ADDIS ABABA UNIVERSITY

Addis Ababa Institute of Technology

School of Chemical and Bio-Engineering

Development and quality evaluation of biscuit and cookies made from wheat flour

Supplemented with kocho powder

Dinkitu Jaleta

ID NO: GSR/2870/12

A Thesis Submitted to Addis Ababa Institute of Technology, school of chemical and Bio-Engineering in partial fulfillment of the Requirements for the Degree of Masters of Science in Chemical Engineering(Food Engineering Stream)

Supervisor: Professor Shimelis Admassu

December,2021

Addis Ababa, Ethiopia

Title

Development and quality evaluation of biscuit and cookies made from wheat flour Supplemented with kocho powder

Declaration

I declare that this thesis entitled **Development and quality evaluation of biscuit and cookies made from wheat flour Supplemented with kocho powder** has been composed my self under the supervision of Prof. Shimelis Admassu, and has not been submitted for any other degree or professional qualification. I confirm that proper credit has been given where other people's work has been referenced.

Dinkitu Jaleta	________________	________________
	Signature	Date

This thesis work has been submitted for examination with my approval as a University Supervisor.

________________	________________	________________
Supervisor	Signature	Date

Acknowledgements

First of all,I would like to praise God. Next, I would to express my gratitude to my thesis advisor, professor.Dr.Eng. Shimelis Admassu for his give me comments/advises and overall support in any time.

In addition, I would like to express my gratitude to kality food share company. Especially,I thank Ms. Meskerem ,Ms. Itseganet and other lab assistants in the kality food share company for their technical in the labratory .

Finally, I thank Addis Ababa University Chemical Engineering lab assistants/ workers. And I thanks to my all families and friends for their advises and ideas.

Abstract

Biscuit and cookies are ready-to-eat inexpensive food products that are consumed among all age groups. This thesis work was performed to develop and quality evaluation of biscuits and cookies made from wheat flour supplemented with kocho powder. The wheat flour and kocho powder were used to develop biscuits (80:20, 70:30, 60:40, and 50:50% of substitution) and 100% wheat flour as a control.The data generated were statistically analyzed by ANOVA using SPSS. Proximate analysis were carried out on the flour,biscuits and cookies samples.And also water and oil absorption capacities were carried out on the flour and texture and color analysis were carrried out on the biscuits samples.The results of proximate composition, energy content and water activity shows that the wheat flour(control flour) contained 14.8% of moisture content, 0.45% 0f ash content, 10.237% of protein value, 1.5% of fat value, 0.5% of fiber, 72.52% of carbohydrate value, 344.5kcal/100g and 0.528% of water activity. The results indicated that the control flour showed higher level of moisture content, protein content, fat content, energy value and lower level of ash content, carbohydrate content, fiber content, water activity content while composite flours showed higher level of ash content, carbohydrate content, fiber content water activity content and lower level of moisture content, , protein content, fat content and energy value. Improvements were also noted in mineral contents such as magnesium, iron and calcium in biscuit produced from the composite flour of wheat supplemented with different levels of kocho powder. Physical (weight, thickness) and sensory (taste, colour, texture, appearance, flavor, overall acceptability) attributes of biscuits made from kocho powder and wheat flour were analyzed. The sensory acceptability was evaluated by a seven point's hedonic scale. As the kocho powder addition decreased from 50 % to 20 %, the thickness, and the sensory attributes (taste, flavor, appreance,color,texture preference and overall acceptability) of the biscuits got increased. From the result, texture, taste, Colour, flavor,appearance and overall acceptability did not show any significant difference(P≥0.05) among different samples. As a result, the high nutritive and flavor rich biscuits and cookies generated in this study are to provide health benefits.

Keywords: *Kocho powder, wheat flour, Biscuits, cookies, quality evaluation, proximate composition*

Table of contents

List of Tables

Tables **Title** **Page no.**

List of Figures

Lists of Acronyms

AACC-- Americans Associations of Cereal Chemist

AAIT – Addis Ababa Institute of Technology

AASTU-Addis Ababa Science of Technology University

ANOVA-- Analysis of Variance

AOAC -Association of Official Analytical Chemist

B121**--**80% of wheat Flour and 20% of Kocho Powder biscuit

B232**--** 70% of Wheat Flour and 30% of Kocho Powder biscuit

B343**--** 60% of Wheat Flour and 40% of Kocho Powder biscuit

B454-- 50% of Wheat Flour and 50% of Kocho Powder biscuit

B565--100% of wheat Flour (control sample) biscuit

CHO- Carbohydrate

EMC-- Equilibrium Moisture Content

KFSC- Kality Food Share Company

RH-- Relative Humidity

SPSS-- Statistical Package System Software

$W_F K_p$- Wheat flour & Kocho powder

W_{F-} Wheat flour

WVTR-- Water Vapor Transmission Rate

CHAPTER ONE

1.INTRODUCTION

1.1 Background

Ethiopia is home to a perennial herbaceous monocot banana like large plant belongs to the family *Musaceae*, known as Green Enset (*Ensete ventricosum*). The plant is endemic to Ethiopia and is cultivated as an important food crop in many countries like southern, south-western andin addition around central parts of the country (Tsegaye A, 2002). The enset product is mainly consumed as kocho, kocho powder which is also known as "bulla" and Amicho.

The Enset product has the potential to improve nutrition, boost food security, foster rural development and support sustainable land care. Kocho powder has an important source of carbohydrate and is also rich sources of minerals (Daba and Shigeta, 2016). The enset and its products are used for different nutritional, medical and non-nutritional purposes. The main food product of enset is the starch in the stem and pseudo stem. The main mineral contents of kocho powder are potassium (708-875 micro grams per gram), sodium (402-441 micro grams per gram), calcium (385-446 micro grams per gram) and other minerals. Enset products supply more calcium and iron kind sources of minerals than most cereals, tubers(majorly store carbohydrate) and root crops (Mulualem and kifle, 2014).

Bula/ kocho powder is a thick pasty porridge made from enset that's been turned into a powder, which is reconstituted in water and often flavored with kibbee (Ethiopian spiced butter). Like injera , the finished edible Kocho is a little spongy, or even rubbery, although it's thicker, firmer, denser and chewier than injera . Its an intriguing side dish to accompany an Ethiopian meal, with an agreeable flavor and texture. Enset products kocho and bulla foods are especially popular at eating house (restaurants) that be in the service of the Ethiopian delicacy of Kitfo (raw minced beef mixed with butter and spice) and a food that people like to eat because of it is special (Brand *et al.,* 1997 and Forsido *et al.,* 2013).

Kocho powder is simple basic starch crop, quite low in protein, not very adaptable to varying food dishes but very high in productivity. The implications of heavy dependence on these poor nutrition crops may have serious implications on the physical and mental health of the Enset consuming and planting people.The supplementation of Kocho powder with different cereals results in the improvement of its nutritional value. Kocho as biscuit can be processed at household level without the application of sophisticated processing and unit operations in oven; and it can also be prepared at a factory level by keeping the quality and quantity.

Wheat *(Triticum aestivum*) is a cereal grain grown all over the world for its highly nutritious and useful gain. It is one of the top three most produced crops in the world, along with corn and rice. According to Okaka (2005), only wheat contains substantial amount of gliadin and glutenin (special protein around 13.709g) which when kneaded with water give gluten, the elastic material important in yeast or aerated baked goods. In terms of total production tonnages used for food, it is currently second to rice as the main human food crop (Curtis *et al.* 2002). Much of the carbohydrate fraction of wheat is starch. Wheat starch is an important commercial product of wheat, but second in economic value to wheat gluten. The principal parts of wheat flour are gluten and starch (International Starch Institute 2008).

The principal ingredient of biscuits is wheat flour. Wheat flour is powder obtained from the milling wheat. There are two different types of wheat flours that are used as base for biscuit makings; "soft" or "weak" varieties and "hard" or "strong" varieties. The soft or weak varieties contains low gluten content of protein and results in biscuits with crumbly texture, while the hard or strong varieties contains high gluten content and the gluten in the flours made with hard wheat give more elastic toughness of dough and hard biscuits (AACC, 2000)**.**

The biscuit got its name from French words "bis" and "cuit", meaning "twice cooked" because originally biscuit was a flat cake that was put back in the oven after being removed from its tin. For centuries this was very hard, dry biscuit was the staple food for sailors and soldiers. From then on, biscuits have undergone several developments in its making. Nowadays, they are made from a combination of flour, shortening, leavening agents and milk or water. Cookies are often served with beverages such as milk, coffee or tea and sometimes "dunked", an approach which releases more flavour from confections by dissolving the sugars,[Lee,laura.2001] while also softening their texture. Factory-made cookies are sold in grocery stores, convenience stores and vending machines.

Therefore, the goal of this study is to partially replace wheat flour with kocho powder in biscuits and cookies to determine the functional properties, nutritional value, and to improve consumers' awareness of the nutritional and medicinal qualities of kocho powder and its added value in the food industry.

1.2 Statement of the Problem

In Ethiopia, foods are infrequently modified to increase amount of nutrient to meet the requirements of calorie for normal person. Locally prepared foods made of cereals or tubers may be low in several amounts of nutrients including protein, minerals; these nutrients are of greater significance due to their influence on physical and cognitive development.Biscuit and cookies are popular food used as breakfast and other meals.The major ingredients of biscuit and cookies is wheat flour. However, most of them lacks indigenous flavor or taste and are low in nutritional quality. In this context, Development and quality evaluation of biscuit and cookies made from wheat flour supplemented with kocho powder is a step towards bridging this gap.

There are some major biscuit types available in Ethiopia are wheat biscuit fortified with chickpea flour, wheat biscuit fortified with semolina etc. Studies on the Development and quality evaluation of biscuit and cookies made from wheat flour supplemented with kocho powder is mainly focused on the quality evaluation parameters such as proximate, energy, mineral, texture, color, sensory attributes of biscuit and cookies made from wheat flour supplemented with kocho powder formulation.Though kocho is an important food crop in southern, southwestern and central parts of the country. Kocho powder has an important source of carbohydrate and is also rich sources of minerals (Daba and Shigeta, 2016). So, the constituents of kocho powder is more importance in order to improve wheat biscuit quality of children's diet. This studies have already been done in using kocho powder in complementary wheat flour to improve the quality of children's diet (Abebe *et al.,* 2006).

As biscuit and cookies is one of the favorite snack items enjoyed worldwide irrespective of the age group, it can be served as a logical vehicle to increase value added biscuit and cookies. Therefore, this study is designed to develop and evaluates of biscuit and cookies made from wheat flour supplemented with kocho powder.

1.3 Research question

- Does kocho powder affect the color of biscuit?
- Does kocho powder affect the nutritive value of biscuit and cookies?
- Which blending ratio can produce good nutrional value to enhance biscuit and cookies?

1.4 Objective

1.4.1 General Objective

The general objective of this research work was Development and quality evaluation of Biscuit and cookies made from wheat flour supplemented with kocho powder.

1.4.2 Specific Objectives

- To evaluate the dough properties of prepared flour.
- To determine the proximate analysis of prepared flour.
- To develop value added biscuit and cookies.
- To evaluate the affect of kocho powder on color of biscuit.
- To assess quality attributes of developed biscuit and cookies.
- To improve/enhance kocho consumption.

1.5 Significance of the study

Studying the development and quality evaluation of biscuit and cookies made from wheat flour supplemented with kocho powder can be a good problem solver to assure the occurrence of high quality product. Studying the quality evaluation on parameters such as proximate, physical, texture and color will give away for producing healthy, nutritional rich and market competitive product. Kocho is simple basic starch crop, quite low in protein, not very adaptable to varying food dishes but very high in productivity.This Study will add value on kocho consumption and production.

The Enset product has the potential to improve nutrition, boost food security, foster rural development and support sustainable land care. The enset and its products are used for different nutritional, medical and non-nutritional purposes.

The consumption of kocho is not well described in our country, so this research will focus on raising consumer awareness and provide the main nutritional and health benefits of kocho powder. Therefore, using kocho powder as a supplementary ingredient in biscuit and cookies to improve its nutritional benefit is a good idea.

1.6 Scope of the Research

This study will concern on development and quality evaluation of Biscuit and cookies made from wheat flour supplemented with kocho powder. Detail work on the quality evaluation on parameters such as proximate, physical, texture and color will be conducted. The microbial and water activity will also be estimated.

CHAPTER TWO

2. LITERATURE REVIEW

There have been many studies done to improve the nutritional quality, color, texture, flavoretc. of biscuits. On the different time the gab occurred on studies of different scholar with this project work is discussed. Being enjoyed by children and adults alike, nutritionally rich biscuits and cookies will have the potential to improve nutritional security and can replace the biscuits and cookies which are otherwise considered as "junk". Most of the enriched foods are expensive. Therefore, the production of other addition foods from locally available raw materials is of most important. Moreover, childrens like to eat biscuit, cookie/snacks confectionary etc. From these sweetened products to do supplementation on biscuit or cookies is much easier. Cookies are the most significant bakery product. It hold a great significance position in snack foods because of variety in taste, crispiness and digestibility.Many making a profit available cookies are prepared from white wheat flour which is nutritionally inferior to whole wheat flour (Shahzad *et al.,* 2006).

2.1 Overview of Enset production or cultivation in Ethiopia

Enset plant is produced originally or naturally in particular region crops for food and the Enset cultivation system is economically feasible and is one of the some successful indigenous and sustainable agricultural systems (Admassu and Struik, 2002). It is providing food for humans for generations and improving the quality of life of the people. It is varies within the species because of their to altitude, soil and climate. This permited worldwide cultivation in the mid to highlands of western Arsi-Bale, the Southern Nations and Nationalities People Regional State (SNNPRS), and in addition around western Oromia including West Shewa, Jima, Ilubabor and Welega (Robert, 1996).

Universal of Enset production from Oromia Region and the national root crop production would have placed calculated 'Enset and root crop production' at more than 25% of the total cereal and pulse production of Ethiopia (Robert, 1996).

Annual household production of Kocho varies from one areas to others. Average annual household production varied from 5-15 quintals in maintenance producing Woredas to 35-70 quintals in excess producing Woredas (Admasu, 2001). The Central Statistics Agency describes the enset production have direct relationship with its area coverage,this means as the area of land under enset production has increased the production also increased (Statistics Agency,1995–2017).

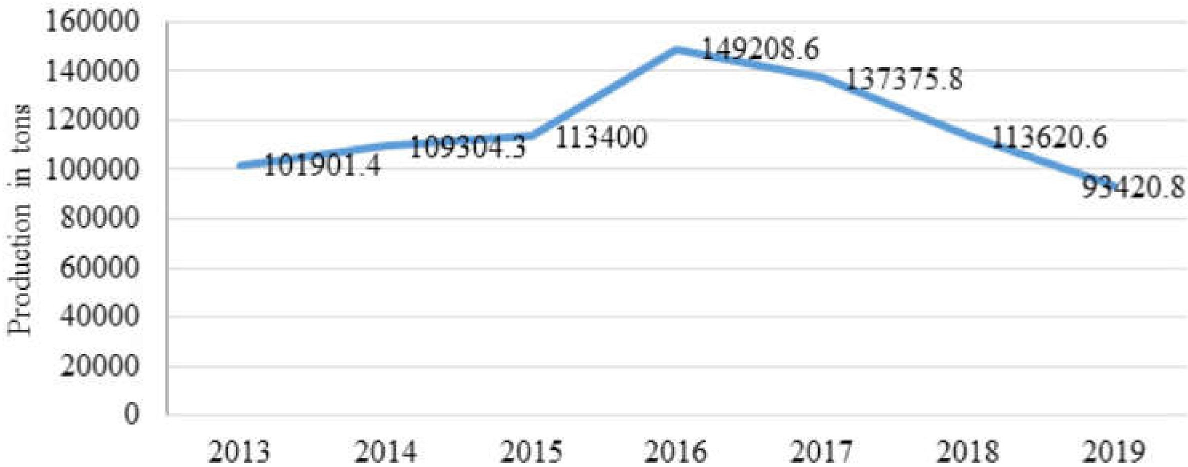


Figure 2.1: Enset production (2013-2019)

Source**:** Statistics Agency,(1995–2017)

2.2 Overview of wheat production in the Ethiopia

Ethiopia is the of wide range or scope wheat producer in the Sub-Saharan Africa with about 0.75 million ha. Wheat is one of the significant cereal crops in the Ethiopian highlands, which range between 6 and 16 N, 35 and 42 E, and from 1500 m to 28 m. It is produced in the greatest amount or quantity. highlands of the northern, central and south-eastern parts of Ethiopia (CSA, 2017; Demeke & Marcantonio, 2013). This means that it can be produced in quantity all regions of the country including pastoral and agro-pastoral areas like Afar, Gambela and Somali regions. But, the majority percent of existing or occurring inside a particular country (domestic) production of wheat is grown in Oromia and Amhara regions of Ethiopia around 85% (Bergh et al., 2012). In terms of regional contribution, the production of wheat formulates from Oromia (57%), Amhara (28%), SNNP (8.7%) and Tigray (6.2%) (CSA, 2013).

