Sudan University of Science and Technology

College of Graduate Studies

كلية الدراسات العليا

Quality of Bread Fortified with Different Levels of Groundnut and Sesame Flour

جودة الخبز المدعم بمستويات مختلفة من دقيق الفول السوداني والسمسم

Dissertation Submitted to Sudan University of Science and Technology in Partial Fulfillment for the Requirements of the Degree of Master of Science in Food Science and Technology

By

Aisha Kamal ALameen Mohamed

B.Sc. (Honors) in Food Science and Technology, Sudan University of Science and Technology (2014)

Supervisor

Associated Professor Dr. Barka Mohammed Kabier Barka

Department of Food Science and Technology,

College of Agriculture Studies, SUST

February, 2018

الآية

بسم الله الرحمن الرحيم

قال تعالى:

(والأرض وضعها للأنام * فيها فاكهة والنخل ذات الأكمام *والحب ذو العصف والريحان * فبأي آلاء ربكما تكذبان)

صدق الله العظيم

سورة الرحمن الآيات (10-13)

Dedication

To dear my mother and dear my Father

To my sisters and brothers

To all my teachers and colleagues

And finally to all my friends

and all Relative for their kind helps and support.

Aisha.

Acknowledgment

First, almost grateful thanks to Allah for giving me health, patience, and assistance to complete this work.

Thanks and all thanks to my supervisor, **Dr. Barka Mohamed Kabeir Barka** for supervising and nice cooperation and help.

My thanks also go to the technical staff at Department of Food Science and Technology, College of Agricultural Studies, Sudan University of Science and Technology for their kind help

Finally, I am deeply thanks to my mother and to my friends Hanadi and Manal.

List of A privation

AACC The American Association of Cereal Chemists Approved Methods of the American Association.

AOAC Association of Official Analytical Chemists.

DM Dry Mater.

AAS Atomic Absorption Spectrophotometer.

FAO Food and Agriculture Organization.

WHO World Health Organization.

UNU United Nation Units.

NCFM North Cairo Flour Mills Company.

CC Cubic Centemiter.

MPN The Most Probable Number**.**

EMB Eosin Methylene Blue Agar.

CFU Colony Forming Units.

EDTA Ethylene Diamine Tetra-Acetic Acid.

Table of Contents

List of Tables

Abstract

This study was conducted to determine the effect of the addition of 5 and 10 % levels of groundnut and sesame flour on nutritional quality and sensory properties of bread. Proximate analyses including moisture, fat, protein, ash and fiber contents were carried out for wheat flour, groundnut flour, sesame flour and bread. Microbiological safety, physical and energy for bread were also carried out. The results obtained showed significant difference ($P <0.05$) in moisture, ash protein, fat, and carbohydrate content between wheat flour, groundnut flour and sesame flour. The addition of groundnut and sesame lead to significant ($P<0.05$) increases in protein, fat and fiber of bread supplemented with groundnut or sesame flour compared to control bread. No significant ($P<0.05$) different in energy between different bread. There are significant ($P<0.05$) different in Fe, Mg, Zn, Ca, P and K between different type of bread. No pathogenic microorganisms such as coliform, *staphylococcus* and *salmonella* were not detected in any type of bread; therefore all bread are safe for human consumption. Referring to sensory characteristics including color, odor, taste, crumb texture, crumb grain and general acceptability the result did not revealed significant ($P<0.05$) different between different type of breads. Thus it is capable to produce nutritious safe breads using 10% groundnut flour or sesame flour having acceptable general characteristic as compared to the control bread without supplementation.

ملخص الأطروحة

تم إجراء هذه الدراسة لتحديد أثر إضافة مستويات 5 و 10% من دقيق الفول السوداني ودقيق السمسم على الجودة الغذائية والخصائص الحسيه للخبز. تم إجراء التحليل التقريبي (الرطوبة، الدهون، البروتين، الرماد والألياف) لدقيق القمح ودقيق الفول السوداني و دقيق السمسم والخبز. كما تم إجراء تحاليل السلامة الميكروبيولوجية والخصائص الفيزيائية والطاقة للخبز.النتائج التي تم الحصول عليها أظهرت فروقات معنوية ($P \leq 0.05$) في الرطوبة، الدهون، البروتين، الألياف والرماد بين دقيق القمح ودقيق الفول السوداني و دقيق السمسم. أدت إضافة الفول السوداني والسمسم لزيادة معنوية ($P < 0.05$) في نسبة البروتين، الدهون والألياف في الخبز المدعم بالفول السوداني أو السمسم مقارنه بالخبز غير المدعم. لا توجد فروقات معنوية ($P<0.05$) في الطاقة بين أنواع الخبز المختلفة. توجد اختلافات معنوية في الحديد، المغنسيوم، الزنك،الكالسيوم والبوتاسيوم بين أنواع الخبز المختلفة. لم تظهر النتائج وجود الميكروبات الممرضة مثل باكتيريا القولون، استافيلوكوكس والسالمونيلا لذلك هو امن للإستهلاك البشري. بالرجوع للخصائص الحسية شاملة اللون، النكهة، الطعم، الملمس والقبول العام للخبز لا يظهر أي فروق معنوية ($P<0.05$) بين الأنواع المختلفة للخبز. بناءا على ذلك يمكن إنتاج خبز مغذي وآمن مدعم باستخدام 10% فول سوداني او سمسم ذو خصائص عامة مقبولة لدي المستهلك مقارنة بخبز دقيق القمح غير المدعم.

CHAPTER ONE

INTRODUCTION

Cereals provide a very substantial proportion of the needs of the world's population for dietary energy, protein, and micronutrients. ‘cereal itself contains high level of healthful micronutrients and macronutrients, compared to foods consumed during non-cereal breakfasts; Grain-based foods, like those produced with wheat, provide complex carbohydrates, that are the best fuel for our bodies, are low in fat, high in fiber, and provide vitamins, especially the 4 key B vitamins, Thiamin, Riboflavin, Niacin, and Folic Acid, as well as iron.

Wheat is also claimed to reduce hair from graying, improves digestion, reduces high blood pressure as it enhances the capillaries, support the growth of *lactobacilli* and can remove heavy metals from the body. It is found to improve hematological toxicity related to chemotherapy in breast cancer patients, it reduces the frequency and requirement of blood transfusions in thalassemia major (Pathak and Shrivastav, 2015).

