the bottom of huge metal cooking pots, followed by the balls of kenkey piled on top. To conserve steam, boiling water is poured into the pot to cover

the balls, and the top is covered with a cloth or polythene sheet. Cooking kenkey over firewood typically imparts a distinct smoky aroma and flavor. Volatile organic compounds (phenols and guaiacols) released from burning wood can penetrate the cooking water and, to a lesser extent, the porous leaf wrappers. For many traditional consumers, this "smokiness" is a marker of authenticity and higher quality.

2.6 Shelf life of Fanti kenkey

The cooked kenkey balls are kept warm until they are sold by being placed in a large container that is lined with polyethylene sheets. Kenkey has a pH of 3.7, a moisture content of roughly 62–68%, and a shelf life of three to four days without refrigeration (Hayford 1998). Fanti kenkey, on the other hand, has a marginally longer shelf life and keeps well in ambient storage for five to nine days (Atople, 2006).

Ga-kenkey has a shelf life of 1-3 days, while Fanti-kenkey has a shelf life of 7-14 days, according to Obodai et al., 2014. This depends on whether it was wrapped in a polyethylene sheet before the plantain leaves. Mensah et al. (2012) conducted a study which revealed that the main concern regarding the use of plastics in Fanti Kenkey cooking is the potential release of plasticizers, which are chemicals, added to plastics to increase their flexibility and durability. The study also revealed that the shelf life of Fanti-Kenkey is 6-10 days, while Ga-Kenkey has a shelf life of 2-5 days.

2.7 The Economic Importance of Fanti-Kenkey

The sour, stiff dumpling known as kenkey, made from fermented maize, is a popular street snack in Ghana. The economy of both rural and urban areas is significantly impacted by the commercial manufacturing and street sales of kenkey. All parties involved in the supply chain, including those who grow maize, provide inputs, process kenkey, and sell it, benefit from the

sale of kenkey. According to Tortoe et al. (2008), a woman with minimal cash can establish kenkey production in her home, albeit the kenkey vending business initially operates out of her residence.

According to Obodai et al. (2014), the socioeconomic significance of kenkey rests in the fact that it provides a primary source of income for several households involved in its manufacture and distribution. Many traditional food processors, both in rural and increasingly urban locations in recent years, rely on it as their primary source of income (Amoa-Awua et al, 2007). According to Kyei-Gyamfi et al. (2025), this commerce has historically provided funding for housing construction and children's education in Yamoransa, thus acting as an unofficial social security system. Highway merchants in hubs like Yamoransa and specialised "kenkey boutiques" in Accra can sell much larger quantities, frequently topping 100+ balls per day, in contrast to small-scale street sellers who might sell 20–30 balls.

2.8 Process Optimisation in Fermented Cereal Production

Process optimisation is a crucial area of food engineering that aims to regulate important processing factors in order to improve product quality, ensure consistency, increase yield, and improve operational efficiency. Response Surface Methodology (RSM) is one of the sophisticated statistical tools that are frequently used to model and optimise processes where a number of variables affect the features of the end product.

Adebayo et al. (2018), for example, used RSM to optimise the temperature and duration of fermentation for Nigerian ogi, a fermented maize porridge, in order to attain a desired balance between titratable acidity, pH, and customer sensory approval. Their program was able to pinpoint the ideal circumstances that shortened the fermentation period while increasing taste. Similar to this, studies on sourdough bread have used central composite design to examine how

the finished loaf's textural qualities, like cohesion and crumb hardness, are affected by the amount of hydration and the length of the proofing process (Clarke & Arendt, 2021). In fermented cereal systems, these experiments demonstrate how well RSM maps the intricate relationships between processing parameters and the quality.

A major emphasis of many studies on food processing has been the optimisation of textural qualities. For instance, in order to increase the springiness and decrease cooking loss of rice flour noodles, Gujral and Singh (2015) optimised the addition of several hydrocolloids using RSM.

In a different study on extruded snacks made from maize, researchers simulated how moisture content and screw speed affected the end product's crispiness and hardness, determining the best processing window to satisfy customer preferences (Jones & Williams, 2019). One of the main goals of the current study on Fanti kenkey is to target and improve particular textural features, and these examples show a clear precedent for doing so using statistical modelling.

Utilising Response Surface Methodology to maximise the production of different fermented and cereal-based food items. Researchers have successfully manipulated process variables to improve textural, chemical, and sensory qualities. A significant vacuum in the literature still exists, nevertheless, in the form of an extensive optimisation research that concentrates on the conventional Fanti kenkey procedure.

The three crucial artisanal steps—steeping time, dough mixing ratio, and cooking time—have not been rigorously modelled in any previous work with regard to their combined effects on the finished textural profile of Fanti kenkey. A new and focused optimisation model for Fanti kenkey producers in Ghana is thus provided by this study, which expands on these tried-and-true approaches to close this gap.

2.9 Summary of Literature and Identification of Research Gaps

Fanti kenkey is a staple dish in Ghana with great cultural and economic significance, as confirmed by the material examined in this chapter. The foundational processes of its manufacturing, from cleaning and steeping maize to fermentation and cooking are acknowledged in this study in accordance with previous research (Nche et al., 1994; Halm et al., 2004).

Previous research has shed light on a number of specific features of the process, such as the chemical properties of the dough (Annan et al., 2003), the microbiology of fermentation (Jespersen et al., 1994), and the possibility of implementing contemporary food safety regulations (Amoa-Awua et al., 2007). A solid basis for comprehending the distinct unit activities involved in kenkey manufacture is provided by this body of work.

Nonetheless, a thorough analysis of the literature identifies a number of noteworthy gaps in spite of their contributions. First off, a piecemeal strategy has been used in the majority of previous studies, concentrating on individual process elements like fermentation or packing separately. A comprehensive, multivariable analysis that examines the interdependent impacts of important processing parameters on the quality of the finished product is conspicuously lacking.

Second, the majority of the current body of work is descriptive. Very little study has been done on the Fanti kenkey process using quantitative modelling and optimisation methods like Response Surface Methodology (RSM). As such, producers are unable to manage for unpredictability and reliably deliver the desired output because they lack a predictive framework.

Last but not least, despite the fact that kenkey's textural qualities are crucial for consumer acceptance, no research has methodically modelled how the three most important artisanal factors—steeping time, the ratio of raw dough to aflata, and final cooking time—collectively affect qualities like cohesion, adhesion, hardness, and springiness.

This thesis is therefore intended to fill in these particular gaps. A thorough, predictive model for the Fanti kenkey production process is developed, going beyond a descriptive, single-variable analysis. In this study, the combined effects of steeping duration, mixing ratio, and cooking time on the textural and chemical qualities of Fanti kenkey will be extensively investigated for the first time using Response Surface Methodology.

The objective is to offer a framework for optimisation that may be applied to standardise production, lower variability, and improve the general quality and marketability of this significant traditional meal.



CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Summary

This section describes the methodology employed in the study. The research study was in two phases: (a) a survey was conducted for *Fanti kenkey* processors to learn about their methods, difficulties, and best practices. (b) In the second section of the study, it was determined how the texture and pH of *Fanti kenkey* are affected by steeping times, mixing ratios, and cooking times.

3.2 Materials

The main raw material for the experiment was yellow maize (*Zea mays* L.) of the "Obaatampa" variety, which was purchased from the Madina market in Accra and is a popular local variety that is chosen for making kenkey due to its high nutritional value. A total of twenty-five kilogrammes were purchased for the tests. A digital pH meter (Model -3510), cooking utensils, a thermometer, a weighing scale, a moisture meter, a Brookfield ct3 Texture Analyser (CT310K), and dried plantain leaves for wrapping were among the other supplies.

3.3 Sampling procedure used for survey of *Fanti-kenkey* processors

A survey of 138 Fanti kenkey processors was conducted in the Eastern area (Kade and Koforidua) and the Central region (Abura, Anomabo, and Nyanyano). This study used a non-probability sampling strategy. In particular, convenience sampling in conjunction with purposive sampling was employed.

Purposive sampling was used to first identify production hubs and popular selling locations within the chosen towns, as these were known to be centres of Fanti kenkey manufacture. Then, convenience sampling was used to choose processors who were available and willing to participate throughout the survey time. This method was thought to be suitable for learning about the customs of these important regions' producers, who are both active and seasoned.

The questionnaire recorded biographical information (sex, age, marital status, and educational attainment), the unit operations required to make *Fanti kenkey*, the quantity of maize used, the crucial unit operations of *Fanti kenkey*, and the consequences of skipping certain unit operations on the finished product.

3.4 Preparation of Fanti-Kenkey

The Fanti kenkey was made using a traditional, standardised process, with modifications made in accordance with the experimental plan. The procedure was as follows:

1. **Cleaning and Steeping:** The experimental design called for the maize grains to be manually sifted to remove any extraneous material before being steeped in tap water in a lidded plastic container at room temperature ($28\pm 2^{\circ}\text{C}$) for 24 to 48 hours.
2. **Milling and Doughing:** The process of milling and doughing involved draining the water after steeping, and then using a commercial plate mill to grind the softened grains into a fine meal. To create smooth, thick dough, the food was kneaded with a tiny bit of water. It was found that the dough had an initial moisture level of roughly 50–55%.
3. **Fermentation:** As determined by the initial survey, the dough was put in a closed container and let to ferment naturally for two days at room temperature.

4. **Preparation of *Aflata* and Mixing:** To make aflata, a thick, gelatinous paste, a part of the fermented dough was combined with water and heated over medium heat while being constantly stirred. After that, the aflata was cooled down to about 40°C. Following the mixing ratios outlined in the experimental design (1:1-1:3), the cooled aflata was thoroughly mixed with the remaining raw fermented dough. In order to replicate the traditional artisanal approach and guarantee a consistent and homogenous mixture, the mixing was done by hand for ten minutes.
5. **Moulding and Cooking:** The finished dough was shaped into homogeneous cylindrical balls weighing roughly 200g apiece, wrapped in plantain leaves, and steam-cooked for the intended amount of time (6-12 hours).



Plate 1: Samples of cooked Fanti kenkey

3.5 Determination of physicochemical characteristics of Fanti-kenkey

A pH meter was used to measure the pH after 20 grams of the sample were dissolved in 20 millilitres of distilled water for calibration.

3.6 Texture Profile Analysis

Texture profile analysis of the Fanti kenkey samples was determined by following the method described. The samples were cut into 40 mm X 40 mmX 40mm cubes after cooling to room temperature, before determining the TPA using the TA XT plus Texture analyser equipped 4mm diameter cylinder probe was used. The test speed of 4 mm/s, rupture test distance of 40 mm, auto trigger of 10 g, and deformation of 20 mm were the settings for the Brookfield ct3Texture Analyser (CT310K). The PDA parameters of adhesion, cohesiveness, hardness, and springiness were noted for each sample.