Table 2.1: Trends of wheat in area coverage,production and yield by regions between 2016/2017 and 2017/2018

Region	2016/2017 production season			2017/2018 production season		
	Area (000 ha)	Production (000 qt)	Yield (qt/ha)	Area (000 ha)	Production (000 qt)	Yield (qt/ha)
Oromia	898.46	26640.26	29.65	898.68	26699.18	29.71
Amhara	554.28	13190.62	23.80	554.66	14047.07	25.33
SNNP	127.21	3287.59	25.84	127.25	3391.96	26.66
Tigray	107.72	2128.67	19.76	107.93	2140.03	19.83
Benishangul gumz	2.08			2.46	59.08	24.06

Source: CSA (2017 & 2018)

2.3 Malnutrition and food security in Ethiopia

In Ethiopia, foods are infrequently modified to increase amount of nutrient to meet the requirements of calorie for normal person. Locally prepared foods made of cereals or tubers may be low in several amounts of nutrients including protein, minerals (zinc and iron); these nutrients are of greater significance due to their influence on physical and cognitive development.

Children at the age of five to twelve have the unfinished diet. This means many of the children do not get a balanced diet during feeding and results in low weight and slow growth. Malnutrition is a prevalent public health harmful and the major cause of death of children in developing countries. Moreover, when the malnourished children are grown up they become low resistant to diseases and, most of them will be of lower the ability to understand things and making decisions.There are different kinds of malnutrition in Ethiopia such as low weight for height (Wasting), low height for age (Stunning), low weight for age (underweight) and micronutrient malnutrition like vitamin A deficiency, Iron deficiency, and Zinc deficiency which includes overweight and obesity which is too heavy or excessive fat for height. In Ethiopia, the major causes of malnutrition are determined food insecurity, poor guiding and child feeding practices, high incidence of infectious diseases, and limited access to quality nutrition services. Household capital, education, and family planning are also key drivers of children's nutrition. All these production of nutritious food is a critical signicance in Ethiopia (Yewelsew, 2006).

2.4 Imporance of nutrional requirements for infants

The major six nutrients that a human being wants to have to be in good health person are CHO, protein, fat, vitamins, minerals and water. Proper supportive feeding helps growing and prevents low height for age among children between 6 and above months of age. Infants are most at risk to malnutrition and infection during the transition period when supportive feeding begins.Infants are insufficient to consume sufficient quality and quantity of nutrients; they will be in pain from famine or malnutrition. Insufficient knowledge about appropriate foods and feeding practices is often a greater determinant of malnutrition than the lack of food. In developing country instruct breast milk energy intake K.cal per day is lower through the baby's age increase. But, at the age of six months and above when the child's birth weight is calculated to have doubled, breast milk is no longer adequate to meet the nutritional needs of the growing infant.

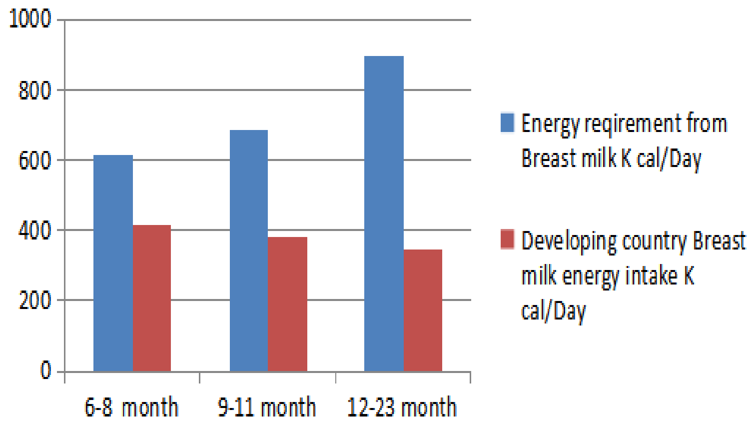


Figure 2.2: Energy gap of milk in developing countries

Source: Geneva, (2000)

2.5. Kocho powder

Enset products are Kocho, amicho and Kocho powder. From those kocho and kocho powder are the foods consumed fermented in Ethiopia which are prepared by processing (Ashenafi Z., 2002). Kocho is an acidic starchy food, is prepared by fermenting a mixture of the scrapping of the trunk and pulverized tem and corn of enset. It needs a lengthy period of processing and preparation. The first stage involves extracting the leaf stalks and grading of the corm. Then the fibres are separated and the pulp is crushed to extract the starch. Then this is put in a pit which has about 1.5 m deep and 1 m diameter, covered airtight with enset leaves before being weighed down with stones (Atlabachew, 2007). It is then allowed to ferment which requires weeks to months, which may be months to some years (Nigatu and Gashe, 1998). The pit is opened at intervals to allow aeration, and the enset leaves are replaced. This is repeated until the desired fermentation quality is reached or the food is needed. Finally, the fermented starch is dried and treated as flour. This can be used to prepare a pan cake - like bread, which is eaten with milk and cabbage. Kocho is increasingly exported to urban markets, Kocho can be stored for a long period of time without spoiling. The quality of Kocho depends on the age of the harvested enset plant, the type of clone (variety), and harvesting season. Mostly, the quality of one enset plant is influenced by the part of leaf sheath and corm processed on the first stage of kocho processing (Atlabachew, 2007). kocho powder is a thick pasty porridge made from enset that's been turned into a powder. It is made by dehydrating the juice collected during the decortication of the stem and pseudo stem.

2.5.1 Nutritional and health benefits of kocho powder

As the principles of good nutrition people are encouraged to eat more starches, especially those high in fiber, vitamins, and minerals. Fiber in foods may help to lower blood-glucose and blood-fat levels. Most people should increase the amount of carbohydrate and fiber they eat in order to lower blood glucose and others. This can be done by eating more kocho powder(bulla), giant taro, yams, sweet potato, cassava, bananas, dried beans, and peas; more whole grain breads,cereals, and crackers; and in addition to eat more fruit and vegetables (Shovic, 1999).

The enset and its products are used for different nutritional, medical and non-nutritional purposes. The main food product of enset is the starch in the stem and pseudo stem. Kocho is the fermented product of these starchy parts and can be baked like bread. Kocho powder is made by dehydrating the juice collected during the decortication of the stem and pseudo stem. The main mineral contents of kocho powder are potassium, sodium, calcium and other minerals. Enset products supply more calcium and iron kind sources of minerals than most cereals, tubers(majorly store carbohydrate) and root crops (Mulualem and kifle, 2014).

2.6 Wheat flour

Wheat flour is a powder made by pulverisation of wheat. There are two different types of wheat flours that are used as base for biscuit makings; "soft" or "weak" varieties and "hard" or "strong" varieties. The soft or weak varieties contains low gluten content of protein and results in biscuits with crumbly texture, while the hard or strong varieties contains high gluten content and the gluten in the flours made with hard wheat give more elastic toughness of dough and hard biscuits (AACC, 2000). Soft flour is comparatively low in gluten and thus results in a loaf with a finer, crumbly texture. Soft flour, or cake flour, is low in gluten content of protein, and other soft flour is pastry flour, which has may be slightly more gluten than cake flour (Abdoulaye *et al.,*2011) .

2.6.1 Nutritional and health benefits of wheat flour

The principal functional protein of wheat flour is gluten. Gluten is moistened and worked by mechanical action, it forms an elastic dough. The longer the dough is worked, the more linkages are formed. This is the reason that dough is to be kneaded well when a strong structure is required. The resulting dough may be stretched in two directions and form sheet or firms, or it may be stretched in all direction under high pressure of expanding gas and form bubbles as does bubble gum. However, gluten films wicked the break down under excessive mechanical action such as over mixing of the dough. Additionally, up on exposure to sufficient heat, gluten coagulate and firms semi-rigid structure.

2.7 Principle of baking

The term baking strictly refers only to the operation of heating dough products in an oven but since there are many steps that must takes place before the oven if baking is to be successful, baking has come to mean all of the science and technology that must precede the oven as well as the oven- heating step it self . In general we will consider baking is the form of cooking that is carried out in an oven and it improves eating qualitiesand shelf life of foods (Desrosier, 1977). It involves simultaneous heat and mass transfer among heat and mass transfer types; in this type first heat is transferred into the food from warm surfaces and next air in the oven and moisture is transferred from the food to air that surrounds it and finally removed from the oven (Fellows, 2000).

Although there are a great many bakery products which grade one into another in terms of their formulas, methods of preparation and product characteristic , it is possible to classify bakery products according to the way in which they are learned. This classification, thought not perfect is useful. Four categories may be defined.

1. Yeast, raised goods include breads and sweat dough leavened by carbondioxide from yeast fermentation.

2. Chemically leavened goods include layer cakes, doughnuts and biscuit raise by carbondioxide from baking powders and chemical Agents.

3. Air-leavened goods include angel cakes and sponge cakes made without baking powder.

4. Partially leavened goods include pie crusts, certain crackers, and other items were not international leavening agents are used yet a slight leavening occurs from expanding stem and other gases during the oven-baking operation.

2.7.1 Preparing of dough

- First mix the cooled margarine with the sugar, and then add liquid ingredients at the lowest speed in the planet mixer or dough-kneading machine to a uniform mass.
- Add the flour with the baking powders and dry ingredients. In case ammonium is used, this has to be mixed with the liquid ingredients. Mix till a supple dough has been formed and everything is well mixed (scrape regularly).
- Do not mix longer than necessary, which results in tougher or softer dough because of an increase in temperature.
- When you are using the dough later, store it in a cool place of approx. 15-20ºC (not in the fridge!). Before processing, re-mix the dough for a short time.
- Shape big rectangular blocks of dough as wide as the feed hopper unit(25cm). Cut slices of approx. 8-15 cm, depending on the thickness of the dough figure, using a (long) knife. These dough slices can also be made with a sheeting machine.

- Preheat the figure roller in the biscuit machine on 2000 Watt for half a minute. Then put it back on 1000 Watt.
- Supply the dough slices till the feed roller has been completely provided with dough.
- Start the machine up in the right position.

2.7.2 Major baking ingredients and their function

1. Wheat flour

There are two different types of wheat flours that are used as base for biscuit makings; "soft" or "weak" varieties and "hard" or "strong" varieties.The principal functional protein of wheat flour is gluten. Gluten is moistened and worked by mechanical action, it forms an elastic dough.

2. Kocho Powder

Enset products are Kocho, amicho and Kocho powder. From those kocho and kocho powder are the foods consumed fermented in Ethiopia which are prepared by processing (Ashenafi Z., 2002).kocho powder is a thick pasty porridge made from enset that's been turned into a powder. It is made by dehydrating the juice collected during the decortication of the stem and pseudo stem.

3. Baking powder

Baking powder used in making cakes and related goods contain particle of sodium bicarbonate as a source of carbon dioxide, and particles of an edible acid to generate the carbon dioxide when water and heat are supplied. The simplified overall reaction in the case of a baking powder containing sodium bi carbonate as the carbon dioxide source and mono calcium phosphate as the baking Acid as follow.

$$3CaH_4(po_4)_2 + 8NaHCo_3 \rightarrow Ca_3(po4)_2 + 4Na_2Hpo_2 + 8Co_2 + 8\ H_2o$$

Monocalcium	sodium	tricalcium	Disodium
Phosphate	bicarbonate	phosphate	phosphate

Such a reaction takes place too rapidly and so its speed and time of occurrence must be controlled. Varies baking powder differ in the time rate of reactions , and baking powders are formulated to produce controlled release of gases for specific bakery product applications.

For example , in making cakes, All ingredients may be mixed together and then deposited as a fluid batter in to pans foam a large bakery hopper. The Fluid batter with its weak cake Flour has very little Gluten development or other means to hold evolved carbon dioxide.

Thus, If there is a major carbon dioxide evolution during mixing or holding batter, the gas will largely escape from the batter and leaving powder will be lost. However when the batter is placed in the oven, starch Gelatinize, Gluten coagulates, and egg proteins, if present, coagulates. if gas is produced while this is taking place, the gas will be trapped and expand the solidifying mass, giving the desire volume increase and cellular structure.

On the other hand, too much gas may evolve in the oven due to an excessive amount of baking powder. This tends to over expand the gas cells, which become weaken and collapse. The result is a course grain structure with lowered volume. It also possible to produce gas in the oven too slowly. When this happen, the gluten, starch, and Eggs set the structure and the crust is formed before all the gas is released. The let gas can then rapture the crump structure and produce cracks in the surface crust.

The time and rate of gas evolution from baking powder can be regulated by the selection of different baking acids that reactor faster or slower with sodium bi carbonate this acids may be used also in different particle size or they may be coated with various materials to control their rate of solution, there by further controlling their rate of reaction with sodium bi carbonate.

Baking powders are of two principal kinds: Fast or slow acting. Some called Double Acting powders, contain both fast and slow reacting acid in combination with sodium bi carbonate. Double acting powders are compounded to give burst carbon dioxide In the batter stage to lighten the batter and make mixing easier, specially for the home baker who may mix by hand and then to liberate additional carbon dioxide in the oven when the structure is being set.

The leavening agent most often used for biscuits is baking soda plus an acid or baking powder. Baking powder may be divide into If a recipe calls for soda, it also calls for an acid,such as buttermilk (Burrier, 2003)

4. Sugar

Sugar, like shortening, is a thundriser in baked goods. It also adds sweetness and , in the form of sucrose, provides additional fermentable substrate in yeast raised goods. Baker's yeast cannot ferment sucrose directly, but hydrolyses it first by means of enzyme inverts in to glucose and fructose, the yeast then immediately ferments the glucose:after the glucose is consumed , it proceeds to ferment the fructose. sugar also has moisture retaining properties in the baked goods. In this respect the hydrolytic products of sucrose, namely , glucose and fructose which together are referred to us invert sugar usually are superior to sucrose.

This is one reason why invert sugar syrups are frequently used in addition to sucrose in various baked goods made without yeast. Corn syrup from the hydrolysis of starch, which contains glucose, maltose, sucrose and dextrins, also has this moisture-retaining property. Sucrose, fructose, glucose, maltose, and dextrins further contribute to the different kinds of browning that baked goods developing in the oven.

5. Oil

Influences taste and crispiness. The more oil, the crispier the biscuit. You can see this at the structure at the bottom of the baked biscuit. The structure is looser when more butter is added. This is one of the advantages by which the baker can distinguish himself from industrial production.

The reason is that the industrial baker mostly works with a system, whereby the dough figures are sucked out of the figure roller. This of course is only possible with a solid, which means low fat dough with less than 40% of fat in relation to the flour. With the Kalmeijer biscuit machine we do not use this principle. We cut the dough figure off with a knife. As there is no friction, pressing or sucking of the dough with the Kalmeijer system, it is possible to use dough with a fat content between 30% till 70% in relation to the flour; in some cases even to 80%. To reduce costs, you can replace the butter by margarine. For the taste and smell however, we prefer real butter.

6.Skimmed Milk powder

Has the same effect as water; but gives the biscuit more flavor and color because of the milk sugar.

7.Sodium Bicarbonate

The biscuit will partly increase and partly flow. To suggest not to add more than 1% in relation to the flour. With higher quantities the biscuit will get a soapy taste and a greenish color.

8.Calcium Bicarbonate

In the oven this product will react very quickly and gives a maximum of gas forming. This creates a huge volume with an unrefined cell structure, which results in a very crispy product. We suggest not to add more than 0.6% in relation to the flour (this has to be mixed with the liquid ingredients).

9. Vanilla

Beside these examples of flavour and colourings, you can also add finely ground nuts, chopped citrus fruit or almond paste. Please note the amount of sugar in your recipe, because there is also 50% of sugar in the almond paste.

The ingredients have to be finely ground; otherwise they cannot be cut by the knife. When using sticky ingredients like chopped citrus fruit, it is adviced to use a Teflon knife.