Bread is described as a fermented confectionary product produced mainly from wheat flour, water, yeast and salt by a series of operations including mixing, kneading, proofing, shaping and baking (Dewettinck *et al*., 2008). The consumption of bread and other baked foods such as biscuits, doughnuts and cakes produced from wheat flour, but the low protein content of wheat flour, which is the most vital ingredient used for their production has been major concern . In developing countries where the supply of animal protein is inadequate to meet the rapid population growth, considerable interests have been shown in supplementing wheat flour with high-protein, high- lysine material (especially legume and oilseed flours, protein concentrates, and isolates) to increase the protein content and improve the essential amino acid balance of flour-based baked products (Young, 2001). In Sudan, there is a wide varieties of oil crops in various parts of the country ranging from largely known and highly utilized ones like soya bean, palm kernel and groundnut, to underutilized ones like walnut, locust bean, African oil bean and sesame seed

Legumes are vital source of dietary protein for large sector of the world's population. The composition is predominant in countries where utilization of animal protein is limited owing to poverty, non availability, religious or cultural lifestyles (Boye *et al*., 2010).

Groundnuts or peanut is a legume which is widely grown as a food crop. It is an herbaceous plant of which there are different varieties such as Boro light, Boro Red, Mokwa, Campala, Guta and Ela .Peanut is an important source of edible oil for millions of people living in the tropics. Vegetable oil had made an important contribution to the diet in many countries, serving as a good source of protein, lipid and fatty acids for human nutrition including the repair of worn out tissue, new cells formation as well as a useful source of energy. Groundnut provides an inexpensive source of high quality dietary protein and oil. (Ayoola *et al*., 2012)

Sesame is commonly known as Sesamum or benniseed. It belongs from the Pedaliaceae family. Sesame is majorly cultivated in India, Sudan, China and Burma. These major countries. Sesame seeds are the affluent source of nutritious fat, protein, carbohydrates, dietary fibre, zinc, magnesium and many other minerals. Sesame oil is distinguished oil as it is highly defiant to oxidative rancidity even during prolonged exposure of air, light and water. This outstanding stability of the oil is attributed due to the presence of potential antioxidandants namely lignans,tocopherols and phytosterols (Prakash and Naik, 2014)

Supplementation of food is of current interest because of increasing nutritional awareness among consumers. Supplementation with legumes is one way to meet the protein needs particularly with the help of baked foods (Shukla *et al*., 2016).

The objectives of this study are:

1- To determine the chemical composition of wheat, groundnut, sesame and breads.

2- To evaluate the effect of groundnut and sesame supplementation on nutritional and microbiological quality of breads.

3- To assess sensory characteristic and overall consumer acceptability of supplemented breads.

CHAPTER TWO

LITERATUREREVIEW

2.1 Cereals grain

Cereals are crop plants from the grass family (*Poaceae*) and produce seeds (fruits) with high starch contents which are used for human consumption, animal feed production and industrial purposes. Among the many cultivated species of cereals, an increasingly important role is played by barley, rye and oats (Perkowski *et al*., 2012). The major cereal crops are wheat, rice, and maize, but sorghum, millets, barley, oats, and rye are important only in some regions. Unprocessed cereals are low in fat, and a good source of fibre and phytochemicals. Cereal grains are made into a very wide range of cereal-based foods using traditional and technologically more advanced processes, which can result in changes in nutritional value (Price and Welch, 2013).

Muesli is a mixture of grain flakes and dried fruits, where can be also added seeds and nuts. It is traditionally consumed for breakfast together with milk, yogurt or hotwater. cereal tends to facilitate consumption of other healthful foods at breakfast and replace consumption of less healthful foods; and cereal consumption may be a marker for a pattern of behaviour that includes healthful eating and high levels of physical activity throughout the day'.

Oats, maize, rye or wheat can be primarily used for the preparation of breakfast cereal and muesli. (Senhofa *et al.,* 2014).

2.2 Wheat

2.2.1 Classification of wheat

Kingdom: Plantae

Family: Poaceae

Genus: Triticum

Species *T.aestivum*

(Pathak and Shrivastav, 2015)

Wheat is one of the prehistoric crops which provides major energy requirement of the human diet across the world. Recently there is increasing demand of wheat due to availability of wide range of end products at lower prices over other cereal crops. According to FAO estimate, world would require around 840 million tonnes of wheat by 2050 from its current production level of 642 million tonnes. This demand excludes the requirement of animal feed and adverse impacts of climate change on wheat production (Sharma *et al*., 2015)

To meet this demand, developing countries should increase their wheat production by 77% and more than 80% of demand should come from vertical expansion .There is an urgent need for enhancing productivity through agronomic (water, nutrients, weed management etc.), genetic and physiological interventions along with resource conservation technologies. Basic and strategic research on climate change monitoring, adaptation, and crop modeling for advance yield forecasts would help in fulfilling future demands (Sharma *et al*., 2015)

Wheat is a major crop and an important component of the human diet, particularly in developing countries. Wheat varieties and cultivars are grown for particular characteristics that are suitable for specific products. For example, hard wheat flour characterized by high levels of gluten is used for bread and fine cakes, whereas durum wheat flour is used for macaroni, spaghetti, and other pasta products · Wheat quality has traditionally been judged on the basis of functionality, mostly on gluten content and color, and, to a lesser extent, nutritional value. Color is an important quality parameter with regard to pasta production and is determined in part by carotenoids as well as other factors determined by the genetic makeup of the variety (Pathak and Shrivastav, 2015).

Wheat belongs to the family Triticeae (=Hordeae) in the grass family Poaceae (Gramineae). Common wheat (*Triticum aestivum*), also known as bread wheat, is a cultivated wheat species. About 95% of the wheat produced is common wheat. Wheat (*Triticum aestivum* L. em Thell.) is the first important and strategic cereal crop for the majority of world's populations. It is the most important staple food of about two billion people (36% of the world population). Worldwide, wheat provides nearly 55% of the carbohydrates and 20% of the food calories consumed globally. It exceeds in acreage and production every other grain crop (including rice, maize, etc.) and is therefore, the most important cereal grain crop of the world, which is cultivated over a wide range of climatic conditions and the understanding of genetics and genome organization using molecular markers is of great value for genetic and plant breeding purposes (Pathak and Shrivastav, 2015)

2.2.2 Classes of wheat:

Durum – Very hard, translucent, light-colored grain used to make semolina flour for pasta.

Hard Red Spring – Hard, brownish, high-protein wheat used for bread and hard baked goods.

Hard Red Winter – Hard, brownish, mellow high-protein wheat used for bread, hard baked goods.

Soft Red Winter – Soft, low-protein wheat used for cakes, pie crusts, biscuits, and muffins.

Hard White – Hard, light-colored, opaque, chalky, medium-protein wheat planted in dry, temperate areas. Used for bread and brewing.

Soft White – Soft, light-colored, very low protein wheat grown in temperate moist areas.