Plate 2: Texture analysis of samples

3.7 Statistical Analysis

The experimental design and statistical analysis were conducted to model and optimize the Fanti kenkey production process.

3.7.1 Survey Data Analysis

Data from the questionnaire survey were analysed for descriptive statistics (frequencies and percentages) using IBM SPSS Statistics (Version 27).

3.7.2 Experimental Design and Optimisation

A **Response Surface Methodology (RSM)** approach was employed to investigate the effects of three independent variables: steeping time (X_1), mixing ratio (X_2), and cooking time (X_3) on the textural properties and pH of Fanti kenkey. The optimisation was done using a Box-Benhken Design (BBD) with three levels and three factors. Thirty (30) experimental runs, comprising factorial and centre points, were part of the design.

The independent variables are shown in Table 1 together with their actual and coded levels. The statistical analysis was carried out using Minitab® statistical software (Version 21), which included the creation of regression models and analysis of variance (ANOVA).

The significance of the model and its terms was evaluated at a 95% confidence level ($p < 0.05$). Excel 2010 was used for preliminary data tabulation and generating descriptive statistics of the experimental results.

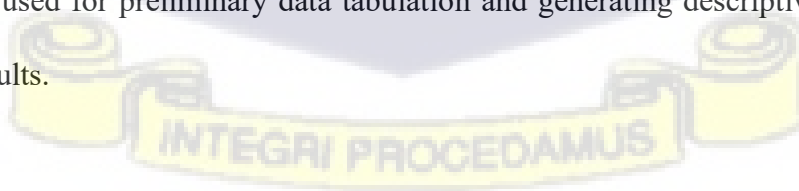


Table 1: Independent Variables and Their Levels for the Central Composite Design

Independent Variable	Code	-1 (Low)	0 (Midpoint)	+1 (High)
Steeping Time (hours)	X ₁	24	36	48
Mixing Ratio (<i>aflata</i> : raw)	X ₂	1:1	1:2	1:3
Cooking Time (hours)	X ₃	6	9	12



CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

4.1 Survey Data Analysis

This survey analysis provides a comprehensive overview of the respondents' demographics, educational levels, business experience, and practices related to their trade. The findings offer insights into various aspects such as the duration of business experience, sources of materials, operational processes, and reasons for engaging in the business.

4.1.1 Demographic Profile of Respondents

The demographic profile of the respondents reveals important insights into their personal and social backgrounds. Regarding marital status, the majority of the respondents are married, comprising 58 individuals, which represents 42% of the total sample. This is followed by single respondents, who make up 40 individuals or 29% of the sample. Widowed respondents account for 23 individuals, or 16.7%, while divorced respondents constitute the remaining 17 individuals, or 12.3%. These statistics indicate that the majority of the respondents are in stable family units, which might influence their engagement in business activities as a means of providing for their families. The age distribution of respondents ranges from 28 to 54 years. This range shows that most respondents are within a mature age group, suggesting that the business sector attracts individuals who are likely to have significant life and work experience. The respondents are also geographically distributed across several locations, including Abura, which accounts for 29.7% of the sample, Anomabo with 20.3%, Kade also at 20.3%, Koforidua with 10.1%, and Nyanyano representing 19.6%. This distribution suggests that the business practices surveyed are common across various communities, providing a broad perspective on the trade across different geographical areas.

4.1.2 Educational Levels of Respondents

The educational backgrounds of the respondents vary significantly, reflecting a diverse range of formal education levels (Figure 1). A considerable portion of the respondents, 44 individuals or 31.9%, reported having no formal education. This is a significant finding as it suggests that a substantial number of individuals engaged in the business have limited formal educational backgrounds. In contrast, 39 respondents, making up 28.3%, have attained primary education, while 20 respondents or 14.5%, and have completed Junior High School. Furthermore, 26 respondents, equivalent to 18.8%, have completed Senior High School, while only 5 respondents or 3.6%, and have attained tertiary education. An additional 4 respondents, or 2.9%, indicated other forms of education. These statistics highlight that the respondent group is largely composed of individuals with primary or secondary education levels, with a relatively small proportion having pursued higher education. This could reflect the accessibility and appeal of the business sector to individuals with varying levels of formal education.

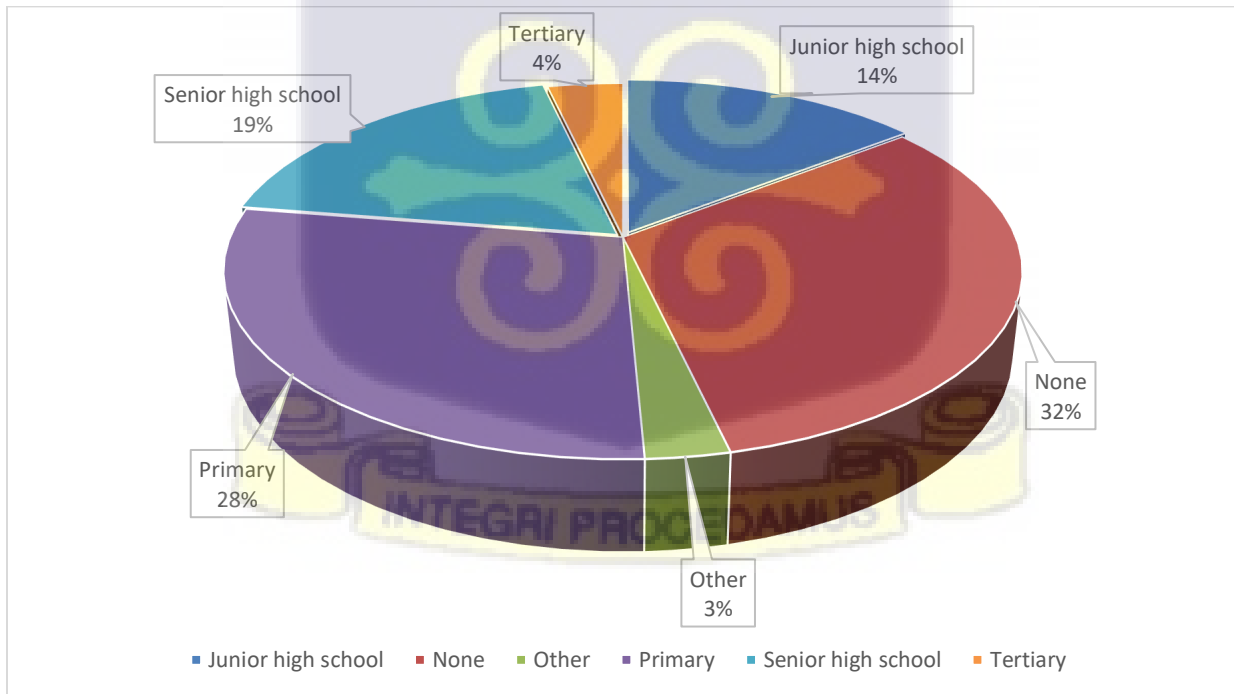


Figure 1: Educational Levels of Respondents

4.1.3 Business Experience and Practices

Respondents' experience in business varies widely, ranging from 1 year to as long as 35 years. Notably, the most frequent duration of business experience among respondents is 1 year, which is reported by only 0.7% of the sample, while the highest duration recorded is 17 years, with 11 respondents or 8% reporting this length of experience. The majority of respondents have been in business for between 1 to 20 years, reflecting a broad spectrum of experience levels. This variation in experience may influence the respondents' business practices and approaches, with longer-tenured individuals potentially possessing more refined skills and strategies.

The primary reasons respondents engage in the business also provide valuable insights. A large majority, 109 respondents or 79%, cited family income as their main motivation for engaging in the business. This suggests that the trade is a significant source of livelihood for many families, likely providing financial support for various household needs. A smaller proportion of respondents, 22 individuals or 15.9%, cited cultural heritage as their motivation, indicating a desire to preserve and continue traditional practices. Only 7 respondents, or 5.1%, reported personal interest as their primary reason for engaging in the business, suggesting that financial and cultural factors are more significant motivators than personal passion or hobby.

The ways in which respondents learned their trade also vary (Figure 2). A significant number of respondents, 64 individuals or 46.4% reported learning the trade through family tradition, indicating that the business is often passed down through generations. Additionally, 43 respondents, or 31.2%, learned through apprenticeship, while 31 respondents or 22.5%, are self-taught. These findings suggest that traditional and informal learning methods play a crucial role in skill acquisition for this trade, with formal education playing a less prominent role.

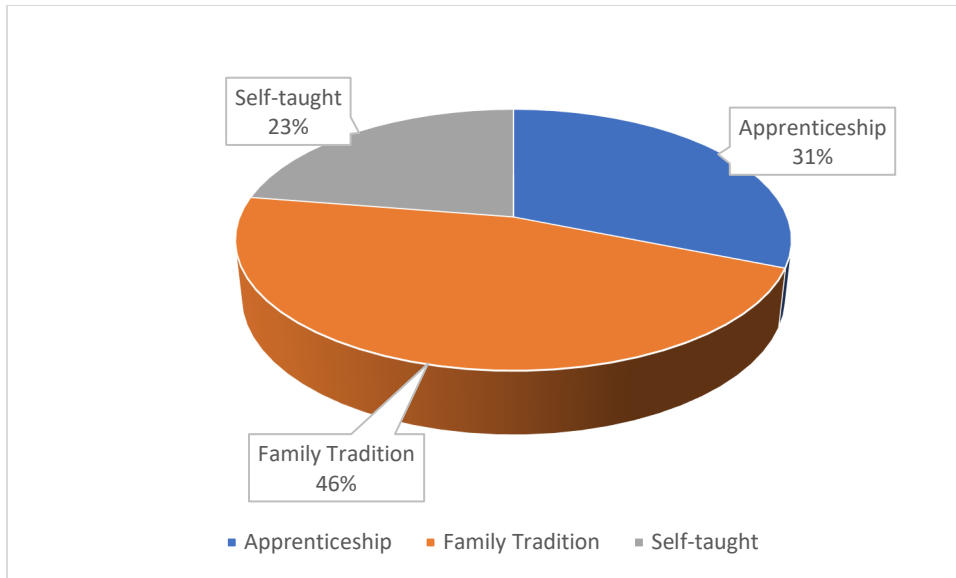


Figure 2: Methods by which respondents acquired their trade skills

4.1.4 Business Operations and Practices

The sources of materials used by the respondents reveal important aspects of their operational practices (Figure 3). The majority, 124 respondents or 89.9%, source their materials from the local market, reflecting a strong reliance on locally available resources. A smaller number of respondents, 8 individuals or 5.8%, use materials from their own farms, while 6 respondents, or 4.3%, obtain materials from other farmers. These findings suggest that most respondents prefer to source materials locally, likely due to convenience and cost considerations.