10. Water

Water is a very important ingredient in bicuits and cookies processing. Addition of water during the processing reduces the viscosity and increases dough extensibility. It is also an essential factor in the rheological behavior of flour dough's. An increase in water outcome in the expansion of biscuits larger with a smaller thickness (Sumnu and Sahin, 2008).

2.7.3 Principle and processing of biscuit and cookies

These products are fragile and characterized by a low moisture content (<6%) low water activity(aw = 0.30) and are highly hygroscopic. Moisture is the decisive criteria for the sensory properties and acceptability by the consumers.

• Loss of Crispness: Biscuits have a low moisture content, high fat level and are fragile in nature. Hence, they have to be protected from these three aspects. Since the biscuits consists of wheat flour, fat and shortening, sugar, salt and flavoring agents they are pre-dominantly sensitive to water vapor interchanges (moisture) and oxygen reactions. They generally have an initial moisture content of 2-3% equilibrating to 10-15% RH. The critical moisture level from the point of loss of crispness varies between 4 to 6%.

There is a well-established relationship between water vapour sorptions and chemical, physical and stability characteristics of biscuits. For predicting product shelf-life and package performance with respect to water vapour transfer, the data required is:

• Water sorption isotherm

• Water Vapor Transmission Rate (WVTR) of the packaging material

• Storage Conditions

Since these are moisture sensitive products, water vapor transmission rate of the packaging material used is of importance as it is closely associated with drying, physical structure and protective action against oxidation. These products not only become brittle and hard but also develop oxidative rancidity at very low moisture contents. Temperature also plays a very important role. As the temperature increases the critical moisture gets reduced since the Equilibrium Moisture Content (EMC) corresponding to the same water activity is decreased.

• Rancidity: Another requirement due to high fat is the prevention of rancidity. When fat gets exposed to moisture and atmosphere, it gets oxidized and this results in rancidity and lowering of shelf-life. Hence the packaging material must be grease resistant to prevent seepage of fat and staining of the pack and have low oxygen permeability to prevent oxidation and rancidity of the fat.

The appropriate films and correct sealing prevents any infestation by insects. The result is a product, which is fresh and tasty throughout its shelf-life. The pack must be perfectly heat-sealed in wrapping materials with the required barrier properties against light, humidity and external odours.

• The packaging must appeal to the potential customers and stand out against other competing products and serve as an effective advertising tool.

• Detailed information about the product such as composition of the product, nutritional value, price information etc.

• Satisfy consumer demand for convenience packaging by providing different pack sizes, convenient packet opening facilities like tear tapes, incision cuts etc.

2.7.3.1 Packaging and storage

Good packaging and storage control are necessary to prevent mould growth, which is a key problem with this product. To prevent it, the product should be properly cooled before packing, taking care to Adhere to hygienic measures. Any surface moisture will encourage contamination (if packed hot in polyethene, moisture will condense inside as the product cools, providing conditions for mold contamination). For this product, polythene bags and paper bags are the most commonly used, which also provide protection against some insect and soil contamination. In large quantities they may be packed in hard board boxes store in an ventilated, cool, dry place, raised off the floor.

2.7.3.2 Packaging Materials

A wide range of packaging materials is used to pack biscuits. Since paper cartons, tins have lost out to flexible packaging materials as the packaging medium, focus is now on the latter. A variety of flexible packaging materials are used for packing biscuits due to advantages such as functionality, lower cost, printability, light weight, savings in freight and other such factors. Flexible Packaging Materials: These are used as wrappers, pre-formed pouches or form-fill pouches.

2.8 Farinograph analysis/ parameters and their meaning

The farinograph parameters determines dough and gluten properties of a flour sample by measuring the resistanceof dough against the mixing action of paddles (blades).

The farinograph test is one of the most commonly used flour quality tests in the world. The results are used as parameters in formulation to estimate the amount of water required to make dough, to evaluate the effects of ingredients on mixing properties, to evaluate flour blending requirements. Farinograph results are also useful for predicting finished product texture characteristics. For example, strong dough mixing properties are related to firmproduct texture (Kalekristos Y, 2010).

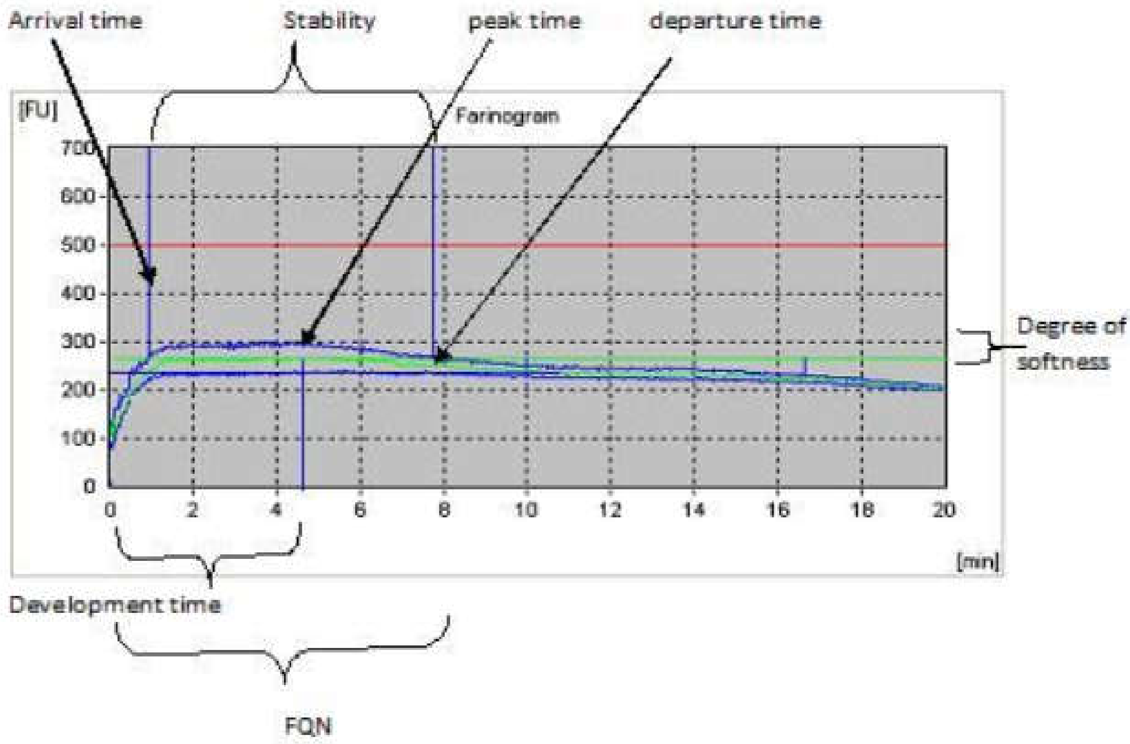


Figure 2.3: the graphical representation of the farinograph

Source: Kalekristos Y, (2010)

The farinograph test measures and records the resistance of dough to mixing with paddles.

- **Absorption** is the amount of water required to center the farinograph curve on the 500-Brabenderunit (BU) line. Absorption is expressed as a percentage.
- **Peak Time** indicates dough development time, beginning at the moment water is added until thedough reaches maximum consistency. Peak time is expressed in minutes.
- **Arrival Time** is the time when the top of the curve touches the 500-BU line. Arrival time isexpressed in minutes.

- **Departure Time** is the time when the top of the curve leaves the 500-BU line. Departure time is expressed in minutes.

- **Stability Time** is the difference in time between arrival time and departure time. Stability time is expressed in minutes.

- **Mixing Tolerance Index (MTI)** is the difference in BU value at the top of the curve at peak timeand the value at the top of the curve 5 minutes after the peak. Mixing tolerance index is expressed in Brabender units (BU).

- **Farinograph quality number (FQN)** is the point of the curve in which the curve has decreased by30 FU after the maximum. Thus weak flour weakens early and quickly giving low quality number. Strong flour weakens late and slowly indicting a high qualitynumber.

- **Degree of softening** is the difference between consistence line and medium line of the torquecurve.

2.9 Summary of literature reviews

To make summarize the literature review explained by different studies engaged in searching supplementation of kocho powder some can be mentioned. Under some research title of development and quality of biscuits from kocho powder only focused on two blending with kocho powder and effect of baking time and temprature on the quality kocho Biscuit.

Kalekristos Yohannes studies Effect of baking time and temprature on the quality of kocho biscuit Enriched with faba bean and wheat. It misses microbiological analysis of biscuit is not studied in this paper. And Development and quality evaluation of biscuits and cookies only made from wheat and kocho powder is not studied. Development and Quality Evaluation of Wheat Based Cookies Supplemented with Fenugreek and Oat Flour was sudied by (Abiyot Negu,2017). But supplementation of kocho powder is not studied. It is not included color and texture analysis in this paper.So,Devlopment and quality evaluation of Biscuits and Cookies made from wheat flour supplemented with kocho powder was selected.

CHAPTER THREE

3. MATERIALS AND METHODS

3.1 Materials

The basic materials required for this study are listed and described below. They are classified into three categories:

- **Raw materials:** The raw materials for the thesis work were collected from Addis Ababa and Dire Hinchini local market, Ethiopia and kality Food Share Company. The major and minor raw material used for the study are the following.

✓ Kocho powder, Hard wheat flour, salt, water, baking powder, sugar, oil, Skimmed milk powder and vanilla flavour.

- **Processing equipments:** Baking trays and oven/ machine, Farinography, Oxy test, mixer, Heat sealer , Scales, PH meter, Roller, Texture analyzerand LAB (L-lightness/darkness, A-red/green, B-yellow/blue) scale.
- **Chemical & reagents:** The major chemical required are sodium bicarbonate & Calcium bicarbonate were brought from supermarket,Addis Ababa.

3.2. Sample collection, preparation and storage

The sample (kocho) was brought or collected from West Shoa around Dire Hinchini and hard wheat flour was collected from Kality Food Share Company.

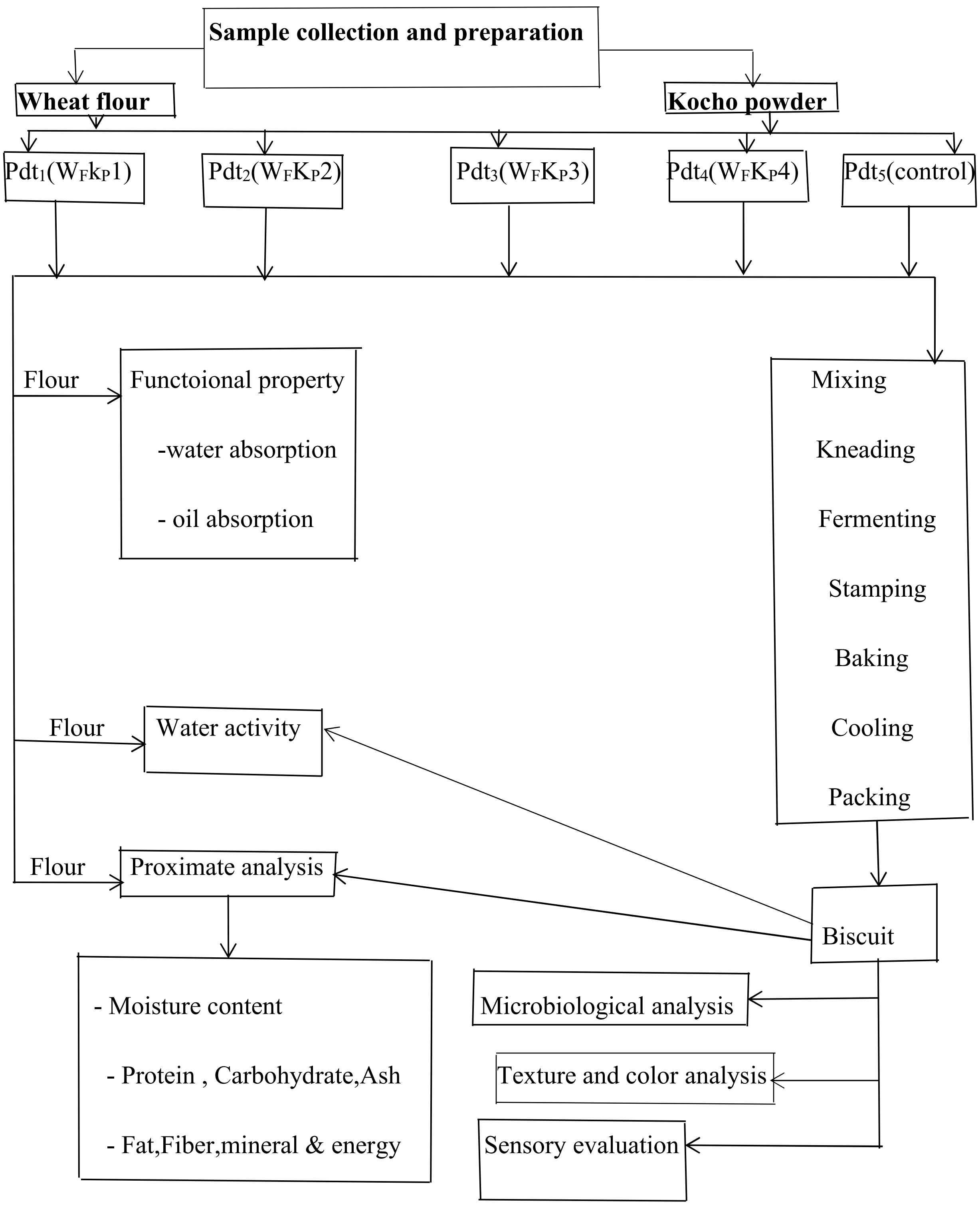
The sample (kocho) was turned into kocho powder needs a lengthy period of processing and preparation. The first stage involves extracting the leaf stalks and grading of the corm. Then the fibres are separated and the pulp is crushed to extract the starch. Then this is put in a pit which has about 1.5 m deep and 1 m diameter, covered airtight with enset leaves before being weighed down with stones. It is then allowed to ferment which requires weeks to months. The pit is opened at intervals to allow aeration, and the enset leaves are replaced. This is repeated until the desired fermentation quality is reached or the food is needed.

Finally, the fermented starch is dried and treated as flour.Then the unwanted material was removed in environmentally safe way. And the sample was storaged for one month.

a b

Figure 3.1: Preparation of wheat flour(a) and kocho powder(b)

3.3 Structure of the Thesis



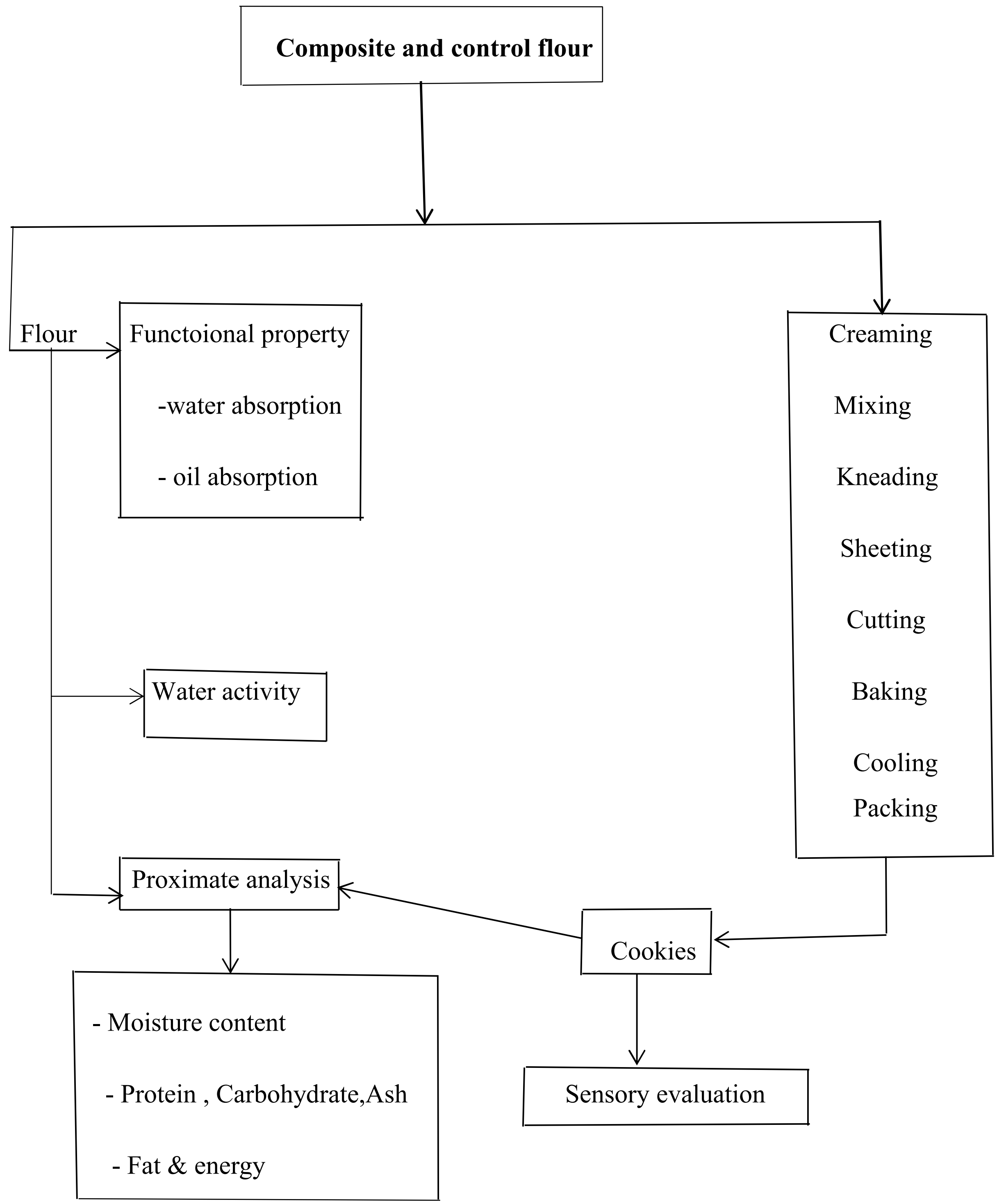


Figure 3.2: Experimental framework of research

3.4 Site of the study

The experiments was conducted at laboratory, School of Chemical & Bio-Engineering, Addis Ababa University, Addis Ababa Science and Technology University, Bless Agri Food Labratory Service PLC, Debrezite Agricultural Research Centers and Kality Food Share Company .