2.2.3 Importance and uses of wheat

Wheat provide us with a nutritious and delicious supply of breads, pasta, cereals, crackers, bagels, and many other food products that has wheat as an ingredient.Wheat is used in many other products that we use Straw particle board (wood) - used in kitchen cabinets, Paper, Milk replacer, Hair conditioners, Biodegradable golf tees, Adhesives on postage stamps, Water-soluble inks, Medical swabs, Charcoal, Biodegradable plastic eating utensils etc.Young cereal plants were valued in ancient times. The plant *Triticum aestivum* can be used for different liver ailments, to help prevent cancer, tooth decay, skin problems such as eczema and psoriasis (Pathak and Shrivastav, 2015)

2.2.4 Nutritional Contents

Globally, there is no doubt that the number of people who rely on wheat for a substantial part of their diet amounts to several billions. Therefore, the nutritional importance of wheat proteins should not be underestimated, particularly in less developed countries where bread, noodles and other products (e.g. bulgar, couscous) may provide a substantial proportion of the diet. Wheat provides nearly 55% of carbohydrate and 20% of the food calories. It contains carbohydrate 78.10%, protein 14.70%, fat 2.10%, minerals 2.10% and considerable proportions of vitamins (thiamine and vitamin-B) and minerals (zinc, iron). Wheat is also a good source of traces minerals like selenium and magnesium, nutrients essential to good health (Topping, 2007).

Wheat grain precisely known as caryopsis consists of the pericarp or fruit and the true seed. In the endosperm of the seed, about 72% of the protein is stored, which forms 8-15% of total protein per grain weight. Wheat grains are also rich in pantothenic acid, riboflavin and some minerals, sugars etc. The barn, which consists of pericarp testa and aleurone, is also a dietary source for fiber, potassium, phosphorus, magnesium, calcium, and niacin in small quantities. The kernel of wheat is a storehouse of nutrients essential to the human diet. Endosperm is about 83% of the kernel weight; it is the source of white flour. The endosperm contains the greatest share of the protein in the whole kernel, carbohydrates, iron as well as many B-complex vitamins, such as riboflavin, niacin, and thiamine. Bran is about 14.5% of the kernel weight (Uauy *et al.*, 2006). Bran is included in whole-wheat flour and is available separately. Of the nutrients in whole wheat, the bran contains a small amount of protein, larger quantities of the B-complex vitamins listed above, trace minerals, and indigestible cellulose material called dietary fiber. Wheat germ is the embryo of the wheat kernel. The germ or embryo of the wheat is relatively rich in protein, fat and several of the B-vitamins (Adams *et al*.,2002) . The outer layers of the endosperm and the aleurone contain a higher concentration of protein, vitamins and phytic acid than the inner endosperm. The inner endosperm contains most of the starch and protein in the grain. It is separated from wheat being milled for flour. (Kumar *et al*.,2011)

2.2.5 Type of wheat flours and it uses

All purpose flour

All-purpose flour is the finely ground endosperm of the wheat kernel separated from the bran and germ during the milling process. All-purpose flour is made from hard wheat or a combination of soft and hard wheat from which the home baker can make a complete range of satisfactory baked products such as yeast breads, cakes, cookies, pastries and noodles. Enriched All- Purpose Flour has iron and B-vitamins added in amounts equal to or exceeding that of whole-wheat flour. Bleached Enriched All- Purpose Flour is treated with chlorine to mature the flour, condition the gluten and improve the baking quality. The chlorine evaporates and does not destroy the nutrients but does reduce the risk of spoilage or contamination. Unbleached Enriched All- Purpose Flour is bleached by oxygen in the air during an aging process and is off-white in color. Nutritionally, bleached and unbleached flour are the same (Kumar *et al*.,2011)

- Bread Flour

Bread flour, from the endosperm of the wheat kernel, is milled primarily for commercial bakers but is also available at retail outlets. Although similar to all-purpose flour, it has greater gluten strength and generally is used for yeast breads (Kumar *et al*.,2011)

- Self rising flour

Self-rising flour is all-purpose flour with salt and leavening added. One cup of self-rising flour contains $1\frac{1}{2}$ teaspoons baking powder and $1/2$ teaspoon salt. Self-rising flour can be substituted for all-purpose flour in a recipe by reducing salt and baking powder according to those proportions (Kumar *et al*.,2011).

- Whole wheat flour

Whole-wheat flour is a course-textured flour ground from the entire wheat kernel and thus contains the bran, germ and endosperm. The presence of bran reduces gluten development. Baked products made from whole-wheat flour tend to be heavier and denser than those made from White flour (Kumar *et al*.,2011).

2.3 Bread

Bread is the most common traditional food product in the entire world. It has a high nutritive value due to the content of easily retainable sugars, lipids and proteins. Enzymes applications have grown to be a common practice in the baking industry with advantage of being considered as natural additives. The exogenous enzymes are being used in the baking industry to improve dough-handling properties. The synthetically additives can be replaced with natural additives, as enzymes (David and Misca., 2012). Proteolytic enzymes are used for processing strong gluten flours with high resistance and elasticity and low extensibility. The dough obtained from strong gluten flours cannot expand under pressure of the gase fermentation which show that it has little capacity to retain the gas. Dough elasticity is improved at low doses of protease and it is reduced at higher doses. A limited action of proteases causes weakening of the gluten network, while a strong action destroys this network, completely loses its elasticity and the dough becomes sticky. Research conducted with alveograph method at optimal concentrations of proteases shows that the enzyme improves the plastics proprieties of the dough, which makes the dough easier to handle during the technological process .The enzyme addition of flours presents the advantage of constant quality flour, which does not modify the technological process, does not affect the health of consumers. The enzymes are used in small quantities and do not influence to a great extent the price of bread. They can be successfully used in the place of chemical additives for synthesis (David and Misca, 2012)

2.4 Legumes

Grain legumes play an important nutritional role in the diet of millions of people in the developing countries and are thus sometimes referred to as the poor man's meat. Since legumes are vital sources of protein, calcium, iron, phosphorus and other minerals, they form a significant part of the diet of vegetarians since the other food items they consume don't contain much protein. Legumes are multipurpose crops and are consumed either directly as food or in various processed forms or as feed in many farming systems. The legume crops are often grown as rotation crops with cereals because of their role in nitrogen fixation. However, over the past few decades, the yields and production of legume crops have been stagnant in the developing countries. Agricultural research and development efforts in many of these countries have concentrated on increasing cereal yields and production and lowering crop losses in order to achieve food security. Due to the diverse roles played by grain legume crops in farming systems and nutritional security, the research on legume crops will have significant impacts on nutritional security and soil fertility, especially in the developing countries (Nedumaran *et al*., 2015).