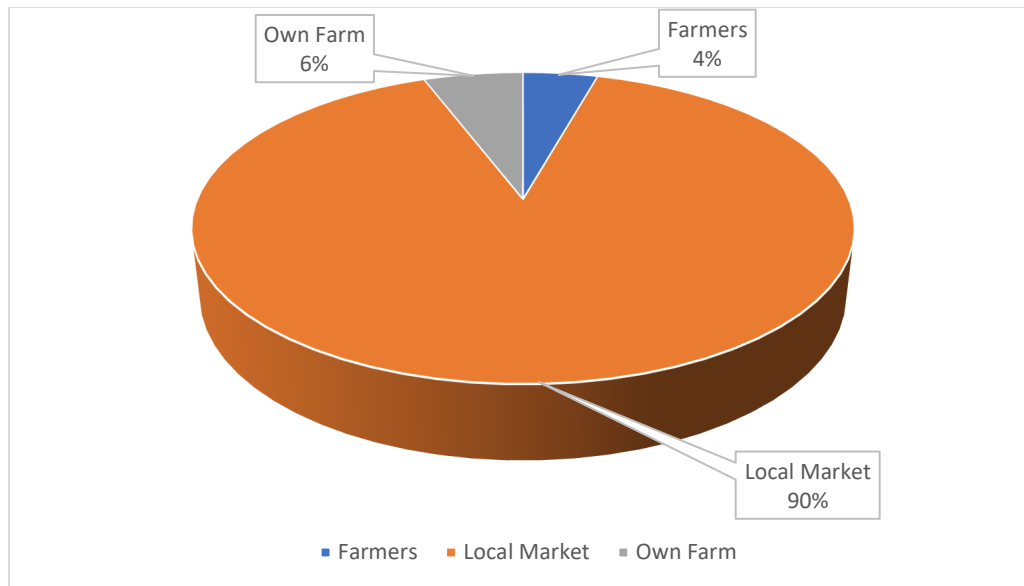


Figure 3: Sources of materials used by the respondents

4.1.5 Amount of maize used

In terms of the amount of maize used in their operations, respondents reported varying quantities. A total of 49 respondents, or 35.5%, use half a bag of maize, while 43 respondents, or 31.2%, use a full bag. Additionally, 46 respondents, or 33.3%, reported using more than one bag. These variations may reflect differences in business scale, production capacity, or customer demand.

4.1.6 Set of unit operations

All respondents, representing 100% of the sample, reported performing a standard set of unit operations, including soaking, milling, fermenting, pre-cooking, and cooking. This indicates a high level of uniformity in the production processes used across the different locations surveyed, suggesting standardized methods that are widely accepted and practiced. However, a small proportion of respondents, 20 individuals or 14.5%, reported skipping some operations. Of these, 7 respondents or 5.1% skipped fermenting, 11 respondents or 8% skipped soaking, and 1 respondent or 0.7% skipped grinding. The majority, 118 respondents or 85.5%, did not skip any

operations. These findings suggest that while most respondents adhere to the standard procedures, a minority might adapt or modify the process based on specific circumstances or preferences.

4.1.7 Effects of Operational Practices

The effects of skipping certain operations were also explored. A majority of respondents, 106 individuals or 76.8% reported that skipping operations had no effect on the final product. In contrast, 32 respondents, or 23.2%, reported that skipping operations had some effect, including changes in texture, taste, shelf life, and colour. These responses indicate that while some deviations from the standard process might not visibly affect the product, others could result in noticeable differences.

Regarding the soaking duration, respondents reported a range of practices. The most common soaking durations were one day, reported by 49 respondents or 35.5%, and two days, reported by 48 respondents or 34.8%. A smaller group, 40 respondents or 29%, reported soaking for three days. The effect of the soaking duration was also assessed, with 86 respondents or 62.3% indicating that it enhances fermentation, while 50 respondents or 36.2% noted that it increases the weight of the product. These findings suggest that soaking duration is an important variable that can impact the fermentation process and the final product's weight.

In terms of dough fermentation duration, respondents again reported varying practices. The most common fermentation durations were one day (49 respondents or 35.5%) and two days (47 respondents or 34.1%). A smaller number of respondents, 31 individuals or 22.5% reported fermenting the dough for three days. The primary indication of successful fermentation, as reported by 88 respondents or 63.8%, was a sour smell, while 47 respondents or 34.1% noted a

change in colour. These findings highlight the importance of sensory cues in determining the readiness of the dough for subsequent processing.

4.1.8 Product Preparation and Usage

In terms of the preparation and usage, all respondents, representing 100% of the sample, reported that their products are cooked, indicating a standardized cooking practice across all locations surveyed. This uniformity suggests a strong adherence to traditional cooking methods, which are likely crucial for ensuring product quality and safety.

The duration of dough usage varied among respondents, with 44 individuals or 31.9% each reporting using the dough for one day or three days, while 45 respondents or 32.6% reported using the dough for two days. The cooking time for "*Aflata*" also varied, with 53 respondents or 38.4% cooking for one hour, 45 respondents or 32.6% cooking for 30 minutes, and 40 respondents or 29% cooking for 1.5 hours. These variations in cooking time and dough usage suggest that while some standard practices are followed, there is also room for individual preferences and adaptations.

When asked about the reasons for half-cooking the product, 95 respondents or 68.8% indicated that it improves texture, while 43 respondents or 31.2% said it reduces cooking time. This suggests that half-cooking is a common practice aimed at enhancing product quality and efficiency.

4.1.9 Characteristics and Market Practices

The survey also explored the proportions used in mixing dough and "*Aflata*." A slight majority, 75 respondents or 54.3%, reported using a 50-50 proportion, while 63 respondents or 45.7% used a 60-40 proportion. Additionally, 98 respondents or 71% indicated that a uniform mixture is

achieved by consistent texture, while 40 respondents or 29% noted uniform colour as an indicator. These findings suggest that achieving a consistent mixture is a key concern for respondents, with texture and colour being the primary indicators of uniformity in their product. This emphasis on consistency indicates a focus on maintaining quality standards in their production processes, likely to meet customer expectations and ensure product satisfaction.

The cooking duration for "Kenkey," traditional fermented dough, also varies among respondents. The most common duration reported is 12 hours, as indicated by 64 respondents or 46.4%, while 40 respondents or 29% reported a cooking duration of 10 hours. The variation in cooking times suggests that while there is some flexibility in preparation, there is also a general adherence to extended cooking times to achieve the desired product quality. The indication of a well-cooked "Kenkey" is marked by specific qualities, with 55 respondents or 39.9% noting a uniform texture and brownish colour, while 42 respondents or 30.4% described it as soft yet firm. These criteria highlight the importance of texture and appearance in evaluating the quality of the final product, reflecting traditional standards and consumer preferences.

All respondents unanimously agreed that their business is profitable, underscoring the economic viability and sustainability of their trade. This suggests that despite varying practices and levels of experience, the business offers sufficient financial returns to support those engaged in it.

4.1.10 Innovations and Traditional Practices

The survey also explored the respondents' openness to innovations in their traditional practices. When asked about the use of alternative leaves for wrapping or cooking their products, 73 respondents or 52.9% indicated that they do not use alternative leaves, while 65 respondents or 47.1% reported that they do. This suggests a near-even split between those who adhere strictly to

traditional practices and those who are open to experimenting with or incorporating alternative materials, perhaps due to availability, cost, or environmental considerations.

Additionally, the respondents provided insights into the reasons for the cylindrical shape of their products. The majority, 77 respondents or 55.8%, stated that the cylindrical shape is traditional, while 61 respondents or 44.2% cited easier packaging as a reason. This indicates that while tradition heavily influences product shape, practical considerations such as packaging convenience also play a significant role.



4.2 Descriptive Statistics

The descriptive statistics (Table 1) provide a summary of the key characteristics for various variables measured across 30 observations:

Table 2: Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Steeping time	30	24	48	36	8.913
Mixing ratio	30	1	3	2	0.743
Cooking time	30	6	12	9	2.228
pH	30	3.76	4.23	4.0527	0.12993
Adhesion	30	6	34.4	11.16	5.9579
Springiness	30	16.2	21.9	18.763	1.1028
Cohesion	30	0.56	0.95	0.7047	0.0751
Hardness	30	109	314.5	166.1333	48.79407

4.2.1 pH

The pH values range from 3.76 to 4.23, with a mean of 4.05. The relatively low standard deviation (0.13) suggests that the pH values are quite consistent across the samples. On average, pH values are 0.13 more or less than 4.05.

4.2.2 Adhesion

Adhesion shows more variability, ranging from 6.0mJ to 34.4mJ. The mean is 11.16mJ, and the standard deviation (5.96mJ) indicates a moderate spread in the adhesion values. For any random ball of *Fanti kenkey*, its adhesion would be 5.96mJ more or less than 11.16mJ.

4.2.3 Springiness

Springiness values range from 16.2mm to 21.9mm, with a mean of 18.76mm. The standard deviation (1.10mm) suggests that the data is relatively consistent, with only slight variation in springiness across samples.

4.2.4 Hardness

Hardness values range from 100g to 314.5, with a mean of 166.13g. The standard deviation (48.794) suggests that the samples are on average 48.794 harder or softer than 166.13g

4.2.5 Cohesion

Cohesion values range from 0.56 to 0.95, with a mean of 0.7047. The low standard deviation (0.0751) suggests that the cohesion values are relatively consistent across the data set.

4.2.6 Cooking Time

Cooking time ranges from 6 to 12 hours, with a mean of 9.00 hours. The standard deviation (2.23) shows some moderate variation in cooking times.

4.2.7 Steeping Time

Steeping time ranges widely, from 24 to 48 hours, with a mean of 36.00 hours. The high standard deviation (8.91) suggests significant variation in steeping times.