3.5 Methods

3.5.1 Preparation of biscuit and cookies

The biscuit and cookies were prepared by varying combinations of hard wheat flour and kocho powder.The total quantity of wheat flour and kocho powder for making Biscuits and cookies as well as for proximate analysis and functional properties of flour 30kg and 20kg respectively. The other ingredients is given in Table 3.1.

Table 3.1: The quantity of ingredients used other than wheat flour and kocho powder for making biscuit and cookies

Ingredients	Total quantity
Baking powder	0.5kg (0.1kg each)
Sugar	12kg (2.4kg each)
Salt	1kg (0.2kg each)
Skimmed milk	3kg (0.6kg each)
Oil	5kg (1kg each)
Water	60kg (12kg each)
Vanilla flavour	1kg (0.2kg each)

The biscuits which was prepared solely with wheat flour was considered as standard and the those addition with of kocho powder as samples. Kocho powder was prepared by drying the kocho available in Dire Hinchini.Therefore the biscuits and cookies from kocho powder and wheat flour was formulate as follow here under.

1. **Product 1**: 80% of wheat Flour and 20% of Kocho Powder (W_FK_P1)
2. **Product 2:** 70% of Wheat Flour and 30% of Kocho Powder (W_FK_P2)
3. **Product 3:** 60% of Wheat Flour and 40% of Kocho Powder (W_FK_P3)
4. **Product 4:** 50% of Wheat Flour and 50% of Kocho Powder (W_FK_P4)
5. **Product 5:** 100% of wheat Flour (W_F5) (control sample)

Preparation of biscuits

The dry ingredients viz. wheat flour, kocho powder, baking powder, milk powder, salt and sugar were added in a mixer and mixed together until well-blended. Measured amount of water and oil was poured into this. All the ingredients were mixed thoroughly by mixer and kneaded well to make this into dough. Small balls were prepared from this dough and each were spread into a thin layer using a roller. Each dough-spread was later cut into the required biscuit shape. These were spread in one layer on aluminum foil and were spread on a tray. Later the dough spreads were baked in a pre-heated oven at 180 ^{o}C for 8minutes. Finally, the biscuit was cooled and packed for analysis.

Preparation of cookies

Cream was prepared by by mixing all ingredients like sugar, sodium bicarbonate, salt, vanilla, oil, milk powder except flour.After cream was formed, the dough was developed by addition of flour in one batch and manually mixed and kneaded well to make this into homogeneous dough.Small balls were prepared from this dough and each were spread into a thin layer using a roller. Each dough-spread was later cut into the required cookies shape. These were spread in one layer on aluminum foil and were spread on a tray. Later the dough spreads were baked in a pre-heated oven at 180 ^{o}C for 8minutes. Finally, the cookies was cooled and packed for analysis.

3.5.2 Product quality analysis

The product quality was analyzed for its color, texture,proximate, water activity,microbial and sensory attributes (taste, texture, appearance, flavor, colour and overall acceptability).

Sensory properties

The sensory attributes of the biscuits were carried out by sensory panelists. The panelists analyzed and scored the sensory attributes applying a 7 point hedonic scale (Table 3.2).

The panelists include 25 undergraduate students and staffs. Each panelist scored based on his/ her own judgment by seeing, tasting and smelling the biscuits and cookies. The sensory evaluation form is given in Appendix 8.

Table 3.2:The seven point hedonic scale used for evaluating sensory attributes of biscuits and cookies

Likability	Score
Like extremely	7
Like moderately	6
Like slightly	5
Neither like nor dislike	4
Dislike slightly	3
Dislike moderately	2
Dislike extremely	1

3.6 Proximate analysis for biscuit and cookies flour

The proximate analysis were conducted at Addis Ababa Institute of technology (AAiT)and all proximate analysis like moisture content, protein, fat, carbohydrate, ash, fiber, mineral and energy were determined according to the methods AOAC, (1990).

3.6.1. Moisture determination

The crucibles were cleaned and dried in an oven at 105°C for 1 hr and placed in a desiccator to cool. The moisture content was determined and calculated as

$$\text{Moisture content(\%)} = \frac{W_2 - W_3}{W_2 - W_1} \times 100\% \text{ ....Equation(3.1)}$$

Where: W1- Weight of crucibiles after cooling

W2- Weight of dry crucibiles

W3- Reweight of ccucibiles(cool & dry)

3.6.2. Fat content

Fat content of the samples was determined by the method of AOAC (1990). The extraction cylinder was washed with hot water and put in to an oven for about 1hour at a temperature of 105°C. After 1 hour it was taken from the oven and put in a desiccator and weighed (W1). The bottom of an extraction thimble was covered with a layer of fat free cotton. About 2 g of the sample was weighed in the thimble (W) and covered with a layer of fat free cotton. Then the thimble was put in the extraction chamber. About 50 ml of petroleum ether was added into the extraction cylinder and moved to the heating plank for extraction for about 4 hr. After 4 hr extraction, the extraction cylinder was dis connected and put into the drying oven at 70°C for 30 min. Then it was put in the desiccator to cool for 30 min and weighed (W2).

$$\text{Crude fat} = \frac{W_2 - W_1}{W} \times 100\% \text{ ....Equation (3.2)}$$

3.6.3. Ash content

The ash represents the in organic component of the sample after all moisture has been removed as well as the organic material. The porcelain crucibleswere cleaned and dried in a muffle furnace at 550°C for 30 min. The dried crucibles were cooledin a desiccator for 30 min and weighed (W_1). About 2.5 g of fresh sample was weighed in driedand cooled crucibles(W_2) and charred on a hot plate under a fume-hood at 370°C until smokingceases. Finally, the sample was ashed in the muffle furnace at 550°C for 5 hr followed by cooling and reweighing (W_3) and calculated as:

$$\%\text{Ash content} = \frac{W_3 - W_1}{W_2 - W_1} * 100 \qquad \text{Equation(3.3)}$$

3.6.4. Protein content determination

Digestion

0.5 g samples was weighed in Kjeldahl flask and 6ml of conc. 98% H2SO4 was added and left for overnight. 3.5 ml of hydrogen peroxide and about 3 g of digestion mixtures (CuSo4 and K2So4) were added to each flask and left for four hours.

Neutralization and distillation

After the sample was cooled, the digest was diluted with 25ml of distilled water and shaked to removed precipitation of sulphate in the solution. 40ml of 40% NaOH solution was added to the digested and diluted solution to neutralize the sulpharic acid.

$(NH4)_2SO4 + 2NaOH \longrightarrow 2NH3 + Na_2SO4 + 2H_2O$

$NH_2 + H_3BO_3$ (boric acid) $\longrightarrow NH_4 + H_2BO_3^-$(borate ion)

Titration

Borate anion (proportional to the amount of nitrogen) was titrated with standard 0.1 N HCl to a reddish color.

$H_2BO_3^- + HCl \longrightarrow H_3BO_3$

Calculation

$$\text{Nitrogen (\%)} = \frac{V_{HCl} \times N_{HCl} \times 14g \times 100}{\text{Weight of sample}} \qquad \text{Equation (3.4)}$$

Where

VHCl = volume of HCl in ml consumed to the end point of titration

NHCl = normality of HCl (used often is 0.1)

14 = the molecular weight of nitrogen

Moles of HCl = moles of NH_3 = moles of N in the sample

3.6.5. Carbohydrates

Total carbohydrate was determined by differences between 100 and total sum of the percentage of crude fat, moisture, ash, fiber and crude protein content.

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

C%=100-[M+F+A+P+F]……………………………………………………….Equation (3.5)

Where: F= the mass percent of fiber

P-the mass percent of protein

F-The mass percent of fat

A-The mass percent of ash

M-Moisture content(%)

3.6.6 Fiber determination

Crude fiber was determined by the method of AOAC (1990).

Digestion:

2g fresh sample was weighed (W_0) and placed into 600ml beaker. 200mls of 1.25% preheated H_2SO_4 was added for acid digestion and the solution was gently boiled for about 30minson hot plate, maintaining constant volume of acid by the addition of hot distilled water. Then 25mlof 28% KOH was added and boiled for another 30min on hot plate for base digestion with occasional stirring.

Filtration:

The porous crucible fitted with 10mm sand layer was pre-heated by pouring hot water into the crucibles. The digested sample solution was then poured from the beaker into the sand filled crucibles and filtered hot through the porous crucibles under vacuum filter.

Washing:

The residue in the crucible was then washed several times with 1%H_2SO_4, 1%NaOH, hot distilled water after each washing, and finally with water - free acetone to dissolve acid and base soluble materials left on the sand and filtered.

Drying and incineration:

The crucible was dried in an electric drying oven at 130°C for about 2hr and cooled in a desiccator for 30 min and weighed (W_1). Then the crucibles were placed in a muffle furnace at 550°C and incinerated for 30 min. Finally, the crucibles were taken out of the furnace, cooled in a desiccator and reweighed (W_2). The loss in weight after ignition was registered as crude fiber and calculated as:

$$\text{Crude fiber }\% = \frac{W_1 - W_2}{W} * 100 \qquad \text{Equation (3.6)}$$

Where:

W= Weight in grams of the dried test material. W_1 = Weight in grams of the sintered glass crucible and contents before ashing. W_2 = Weight in grams of the sintered glass crucible after ashing.

3.6.7 Mineral content

The mineral contents like Calcium, magnesium, and Iron were determined by dry ashing by Atomic Absorption Spectrophotometer.

3.6.8 Energy requirement

Gross energy was determined according to the metthod of Osborne and Voogt (1978).The percent calories in selected samples were calculated by multiplying the percentage of crude protein and carbohydrate with 4 kcal/g and crude fat with 9 kcal/g. The values were then converted to calories per 100gm of the sample.

Gross energy (%) = (9x crude fat %) + (4 x crude protein %) + (4 x crude carbohydrate %) Kcal/100g

Gross energy (%) = (9x F %) + (4 x P %) + (4 x C %) Kcal/100g………………….Equation (3.7)

3.7 Functional properties

3.7.1 Water absorption capacity (WAC)

The water absorption capacities of wheat flour and its blends samples were determined by the method of Soluski *et al.,* (1976). 1g of each flour samples (w1) were mixed with 10 ml distilled water and kept at ambient temperature for 30 min and then centrifuged for 10 min at 2000 rpm. The aqueous supernatant obtained after centrifuging was decanted and the sample weighed again (w2). The results were calculated and expressed as percentage of water absorbed per gram of sample.

$$WAC(g/g) = \frac{W_2 - W_1}{W_1} \times 100 \text{ ……… Equation (3.8)}$$

3.7.2 Oil absorption capacity (OAC)

The oil absorption capacity of wheat flour and its blends samples was determined by the method of Adeleke and Odedeji (2010) About 10 ml (V1) of oil was added to 1g of flour in a 25 ml centrifuge tube and was stirred for 2 min and centrifuged at 4000 rpm for 20 min. The amount of oil separated as supernatant was decanted and measured using 10 ml cylinder (V2). Oil absorption capacity was expressed as ml of oil bound by 100 g dried flour.

$$OAC(ml/g) = \frac{V_1 - V_2}{\text{wt of sample}} \times 100 \text{ ……… Equation (3.9)}$$

3.8 Experimental design and standard data analysis

Experimental analysis of results was given as mean and standard deviation using one-way analyses of variance (ANOVA) of the data was done with the help of software SPSS version 20. Accordingly, all analysis was measured in duplicate of each sample and differences considered to be significant were set at 5% level ($P \leq 0.05$). The process parameters for Kocho biscuit and cookies were evaluated from the standard biscuit and cookies.

Table 3.3: Experimental design

Experimental samples	Wheat flour	Kocho powder
W_FK_P1	80%	20%
W_FK_P2	70%	30%
W_FK_P3	60%	40%
W_FK_P4	50%	50%
W_F5	100%(control sample)	_

CHAPTER FOUR

4. RESULTS AND DISCUSION

4.1 Proximate composition and energy content of flours

The proximate composition of the wheat flour and kocho powder composites was analyzed and shown in Table 4.1.

The results of proximate composition, energy content and water activity shows that the wheat flour(control flour) contained 14.8% of moisture content, 0.45% 0f ash content, 10.237% of protein value, 1.5% of fat value, 0.5% of fiber, 72.52% of carbohydrate value, 344.5kcal/100g of energy content and 0.528% of water activity.

The results from proximate analysis indicated that the control flour showed higher level of moisture content, protein content, fat content, energy value and lower level of carbohydrate content, ash content, fiber content, water activity content while blend ratio flour showed higher level of carbohydrate content, ash content,fiber content, water activity content and lower level of moisture content, protein content, fat content and energy value . This was indicated that kocho powder rich in fiber and carbohydrate content whereas wheat flour has more fat and protein content.So, Supplementation of kocho powder with wheat flour was important in order to improve flavor or taste and nutritional quality of biscuit.

The water activity of the flours was ranged from 0.528% to 0.532%. This was indicated that the water activity was suitable for reducing the chemical change of inside the flours.

Table 4.1: Proximate composition and energy content of flours on % dry basis

Flour blend type	Parameters							
	Mc	**Ash**	**Protein**	**Fat**	**Fiber**	**CHO**	**Energy**	**Aw**
W_FK_P1	14.000±0.000[b]	0.600±0.070[ab]	7.787±0.123[b]	1.075±0.106[b]	0.500±0.000[d]	76.038±0.477[d]	344.175±0.459[d]	0.532±0.000[c]
W_FK_P2	13.900±0.141[c]	0.700±0.000[d]	6.125±0.000[bc]	0.910±0.127[c]	1.000±0.000[c]	77.365±0.268[c]	340.150±0.070[c]	0.534±0.001[bc]
W_FK_P3	14.000±0.000[b]	0.750±0.282[c]	5.950±0.000[bc]	0.500±0.000[d]	2.000±0.000[b]	77.400±0.282[b]	337.900±1.131[a]	0.535±0.000[b]
W_FK_P4	14.000±0.000[b]	0.800±0.141[b]	5.162±0.123[c]	0.500±0.000[d]	2.125±0.176[a]	77.413±0.017[a]	334.800±0.565[ab]	0.537±0.000[a]
W_F	14.800±0.353[a]	0.450±0.000[a]	10.23±0.123[a]	1.500±0.000[a]	0.500±0.000[d]	72.520±0.123[e]	344.500±0.000[b]	0.528±0.000[e]

[a-e] Means with the same column within the same letters are not significantly different($P \geq 0.05$)

Where: Mc- moisture content, CHO- Carbohydrate, aw- Water activity

All unit of ash, Mc,CHO, fiber, protein & fat is **g/100g(%)**

Energy in **kcal/100g**

4.2 Functional property

The water and oil adsorption capacity of each flour mixes and control samples shown in the Table 4.2. Water adsorption holding capacity is one of functional property of the flour. Water absorption capacity is a critical function of protein in different kinds of food products like soups, dough and baked products(cookies, cakes, breads, bars,sweet goods…) Adeyeye and Aye,(1998).Protein has both hydrophilic and hydrophobic nature and therefore they can interact with water in foods.