The recent rise in prices has led to an increase in demand for legumes worldwide through both income and population growth. The increasing demand for livestock feed in developing countries is a significant change in the demand structure. In addition, the significant demand of soybean in the bio-diesel industry due to the recent policies in Europe and the US has also contributed to the increase in the demand and prices of legumes as substitute crops. These factors indicate that, in the near future, there will be substantive shifts in the utilization patterns and price structure of grain legumes (Nedumaran *et al*., 2015).

However, pulses lag behind cereals in terms of area expansion and productivity gains. The main reason for this lag is that pulses are considered secondary to cereals in terms of consumer preferences and consequently, research activities focus more on cereals. Due to the high cereal productivity, pulses are being pushed to marginal areas of cultivation having low rainfall and poor soil fertility. Other reasons responsible for the lag include highly unstable prices of pulses due to high variability in their yield and high competition from cereal crops, such as rice and wheat, due to the government price support policy. The grain legume crops have potential health benefits, which include reducing cardiovascular, diabetic and cancer risks (Nedumaran *et al.*, 2015)

2.5 Groundnut

2.5.1 Scientific classification

Groundnut was classified by Alper (2003)as follows

Kingdom: Plantae

Family: Fabaceae

Genus: Arachis

Species: A. hypogaea

2.5.2 Origin of Groundnut

Groundnut, also known as Peanut (*Arachis hypogaea* L.) is a legume originating from South America and the fourth most popular oil seed in the world, following soy, cotton and canola. The largest worldwide producers of peanut are in Asia, where more than half of its worldwide production is concentrated . In Brazil, the São Paulo State was responsible for 89 % of the national production at the 2013/2014 season . The peanut is mainly used for human consumption *in natura*, processing, or oil production. The peanut is currently being studied as a promising raw material for biodiesel production because of the high concentration of oil in its seeds. (Arrud *et al.*,2015)

2.5.3 Utilization of groundnut

Groundnuts are used in various forms, which include groundnut oil, roasted, and salted groundnut, boiled or raw groundnut or as paste popularly known as groundnut (or peanut) butter. The tender leaves are used in certain parts of West Africa as a vegetable in soups. Groundnut oil is the most important product of the crop, which is used for both domestic and industrial purposes. About 75% of the world groundnut production is used in extraction of edible oil. Groundnut oil is the cheapest and most extensively used vegetable oil in India. It is used mainly for cooking, for margarine and vegetable ghee, salads, for deep-frying, for shortening in pastries and bread, for pharmaceutical and cosmetic products, as alubricant and emulsion for insecticides and as a fuel for diesel engines (Prasad et al.,2010).The press cake containing 40-50% protein is used mainly as a high-protein livestock feed and as a fertilizer. The dry pericarp of the mature pods (known as shells or husks) is used for fuel, as a soil conditioner, filler in fertilizers and feeds, or is processed as substitute for cork or hardboard or composting with the aid of lignin decomposing bacteria. The foliage of the crop also serves as silage and forage. With the recent thrust on bioenergy, possibilities are being tested for using groundnut as a bio-diesel crop, because groundnut produces more oil per hectare than any other food crop (Prasad et al.,2010)

2.5.4 Nutrition value of groundnut

Groundnuts are rich in nutrients, providing over 30 essential nutrients and phytonutients. Groundnuts a good source of niacin, folate, fiber, magnesium, zinc, iron, calcium and phosphorus, and contain levels of vitamin A and vitamin E. They also are naturally free of transfats and sodium,and contain about 25% protein.grounds are used to help fight malnutrition, because they are high protein, high energy and nutrient (Lopes *et al*., 2011). Groundnuts also provid unique bioactive components that act as antioxidants and have been shown to be disease preventative.

2.5.5 Health Benefits of groundnut

Groundnuts have provided complex nutrition to many diets and improve health. groundnuts, groundnut butter, and groundnut oil all help to prevent chronic diseases including heart disease, diabetes, and cancer. groundnuts, groundnut butter, and groundnut oil have significant leves of phytosterols are well known for their ability to redue cholesterol. Flavonoids are also found groundnut lowering effects and may act to reduce inflammation, which is one of the underlying mechanisms that trigger chronic disease. the unique nutrient profile and bioactive components of groundnuts play a beneficial role in many areas of health and disease prevention (Elhassan ,2015)

2.6 Sesame

2.6.1 Classification

Kingdom:	Plantae
Family:	Pedaliaceae
Genus:	Sesamum
Species:	S. indicum

2.6.2 Origin and Distribution

Discussion continues about the exact origin of sesame. It is often asserted that sesame has its origin in Africa and spread early through West Asia, China and Japan, which themselves became secondary centers of diversity. With the exception of Sesamum prostratum Retz., all the wild Sesamum species are found in Africa. This variability and the importance of sesame in the economies of several African countries could further justify the African continent to be the ultimate centre of origin. However, (Bedigian, 2003) demonstrated that the crop was first domesticated in India, citing morphological and cytogenetic affinities between domesticated sesame and the south Indian native S. mulayanum Nair., as well as archeological evidence that it was cultivated at Harrapa in the Indus Valley between 2250 and 1750 BC. All these assertions make it difficult to say with certainty the exact origin of the crop. Due to its relatively low productivity sesame ranks only ninth among the top thirteen oilseed crops, which make up 90% of the world production of edible oil (Kafiriti and Mponda, 2010)

2.6.3 Usage of sesame

There are many foods with sesame as an ingredient. Sesame oil is an excellent salad oil and is used by the Japanese for cooking fish. The seeds are also used on bread and then eaten in Sicily. In Greece, seeds are used in cakes, while in Togo and Africa the seeds are a main soup ingredient. Mechanically hulled sesame seed enriches bakery and candles and is also the base for the creamy. Refined sesame oil has antioxidant properties allowing for its greater shelf-life for use in the food industry. Roasted sesame oil resists rancidity due to the antioxidants formed during seed roasting and the particular roasted sesame flavor improves taste of fried products. African countries use the seeds as spice, seed oil, frying vegetables and meat, eaten raw or fried and used in confections such as candy and baking (Anilakumar *et al.,* 2010)

African people use sesame to prepare perfumes and cologne has been made from sesame flowers. Myristic acid from sesame oil is used as an ingredient in cosmetics. Sesamin has bacteri- cide and insecticide activities plus it also acts as an antioxidant that can inhibit the absorption of cholesterol and the produc- tion of cholesterol in the liver. Sesamolin also has insecticidal properties and is used as a synergist for pyrethrum insecticides. Sesame oil is used as a solvent, oleaginous ve- hicle for drugs, skin softener and used in the manufacture of margarine and soap. Chlorosesamone, obtained from roots of sesame, has antifungal activity (Begum et al., 2000).