4.2.8 Mixing Ratio

Mixing ratio ranges from 1 to 3, with a mean of 2.00. The standard deviation (0.743) indicates some variability in mixing ratios across the samples

4.3 Correlation Analysis

Table 3 shows the correlation of various measured properties

Table 3: Correlations

		Steepin g time	Mixing ratio	Cookin g time	pH	Adhesio n	Springines s	Cohesion	Hardness
Steeping time	Pearson Correlatio n	1.000	0.000	0.000	-0.279	-0.093	-0.219	-.408*	-0.043
	p-value		1.000	1.000	0.136	0.626	0.245	0.025	0.822
Mixing ratio	Pearson Correlatio n	0.000	1.000	0.000	0.000	.687**	.556**	.470**	.662**
	p-value	1.000		1.000	1.000	0.000	0.001	0.009	0.000
Cooking time	Pearson Correlatio n	0.000	0.000	1.000	0.172	0.155	-0.051	0.074	-0.034
	p-value	1.000	1.000		0.365	0.413	0.791	0.697	0.857
pH	Pearson Correlatio n	-0.279	0.000	0.172	1.000	0.145	0.045	0.132	0.082
	p-value	0.136	1.000	0.365		0.445	0.814	0.488	0.668

Adhesion	Pearson Correlation	-0.093	.687**	0.155	0.145	1.000	.566**	.619**	.744**
	p-value	0.626	0.000	0.413	0.445		0.001	0.000	0.000
Springiness	Pearson Correlation	-0.219	.556**	-0.051	0.045	.566**	1.000	.711**	.457*
	p-value	0.245	0.001	0.791	0.814	0.001		0.000	0.011
Cohesion	Pearson Correlation	-.408*	.470**	0.074	0.132	.619**	.711**	1.000	.387*
	p-value	0.025	0.009	0.697	0.488	0.000	0.000		0.035
Hardness	Pearson Correlation	-0.043	.662**	-0.034	0.082	.744**	.457*	.387*	1.000
	p-value	0.822	0.000	0.857	0.668	0.000	0.011	0.035	

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

4.3.1 Correlation of pH with cooking time, steeping time and mixing ratio

4.3.1.1 pH

It was observed that pH has a weak positive relationship with cooking time and a weak negative relationship with the steeping time. However, there is no correlation between the pH of *Fanti*

kenkey and its mixing ratio. pH increases marginally with increasing cooking times and decreases marginally with increasing steeping times. It is worth mentioning also that these correlations are not statistically significant as all three p-values are greater than 0.05. Thus, in the larger population, there would be no significant correlation between pH and steeping time, cooking time and mixing ratio of *Fanti kenkey*.

4.3.2 Correlation of texture with cooking time, sleeping time and mixing ratio

4.3.1.2 Adhesion

Adhesion has a strong positive correlation with mixing ratio – *Fanti kenkey* adhesion increases with increasing mixing ratios. Thus, as the proportion of pre-cooked dough increases, the *Fanti kenkey* becomes more adhesive. It is also worth noting that this correlation is significant at the 0.05 alpha levels. There is also a weak positive relationship between adhesion and cooking time and a very weak negative relationship between adhesion and steeping time.

4.3.1.3 Cohesion

There exists a moderate positive relationship between cohesion and mixing ratio – *Fanti kenkey* gets more cohesive with increasing proportions of pre-cooked dough. The opposite is true for cohesion and steeping time - the longer the steeping time, the less cohesive the *Fanti kenkey* becomes. However, cohesion has a very weak (if any) positive relationship with cooking time.

4.3.1.4 Springiness

There is a moderate positive relationship between springiness and the proportion of pre-cooked dough – *Fanti kenkey* gets more elastic with increasing proportions of pre-cooked dough. This

relationship is significant at the 0.05 alpha level – even in the larger population, *Fanti kenkey* would get more elastic with increasing proportions of pre-cooked dough.

4.3.1.5 Hardness

There is a very weak negative relationship between the hardness of *Fanti kenkey* and its cooking and steeping times (-0.034 and -0.043 respectively). For every one hour increase in cooking and steeping times, the hardness of *Fanti kenkey* reduces slightly. However, there is a strong positive correlation between hardness and mixing ratio – it gets harder with increasing proportions of fermented dough.

Worthy of mention is the fact that, there is a strong positive relationship between mixing ratio and all texture indicators of *Fanti kenkey* and these relationships are all significant.



4.4 Multiple Regression Analysis

4.4.1 pH versus Steeping time, Mixing ratio, Cooking time

Table 4: Regression Equation of pH versus Steeping time, Mixing ratio, Cooking time

$$\text{pH} = 3.956 + 0.0190 \text{ Steeping time} - 0.000429 \text{ Steeping time}^2$$

4.4.1.1 Initial pH (Steeping Time = 0)

According to the equation, the pH is roughly 3.956 at the beginning of steeping (Steeping time = 0 hours). This represents the pH of the maize prior to the onset of substantial fermentation during steeping.

4.4.1.2 Effect of Short Steeping Times

Depending on the general context of the reaction, the linear term ($0.0190 * \text{Steeping time}$) may dominate an initial minor increase in pH or contribute to a gradual fall for extremely short steeping intervals. But once the fermentation process begins, acids are created.

4.4.1.3 Optimal Steeping Time and pH Drop

It is crucial to consider the quadratic term ($-0.000429 * \text{Steeping time}^2$). It suggests that after a while, the build-up of lactic acid and other organic acids created by microbes during fermentation will cause longer steeping times to result in a more noticeable drop in pH. For Fanti kenkey to retain its distinctively sour flavour, texture, and preservation, this acid production is necessary.

4.4.1.4 Significance for Quality Control

A producer could use this equation (or a graph generated from it) to predict the necessary steeping time if they wish to attain a pH of roughly 3.5 for a particular batch. This keeps the shelf life, flavour, and quality of the product constant.

4.4.1.5 Over-Fermentation

Lower pH is preferable, but if the initial microbial load isn't managed, too lengthy steeping times may cause over-fermentation and an overly sour product that customers may not like. If the initial microbial load isn't controlled, it may even cause spoiling by unwanted microorganisms. The equation demonstrates how the pH keeps decreasing over time, especially the quadratic term.

The impact of steeping time on pH during the manufacturing of Fanti kenkey can be quantitatively understood thanks to this regression equation. It identifies a critical phase of substantial pH decline caused by microbial fermentation after an initial phase, sometimes with little to no pH changes or modest positive pH changes. By carefully controlling the steeping time, this equation can be a potent tool for process optimisation for kenkey producers, guaranteeing the proper sourness, consistent product quality, and enhanced shelf stability.

4.4.2 Cohesion versus Steeping time, Mixing ratio, Cooking time.

Table 5: Regression Equation Cohesion versus Steeping time, Mixing ratio, Cooking time

$$\text{Cohesion} = 0.654 + 0.00396 \text{ Steeping time} - 0.046 \text{ Mixing ratio} + 0.0596 \text{ Mixing ratio} * \text{Mixing ratio} - 0.00375 \text{ Steeping time} * \text{Mixing ratio}$$

4.4.2.1 Positive Linear Effect of Steeping Time (0.00396 * Steeping time)

This phrase implies that, under normal circumstances, extending the steeping period somewhat improves the dough's cohesiveness. This can be the result of protein hydration or modifications in starch structure brought on by extended soaking.

A producer may notice a slightly stickier dough, which could make it simpler to handle or require less effort to form, if they increase the steeping time from 24 to 48 hours while maintaining the same mixing ratio.

4.4.2.2 Negative Linear Effect of Mixing Ratio (-0.046 * Mixing ratio)

This word suggests that the cohesiveness generally reduces when the mixing ratio increases (i.e., comparatively more aflata or less raw dough, assuming the ratio is aflata: raw), making the dough more fluid and less cohesive.

A dough made with a 1:2 (raw: aflata) mixing ratio is probably more cohesive than one made with a 1:3 ratio, which is runnier and less cohesive.

4.4.2.3 Positive Quadratic Effect of Mixing Ratio (0.0596 * Mixing ratio²)

The presence of this quadratic factor with a positive coefficient indicates that the mixing ratio's impact on cohesiveness is not entirely linear. While cohesiveness is decreased by initial increases in mixing ratio (more aflata), this effect may slow down or even reverse at very high mixing ratios. This could mean the measurement is impacted or that the dough is so diluted after a certain point that its stickiness reaches a minimum and doesn't go down any further in the same manner.

4.4.2.4 Negative Interaction Effect (-0.00375 * Steeping time * Mixing ratio)

This suggests that the steeping time and mixing ratio interact. The negative coefficient indicates that the cohesiveness is lost more as a result of the combined impacts of the high steeping duration and high mixing ratio than would be predicted from their separate effects. Stated differently, a larger water content has a cohesive-reducing impact that is made worse by longer steeping. The dough may become much less cohesive and possibly very difficult to mould if maize is steeped for a long period of time (example, 72 hours) and then combined with a high

aflata content (1:3 or 1:4 raw: aflata) as opposed to a dough with a shorter steeping time and less aflata. Starches may be broken down by the lengthy steeping.

On the other hand, if steeping is brief (example, 24 hours), even with a high mixing ratio, the cohesiveness may not decrease as much as it would with extended steeping since the negative influence of the interaction term is less.

This equation allows kenkey producers to scientifically optimize their process. This formula can be used by a producer who is having trouble with dough that is too sticky or watery to determine whether they need to change the amount of time they steep, the ratio of aflata to raw dough during mixing, or both in order to get the right consistency. For example, they might slightly raise the mixing ratio or take into account the combined effect with steeping time if the dough is very sticky (high cohesion).

4.4.3 Adhesion versus Steeping time, Mixing ratio, Cooking time

Table 6: Regression Equation of Adhesion versus Steeping time, Mixing ratio, Cooking time

$$\text{Adhesion} = -4.63 + 0.194 \text{ Steeping time} + 11.10 \text{ Mixing ratio} - 0.179 \text{ Steeping time} * \text{Mixing ratio}$$

4.4.3.1 Positive Linear Effect of Steeping Time (0.194 * Steeping time)

This phrase implies that an increase in steeping time results in an increase in adhesion, assuming all other factors remain constant. A gummier or stickier texture can be produced by longer steeping times, which increase fermentation and the enzymatic breakdown of starch. A producer may need to dust the dough with more flour or modify their handling methods if they

increase the steeping time from 24 to 48 hours while maintaining the same mixing ratio because the dough will become substantially stickier to work with.

4.4.3.2 Strong Positive Linear Effect of Mixing Ratio (11.10 * Mixing ratio)

This term indicates a very strong positive correlation between adhesion and the mixing ratio. The stickiness greatly increases as the mixing ratio rises, indicating comparatively more aflata. In other words, dough becomes stickier and more difficult to work with when more aflata is added. The significant influence of water content on stickiness is indicated by the large coefficient (11.10). A slight increase in water content during mixing, such as going from a 1:1.5 raw: aflata ratio to a 1:1.75 ratio could significantly increase the dough's stickiness, making it difficult to handle or mould.