Table 4.2 shows the water adsorption capacity ranged between 7.8600 ml per g to 8.5450 ml per g for all flour mixes and control samples. From this study, water adsorption capacity has different value with increasing of blend proportion of kocho powder.This results observed that variation in different flours may be due to different concentration of protein. Water adsorption holding capacity was found to be lower than the result reported by Butt and Batool (2010) and Kuntz (1971).

The oil adsorption for the flours was 9.4100 ml per gm which was higher in WFKP1 of the sample,where the proportion of kocho powder decrease 20% and wheat flour of 80%. From this study, oil adsorption capacity has different value with increasing of blend proportion of kocho powder.

Table 4.2: Water and Oil adsorption of flours

Flour blends	Parameters	
	Water adsorption(ml)	Oil adsorption(ml)
W_FK_P1	7.8600 ± 0.0282^{d}	9.4100 ± 0.0000^{a}
W_FK_P2	8.3450 ± 0.1343^{b}	9.0150 ± 0.0919^{c}
W_FK_P3	8.1500 ± 0.1272^{c}	9.3450 ± 0.1060^{b}
W_FK_P4	8.5450 ± 0.0495^{a}	9.2850 ± 0.1060^{b}
W_F	8.1000 ± 0.0707^{c}	8.8700 ± 0.0141^{d}

$^{a-d}$ Means with the same column within the same letters are not significantly different($P \geq 0.05$)

4.3 Farinography analysis

The Farinograph parameters of blend and control flours are shown in appendix 2. The result shows that the consistency, development time, stability, degree of softeening and farinograph quality number(FQN) of the wheat flour (control sample) was better than the all blend ratio. WFKP4 shows 3.2 stability and 45 FQN (farinograph quality number) which was almost closer to wheat(control) flour FQN.

The graph of WFKP2 in figure 4.1 was observed some better consistency than that of WFKP1, WFKP3, WFKP4. The result WFKP4 in figure 4.3 showed the stability of the dough increases with the kocho powder content increases and the graph of WFKP4 also show that which have good stability as compared to the other mixes.

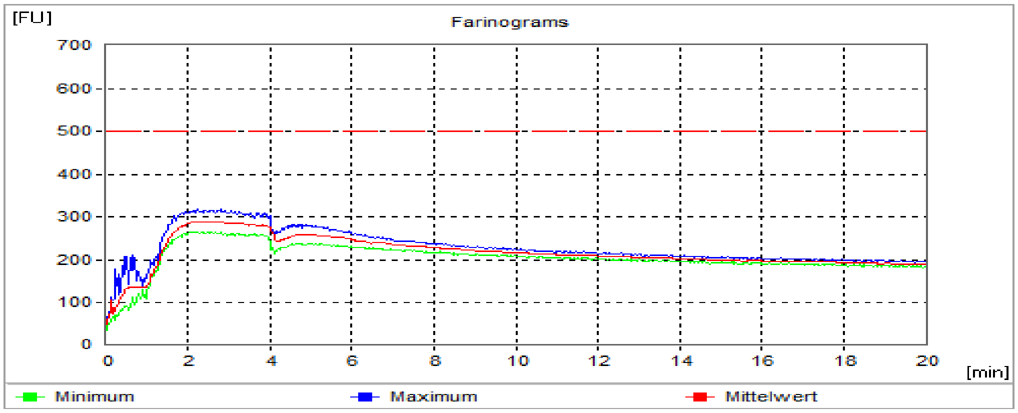


Figure 4.1: Farinograph results of WFKP1

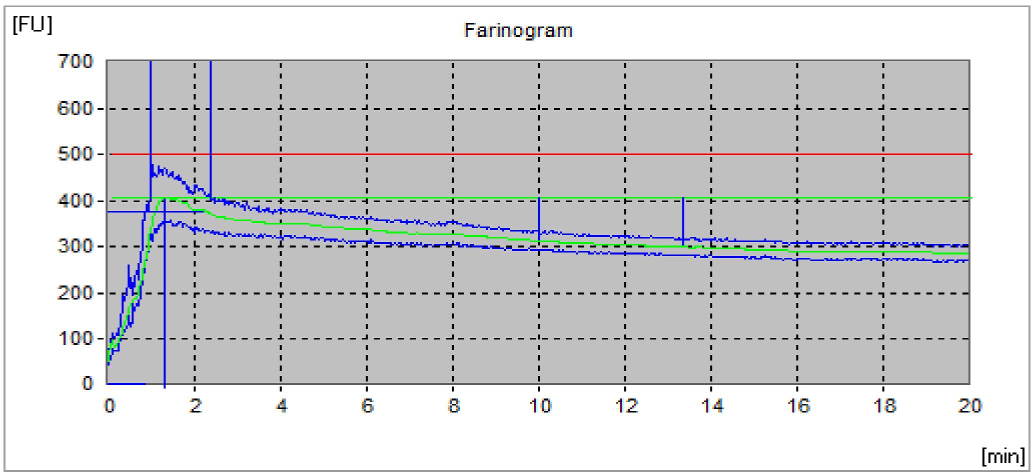


Figure 4.2: Farinograph results of WFKP2

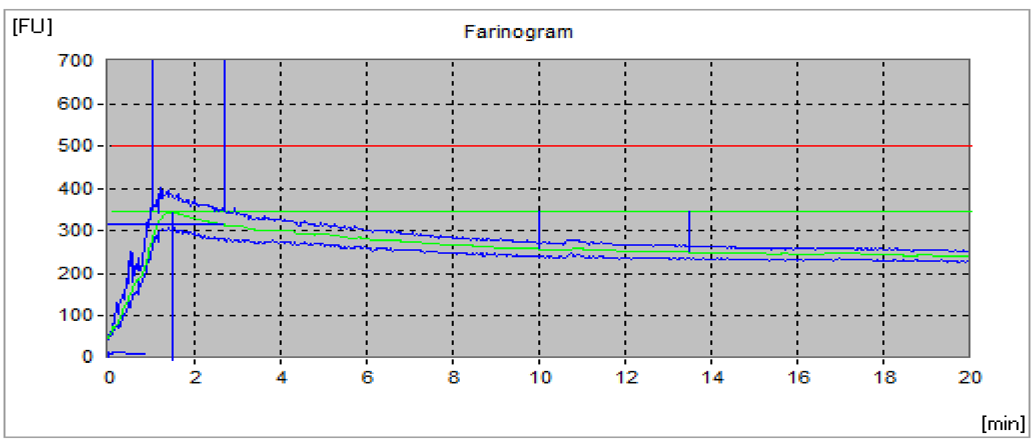


Figure 4.3: Farinograph results of WFKP3

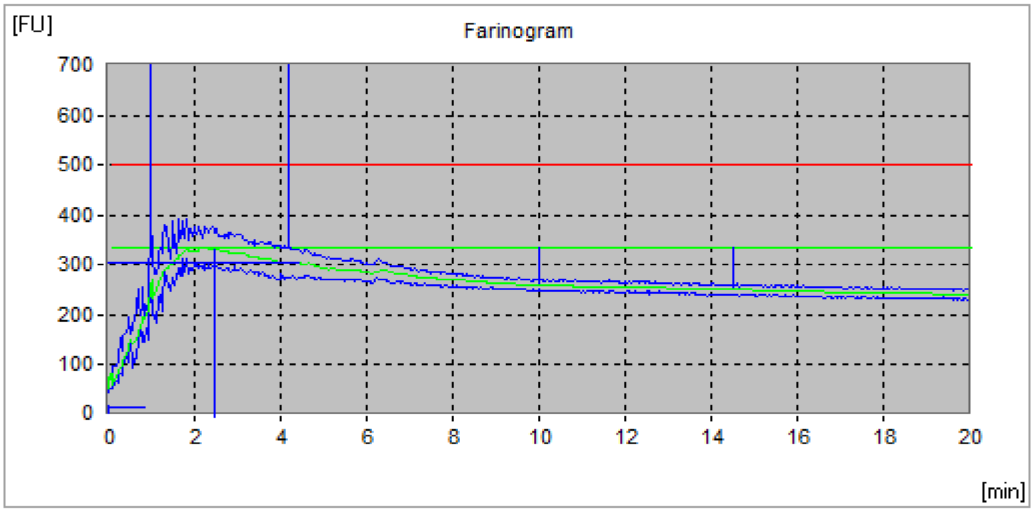


Figure 4.4: Farinograph results of WFKP4

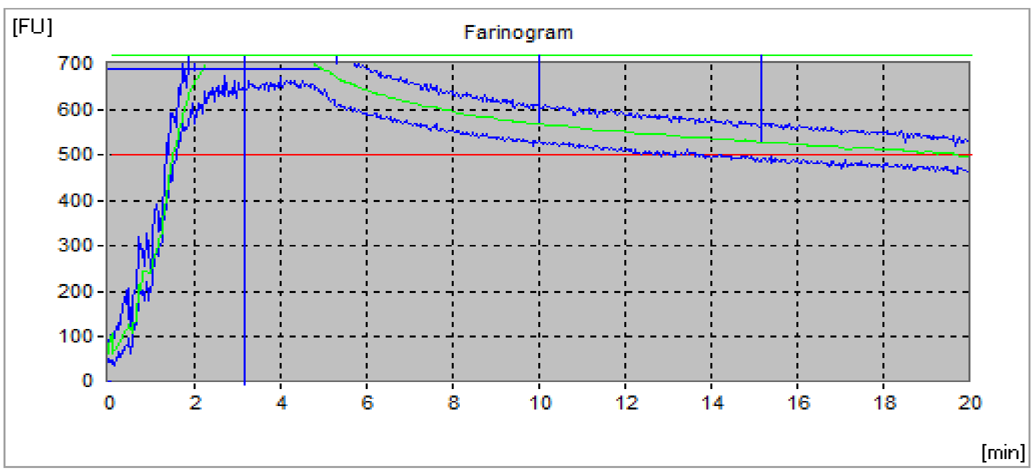


Figure 4.5: Farinograph results of WF

4.4 Proximate analysis of Biscuits

Biscuits were analyzed for their proximate composition as shown Table 4.3.

- **Moisture content of biscuit**

The Moisture content of biscuits as showed in the Table 4.3. The moisture content of the biscuits was ranged from 14.9100 g/100g to 9.9800 g/100g with respect to blend ratio. This indicates the moisture content increasing with increasing blend ratio. The highest moisture content was observed in biscuit developed from 50% WF & 50% KP and the lowest was observed in control biscuit samples.

- **Ash content of biscuit**

The ash content of biscuit is shown in Table 4.3. The ash content of the biscuits was ranged from 4.000 g/100g to 3.1250 g/100g with respect to blend ratio. This indicates the ash content increasing with increasing blend ratio. The highest ash content was observed in biscuit developed from 50% WF & 50% KP and the lowest was observed in control biscuit.An increase in ash content was observed with the ratio of kocho powder. This might be because of the high amount ash content found in kocho powder.The present finding was lower than the result of Omah and Okafor (2015), reported have higher ash content than result obtained in this study.

- **Protein content of biscuit**

The protein content of biscuit is shown in Table 4.3. Protein content of biscuit samples increased with the decrease of blend proportion and ranged from 11.125% to 7.6%.The protein content was highest in B565 (control sample)(11.125%) and lowest in B454(7.6%).

- **Fat content of biscuit**

Fats are an essential part of biscuits being the third largest component among flour and sugar (Manley,2000). Cookies are rich source of fat and carbohydrates (Kure *et al*., 1998). The fat content of biscuit samples increased with the decrease of blend proportion and ranged from 10.2875% to 6.8% as shown in Table 4.3. The fat content was highest in B565 (control sample)(10.287%) and lowest in B454(6.8%). The fat content of blend ratio of biscuit was lower than the control samples. This was due to increase fiber content of wheat flour than kocho powder. The Fat content of biscuit was higher in wheat flour and lower in 50% Wheat flour ; 50% kocho powder (B454) .

- **Fiber content of biscuit**

Type of Foods that has more fiber are significance to easily passage of waste by more larger the inside walls of the colon, make productive anti-constipation, decreased cholesterol level in the blood and lowered the risk of cancers (Wardlaw and Kessel, 2005).

The Fiber content of biscuits made from composite and control flour (wheat flour) ranged from 3.9% to 2.625% as shown in Table 4.3. From the result, an increase of fiber content of the biscuit was observed as the proportion of kocho powder was increased in the formulation. This was due to increase fiber content of kocho powder than wheat flour as shown in Table 4.3.

- **Carbohydrate content of biscuit**

The carbohydrate content of biscuit is shown in Table 4.3. The carbohydrate content of the biscuits was ranged from 57.8875 g/100g to 62.94 g/100g with respect to blend ratio.The highest carbohydrate content was observed in biscuit developed from 50% Wheat flour & 50% Kocho Powder(B454) and the lowest was observed in control biscuit (B565). An increase in carbohyrate content was observed with the ratio of kocho powder. This might be because of the high amount carbohyrate content found in kocho powder due to it was whole starch food. The results of present study was found less than the result reported by Eneche (1999) and Magda *et al*. (2008).

- **Energy content of biscuit**

The value of gross energy content of biscuits varies along the different mixing ratios as shown in Table 4.3. The gross energy content of biscuits was ranged from 368.6375 kcal/100g to 343.36 kcal/100g. The maximum value of energy content was observed in control biscuit while the minimum value of energy content was recorded in biscuit with highest blend ratios.This was due to the fat and protein content was decrease in blend ratio, since energy is the result of protein, fat and carbohyrate.

Table 4.3: Proximate analysis and energy content of biscuits on % dry basis

Sample code	Proximate analysis parameters						
	Mc	Ash	Protein	Fat	Fiber	CHO	Energy
B121	11.150±0.212[c]	3.500±0.000[d]	9.350±0.141[b]	7.625±0.176[b]	3.800±0.000[c]	60.775±0.530[d]	349.125±0.035[b]
B232	12.190±0.141[bc]	3.675±0.106[c]	9.175±0.106[c]	6.910±0.127[c]	3.875±0.176[b]	61.415±0.473[c]	344.100±2.757[d]
B343	12.380±0.000[b]	3.900±0.141[b]	8.180±0.098[d]	6.900±0.141[c]	3.900±0.141[a]	62.320±0.523[b]	343.650±0.427[c]
B454	14.910±0.014[a]	4.000±0.000[a]	7.600±0.014[e]	6.800±0.000[d]	3.900±0.000[a]	62.940±0.000[a]	343.360±0.056[d]
B565	9.980±0.070[d]	3.125±0.176[e]	11.125±0.176[a]	10.287±0.053[a]	2.625±0.176[d]	57.887±0.654[e]	368.637±1.431[a]

[a-e] Means with the same column within the same letters are not significantly different($P \geq 0.05$)

All unit of ash, Mc,CHO, fiber, protein & fat is **g/100g(%)**

Energy in **kcal/100g**

Where: B121--80% of wheat Flour and 20% of Kocho Powder biscuit

B232-- 70% of Wheat Flour and 30% of Kocho Powder biscuit

B343-- 60% of Wheat Flour and 40% of Kocho Powder biscuit

B454-- 50% of Wheat Flour and 50% of Kocho Powder biscuit

B565--100% of wheat Flour (control sample) biscuit

4.5 Proximate composition of Cookies

The proximate composition of cookies was analyzed and shown in Table 4.4. The results of proximate composition and energy content shows that the wheat cookies (control cookies) contained 8.89% of moisture content, 2.25% 0f ash content, 11.51% of protein value, 11.28% of fat value, 2.25% of fiber, 63.82% of carbohydrate value and 402.84kcal/100g of energy content.

The results from proximate analysis indicated that the control cookies showed higher level of protein content, fat content, energy value and lower level of moisture content, carbohydrate content, ash content, fiber content, while composite cookies showed higher level of carbohydrate content, ash content, fiber content, moisture content and lower level of protein content, fat content and energy value . This was indicated that kocho cookies rich in fiber and carbohydrate content whereas wheat cookies has more fat and protein content.So, Supplementation of kocho powder with wheat flour was important in order to improve flavor or taste and nutritional quality of cookies.