2.6.4 Nutrition value of sesame

Sesame is an amazingly healthful food utilized for over 5,000 years, it is a most potent, nutrient-dense medicinal foods still used from ancient times. Sesame seeds are not only praised for their nutritional content in seed form, but are also highly valued for their rancid-resistant oil. Sesame seed majorly constitutes of oil, protein, carbohydrate and many minor minerals and vitamins. The chemical composition of sesame oilseed is about 50-52% oil, 17-19% protein and around 16-18% carbohydrate (Tunde-Akintunde and Akintunde,2004). The sesame hull also comprises of oxalic acid, crude fibre, zinc and iron and Sesame seeds are a significan tsource of important minerals which comprises Potassium, Phosphorus, Magnesium, Calcium and Sodium (Loumouamou *et al*., 2010). Potassium has the highest concentration, which also plays a vital role in the synthesis of amino acids and proteins. Calcium and Magnesium together are required for the major functions like photosynthesis, nucleic acids and carbohydrate. As oxalic acid is considered as an anti-nutritional factor which interferes with the bioavailability and absorption of calcium. A study by (Akinoso *et al.*, 2010) Sesame seed contains a significant amount of vitamin B. Since, the vitamin B is present in the seed coat or the hull of the seed, therefore hulled sesame seed contains no vitamin B, sesame seed flour or whole sesame seed should be consumed for complete intake of vitamin B. Among the other vitamins in sesame seed, the existence of vitamin E is very interesting in relation to its effectiveness as a health food. Besides lignans and tocopherol sesame is also enriched with another bioactive constituents i.e. phytosterols (Prakash and Naik, 2014)

2.6.5 Health Benefits of sesame

Sesame seeds are widely considered to be healthful foods. They are high in energy but contain many health benefiting nutrients, minerals, antioxidants and vitamins that are essential for wellness and have positive effects on human health. Many of these minerals have vital role in bone mineralization, red blood cell production, enzyme synthesis, hormone production as well as regulation of cardiac and skeletal muscle activities. The seeds are especially rich in mono-unsaturated fatty acid oleic acid which comprise up to 50% fatty acids in them. Oleic acid helps to lower LDL or "bad cholesterol" and increase HDL or "good cholesterol" in the blood. The seeds are also very good source of dietary proteins with fine quality amino acids that are essential for growth, especially in children. In addition, sesame seeds contain many health benefiting compounds such as sesamol and sesaminol which are phenolic anti-oxidants and help stave off harmful free radicals from the body. Sesame oil has a high percentage of polyunsaturated fatty acids (omega-6-fay acids) but keeps at room temperature uniquely due to the presence of sesamol and sesamin, two naturally-occurring preservatives Akintunde *et al* (2012). sesame oil promotes protective action on cardiovascular through acknowledged antioxidant property. sesame oil improves the effectiveness of the oral anti-diabetic drug glibenclamide in type 2 diabetic patients. Another study concluded that substitution of sesame oil as the sole edible oil has an additive effect in further lowering blood pressure and plasma glucose in hypertensive diabetics. sesame seeds contain an anti-cancer compound called phytate, but the magnesium in sesame seeds also possess anti-cancer properties. According to Wark *et al.*

(2012) it was found that the risk of colorectal tumours decreased by 13% and the risk of colorectal cancer decreased by 12% with consumption of every 100 mg of magnesium. sesame oil or sesamol may be beneficial for reducing the inflammatory response in inflammation- associated diseases (Liu, 2013).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Materials

Groundnut seeds were obtained from Alhuda of Aljazeera state. While wheat flour and sesame seeds was brought from the local market in Khartoum North.

Other food materials (yeast, salt, sugar, ascorbic acid and oil etc…) were obtained from the local market.

3.2 Chemicals

All chemicals and reagents were of analytical grade were purchased from local chemical suppliers companies.

3.3 Methods

3.3.1 Preparation of groundnut seeds

Groundnut seeds were slightly roasted and then milled. The milled (groundnut flour) sealed in polyethylene bags and kept in refrigerator at 5ºC till use.

3.3.3 Preparation of sesame seeds

The sesame seeds were cleaned to remove extraneous materials and washed with water The seeds were dried in air, then slightly roasted and milled to obtain the sesame flour.

3.3.4 Blends of wheat flour

Wheat flour was supplemented with groundnut and sesame flour at 5 and 10%(w/w). Each treatment was mixed thoroughly by mixture to achieve uniformity in flour blends.

3.4 Preparations of bread samples

Bread preparation was carried out according to Badi *et al.*, (1978).
Method Bread formula:

Flour	250g
Yeast	3g
Salt	1.5g
Ascorbic acid	0.2g
Sugar	3g
Water	160ml

Control bread was prepared without adding groundnut or sesame. Other formula were prepared by partial substitution of wheat flour with groundnut and sesame at levels of (5 and 10% (w/w). The blends were mixed with dry ingredients (Yeast, Salt, Sugar, and Ascorbic acid).

3.5 Proximate composition

The determination of chemical composition was carried out according to AACC (2000) methods.

3.5.1.1 Determination of Moisture content

Three grams of well-mixed samples were weighed accurately in clean preheated moisture dish of known weight by using sensitive balance.

The uncovered dishes with the sample were kept in an air oven provided with a fan at 130°C for 1 hour. The dish was then covered and transferred to desiccators and weighed after cooling to room temperature. The loss of weight was calculated as percent of moisture content as follow

$$\text{Moisture content \%} = \frac{Wt1 - Wt2}{Sample\ wt.} X100$$

Where:

Wt_1 = Weight of sample + dish before oven dry.

Wt_2 = Weight of sample + dish after oven dry.

3.5.1.2 Determination of fat content

Crude fat was determined according to the standard method of AOAC (1990). A sample of 3 g was weighed into an extraction thimble and covered with cotton; that was previously extracted with hexane (BP60-70°C), and then the sample and a pre-dried and weighed Erlenmeyer flask containing about 50 ml were attached to extraction unit for 45 minutes. At the end of distillation period, the solvent was recovered from the oil. Later, the flask with the remaining crude hexane extract was put in an oven at 105 °C for about an hour. Cooled in a desiccators, reweighed and dried extract was recorded as crude fat% (DM) according to the following formula:

$$\text{Crude fat \% (DM)} = \frac{\text{Dry extract w.t (g) x 100 x 100}}{\text{Wt. sample } (100 - \text{\% moisture})}$$

3.5.1.3 Determination of crude protein:

The determination of crude protein was carried out on the samples according to AOAC (1990) methods.