4.4.3.3 Negative Interaction Effect (-0.179 * Steeping time * Mixing ratio)

This key phrase denotes a relationship between mixing ratio and steeping time. The negative coefficient indicates that the predicted adhesion from the individual beneficial impacts of a high steeping period and a high mixing ratio is reduced when these factors are combined. To put it another way, when both elements are high, the dough becomes less sticky than you might anticipate, even if they both promote adhesion separately. This points to a potential time at which the dough may get overly hydrated and fermented, which would cause structure to break down instead of just make it more sticky.

4.4.4 Springiness versus Steeping time, Mixing ratio, Cooking time

Table 7: Regression Equation of Springiness versus Steeping time, Mixing ratio, Cooking time

$$\text{Springiness} = 16.552 + 1.138 \text{ Mixing ratio}$$

4.4.4.1 Quality Control and Consistency

Based on the mixing ratio they have selected, producers can use this equation to forecast how springy their kenkey will be. This is crucial for preserving a constant level of product quality. In order to attain the required springiness, the equation offers a scientific foundation for standardising mixing procedures.

4.4.4.2 Product Development and Optimization

Depending on the desired springiness (such as a softer or firmer kenkey), a manufacturer might modify the mixing ratio. For example, they would raise the mixing ratio to improve springiness.

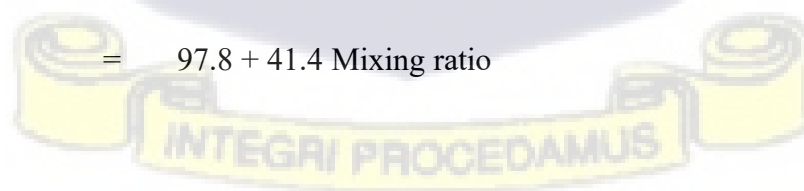
This formula can be used to understand how variations in constituent ratios may impact the final texture when creating new Fanti Kenkey formulas (e.g., utilising different varieties of maize or additives).

The equation "Springiness = 16.552 + 1.138 Mixing ratio" is a valuable tool for Fanti kenkey producers. By measuring the correlation between a particular mixing ratio and the resulting springiness, it gives producers more control over the quality, consistency, and development potential of their products. Producers can fulfil consumer desires and uphold high standards for their Fanti kenkey by comprehending and utilising this link to optimise their procedures.

4.4.5 Hardness 1 versus Steeping time, Mixing ratio, Cooking time

Table 8: Regression Equation Hardness 1 versus Steeping time, Mixing ratio, Cooking time

Hardness 1 = 97.8 + 41.4 Mixing ratio



4.4.5.1 Dominant Factor in Hardness

There is a substantial positive link between the mixing ratio and hardness, as seen by the large coefficient (41.4). A considerably harder kenkey would result from raising the raw dough content (higher mixing ratio), assuming our assumption of an aflata-to-raw dough ratio is correct. Since additional aflata typically results in softer dough, this may initially seem paradoxical. However, raising the aflata level to a certain extent can result in increased gelatinisation and a denser, harder gel matrix after cooking in intricate starch-based systems like kenkey.

4.4.5.2 Precise Control for Desired Texture

Achieving a consistent and desired amount of kenkey stiffness is made possible by this equation. It can be used by producers to adjust their ratios of mixing. If consumers prefer a softer kenkey, the producer would have to reduce the mixing ratio. On the other hand, a stiffer product would require a higher mixing ratio.

The formula "Hardness 1 = 97.8 + 41.4 Mixing ratio" offers important information on the manufacturing of Fanti kenkey. It draws attention to the mixing ratio as the primary determinant of the stiffness of the kenkey. In order to guarantee that their Fanti kenkey constantly satisfies the required textural profile, producers can use this mathematical relationship for exact texture customisation, strict quality control, and efficient troubleshooting. Because the mixing ratio has a substantial effect on hardness, strict adherence to established protocols is required.

4.4.6 Hardness 2 versus Steeping time, Mixing ratio, Cooking time

Table 9: Parameter Estimates of hardness 1 on mixing ratio, cooking time and steeping time

$$\text{Hardness 2} = 71.0 + 49.2 \text{ Mixing ratio}$$

4.4.6.1 Even Stronger Influence on Secondary Hardness

In comparison to "Hardness 1" (41.4), the coefficient for "Hardness 2" (49.2) is even greater. This implies that the kenkey's secondary firmness and cohesive qualities are even more significantly impacted by the mixing ratio than its initial hardness. The kenkey will become even firmer following the initial compression if a larger mixing ratio results in stiffer kenkey (as predicted for Hardness 1). This could indicate a chewing-resistant, extremely dense product.

4.4.6.2 Impact on Mouth feel and Chewiness

The sensation of the product in the mouth following the first bite is closely associated with "Hardness 2". A very dense, compact, and possibly tough or chewy texture that takes a lot of work to break down could be indicated by a high "Hardness 2" in Fanti kenkey. This metric would be closely monitored by producers who are aiming for a particular mouth feel (e.g., easily meltable or satisfyingly chewy).

4.4.6.3 Refined Texture Control

An improved texture control tool is offered by this equation. Not only can manufacturers manage the kenkey's initial hardness, but they can also control its maintained firmness and "chew" by varying the mixing ratio. Assuming consumers complain that the kenkey gets mushy too quickly, for example, a small increase in the mixing ratio (assuming it does result in a firmer kenkey) can help make it more durable after the initial bite.

The formula "Hardness 2 = 71.0 + 49.2 Mixing ratio" is a useful tool for comprehending and managing the textural characteristics of Fanti kenkey, especially its cohesive and steady hardness throughout consumption. Producers may exactly customise the mouth feel of their kenkey thanks to the high coefficient, which shows that the mixing ratio is a dominant factor. When producers

use this equation in conjunction with the one for "Hardness 1," they can suit unique consumer preferences and achieve unmatched consistency for the Fanti kenkey eating experience.

4.5 Response Surface Methodology

Table 10: Regression Coefficients

Parameter (Y)	Cohesion	Adhesion	Springiness	Hardness 1	Hardness 2	pH
B ₀	0.673	11.647	18.827	180.500	169.500	4.084
Steeping time (X ₁)	-0.043	-1.975	-	-	-	-0.143
Mixing ratio (X ₂)	0.058	4.650	1.138	41.100	49.300	-
Cooking time (X ₃)	-	-	-	-	-	-
R ² (adj)	40.01%	99%	37.94%	68.64%	66.72%	77.22%
R ²	57.15%	75.63%	42.37%	82.08%	80.98%	80.48%

4.5.1 Steeping Time (X₁)

Steeping time refers to how long the maize grains are soaked before milling and fermentation.

- Cohesion: -0.043.

The cohesiveness of the kenkey somewhat diminishes with increasing steeping time.

If you steep your maize for too long, it may become less likely to keep a precise ball shape and become a little more crumbly. Serving it could make it crumble more easily.

- Adhesion: -1.975

The stickiness (adhesion) of the kenkey is greatly decreased by lengthening the steeping period. The kenkey may become less sticky in your hands and less likely to stick to the plastic or leaves it is wrapped in if steeped for a longer period of time. Its mouthfeel may be impacted by too little stickiness, yet handling may benefit from this.

- pH: -0.143

A longer steeping period results in a lower pH, which makes the kenkey more sour or acidic. You will probably get a lot sour kenkey if you steep it for 36 hours instead of the usual 24. This is because lactic acid bacteria, which produce acids, can ferment more when steeped for a longer period of time. You may need to carefully manage the steeping duration if your customers want a softer flavour.

- Springiness, Hardness 1, Hardness 2

The "—" indicates that the study found no significant linear relationship or effect of steeping time on these parameters.

4.5.2 Mixing Ratio (X2)

Mixing ratio typically refers to the proportion the ratio of raw dough to cooked dough (*aflata*)

- Cohesion: 0.058

The cohesiveness of the kenkey is marginally increased by a decreased mixing ratio. A somewhat stronger ball may form from the finished kenkey if you add a little more aflata when making your dough.

- Adhesion: 4.650

The stickiness (adhesion) of the kenkey is greatly increased by a higher mixing ratio. Your kenkey will be notably stickier if you utilise a higher aflata content. This can make it more

difficult to handle and cause the kenkey to stick to the wrapper more or give you a gummy mouth.

- Springiness: 1.138

The kenkey becomes more springy with a larger mixing ratio.

Kenkey produced with a wetter dough is more likely to be durable or "bouncy" when pushed, better reverting to its former shape. This might make for a pleasing mouthfeel.

- Hardness 1: 41.100 & Hardness 2: 49.300

A higher raw dough to aflata mixing ratio significantly increases both measures of kenkey hardness. However, adding too much raw dough during mixing could result in a denser, more resilient gel structure when the kenkey is cooked, which would make it harder. Therefore, if your kenkey is constantly too hard, think about adding a little less raw dough when mixing.

- pH

The "—" indicates no significant linear effect of mixing ratio on pH.

4.5.3 Cooking Time (X3)

This implies that changes in cooking time did not significantly affect the measured Cohesion, Adhesion, Springiness, Hardness, or pH linearly within the range examined in this investigation. Even though the study didn't find a linear relationship, cooking time is important for both starch gelatinisation and safety. This finding may suggest that, after a minimum cooking time is reached, additional cooking times (within acceptable bounds) do not significantly change these particular textural characteristics. This does not imply that cooking time is not significant! Make sure the kenkey is cooked all the way through for safety and the right transformation of the starch.

4.5.4 R-squared (R²) Values

The R^2 values indicate the extent to which the components (X1, X2, X3) that are part of the model can account for the variation in each parameter (Y). A greater R^2 (nearer 100%) indicates that the model is more successful in forecasting the result. Adjusted for the number of components is R^2 (adj).

- Adhesion (99% R^2 adj)

This indicates that the stickiness of your kenkey can be nearly entirely explained and predicted by the steeping period and mixing ratio. Concentrate on these two elements if you wish to manage stickiness.

- pH (77.22% R^2 adj)

The main cause of the kenkey's sourness is steeping time, along with potentially other unquantifiable elements.

- Hardness 1 (68.64% R^2 adj) & Hardness 2 (66.72% R^2 adj)

Mixing ratio, along with other factors, explains a good amount of the variation in kenkey hardness.

- Cohesion (40.01% R^2 adj)

A moderate level of cohesiveness can be explained by our factors. Your kenkey's ability to hold together may be significantly influenced by additional elements that are not measured here.

- Springiness (37.94% R^2 adj)

As with cohesiveness, our parameters account for less than half of the variation in springiness. This implies that additional elements of your process, like as the kind of maize you use, the

particular conditions under which it ferments, and the way you knead it, may have a significant impact on springiness.