The moisture content of the cookies ranges from 8.89% to 13.91% with respect to blend ratio. The highest moisture content was observed in cookies developed from 50%WF:50%KP and the lowest was observed in control cookies (100%WF) . As blending ratio of kocho powder increase, the moisture content of the cookies was increased significantly ($P<0.05$). This is because of the high water holding capacity of highest blend ratio (8.545ml) (Table 4.2).The crude fiber content of the cookies made from composite and control flour ranged from 2.25% to 3.70%. The crude fiber content of the cookies was found significant ($p< 0.05$). The ash content of cookies developed from wheat and blended flour ranges from 2.25% in control to 3.11% in highest blend ratio flour cookies.

The carbohydrate content of the formulated cookies was ranged from 63.82% to 66.31%. These values compared favorably with 61.0-66.5% ranges from previous works by Eneche (1999).The gross energy content of cookies was ranged from 402.84kcal/100g to 365.75kcal/100g. The minimum value of energy content was observed in 50% wheat flour: 50% kocho powder cookies while the maximum value was recorded in control cookies . This could be because of the crude fat and crude protein content was high in control cookies, since energy is the result of protein, fat and carbohydrate.

Table 4.4: Proximate composition and energy content of cookies on % dry basis

Sample code	Proximate composition parameters						
	Mc	**Ash**	**Protein**	**Fat**	**Fiber**	**CHO**	**Energy**
C121	10.14±0.21^{c}	2.50±0.00^{d}	9.51±0.14^{b}	8.90±0.16^{b}	2.85±0.00^{c}	63.84±0.53^{d}	373.5±0.03^{b}
C232	11.18±0.14^{bc}	2.67±0.10^{c}	9.25±0.10^{c}	7.90±0.11^{c}	3.10±0.11^{b}	65.95±0.47^{c}	371.70±2.75^{d}
C343	11.39±0.00^{b}	2.91±0.14^{b}	8.21`±0.09^{d}	7.83±0.14^{c}	3.35±0.14^{a}	66.10±0.52^{b}	367.71±0.42^{c}
C454	13.91±0.01^{a}	3.11±0.00^{a}	7.69±0.01^{e}	7.75±0.00^{d}	3.70±0.00^{a}	66.31±0.00^{a}	365.75±0.05^{d}
C565	8.89±0.07^{d}	2.25±0.17^{e}	11.51±0.76^{a}	11.28±0.04^{a}	2.25±0.17^{d}	63.82±0.65^{e}	402.84±1.43^{a}

$^{a-e}$ Means with the same column within the same letters are not significantly different(P≥0.05)

All unit of ash, Mc,CHO, fiber, protein & fat is **g/100g(%)**

Energy in **kcal/100g**

Where: C121--80% of wheat Flour and 20% of Kocho Powder cookies

C232-- 70% of Wheat Flour and 30% of Kocho Powder cookies

C343-- 60% of Wheat Flour and 40% of Kocho Powder cookies

C454-- 50% of Wheat Flour and 50% of Kocho Powder cookies

C565--100% of wheat Flour (control sample) cookies

4.6 Mineral analysis

Minerals are a nutrients necessary for the health and maintenance of several human body functions like maintenance and repair of tissues and bones, oxygen transportation, normalizing the nervous system and simulating growth.

Table 4.5 shows the mineral content of biscuit produced from composite flours of wheat flour blended with different blending ratio of kocho powder.The result showed that Calcium is the most abudant element in all samples. The highest Calcium content recorded (73.3333±0.27525)mg/100g in biscuit made from 50% wheat flour and 50% kocho powder and the lowest Calcium content (24.3333±0.57735 mg/100g) in biscuit made from 100% Wheat flour (control samples) .The result indicated that increase in calcium content was resulted with the increase in kocho powder supplementation.

The magnesium content was ranged from 2.8333±0.28868 mg/100g to 4.8333±0.28868 mg/100g and observed least magnesium content in control (2.8333±0.28868 mg/100g) biscuit as compared to others.The result indicated that increase in magnesium content was resulted with the increase in kocho powder supplementation.

The Iron content high value 1.1667±0.28868 mg/100g was recorded in WF_5 and the low value 0.7667±0.05774 mg/100g was showed in $WFKP_4$.

Table 4.5: Mineral content of biscuits

Sample code	Minerals(mg/100g)		
	Fe	Ca	Mg
B121	1.0500±0.0866^{a}	32.3333±1.5275^{c}	3.0000±0.0000^{c}
B232	0.9333±0.0577^{b}	35.6667±0.5773^{c}	4.0000±0.0000^{b}
B343	0.8667±0.0288^{b}	53.3333±5.7735^{b}	4.5000±0.5000^{a}
B454	0.7667±0.0577^{c}	73.3333±0.2752^{a}	4.8333±0.2886^{a}
B565	1.1667±0.2886^{a}	24.3333±0.5773^{d}	2.8333±0.2886^{d}

$^{a-d}$ Means with the same column within the s ame letters are not significantly different(P≥0.05)

4.7 Microbiological analysis of biscuits

Determining total microbial count is very important to extend the shelf life and keeping quality of the food. The spoilage of many foods may be due to the total viable counts reached which is from10 – 10 X 10^{6} cfu/g in the product Ray and Bhunia, (2007). Allen *et al.* (2004); Ray and Bhunia(2007), notified that the maximum bacteria (aerobic) plate count for cookies is 5.30 X 10^{4} cfu/gand, 5.0 X 10^{3} cfu/g for mould and yeast counts.

From the study, Table 4.6 shows the results obtained for the total bacterial counts of the biscuits samples 7.0 X 10^{3}cfu/g with the highest being recorded for biscuits made from 60% wheat flour ; 40% kocho powder,while the lowest counts were obtained in biscuits made from 100% wheat flour. From the results, a decrease in Total Bacterial Count was observed with decrease in proportion of kocho powder.

Coliforms of the biscuits samples ranged from 2.9 X 10^2 MPN/g to 1.2X 10^2 MPN/g with the highest being recorded for biscuits made from 70% wheat flour ; 30% kocho powder and 50% wheat flour; 50% kocho powder, while the lowest counts were obtained in biscuits made from 80% wheat flour; 20% kocho powder and 100% wheat flour.

E.Coli of the biscuits samples ranged from 2.8 X 10^1 MPN/g to 2.0X 10^1 MPN/g with the highest being recorded for biscuits made from 50% wheat flour ; 50% kocho powder,while the lowest counts were obtained in biscuits made from 100% wheat flour.

Yeast and molds of the biscuits samples 5.6 X 10^3cfu/g with the highest being recorded for biscuits made from 70% wheat flour ; 30% kocho powder,while the lowest counts were obtained in biscuits made from 60% wheat flour and 40% kocho powder.

Table 4.6: Microbilogical analysis of biscuits

Sample Code	**Microbial tests**			
	TPC cfu/g	COLIFORM MPN/g	E.COLI MPN/g	YEAST AND MOLDs cfu/g
B121	6.6X 10^3	2.6 X10^2	2.0 x 10^1	5.5 X 10^3
B232	6.6 X 10^3	2.8 X 10^2	2.8 x 10^1	5.6 X10^3
B343	7.0 X 10^3	1.5 X 10^2	2.7 x 10^1	5.0 X 10^3
B454	6.9 X 10^3	2.9 X 10^2	2.8 x 10^1	5.2 X 10^3
B565	6.5 X 10^3	1.2 X10^2	2.0 x 10^1	5.2 X 10^3

Where: TPC- Total Plate Count

4.8 Textural analysis of biscuits

The textural analysis of biscuits were carried out using a texture analyzer. The application of three-point bend rig (fructure test, strength and crispness) taste is the most convenient and accurate measurement method for textural analysis.It was used for determining the breaking strength of the biscuits.

Table 4.7: Textural results of biscuits

Sample Code	Textural analysis			
	Time(s)	Laod(N)	Diameter(cm)	Stress at maximum load(Mpa)
B121	14.1500 ± 0.0989^a	0.0365 ± 0.0003^b	2.3948 ± 0.0135^a	0.0125 ± 0.0004^e
B232	10.3500 ± 0.0707^b	0.0362 ± 0.0001^b	1.6880 ± 0.0091^b	0.0476 ± 0.0000^b
B343	9.7195 ± 0.0700^c	0.0312 ± 0.0003^d	1.6443 ± 0.0084^{bc}	0.0330 ± 0.0004^d
B454	9.0710 ± 0.0650^e	0.0321 ± 0.0001^c	1.4660 ± 0.0080^d	0.0364 ± 0.0001^c
B565	9.5090 ± 0.0707^d	0.0602 ± 0.0010^a	1.6095 ± 0.0068^c	0.0790 ± 0.0013^a

$^{a-e}$ Means with the same column within the same letters are not significantly different ($P \geq 0.05$)

The strength of the kocho biscuit to break the biscuit is called Load at maximum load (in KN). From the result Table 4.7 the force required to break the biscuit samples vary along the blend proportion. The higher value for strength at maximum load was 0.0602 KN in control sample.

4.9 Color analysis of biscuits

The color of the biscuits was measured by using LAB scale instrument. From Table 4.8, the color tests of the biscuits shows that $WFKP_3$ had higher intensity of 10.307. That means increase intensity with increase amount of kocho powder.Which indicates that the darkness of kocho biscuits.

Table 4.8: Color analysis of biscuits

Sample code	Color test
B121	9.934
B232	10.118
B343	10.307
B454	10.193
B565	10.141

4.10 Water activity of biscuits

The water activity content of biscuit is shown in Table 4.9. The results in all biscuit samples shows that below 0.5% as can be seen in Table 4.9. This was indicates the results good for preventing microbial growth. The mixes show different value of water activity along the blend ratio and control samples.The highest water activity content was observed in biscuit developed from 60% WF & 40% KP and the lowest was observed in biscuit developed from 80% WF & 20% KP.The relationship of water activity with shelf-life is of critical significance in work with biological control formulations (Connick, 1996). The shelf life of the bakery products especially, biscuit is have an influenced by the water activity (Bolandi *et al.,* 2008).

Table 4.9: The water activity of biscuits

Sample code	Water activity test
B121	0.483±0.000[d]
B232	0.500±0.000[a]
B343	0.502±0.000[a]
B454	0.495±0.000[c]
B565	0.498±0.000[b]

[a-e] Means with the same column within the same letters are not significantly different ($P \geq 0.05$)

4.11 Physical attributes of biscuits

From the Table 4.10, The average weight of the five samples did not follow any trend. The mean weight of biscuits produced from wheat flour and kocho powder composite flour ranged from 10.35 to 13.57g.

However, the thickness of the different samples followed a specific trend which is similar to the sensory attributes.The thickness of biscuits ranged from 0.466 to 0.75cm. An increase in thickness of biscuits was seen with the decrease in blending ratio significantly($P<0.05$). As the kocho powder decreased from 50 % (Sample 4) to 20 % (Sample 1), the thickness increased. The increase in thickness may be attributed to increased air pockets and crispness.

Table 4.10: Physical attributes of biscuits made from wheat flour supplemented with kocho powder

Sample code	Physical analysis	
	Weight(g)	**Thickness(cm)**
B121	10.5±0.39[c]	0.716±0.057[a]
B232	13.57±0.05[a]	0.7±0.600[a]
B343	10.89±0.10[c]	0.633±0.066[b]
B454	10.35±0.28[c]	0.466±0.088[c]
B565	11.97 ± 0.03[b]	0.75±0.048[a]

[a-c] Means with the same column within the same letters are not significantly different ($P \geq 0.05$)

4. 12 Sensory attributes of biscuits

Sensory analysis plays a key role inmodification, improvement, development and acceptance of new food products Kumar *et al.,*(2015).Sensory properties of products are the most vital attributes of food quality as they are mostapparent to consumers and perceived by the senses such as sight, smell, taste, touch and hearing.Therefore, Sensory analysis plays a major role in defining food quality.

The average of sensory values for the attributes like color, taste, texture, appearance, flavor and the overall acceptability of the biscuits are shown in Table 4.11. The ANOVA and the significance for each attribute is given as Appendix 8.

Table 4.11: Sensory attributes of Biscuits made from wheat flour supplemented with kocho powder

Sample code	Taste	Texture	Color	Appearance	Flavor	Overall acceptability
B121	6.0500±0.0424^{b}	5.9850±0.0212^{b}	6.1100±0.014^{b}	6.1750±0.0212^{b}	5.8850±0.0070^{b}	6.1300±0.0141^{b}
B232	5.9800±0.0282^{c}	5.8950±0.0212^{b}	6.1100±0.014^{b}	6.0900±0.0141^{c}	5.6900±0.0141^{b}	5.8850±00700^{c}
B343	5.8500±0.0141^{c}	5.7000±0.0282^{c}	5.9250±0.007^{c}	5.9900±0.0141^{c}	5.4600±0.0282^{c}	5.8850±0.0070^{c}
B454	5.5100±0.0141^{d}	5.5800±0.0282^{d}	5.5450±0.035^{d}	5.5800±0.0282^{d}	5.2200±0.02 82^{d}	5.6500±0.0141^{d}
B565	6.3950±0.0070^{a}	6.3350±0.0212^{a}	6.3000±0.028^{a}	6.2450±0.0070^{a}	6.1350±0.0212^{a}	6.2850±0.0070^{a}

$^{a-d}$ Means with the same column within the same letters are not significantly different ($P \geq 0.05$)

From the result, texture, taste. Colour, flavor,appearance and overall acceptability did not show any significant difference ($P \geq 0.05$) among different samples. However, maximum score in taste, texture, color, appearance, flavor and overall acceptability was shown by Sample 1, which has minimum amount of kocho powder i.e. 20 %. This indicates that kocho powder addition changes the baking quality of the biscuits. Hence to make kocho powder added biscuits , minimum use of kocho powder is recommended. As kocho powder is nutritionally significant, kocho powder added biscuits will boost nutrition.

4.13 Sensory attributes of cookies

The average of sensory values for the attributes like color, taste, texture, appearance, flavor and the overall acceptability of the cookies are shown in Table 4.12.

According to the result obtained from the sensory analysis, the values of the taste, texture, colour, appearance, flavor and overall acceptability of the cookies ranged from 6.6 to 5.9, 6.7 to 6.0, 6.3 to 6.8, 6.81 to 6.02, 6.6 to 5.65 and 6.72 to 6.07 respectivily. The control (100%wheat cookies) was rated significantly ($P \leq 0.05$) higher than the rest of the cookies for the attributes of texture, colour, appearance, flavour and overall acceptability.

Table 4.12: Sensory attributes of cookies made from wheat flour supplemented with kocho powder

Sample code	Taste	Texture	Color	Appearance	Flavor	Overall acceptability
C121	6.60 ± 0.04^{b}	6.55 ± 0.02^{b}	6.7 ± 0.14^{b}	6.75 ± 0.02^{b}	6.51 ± 0.07^{b}	6.63 ± 0.8^{b}
C232	5.90 ± 0.02^{d}	6.40 ± 0.12^{c}	6.6 ± 0.17^{c}	6.66 ± 0.01^{c}	5.80 ± 0.14^{c}	6.27 ± 0.4^{c}
C343	6.15 ± 0.01^{c}	6.01 ± 0.02^{d}	6.3 ± 0.00^{d}	6.22 ± 0.11^{c}	5.75 ± 0.28^{c}	6.19 ± 0.8^{c}
C454	6.11 ± 0.01^{c}	6.50 ± 0.02^{b}	6.7 ± 0.03^{b}	6.02 ± 0.02^{d}	5.65 ± 0.02^{d}	6.07 ± 0.3^{d}
C565	6.63 ± 0.00^{a}	6.73 ± 0.02^{a}	6.8 ± 0.02^{a}	6.81 ± 0.18^{a}	6.60 ± 0.21^{a}	6.72 ± 0.6^{a}

$^{a\text{-}d}$ Means with the same column within the same letters are not significantly different ($P \geq 0.05$)

CHAPTER FIVE

5.CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Biscuit and cookies are popular food used as breakfast and other meals that are consumed among all age groups. This thesis work was performed to develop and quality evaluation of biscuits and cookies made from wheat flour supplemented with kocho powder. The wheat flour and kocho powder were used to develop biscuits (80:20, 70:30, 60:40, and 50:50% of substitution) and 100% wheat flour as a control.The data generated were statistically analyzed by ANOVA using SPSS. Proximate analysis were carried out on the flour, biscuits and cookies samples.And also water and oil absorption capacities were carried out on the flour and texture and color analysis were carrried out on the biscuits samples.