A 0.2 gram of sample, plus 0.4 gram catalyst mixture (potassium sulfate + cupric sulfate 10:1 by wt), and 7 ml concentrated nitrogen free sulfuric acid, were mixed in a small Kjeldahl flask (100 ml). The mixture was digested for two hours, then cooled, diluted, and placed in the distillation apparatus. Fifteen milliliters of 40% NaOH solution were added and the mixture was heated and distilled until 50 ml were collected in a 100 ml conical flask. The ammonia evolved was received in 10 ml of 2% boric acid solution plus 3-4 drops of universal indicators (methyl red and bromo cresol green). The trapped ammonia was titrated against 0.02N HCL.

The percentage (g/100) of protein was calculated by using an empirical factor to convert nitrogen into protein as follows:

$$\text{Nitrogen content \%} = \frac{\text{TV} \times \text{N} \times 14.00 \times 100}{1000 \times \text{Wt. of sample}}$$

$$\text{Protein content \%} = (\text{nitrogen content \%}) \times F$$

Where:

TV = Actual volume of HCL used for titration (ml HCL – ml blank).

N = Normality of HCL.

14.00 = Each ml of HCL is equivalent to 14 mg nitrogen.

1000 = To convert from mg to gm.

6.25 = Constant factor for sorghum and legumes.

5.7 = constant factor for wheat flour.

3.5.1.4 Determination of crude fiber:

Two grams of an air dried fat-free sample were transferred to a dry 600 ml beaker. The sample was digested with 200 ml of 1.25% (0.26N) H_2SO_4 for 30 minutes, and the beaker was periodically swirled. The contents were removed and filtered through Buchner funnel, and washed with boiling water. The digestion was repeated using 200 ml of 1.25% (0.23N) Na OH for 30 minutes, and treated similarly as above. After the last washing the residue was transferred to ashing dish, and dried in an oven at 105°C over night then cooled and weighed. The dried residue was ignited in a muffle furnace at 550°C to constant weight, and allowed to cool, then weighed.

The fibre percentage was calculated as follows:

$$\text{Crude fibre \%} = \frac{W1 - W2}{Dry\ sample\ weight} \times 100$$

Where:

W1 = The weight of oven dry sample after treatment by H_2SO4 and KOH

W2 = The weight of the treated sample after ashing.

3.5.1.5 Determination of ash

Three grams were weighed in empty crucible of known weight. The sample was heated in a Muffle-Furnace at 550°C until its weight is stable. The residue is cooled to room temperature after removed from a Muffle-furnace and placed in a desiccators then weighed. The process was repeated until constant weight was obtained. Ash content was calculated using the following equation:

$$\text{Ash content \%} = \frac{(\text{Wt1} - \text{Wt2})}{\text{Sample wt.x}(100-\text{m})} \text{X}100$$

Where:

Wt_1 = Weight of crucible with ashed sample.

Wt_2 = Weight of empty crucible.

m=%moisture

3.5.1.6 Determination of carbohydrates

The carbohydrates were calculated by difference. The sum of moisture, fat, protein, fiber and ash contents was subtracted from 100 as it was described by West *et al.* (1988).

3.6 Determination of mineral content

Minerals of raw and processed samples were extracted according to Pearson's method (1981). Each sample was burnt in a muffle furnace at 550°C for six hours and each crucible was cooled in the desiccator and weighed. Each sample was placed in a sand bath for 10 minutes after addition of 5 ml of 5N HCL. Then the solution was carefully filtered in a 100 ml volumetric flask and finally distilled water was added to make up to mark. The extracts were stored in bottles for further analysis. Minerals of Fe, K, Ca, P, Zn, and Mg were determined using atomic absorption spectrophotometer type AA-6800 Shimadzu, Japan.

3.6.1 Determination of iron content

After preparing the sample as above, which is desired to determine an element concentration, the hollow cathode lamp was selected according to which element concentration is searched, because each element has specific hollow cathode lamp. The acetylene cylinder was opened and compressor was adjusted to the ratio of inlet, 2:8 units for acetylene and air. The software is provided with parameters such as element, which is searched, wavelength and number of sample with labels. The burner is ignited to create a suitable flame of Air-Acetylene. Through this flame ray of electromagnetic from hollow cathode lamp was passed. The sample is provided to the instrument through sample capillary tube. When the sample reach's the flame, it is changed to gaseous state and then free atoms. These free atoms absorb a part of the electromagnetic ray.

3.6.2 Preparation of Fe standard curve

From a standard solution concentration, various dilutions were prepared.

Calculation:

Mineral content (ppm) = dilution factor x reading from Atomic Absorbation Spectrophotometer (A.A.S)

Dilution factor =

$$\frac{\text{Volume of stock solution x vol. of solution taken for reading}}{\text{Sample weight x volume taken for sample}}$$

3.6.3 Determination of potassium content

The potassium content of each extracted sample was determined according to AOAC (1984) using flame photometer (Corning 400). One milliliter of extract was taken and diluted in a 50 ml conical flask with distilled water. The standard solutions of the KCl and NaCl were prepared by dissolving 2.54, 3.33 g of KCl and NaCl, respectively. Ten milliliters of this

solution were taken and diluted with 1000 ml distilled water to give a 10 ppm concentration. The flame photometer was adjusted to zero using distilled water as a blank and to 100 using standard solution.
Calculations of the alkaline metals were effected by

$$K\% = \frac{[F.R \times D.F. \times 100]}{10^6 \times S \times 10}$$

Where:

F.R = Flame photometer reading

D.F = Dilution factor

S = Sample weight

3.6.4 Determination of calcium content

Calcium content was determined according to the method by Chapman and Pratt (1961). tow ml of the sample extract was placed in a 50 ml conical flask. Ten milliliters of distilled water were then added to the contents in the flask. About 3-4 drops of 5 N NaOH were added with small amount of meroxide indicator (0.5 g of ammonium purpurate was mixed with 100g of powdered K2SO4) giving a pink color. The contents of the flask were titrated with 0.1 N EDTA (ethylene diamine tetra-acetic acid) until violet color, indicating the end point was obtained.