4.6 Numerical Optimization of Fanti Kenkey Production

4.6.1 Defining the Optimisation Criteria

To determine the ideal combination of steeping duration, mixing ratio, and cooking time that would produce the most desired Fanti kenkey, numerical optimisation was carried out using Minitab®'s Response Optimiser tool once the regression models were developed. The goals for each response variable were set based on achieving a high-quality product as identified from literature and consumer preferences noted during the survey phase. The criteria for the optimization are outlined in Table 1.

1. **Hardness:** A moderate hardness is desirable. Kenkey that is too soft may be seen as being pasty or improperly prepared, while kenkey that is too hard is challenging to eat. Consequently, the hardness objective was established as 160 -180g.
2. **Adhesion:** Low adhesion is generally preferred, as very sticky kenkey is undesirable. The goal was to "**minimize**" adhesion.
3. **Springiness:** High springiness is a key indicator of good texture and elasticity. The goal was to "**maximize**" springiness.
4. **Cohesion:** High cohesion is desirable as it indicates the product holds together well. The goal was to "**maximize**" cohesion.
5. **pH:** The pH should be within a specific range to ensure the characteristic sour taste and microbial stability. The goal was to keep the pH 3.8 –4.1.

4.6.2 Optimal Production Parameters

A solution with a composite desirability of 0.673 was obtained by numerical optimisation based on the specified criteria. Table 2 displays the suggested ideal settings for creating Fanti kenkey with the most desired textural characteristics.

Table 11: Optimized Process Parameters and Predicted Responses

Parameter	Optimal Value
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Independent Variables (Inputs)

Steeping Time (hours)	[e.g., 30 hours]
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Mixing Ratio	1:2
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Cooking Time (hours)	9 hours
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Predicted Responses (Outputs)

Hardness (g)	175 g
--------------	-------

Adhesion (mJ)	11.647 mJ
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Springiness (mm)	18.827 mm
------------------	-----------

Cohesion	0.673
----------	-------

pH	4.084
----	-------

Composite Desirability	0.673
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According to this approach, a Fanti kenkey that is elastic, holds together well, is not overly sticky, and has an acceptable hardness is produced by combining a shorter steeping time with a

higher proportion of aflata and a reasonably lengthy cooking time. For growers looking to consistently manufacture high-quality Fanti kenkey, these optimised criteria offer a standardised, scientifically based guidance.

4.7 Practical Application of Predictive Models for Tailoring Fanti Kenkey Texture

Although a single set of parameters was found by the numerical optimisation in Section 4.6 to create a Fanti kenkey with high attractiveness based on a balanced set of quality qualities, it is important to recognise that customer preferences for textural characteristics can differ. The market may contain customers who want a softer, semi-soft, or tougher end product, according to the survey done in the first phase of this study. Therefore, intentional product diversifications as well as standardisation represent a crucial practical application of this research.

Producers can use the regression models created in this study as effective prediction tools. Through the manipulation of the three primary variables—steeping time, mixing ratio, and cooking duration—a producer can consistently aim for a particular texture. For example, Table 14 shows that we can forecast the settings needed to get various hardness levels based on the models.

Table 12: Predicted Production Parameters for Different Fanti Kenkey Textural Profiles

Desired Product Profile	Target Hardness (g)	Predicted Steeping Time (hours)	Predicted Mixing Ratio (aflata: raw)	Predicted Cooking Time (hours)	Expected Characteristics
Soft Texture	~120g	36	1:1	6	Softer bite, suitable

					for immediate consumption or for consumers who prefer less chewiness.
Standard/Medium Texture	~175g	30	1:2	8	Balanced, firm but elastic texture with good springiness, as identified in the optimization.
Hard Texture	~230g	24	1:3	12	Very firm and chewy, may have a longer shelf life, preferred by consumers who enjoy a very robust texture.

Producers are able to transition from erratic, artisanal production to targeted manufacture because to this predictive skill. For instance, in order to cater to different market niches, a company might develop two separate product lines: a "soft" Fanti kenkey and a "firm" Fanti kenkey. In addition to satisfying a wider range of consumer preferences, this gives producers a major competitive edge and enables them to defend premium pricing for a reliable, consistent product

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The analysis of the response surface methodology successfully generated prediction models for significant quality criteria. This study's key discovery is that these models can be used as a practical tool for product engineering, which involves more than just identifying the optimal configuration. To satisfy a variety of consumer tastes, producers may reliably and consistently produce Fanti kenkey with a range of textural profiles—from soft to hard—by adjusting the input variables of steeping duration, mixing ratio, and cooking time. This creates new chances for product differentiation and market segmentation by transforming the production process from an intuitive craft to a standardised procedure based on predictive science.

This study successfully modelled and optimised the key production variables of Fanti kenkey to establish a scientific basis for improving product consistency and quality. The study verified that the final textural characteristics and pH of the product are significantly and predictably impacted by the standard processing steps of steeping time, aflata to raw dough ratio, and cooking time.

It was determined that the most important element affecting adhesion, cohesiveness, hardness, and springiness was the mixing ratio. This is explained by how the aflata, which creates the final product's structural matrix, uses starch gelatinisation.

Response Surface Methodology was successfully applied to accomplish the main goal of this thesis. The following ideal parameters can be used to dependably manufacture the most desired Fanti kenkey, which has high springiness (18.827 mm), high cohesion (0.673), low adhesion (11.647 mJ), and moderate hardness (175 g), according to numerical optimisation:

- **Steeping Time:** 30 hours

- **Mixing Ratio (*aflata* to raw dough):** 1:2
- **Cooking Time:** 8 hours

To Control Firmness and Elasticity: In order to regulate firmness and elasticity, the mixing ratio is your most effective instrument. Increase the proportion of cooked paste (*aflata*) to raw dough (target for a ratio of 1 part *aflata* to 2 parts raw dough) to create a kenkey that is firmer, chewier, and more elastic and that remains intact. Lower the *aflata* content (e.g., closer to 1:2) to produce a softer result.

To Ensure a Cohesive Product: Steeping too much should be avoided. Steeping for longer than 48 hours can result in a final product that is less likely to keep together, even though it is essential for fermentation. For the best balance between taste development and structural integrity, steep for 24 to 36 hours.

For Consistency and Shelf-Life: To guarantee a constant texture and microbiological stability, it is essential to cook the kenkey properly, which calls for a controlled cooking time of at least 8 hours.

5.2 Recommendations

Based on the findings of this study, the following recommendations are proposed to improve the quality, consistency, and economic viability of Fanti kenkey production.

5.2.1 Recommendations for Fanti Kenkey Producers and Industry Stakeholders

1. Adopt Process Parameter Optimisation for a Standard, High-End Product:

Producers are urged to use the ideal parameters found in this study in order to create a Fanti kenkey with a consistently superior texture (high elasticity, strong cohesion, and moderate firmness): a steeping time of roughly 30 hours, a mixing ratio of 1 part *aflata* to

2 parts raw dough, and a cooking time of 8 hours. This offers a precise, scientifically supported formula for a superior product fit for cutthroat marketplaces.

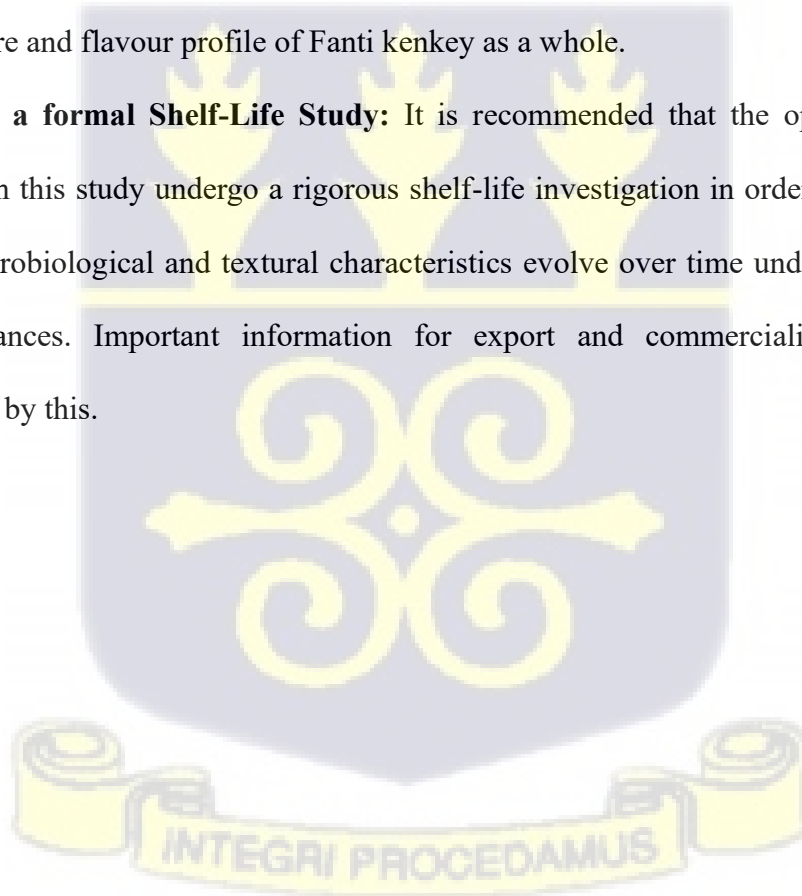
2. Utilize the Mixing Ratio as a Primary Tool for Product Diversification: In order to accommodate a wide range of consumer texture preferences, producers should carefully manage the ratio of aflata to raw dough. According to the study's models, a softer kenkey will always be produced at a lower ratio (e.g., 1:2), but a much harder, chewier kenkey will be produced at a higher ratio (1:3). In order to reach a larger consumer base, producers can utilise this information to develop and promote distinct product lines (such as "Soft Bite" vs. "Extra Firm").

3. Implement Simple Process Control Tools: Producers should use straightforward, inexpensive process management systems to guarantee that these ratios and deadlines are regularly followed. Using timers to standardise steeping and cooking times and weighing scales to precisely measure dough proportions for the mixing ratio are two examples of this. As a result, the process shifts from subjective estimation to objective control, which is the basis of quality control.

5.2.2 Recommendations for Future Research

1. Conduct Sensory Evaluation and Consumer Acceptance Studies: In this study, instrumental texture analysis was the main focus. As advised, a crucial next step is to perform sensory panel assessments in order to match consumer perception and choice with the instrumental data (hardness, springiness, etc.). The "optimal" product would be validated, and the appropriate range of textural features for various Ghanaian and international market sectors would be determined.