The results indicated that the control flour showed higher level of moisture content, protein content, fat content, energy value and lower level of ash content, carbohydrate content, fiber content, water activity content while composite flours showed higher level of ash content, carbohydrate content, fiber content water activity content and lower level of moisture content, , protein content, fat content and energy value. Physical (weight, thickness) and sensory (taste, colour, texture, appearance, flavor, overall acceptability) attributes of biscuits made from kocho powder and wheat flour were analyzed. The sensory acceptability was evaluated by a seven point's hedonic scale. As the kocho powder addition decreased from 50 % to 20 %, the thickness, and the sensory attributes (taste, flavor, appreence,color,texture preference and overall acceptability) of the biscuits got increased.

It was concluded that biscuit and cookies produced from the composite flour of wheat supplemented with kocho powder are both nutritious and acceptable sensory quality. Therefore, the results of this study will enhance the utilization of kocho powder in production of biscuit and cookies.

5.2 Recommendations

This study shows that Kocho in the form of biscuit and cookies supplemented with wheat flour is a good source of nutritional and acceptale sensory quality.The locally available and less utilized Enset plant for Kocho can also be processed to biscuit and cookies at an industrial level. The addition of kocho powder in different ratio did not make any significant difference among samples with respect to sensory attributes. This means that we can add kocho powder at any of the four levels tested to make biscuit having good acceptability. The maximum score in sensory attributes were for minimum kocho powder addition i.e. 20 %. Since kocho powder has good nutritive value but higher cost, it is recommended to incorporate kocho powder at minimum level of 20 % to 80% wheat flour while making biscuit and cookies added with kocho powder.

Generally, Based on this study,the following recommendations were made:

- ✓ The utilization of kocho powder as a medicinal purpose in terms of high mineral content in order to decrease heart related disorders.
- ✓ The shelf life and microstructure of the biscuit and cookies should be studied for the future.
- ✓ Further research work should be focused on the microbial, mineral, color and textural analysis of cookies made from wheat flour supplemented with kocho powder.

References

AACC(American Association of cereal chemist),(2000).American association of cereal chemist, inc., 10th ed., MN, USA.

Abebe, Y., Stoecker, B. J., Hinds, M. J. and Gates, G. E., (2006). Nutritive value and sensory acceptability of corn- and kocho- based foods supplemented with legumes for infant feeding in Southern Ethiopia. African journal of food, agriculture, nutrition and development, 6(1): http://dx.doi.org/10.4314/ajfand.v6i1.19172

Abdoulaye.,K. Brou and C.jie,(2011). Phytic acid in cereal grains: structure, healthy or harmful ways to reduce phytic acid in cereal grains and there effects on nutritional quality. American journal of plant nutrition and fertilization technology 1(1):1-22

Abiyot Negu, (2017).Development and Quality Evaluation of Wheat Based Cookies Supplemented with Fenugreek and Oat Flour

Adams, M.,(1990).Tropical Aspects of Fermented Foods. Trends in Food Science And Technology 1:141-144.

Adeleke, R.O., and Odedeji, J.O. (2010). Functional Properties of Wheat and Sweet Potato Flour Blends.Pakistan Journal of Nutrition 9: 535-538.

Admassu Tsegaye, (2002). On indigenous production, genetic diversity and crop ecology of enset (Ensete ventricosum (Welw.) Cheesman). Doctoral Thesis, Wageningen University Netherlands. pp 198.

Admasu Tsegaye and P.C. Struik (2001). Enset (*Ensete ventricosum*), Kocho yield under different crop establishment methods as compared to yields of other carbohydrate food crops. Netherland journal of agricultural science 49, 81-94.

Adeyeye, E.I., and Aye, P.A. (1998). The effect of sample preparation on proximate composition and thefunctional properties of African yam bean flours. Note 1 La Rivista Italiana Della SostanzeGrasse, LXXVMaggio. pp. 253-261.

AOAC (1990). Official Methods of Analysis 15th Edition. Association of Official Analytical Chemist Washington D.C. p1204-1207.

AOAC (2000). Food composition; additives; natural contaminants. In: Official Methods of Analysis of foods AOAC International, Vol. II, 17th (edited by H. William). Pp. 12–42. Washington, DC: Association of Official Analytical Chemists (AOAC). Official method 942.15, 982.14.

Allen, M. J., Edberg, S. C., and Reasoner, D. J. (2004). Heterotrophic plate count bacteria what is their significance in drinking water? *International journal of food microbiology*, *92*(3), 265-274.

Ashenafi Z, (2002): Enset products(kocho and bulla) are foods consumed. Journal of the science

Atlabachew, M. (2007). Studies on Commercially Available Enset (Ensete ventricosum(Welw.), Cheesman) Food Products (Kocho and Bulla) for Major, Minor and TraceElements. Addis Abeba University, Ethiopia.

Bergh, K., Chew, A., Gugerty, M. K., & Anderson, C. L. (2012). Wheat value chain: Ethiopia (Evince School Policy Analysis and Research, EPAR Brief number 104). Univerity of Washington.

Bolandi, F. Shahidi, N. Sedaghat, R. Farhoush and H. Mousavi-Nik (2008). Shelf-life Determination ofSaffron Stigma Water Activity and Temperature Studies. World Applied Sciences Journal 5 (2):132-136, Damghan, Iran.of food and Agriculture, 1:1-22.

Burrier, Anna Lucas, Paula May, Sandra Bastin, Rosie Allen (2003). Bread and biscuit project, GallatinCounty University of Kentucky College of Agriculture, Lexington, and Kentucky StateUniversity, Frankfort.

Brandt, Anita Spring, Clifton Hiebsch, J. Terrence mccabe, Endale Tabogie, Mulugeta Diro, Gizachew Wolde-Michael, Gebre Yntiso, Masayoshi Shigeta, and Shiferaw Tesfaye (1997). The Tree against Hunger Enset-Based Agricultural Systems in Ethiopia, American Association for the Advancement of Science with Awassa Agricultural Research Center.

Butt, and Batool, R. (2010) "Nutritional and Functional Properties of Some Promising Legumes Protein Isolates", Pak, J. Nutri. 9(4): 373-379.

Central Statistics Agency,(1995–2017). Central Statistics Agency-Agricultural Sample Survey (Belg and Meher seasons). Retrieved from http://www.csa.gov.et/survey-repor t/category/58-mehermain-season-agricultural-sample-survey

CSA. (2013). Agricultural sample survey report on area and production of major crops (Private peasant holdings, Meher season 2012/2013 (2005 E.C.)). The FDRE statistical bulletin, Volume 1.

CSA. (2016). Agricultural sample survey report on area and production of major crops (Private peasant holdings, Belg season 2015/2016 (2008 E.C.)). The FDRE statistical bulletin, Volume V.

CSA. (2017). Agricultural sample survey report on area and production of major crops (Private peasant holdings, Meher season 2016/2017 (2009 E.C.)). The FDRE statistical bulletin, Volume I.

CSA. (2018). Agricultural sample survey report on area and production of major crops (Private peasant holdings, Meher season 2017/2018 (2010 E.C.)). The FDRE statistical bulletin, Volume I.

Connick JR, D. J. Daigle, C. D. Boyette, K. S. Williams, B. T. Vinyard and P. C. Quimby JR (1996).Water Activity and Other Factors that Affect the Viability of Colletotrichum truncatum Conidia in Wheat Flour Kaolin Granules (Pesta). Journal of Biocontrol Science and Technology 6, 277-284.

Curtis BC, Rajaram S, Macpherson HG. Bread wheat: improvement and production. Rome, Italy: Food and Agriculture Organisation of the United Nations; (2002). pp. 221–222. [Google Scholar]

Daba, T. and Shigeta, M. (2016). Enset (*Ensete ventricosum*) production in Ethiopia: its nutritional and socio cultural values. Agricultural food science research, 3(2): 66-74.

Demeke, M., & Marcantonio, D. (2013). Analysis of incentives and disincentives for wheat in Ethiopia. Technical notes series. MAFAP, FAO.

Desrosier, N.W. (1977). Elements of Food Technology. Westport, CT: AVI.

Eneche, E.H. (1999). Biscuit-making potential of millet/pigeon pea flour blends. Plant Foods Hum. Nutr.,54: 21-27

Fellows, J.P. (2000). Food process technology principle and practices. Second edition Woodhead
Publishing Limited and CRC Press LLC

Forsido, S.F., Rupasinghe, V. and Astatkie, T. (2013) Antioxidant Capacity, Total Phenolic and Nutritional Content in Selected Ethiopian Staple Food Ingredients. *Int J Food Sci Nutr,* 64(8), pp. 915–920, Ethiopia.

Geneva, W. H. O. (2000). WHO/PAHO. Guiding principles for complementary feeding of the breastfed child. *World Health Organization, UNICEF*, *0*(8), 0–22.

International Starch Institute. (2008). TM 33-1www - ISI Technical Memorandum on Production of starch. Retrieved 11 August 2008.

Kalekristos Yohannes.,(2010). Influence of Baking Time and Temperature on the Quality of KochoBiscuit Enriched with Faba Bean and Wheat.

Kumar, K.A., Sharma, G.K., Khan, M.A., and Semwal, A.D. (2015). Optimization of Multigrain Premixfor High Protein and Dietary Fibre Biscuits Using Response

Surface Methodology (RSM).Food Nutri. Sci. 6: 747-756. h p:// dx.doi.org/10.4236/fns.2015.69077

Kuntz ID (1971). Hydration of macromolecules III. Hydration of polypeptides J Am Chem Socie 93:514–515

Kure, O.A., Bahago, E.J., and Daniel, E.A., (1998). Studies on the proximate composition and effect of flour particle size on acceptability of biscuit produced from blends of soyabeans and plantain flours. Namida Tech-Scope J., 3: 17-21.

Lee, Laura,(2001). The Pocket Encyclopedia of Aggravation. New York: Black Dog & Leventhal.

Magda, R.A., Awad, A.M., and Selim, K.A. (2008). 4-Evaluation of mandarin and navel orange peels as natural sources of antioxidant in biscuit. Alex J. Food Sci. Technol., 82: 75-82.

Manley, D. (2000). Technology of Biscuits, Crackers, and Cookies, Woodhead Publishing Limited, Third edition, England.

Mulualem, T., and kifle, A. (2014) Evaluation of Farmers' Indigenous Knowledge andSelection of Enset (Ensete ventricosum Welw. Cheesman) Cultivars in Ojojea WaterShade, Kembata- Tembaro Zone, South Ethiopia. *Journal of Agricultural Sciences*,2(1), pp. 007-012

Nigatu, A., and Gashe, B.A. (1998) Effect of Heat Treatment on the Antimicrobial Propertiesof Teff Dough, Enjera, Kocho and Aradisame and the Fate of Selected Pathogens.*World Journal of Microbiology & Biotechnology*, 14, pp. 63-69

Okaka JC. Handling, storage and processing food plant. Nigeria: OCJ Academic Publishers Enugu; (2005). p. 266. [Google Scholar]

Omah, E.C., and Okafor, G.I. (2015). Production and Quality Evaluation of Cookies from Blends of MilletPigeon Pea Composite Flour and Cassava Cortex. Journal of Food Resource Science 4 (2): 23-32,2015 ISSN 2224-3550 / DOI: 10.3923/jfrs.2015.23.32

Osborne, D. R., and Voogt, P. (1978). The analysis of nutrients in foods. Acadamic Press, London, U.K., 240-PP.

Ray, B., & Bhunia, A. (2007). *Fundamental food microbiology*. CRC press.

Robert Shank and Chernet Ertiro (1996). A Linear Model for Predicting Enset Plant Yield and Assessment of Kocho Production in Ethiopia United Nations development programmed Emergencies Unit for Ethiopia Addis Ababa, Ethiopia.

Shahzad H., Faqir M. Anjum, Masood S., Butt, Muhammad I., Ali A. (2006). Physical and Sensory Attributes of Flaxseed Flour Supplemented Cookies. Institute of Food Science and Technology, University of Agriculture, Faisalabad, Pakistan 30, 87-92.

Shovic, A. (1999) Food Choices for Healthful Living based on food group lists, ADAP(Agricultural Development in the American Pacific) Project, University of Hawaii.

Soluski, FW., Garratt, MO., and Slinkard, AE. (1976). Functional properties of ten legume flours. Int J Food SciTechnol 9:66–69

Sumnu, S., And Sahin, S. (2008). Food Engineering Aspects of Baking Sweet Goods, CRC Press Tay-lor & Francis Group

Tsegaye A. and P.C struik,(2002). Analysis of Enset (Enset ventrciosum) Indigenous production method farm-based bio diversity in major Enset-growing regions of southern Ethiopia .experimental agriculture,38:291-315.

Wang, J.C .and Kinsella, J.E. (1976). Functional properties of novel proteins: Alfalfa leaf protein.J.Food Sci.,41:1183-1183

Wardlaw, G. M., and Kessel, M. (2005). Perspectives in nutrition (13th Edition) New York: McGraw Hill Higher Education publisher.

Yewelsew Abebe, Barbara J. Stoecker, Margaret J. Hinds, Gail E. Gates (2006). Nutritive value and sensory acceptability of corn- and Kocho-based foods supplemented with legumes for infant feeding in southern Ethiopia. African journal of food, agriculture, nutrition and development volume 6 No. 1.

Zippel K, (2002). Enset cultivation improves soil by permanent soil tillage due to its high demands to soil fertility and soil structure, 78:225-231.

Appendices

Appendix 1: Some photos of labratory equipments used

Mixer **Oven**

Texture analyser **Water activity instrument**

Appendix 2: Farinograph result for flour blend and control sample

Evaluat-ion	Moisture of flour(%)	Consiste-ncy (FU)	Water absorptio-n(%)	Develop-ment time(min)	Stability (min)	Degree of softening (FU)	Farinog r-aph Quality Number
W_FK_P1	15.5	290	50.8	2.5	2.3	73	41
W_FK_P2	15.9	408	53.7	1.4	1.4	94	23
W_FK_P3	16.8	345	52.1	1.5	1.7	89	27
W_FK_P4	16.9	333	51.8	2.5	3.2	74	45
W_F	14	721	50.5	3.2	3.4	152	50

Appendix 3: Biscuit or cookies Sensory Evaluation Form

Assessor's Code:________________Age: ______Sex: __________ Date:______________________

Instruction

You are presented with five samples; each labeled with a three digit code. Please assess each sample in the order provided, from left to right and record your scores for each attribute in the table below. Cleanse your palates with water after each sample. You are not permitted to re-taste the samples.

Sample code	Taste	Texture	Color	Appearance	Flavor	Overall acceptability
	7= Like extremely **3**= Dislike slightly **6**= Like moderately **2**= Dislike moderately **5**= Like slightly **1**= Dislike extremely **4**=Neither like nor dislike					
B121						
B232						
B343						
B454						
B565						

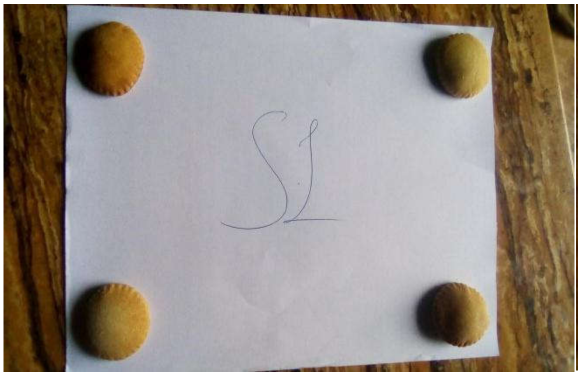
Please comment on why you preferred one of the samples.

____

____

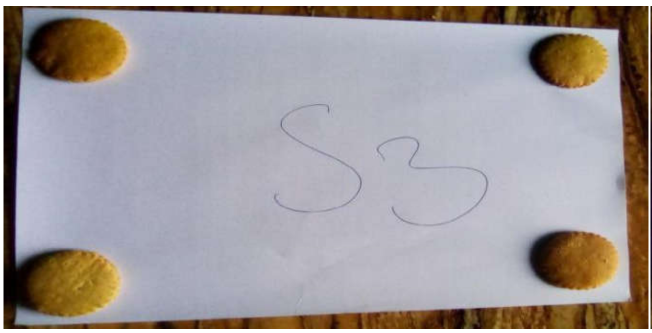
____Thank you for your participation.