Calculation:

$$Ca\% = \frac{[T.R \times N\ (EDTA) \times D.F \times M.wt \times 100]}{10^6 \times S \times 2 \times valency}$$

Where:

T.R. = titration reading

N (EDTA) = normality of EDTA

D.F. = dilution factor

M.wt. = molecular weight of the element estimated

S = sample weight

3.6.5 Determination of phosphorous content

Analysis of phosphorous was carried out according to the method of Champman and Pratt (1961). Two milliliters of the extract were pippetted into a 50 ml volumetric flask. Ten milliliters of ammonium molybdate-ammonium vanadate reagent [22.5g of (NH_4) 6MO7O24-4H_2O in 400 ml distilled water +1.25 g ammonium vanadate in 300 ml boiling water + 250 ml conc. HNO_3, and then diluted to 1liter] were added. The contents of the flask were mixed and diluted to volume. The density of the color was read after 30 minutes at 470 nm using colorimeter (Lab System Analysis-9filters, J. Mitra and Bros Pvt. Ltd). A standard curve of different KH_2PO_4 concentration was plotted to calculate the ion phosphorous concentration.

Calculation:

$$P (\%) = \frac{R \times D \times 1000}{10^6 \times S}$$

Where:

R = Reading curve

D = Ash dilution

S = oven dry weight of sample

3.7 Physical characteristics of loaf bread

The loaves were left to cool for 1 hr at room temperature (38±2°C) for analysis.

3.7.1 Loaf weight

The weight of the bread was measured using sensitive balance (KERN, 440 – 45N, Max =1000g, d = 0.1g).

3.7.2 Bread volume

The loaf volume was determined by the seed displacement method according to Pyler (1973). The loaf was placed in a container of known volume into which small seeds (millet seeds) were run until the container is full. The volume of seeds displaced by the loaf was considered as the loaf volume.

3.3 Bread specific volume

The specific volume of the loaf was calculated according to the AACC method (2000) by dividing volume of bread (CC) by weight of bread (g).

3.8 Microbiological methods

3.8.1 Sterilization of Glassware

Petri dishes, test tube, flask, pipettes…etc., were sterilized in hot air oven at 160 – 180 c° for 2 to 3 hours before they were washed dried and packed in stainless steel cans or sometimes in aluminum foil.

3.8.2 Sterilization of media

Culture media were prepared following manufacturing instructions then sterilization was achieved by autoclaving at 121 C° for 15 minutes and 15 pressure.

3.8.3Preparation of serial dilutions

Aseptically 10 grams of the sample were homogenized in 90 ml of sterile diluents (0.1 Peptone water). It was mixed well to give dilution (10^{-1}) by using sterile pipette 1ml was transferred aseptically from dilution (10^{-1}) to a test tube containing 1ml of sterile diluents (10^{-2}). In the same away the preparation of serial dilution was continued until the dilution (10^{-6}). One ml of each dilution was transferred into sterile petri dish, and then 15 ml of sterile melted Plate Count Agar medium were added to each plate. The inoculums was mixed medium and allowed to solidify.

The plates were incubated at 37 C° for 48 hours. A colony counter was used to count the viable bacterial colonies after incubation and the results were reported as colony- forming units (CFU) per gram.

3.8.4 Total Viable Count of Bacteria

It was carried out by using the spread plate count method as described by Harrigan, (1998).

3.8.5 Determination of Coliform Bacteria

It was carried out by using the most Probable Number (MPN) technique as following:

3.8.5.1 Presumptive Coliform test

10, 1.0 and 0.1 ml prepared samples was inoculated in triplicates of MacConkey Borth test containing Durham tubes. The tubes were incubated at 37 C° for 48 hours. The production of acid together with sufficient gas to fill the concave of the Durham tube is recorded as positive presumptive test.

3.8.5.2 Confirmed test for Total coliforms

Form every tube showing positive results a tube of Brilliant Green 2% bile Broth was inoculated by using a sterile loop. The tubes were inoculated at 37 C° for 48 hours, and then the tubes showing positive and negative result were recorded. The Most Probable Number (MPN) of total colliform was found out by using the Most Probable Number (MPN) tubes.

3.8.5.3 Confirmed *E.coli* test

Medium used was EC Broth. From every tube showing positive result in the presumptive test used to inoculate a tube of EC Broth containing Durham tube were inoculated at 44.5 C° for 24 hours. Tubes showing any amount of gas were considered positive. For further confirmation of E. coli tubes of EC Broth showing positive results at 44.5C° for 24 hours were streaked on Eosin Methylene Blue Agar (EMB) plates. The plates incubated at 37C° for 48 hours. Colonies of E. coli are usually small with metallic green sheen on EMB Agar.

3.8.6 Staphylococcus aureus

Medium used was Baird-Parker Agar; 0.1 ml from every dilution was transferred onto the surface of each well dried Baird-Parker Agar medium plates. The inoculum was spreaded all over the plate using sterile bent glass rod. The plates were incubated at 37C° for 24 hours, after that period of incubation the plates were examined and counted *Staphilococcus aureus* appear black shiny convex and surrounded by a zone clearing 2-5 mm in width of colony.

3.8.7 Yeast and Moulds

From suitable dilution of sample 0.1 ml was aseptically transferred onto solidified Potato-Dextrose Agar containing 0.1 gram chloramphenicol per one liter of medium to inhibit bacterial growth. The sample was spread all over the plates using sterile bent glass rod. Plates were incubated at 28C° for 72 hours. Colonies were counted using a colony counter and the result were presented as CFU/gram.

3.8.8 Detection of *Salmonella*

Ten gram of the sample were added to a conical flask containing 90 ml of sterile Nutrient Broth and incubated at 37C° for 24 hours. A loopfull of 24 hours incubated Nutrient Broth was transferred aseptically to sterilized Selenite Cysteine Broth and incubated at 37 C° for 24 hours. A loopfull of 24 hours inoculums of Selenite Cysteine Broth was streak on Bismuth Sulphite Agar surface and incubated at 37 C° for 24-72 hours. Black metallic sheen discrete colonies indicated the presence of *Salmonella.*

3.9 Sensory evaluation of loaf bread

The loaves were sliced with an electric knife and prepared for sensory evaluation same day. The sensory evaluation of bread samples (aroma, taste, crumb texture, crumb color, crumb cell uniformity, general acceptability) was carried out by 15 semi trained panelists. The surrounding conditions were kept the same all through the panel test.

3.10 Statistical analysis

The analysis of variance was performed to examine the significant effect in all parameters measured. Duncan Multiple Range Test was used to separate the means of treatment.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Chemical composition of raw material

The chemical composition of wheat flour, groundnut and sesame are given in (Table 1). In general, sesame and groundnut contain high levels of protein, ash, crude fibre and fat content as compared to wheat flour.

The moisture content of wheat flour was 11.90% (Table 1). This result is similar to finding of Sudha *et al*., (2007), who reported 10.2-11.2% moisture content for wheat flour. However Abdulla, (2003) had reported the highest value of moisture content in wheat flour which was 13.45%. While Chaima and Gernah, (2007) had reported lower value of 8.5%. These variations in moisture might be due to variety variation, storage condition and stages of harvesting.