2. **Investigate the Impact of Maize Variety:** There was only one common variety of maize utilised in this study ("Obaatanpa"). Future studies should look into how the ideal processing parameters are impacted by different types of maize, each of which has a varied starch and protein content. The models would probably need to be modified to account for various raw materials.
3. **Model the Effect of Fermentation Time and Temperature:** In order to restrict the study's scope, fermentation was kept constant. Temperature and fermentation duration should be considered as important variables in a future, more thorough optimisation study in order to comprehend how they interact with steeping and mixing and how they affect the texture and flavour profile of Fanti kenkey as a whole.
4. **Perform a formal Shelf-Life Study:** It is recommended that the optimised products created in this study undergo a rigorous shelf-life investigation in order to ascertain how their microbiological and textural characteristics evolve over time under various storage circumstances. Important information for export and commercialisation would be provided by this.



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APPENDICES

Appendix A

Cohesion

Coded Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	0.6729	0.0258	26.05	0.000	
Steeping time	-	0.0242	-1.76	0.109	1.00
		0.0425			
Mixing ratio	0.0575	0.0242	2.38	0.039	1.00
Mixing ratio*Mixing ratio	0.0596	0.0354	1.69	0.123	1.00
Steeping time*Mixing ratio	-	0.0342	-1.32	0.217	1.00
		0.0450			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.0683322	57.15%	40.01%	0.00%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
--------	----	--------	--------	---------	---------

Model	4	0.062280	0.015570	3.33	0.056
Linear	2	0.040900	0.020450	4.38	0.043
Steeping time	1	0.014450	0.014450	3.09	0.109
Mixing ratio	1	0.026450	0.026450	5.66	0.039
Square	1	0.013280	0.013280	2.84	0.123
Mixing ratio*Mixing ratio	1	0.013280	0.013280	2.84	0.123
2-Way Interaction	1	0.008100	0.008100	1.73	0.217
Steeping time*Mixing ratio	1	0.008100	0.008100	1.73	0.217

ratio

Error	10	0.046693	0.004669		
Lack-of-Fit	8	0.023426	0.002928	0.25	0.937
Pure Error	2	0.023267	0.011633		
Total	14	0.108973			

Response Surface Regression: Adhesion versus Steeping time, Mixing ratio, Cooking time

Coded Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	11.647	0.659	17.66	0.000	
Steeping time	-1.975	0.903	-2.19	0.051	1.00
Mixing ratio	4.650	0.903	5.15	0.000	1.00
Steeping time*Mixing ratio	-2.15	1.28	-1.68	0.120	1.00

ratio

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
2.55383	75.63%	68.99%	17.63%

Analysis of Variance

Source	DF	Adj SS	MS	F-Value	P-Value
Model	3	222.675	74.225	11.38	0.001
Linear	2	204.185	102.093	15.65	0.001
Steeping time	1	31.205	31.205	4.78	0.051
Mixing ratio	1	172.980	172.980	26.52	0.000
2-Way Interaction	1	18.490	18.490	2.84	0.120
Steeping 1 time*Mixing ratio	1	18.490	18.490	2.84	0.120
Error	11	71.742	6.522		
Lack-of-Fit	9	68.722	7.636	5.06	0.176
Pure Error	2	3.020	1.510		

Total 14 294.417

Coded Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	18.827	0.269	70.07	0.000	
Mixing ratio	1.138	0.368	3.09	0.009	1.00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
1.04064	42.37%	37.94%	19.41%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	1	10.351	10.3513	9.56	0.009
Linear	1	10.351	10.3513	9.56	0.009
Mixing ratio	1	10.351	10.3513	9.56	0.009
Error	13	14.078	1.0829		
Lack-of-Fit	11	12.258	1.1144	1.22	0.533
Pure Error	2	1.820	0.9100		
Total	14	24.429			

Coded Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	180.5	10.0	18.01	0.000	
Mixing ratio	41.4	13.7	3.01	0.010	1.00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
38.8157	41.15%	36.62%	19.21%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	1	13695.1	13695.1	9.09	0.010
Linear	1	13695.1	13695.1	9.09	0.010
Mixing ratio	1	13695.1	13695.1	9.09	0.010
Error	13	19586.6	1506.7		
Lack-of-Fit	11	18777.9	1707.1	4.22	0.207
Pure Error	2	808.7	404.3		
Total	14	33281.7			

Coded Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	169.5	13.7	12.39	0.000	
Mixing ratio	49.3	18.7	2.63	0.021	1.00

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	1	19404.5	19404.5	6.91	0.021
Linear	1	19404.5	19404.5	6.91	0.021
Mixing ratio	1	19404.5	19404.5	6.91	0.021
Error	13	36495.2	2807.3		
Lack-of-Fit	11	36002.6	3273.0	13.29	0.072
Pure Error	2	492.7	246.3		
Total	14	55899.7			

Coded Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	4.0843	0.0226	180.79	0.000	
Steeping time	-0.1425	0.0211	-6.74	0.000	1.00
Steeping	-0.0618	0.0309	-2.00	0.069	1.00
time*Steeping time	0.0618				

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.0597714	80.48%	77.22%	69.38%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	2	0.176702	0.088351	24.73	0.000

Linear	1	0.162450	0.162450	45.47	0.000
Steeping time	1	0.162450	0.162450	45.47	0.000
Square	1	0.014252	0.014252	3.99	0.069
Steeping 1	1	0.014252	0.014252	3.99	0.069

time*Steeping

time

Error	12	0.042871	0.003573		
Lack-of-Fit	10	0.041605	0.004160	6.57	0.139
Pure Error	2	0.001267	0.000633		
Total	14	0.219573			



Appendix B

QUESTIONNAIRE SURVEY FOR FANTI KENKEY PROCESSORS

1. Location:

2. Age:

3. Sex

a) Male

b) Female

4. Marital status

a) Single

b) Married

c) Divorced

d) Widowed

5. Education

a) None

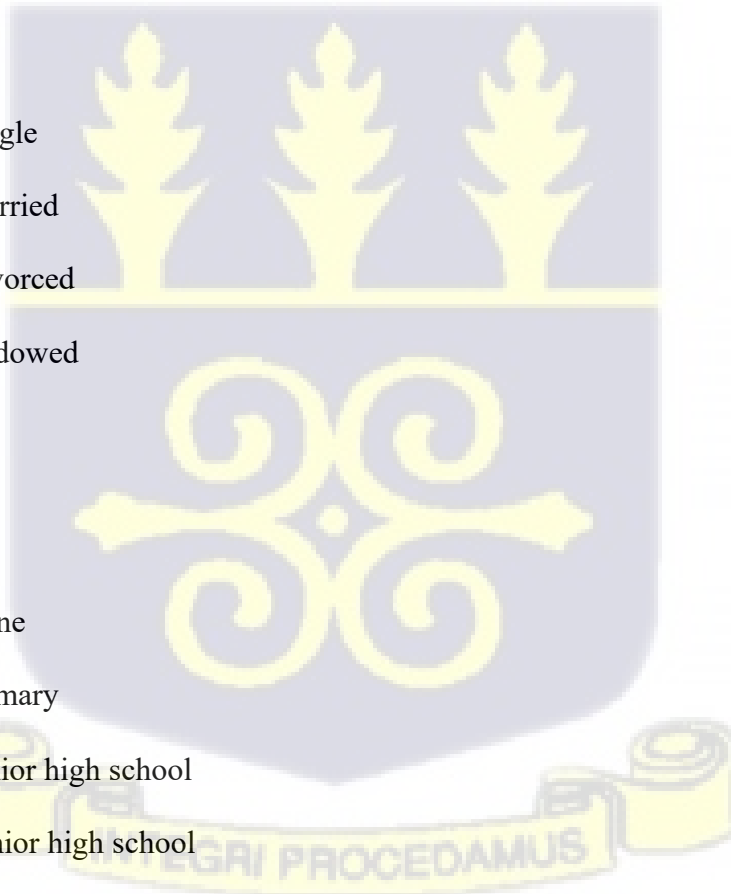
b) Primary

c) Junior high school

d) Senior high school

e) Tertiary

f) Other (Specify):



6. How long have you been in Fanti kenkey business?

.....
.....

7. How did you learn how to produce Fanti kenkey?

.....

8. Is there a specific reason why you make kenkey?

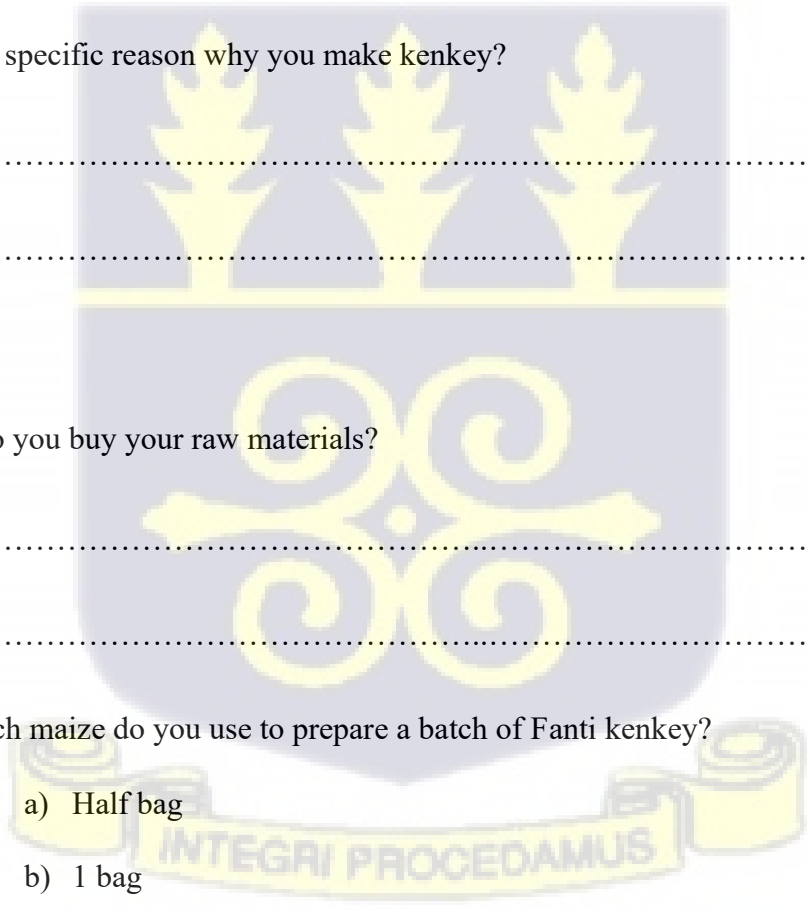
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9. Where do you buy your raw materials?