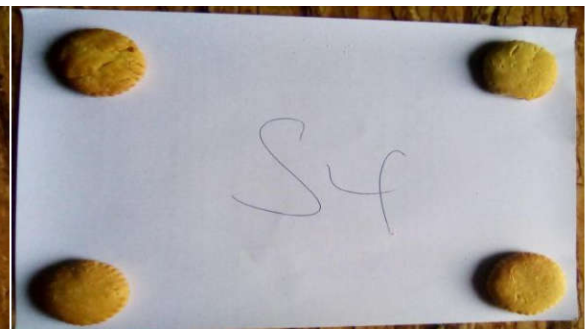
Appenix 4: Biscuits made from wheat flour supplemented with kocho powder



80% WF & 20% KP

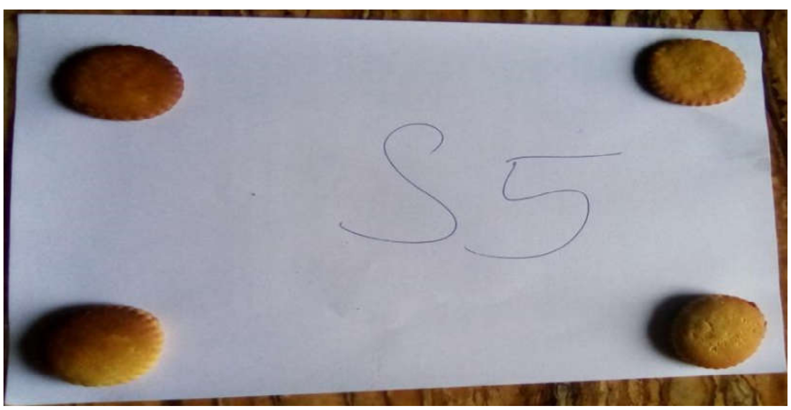
70% WF & 30% KP





60% WF & 40% KP

50% WF & 50% KP



100% WF

Appendix 5: ANOVA table for flour proximate analysis

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Moisture	80:20	2	14.0000	.00000	.00000	14.0000	14.0000	14.00	14.00
	70:30	2	13.9000	.14142	.10000	12.6294	15.1706	13.80	14.00
	60:40	2	14.0000	.00000	.00000	14.0000	14.0000	14.00	14.00
	50:50	2	14.0000	.00000	.00000	14.0000	14.0000	14.00	14.00
	Control	2	14.8000	.00000	.00000	14.8000	14.8000	14.80	14.80
	Total	10	14.1400	.35340	.11175	13.8872	14.3928	13.80	14.80
Ash	80:20	2	.6000	.07071	.05000	.1147	1.3853	.70	.80
	70:30	2	.7000	.00000	.00000	.4000	.4000	.40	.40
	60:40	2	.7500	.28284	.20000	-1.9412	3.1412	.40	.80
	50:50	2	.8000	.14142	.10000	-.5706	1.9706	.60	.80
	Control	2	.4500	.00000	.00000	.8000	.8000	.80	.80
	Total	10	.6500	.18409	.05821	.5183	.7817	.40	.80
Protein	80:20	2	7.7875	.12374	.08750	6.6757	8.8993	7.70	7.88
	70:30	2	6.1250	.00000	.00000	6.1250	6.1250	6.13	6.13
	60:40	2	5.9500	.00000	.00000	5.9500	5.9500	5.95	5.95
	50:50	2	5.1625	.12374	.08750	4.0507	6.2743	5.08	5.25
	Control	2	10.2375	.12374	.08750	9.1257	11.3493	10.15	10.33
	Total	10	7.0525	1.90644	.60287	5.6887	8.4163	5.08	10.33
Fat	80:20	2	1.0750	.10607	.07500	.1220	2.0280	1.00	1.15
	70:30	2	.9100	.12728	.09000	-.2336	2.0536	.82	1.00
	60:40	2	.5000	.00000	.00000	.5000	.5000	.50	.50
	50:50	2	.5000	.00000	.00000	.5000	.5000	.50	.50
	Control	2	1.5000	.00000	.00000	1.5000	1.5000	1.50	1.50
	Total	10	.8970	.40122	.12688	.6100	1.1840	.50	1.50

Fiber	80:20	2	.5000	.17678	.12500	.5000	.5000	.50	.50
	70:30	2	1.0000	.00000	.00000	.5000	.5000	.50	.50
	60:40	2	2.0000	.00000	.00000	2.0000	2.0000	2.00	2.00
	50:50	2	2.1250	.00000	.00000	.5367	3.7133	2.00	2.25
	Control	2	.5000	.00000	.00000	1.0000	1.0000	1.00	1.00
	Total	10	1.2250	.74954	.23702	.6888	1.7612	.50	2.25
Carbohydrate	80:20	2	74.2625	.47730	.33750	69.9742	78.5508	73.93	74.60
	70:30	2	76.6650	.26870	.19000	74.2508	79.0792	76.48	76.86
	60:40	2	78.4500	.28284	.20000	75.9088	80.9912	78.25	78.65
	50:50	2	79.1375	.01768	.01250	78.9787	79.2963	79.13	79.15
	Control	2	71.6625	.12374	.08750	70.5507	72.7743	71.58	71.75
	Total	10	76.0355	2.91787	.92271	73.9482	78.1228	71.58	79.15
Energy	80:20	2	337.8750	.45962	.32500	333.7455	342.0045	337.55	338.20
	70:30	2	339.3500	.07071	.05000	338.7147	339.9853	339.30	339.40
	60:40	2	342.1000	1.13137	.80000	331.9350	352.2650	341.30	342.90
	50:50	2	341.7000	.56569	.40000	336.6175	346.7825	341.30	342.10
	Control	2	341.1000	.00000	.00000	341.1000	341.1000	341.10	341.10
	Total	10	340.4250	1.72904	.54677	339.1881	341.6619	337.55	342.90
wateractivity	80:20	2	.5320	.00000	.00000	.5320	.5320	.53	.53
	70:30	2	.5340	.00141	.00100	.5213	.5467	.53	.54
	60:40	2	.5350	.00000	.00000	.5350	.5350	.54	.54
	50:50	2	.5375	.00071	.00050	.5311	.5439	.54	.54
	Control	2	.5280	.00000	.00000	.5280	.5280	.53	.53
	Total	10	.5333	.00340	.00108	.5309	.5357	.53	.54

Appendix 6: ANOVA table for functional properties

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
WAC	80:20	2	7.8600	.02828	.02000	7.6059	8.1141	7.84	7.88
	70:30	2	8.3450	.13435	.09500	7.1379	9.5521	8.25	8.44
	60:40	2	8.1500	.12728	.09000	7.0064	9.2936	8.06	8.24
	50:50	2	8.5450	.04950	.03500	8.1003	8.9897	8.51	8.58
	100	2	8.1000	.07071	.05000	7.4647	8.7353	8.05	8.15
	Total	10	8.2000	.25360	.08019	8.0186	8.3814	7.84	8.58
OAC	80:20	2	9.4100	.00000	.00000	9.4100	9.4100	9.41	9.41
	70:30	2	9.0150	.09192	.06500	8.1891	9.8409	8.95	9.08
	60:40	2	9.3450	.10607	.07500	8.3920	10.2980	9.27	9.42
	50:50	2	9.2850	.10607	.07500	8.3320	10.2380	9.21	9.36
	100	2	8.8700	.01414	.01000	8.7429	8.9971	8.86	8.88
	Total	10	9.1850	.22604	.07148	9.0233	9.3467	8.86	9.42

Appendix 7: ANOVA table for biscuit proximate

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Moisture	B121	2	11.1500	.21213	.15000	10.0441	12.8559	11.80	12.10
	B232	2	12.1900	.14142	.10000	11.6294	13.1706	12.80	13.00
	B343	2	12.3800	.00000	.00000	11.8000	12.8000	12.80	13.80
	B454	2	14.9100	.01414	.01000	14.6329	14.8871	14.75	14.77
	B565	2	9.9800	.07071	.05000	8.3147	10.5853	9.90	10.00
	Total	10	12.8720	.12090	.03823	12.7855	13.9585	13.75	13.10
Ash	B121	2	3.5000	.00000	.00000	3.5000	3.5000	3.50	3.50
	B232	2	3.6750	.10607	.07500	2.7220	4.6280	3.60	3.75
	B343	2	3.9000	.14142	.10000	2.6294	5.1706	3.80	4.00
	B454	2	4.0000	.00000	.00000	4.0000	4.0000	4.00	4.00
	B565	2	3.1250	.17678	.12500	1.5367	4.7133	3.00	3.25
	Total	10	3.6400	.33813	.10693	3.3981	3.8819	3.00	4.00
Protein	B121	2	9.3500	.14142	.10000	8.0794	10.6206	9.25	9.45
	B232	2	9.1750	.10607	.07500	8.2220	10.1280	9.10	9.25
	B343	2	8.1800	.09899	.07000	7.2906	9.0694	8.11	8.25
	B454	2	7.6000	.01414	.01000	7.4729	7.7271	7.59	7.61
	B565	2	11.1250	.17678	.12500	9.5367	12.7133	11.00	11.25
	Total	10	9.0860	1.27370	.40278	8.1748	9.9972	7.59	11.25

Fat	B121	2	7.6250	.17678	.12500	6.0367	9.2133	7.50	7.75
	B232	2	6.9100	.12728	.09000	5.7664	8.0536	6.82	7.00
	B343	2	6.9000	.14142	.10000	5.6294	8.1706	6.80	7.00
	B454	2	6.8000	.00000	.00000	6.8000	6.8000	6.80	6.80
	B565	2	10.2875	.05303	.03750	9.8110	10.7640	10.25	10.33
	Total	10	7.7045	1.39920	.44247	6.7036	8.7054	6.80	10.33
Fiber	B121	2	3.8000	.00000	.00000	3.8000	3.8000	3.80	3.80
	B232	2	3.8750	.17678	.12500	2.2867	5.4633	3.75	4.00
	B343	2	3.9000	.14142	.10000	2.6294	5.1706	3.80	4.00
	B454	2	3.9000	.00000	.00000	3.9000	3.9000	3.90	3.90
	B565	2	2.6250	.17678	.12500	1.0367	4.2133	2.50	2.75
	Total	10	3.6200	.53448	.16902	3.2377	4.0023	2.50	4.00
Carbohydrate	B121	2	60.7750	.53033	.37500	56.0102	65.5398	60.40	61.15
	B232	2	61.4150	.47376	.33500	57.1584	65.6716	61.08	61.75
	B343	2	62.3200	.52326	.37000	57.6187	67.0213	61.95	62.69
	B454	2	62.9400	.00000	.00000	62.9400	62.9400	62.94	62.94
	B565	2	57.8875	.65407	.46250	52.0109	63.7641	57.43	58.35
	Total	10	61.0675	1.88546	.59624	59.7187	62.4163	57.43	62.94
Energy	B121	2	349.1250	.03536	.02500	348.8073	349.4427	349.10	349.15
	B232	2	343.6500	2.75772	1.95000	318.8729	368.4271	341.70	345.60
	B343	2	344.1000	.42426	.30000	340.2881	347.9119	343.80	344.40
	B454	2	343.3600	.05657	.04000	342.8518	343.8682	343.32	343.40
	B565	2	368.6375	1.43189	1.01250	355.7725	381.5025	367.63	369.65
	Total	10	349.7745	10.24163	3.23869	342.4481	357.1009	341.70	369.65

Appendix 8: ANOVA table for sensory analysis

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Taste	S1	2	6.0500	.04243	.03000	5.6688	6.4312	6.02	6.08
	S2	2	5.9800	.02828	.02000	5.7259	6.2341	5.96	6.00
	S3	2	5.8500	.01414	.01000	5.7229	5.9771	5.84	5.86
	S4	2	5.5100	.01414	.01000	5.3829	5.6371	5.50	5.52
	S5	2	6.3950	.00707	.00500	6.3315	6.4585	6.39	6.40
	Total	10	5.9570	.30324	.09589	5.7401	6.1739	5.50	6.40
Texture	S1	2	5.9850	.02121	.01500	5.7944	6.1756	5.97	6.00
	S2	2	5.8950	.02121	.01500	5.7044	6.0856	5.88	5.91
	S3	2	5.7000	.02828	.02000	5.4459	5.9541	5.68	5.72
	S4	2	5.5800	.02828	.02000	5.3259	5.8341	5.56	5.60
	S5	2	6.3350	.02121	.01500	6.1444	6.5256	6.32	6.35
	Total	10	5.8990	.27501	.08697	5.7023	6.0957	5.56	6.35
Colour	S1	2	6.1100	.01414	.01000	5.9829	6.2371	6.10	6.12
	S2	2	6.1100	.01414	.01000	5.9829	6.2371	6.10	6.12
	S3	2	5.9250	.00707	.00500	5.8615	5.9885	5.92	5.93
	S4	2	5.5450	.03536	.02500	5.2273	5.8627	5.52	5.57
	S5	2	6.3000	.02828	.02000	6.0459	6.5541	6.28	6.32
	Total	10	5.9980	.27001	.08539	5.8048	6.1912	5.52	6.32

Apperance	S1	2	6.1750	.02121	.01500	5.9844	6.3656	6.16	6.19
	S2	2	6.0900	.01414	.01000	5.9629	6.2171	6.08	6.10
	S3	2	5.9900	.01414	.01000	5.8629	6.1171	5.98	6.00
	S4	2	5.5800	.02828	.02000	5.3259	5.8341	5.56	5.60
	S5	2	6.2450	.00707	.00500	6.1815	6.3085	6.24	6.25
	Total	10	6.0160	.24713	.07815	5.8392	6.1928	5.56	6.25
Flavor	S1	2	5.8850	.00707	.00500	5.8215	5.9485	5.88	5.89
	S2	2	5.6900	.01414	.01000	5.5629	5.8171	5.68	5.70
	S3	2	5.4600	.02828	.02000	5.2059	5.7141	5.44	5.48
	S4	2	5.2200	.02828	.02000	4.9659	5.4741	5.20	5.24
	S5	2	6.1350	.02121	.01500	5.9444	6.3256	6.12	6.15
	Total	10	5.6780	.33674	.10649	5.4371	5.9189	5.20	6.15
Overallaccept	S1	2	6.1300	.01414	.01000	6.0029	6.2571	6.12	6.14
	S2	2	5.8850	.00707	.00500	5.8215	5.9485	5.88	5.89
	S3	2	5.8850	.00707	.00500	5.8215	5.9485	5.88	5.89
	S4	2	5.6500	.01414	.01000	5.5229	5.7771	5.64	5.66
	S5	2	6.2850	.00707	.00500	6.2215	6.3485	6.28	6.29
	Total	10	5.9670	.23185	.07332	5.8011	6.1329	5.64	6.29

Appendix 9: ANOVA table for textural analysis

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Time	B121	2	14.1500	.09899	.07000	13.2606	15.0394	14.08	14.22
	B232	2	10.3500	.07071	.05000	9.7147	10.9853	10.30	10.40
	B343	2	9.7195	.07000	.04950	9.0905	10.3485	9.67	9.77
	B454	2	9.0710	.06505	.04600	8.4865	9.6555	9.03	9.12
	B565	2	9.5090	.07071	.05000	8.8737	10.1443	9.46	9.56
	Total	10	10.5599	1.94221	.61418	9.1705	11.9493	9.03	14.22
Load	B121	2	.0365	.00031	.00022	.0337	.0393	.04	.04
	B232	2	.0362	.00018	.00013	.0345	.0378	.04	.04
	B343	2	.0312	.00039	.00028	.0277	.0347	.03	.03
	B454	2	.0321	.00012	.00008	.0311	.0332	.03	.03
	B565	2	.0602	.00104	.00074	.0508	.0695	.06	.06
	Total	10	.0392	.01126	.00356	.0312	.0473	.03	.06
Diameter	B121	2	2.3948	.01358	.00960	2.2728	2.5168	2.39	2.40
	B232	2	1.6880	.00919	.00650	1.6054	1.7706	1.68	1.69
	B343	2	1.6443	.00841	.00595	1.5686	1.7199	1.64	1.65
	B454	2	1.4660	.00806	.00570	1.3936	1.5384	1.46	1.47
	B565	2	1.6095	.00686	.00485	1.5478	1.6711	1.60	1.61
	Total	10	1.7605	.34347	.10862	1.5148	2.0062	1.46	2.40
Stressatmaxload	B121	2	.0125	.00045	.00032	.0085	.0166	.01	.01
	B232	2	.0476	.00007	.00005	.0470	.0482	.05	.05
	B343	2	.0330	.00042	.00029	.0292	.0367	.03	.03
	B454	2	.0364	.00013	.00009	.0352	.0376	.04	.04
	B565	2	.0790	.00137	.00097	.0667	.0913	.08	.08
	Total	10	.0417	.02301	.00728	.0252	.0582	.01	.08