.....
.....

10. How much maize do you use to prepare a batch of Fanti kenkey?

- a) Half bag
- b) 1 bag
- c) More than 1 bag



11. What are the unit operations in Fanti kenkey preparation?

.....

.....

12. Can any of the unit operation be skipped?

.....

.....

13. If yes, what are they?

.....

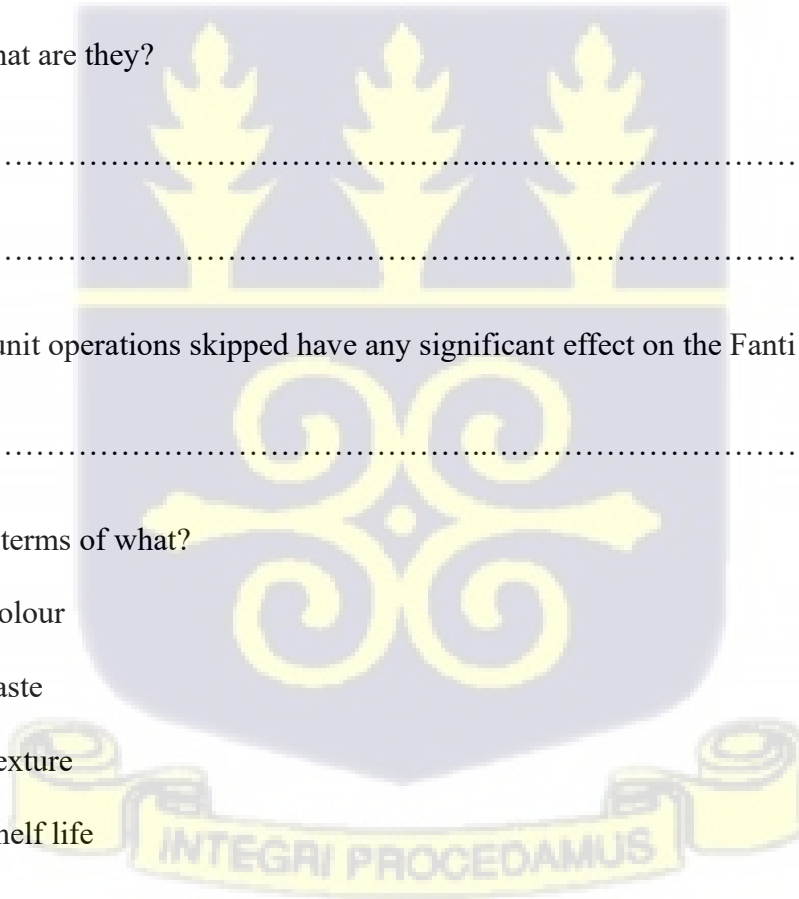
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14. Will the unit operations skipped have any significant effect on the Fanti kenkey?

.....

15. If yes, in terms of what?

- a) Colour
- b) Taste
- c) Texture
- d) Shelf life



16. How long do you soak your maize before milling?

.....

.....

17. What effect will duration of steeping have on the Fanti kenkey?

.....

.....

18. How long do you take to ferment your dough after milling?

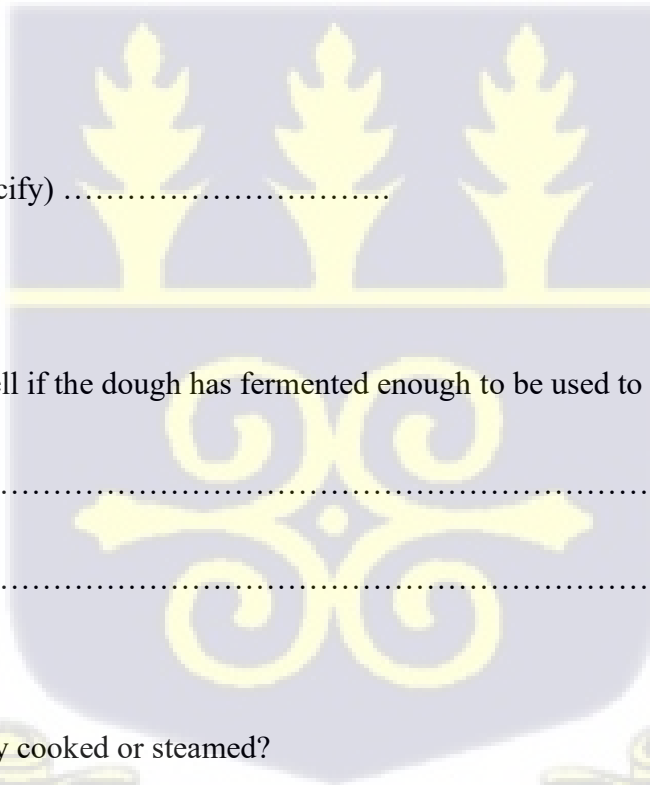
a) A day

b) 2 days

c) 3 days

d) A week

e) Other (specify)



19. How do you tell if the dough has fermented enough to be used to make Fanti kenkey?

.....

.....

20. Is Fanti kenkey cooked or steamed?

.....

21. How long can you use same dough for Fanti kenkey?

.....

.....

22. How long do you cook your *aflata*?

.....

.....

23. Why is it a must to cook your dough half- way through?

.....

.....

24. What proportion of dough and *aflata* do you mix?

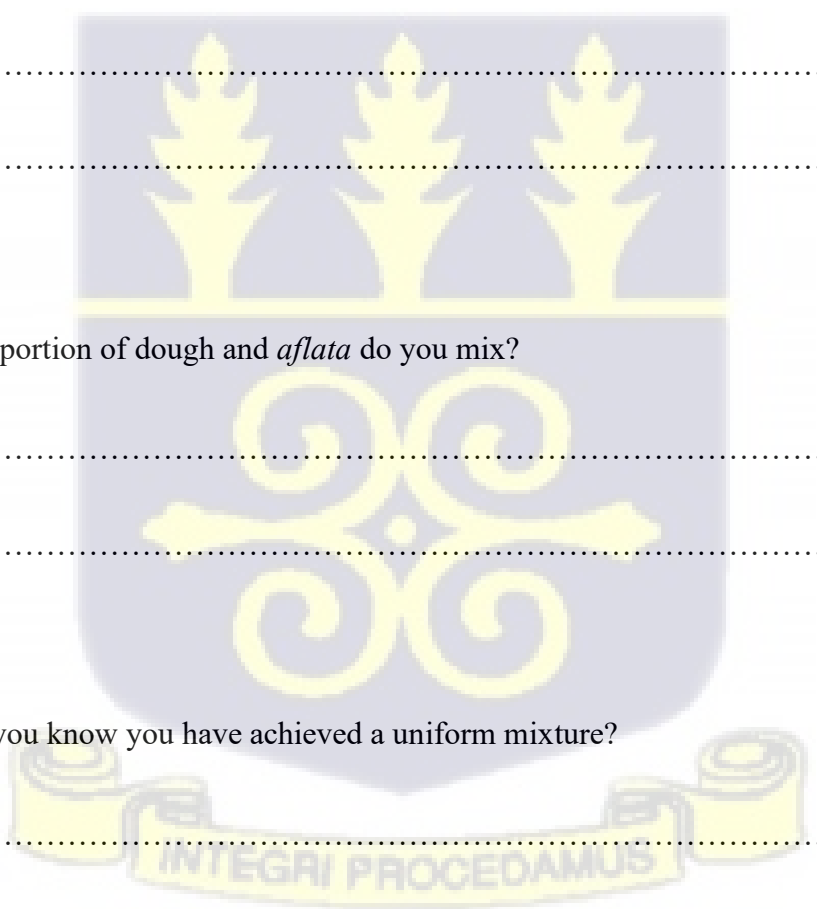
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.....

25. How do you know you have achieved a uniform mixture?

.....

.....



26. How many hours does it take for Fanti kenkey to be well cooked?

.....

.....

27. How do you tell your Fanti kenkey is well cooked and ready?

.....

.....

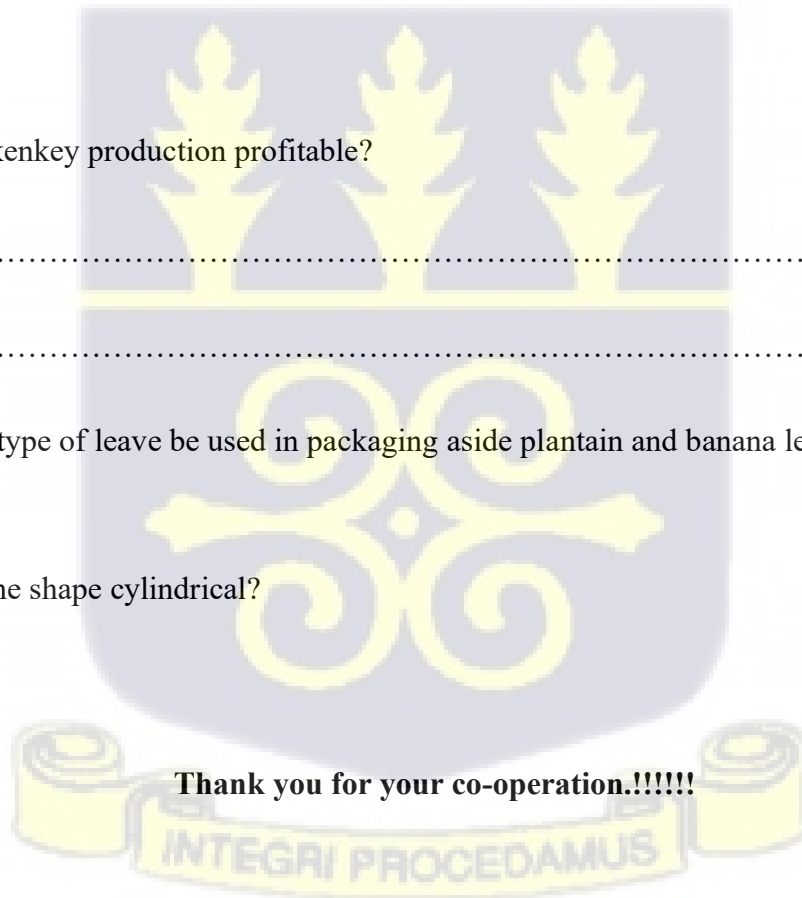
28. Is Fanti kenkey production profitable?

.....

.....

29. Can any type of leave be used in packaging aside plantain and banana leaves?

30. Why is the shape cylindrical?



Thank you for your co-operation!!!!!!