Protein is one of three major food compounds, along with carbohydrate and fat. Protein is a key specification for wheat and flour purchasers since it is related to many processing properties such as water absorption and glutens strength. Protein content also is related to finished product attributes as texture and appearance. The protein content of wheat flour was 10.75% (Table 1). This result is slightly higher than Tang *et al*., (2008). Sudha *et al*., (2007) reported protein content of 10.3% for wheat flour. In addition to that, Mohammed (2007) had reported high value of 11.87% protein for wheat flour. These variations in protein might be due to variation in variety of wheat.

The fat content of wheat flour was 1.01% (Table 1), Nevertheless Chinma and Gernah, (2007), Mohammed, (2002) and Pellet, (1994) had reported fat values of 1.90, 1.33-1.43 and 1.5%, respectively. These variations in fat content could be due to wheat variety and component levels of different component in wheat.

Dietary fiber plays a very important role in human diet. Fiber content of wheat was 0.72% (Table 1). Chinma and Grenah, (2007) stated value of 1.80%. On the other hand Suleiman (2005) found value of 2.35% fiber in wheat flour. This variation might be due to level of indigestible cellulose, hemi cellulose, lignin, gum and mucilage .

Ash content of wheat flour was 0.60 % (Table 1). This result of ash is higher than that of Sudha *et al.*, (2007), which was 0.45%. While Mohammed, (2007) and Sulieman, (2005) reported 0.75%, and 1.70% ash, respectively.

The carbohydrates content of wheat flour was 75% (Table 1), However, Kulp, (1980) and Pellet, (1994) reported lower carbohydrates content of 54 – 72 and 71.37%, respectively. This due to high level of component in wheat flour.

The moisture content of groundnut is low 6.59%, this makes its shelf-life to be long and contribute to the stability againest rancidity of its content the oil. (Table 1). This result is similar to finding of Singh and Diwakar, (1993) who reported 6% moisture content for groundnut. While Ayoola *et al*., (2012) had reported high moisture of 7.48% for groundnut.

The protein content of groundnut was 25.42% (Table 1). This result is similar to finding of, Singh and Diwakar, (1993) who reported 25.2% protein content for groundnut. While Ayoola *et al*., (2012) had reported slighitly lower protein value of 24.70% for groundnut than our findings.

The fat content of groundnut was 50.62% (Table 1). Nevertheless, Singh and Diwakar, (1993) and Ayoola *et al*., (2012) had reported lower fat levels of 48.2 and 46.10%, respectively. The variation in fat content could be due to variety and analytical methods variation.

The crude fibre can aid digestibility in human. Fiber content of groundnut was 0.83% as presented in (Table 1). However, Singh and Diwakar, (1993) and Ayoola *et al*., (2012) had reported higher fiber content of 2.1% and 2.83% for groundnut respectively.

Ash content of groundnut was 2.05% as presented in (Table 1), However, Atasie *et al*., (2009) reported level of 3.8% fiber content .

The carbohydrates content of groundnut was 14.41%. However, Singh and Diwakar, (1993) and Ayoola *et al*., (2012) had reported carbohydrates content of 16% and 17.41% respectively, for groundnut.

The moisture content of sesame was 6.79% (Table 1). This result is higher than the finding by Zebib *et al*., (2015), Anilakumar *et al.*, (2010) and Makinde and Akinoso (2014), who had reported moisture content of 3.75, 4.0 and 4.81% for sesame, respectively.

The protein content of sesame was 21.81% (Table 1). Zebib *et al*., (2015), Makinde and Akinoso (2014) had reported higher values of 34.41and 26.79% for seasme, respectively. While Anilakumar *et al.*, (2010) had reported the lower protein value of 18.3% for sesame. This variation in protein for sesame could be due to variety, storage condition, growing climate of sesame.

The fat content of sesame was 49.55% (Table 1). Nevertheless, Makinde and Akinoso (2014), Zebib *et al*., (2015) and Anilakumar *et al.*, (2010) had reported fat levels of 47.73, 47.37 and 43.3%, respectively. The variation in fat content could be due to variances in sesame variety and analytical methods.

Fiber content of sesame was 8.52% (Table 1), However, Makinde and Akinoso (2014), Zebib *et al*., (2015) had reported lower level of 6.62% and 3.76% fiber for sesame, respectively.

The ash content of sesame flour was 2.37% (Table 1). This result is lower than that reported by Makinde and Akinoso (2014) and Anilakumar *et al.,* (2010) which were 4.62% and 5.2% ash for sesame, respectively.

The carbohydrates content of sesame was 10.94%. This result is slightly higher than the finding by Makinde and Akinoso (2014) they reported 9.65% carbohydrates for sesame.

Table 1: Chemical composition of wheat flour , groundnut and sesame

Types of raw materials	Moistuer content (%)	Fat content (%)	Ash content (%)	Protein content (%)	Fiber content (%)	Carbohydrate content (%)
Wheat	11.90±0.10[a]	1.01±0.064[c]	0.60±0.02[b]	10.75±0.09[b]	0.72±0.17[b]	75.00±0.23[a]
Groundnut	6.57±0.16[b]	50.64±0.49[a]	2.05±0.23[a]	25.42±2.59[a]	0.83±0.15[b]	14.41±3.02[b]
Sesame	6.79±0.36[b]	49.55±0.48[b]	2.37±0.02[a]	21.81±0.53[a]	8.52±0.13[a]	10.94±1.18[b]

Values are mean ±SD of triplicate independent analysis.

Values in the same column carrying different superscribe litter are significant different at ($P<0.05$).

4.2 Mineral content

Sesame and groundnut had high concentration of calcium, magnesium, Zinc, Iron, phosphorus and potassium (Table 2) There is significant differences ($P<0.05$) in minerals between different raw materials (wheat flour, groundnut and sesame flour).

The total minerals were high in sesame and groundnut but the lowest was in wheat. sesame content were 351.71, 5.51, 862.31, 9.43, 380.70 and 385.68 mg/100g for Mg, Zn, Ca, Fe, P and K, respectively. This result is similar to the finding of Deme *et al.*, (2017). They reported that Magnesium , Zinc and phosphorus content of sesame was 342.78, 5.23 and 352.68 mg/100g, respectively. However, they reported higher value for calcium (1111.61 mg/100g) and potassium (476.64mg/100g) but lower value of Iron (8.33mg/100g).

Groundnut is a good source of minerals (Table 2). Zinc and iron content of groundnut was 5.31 and 2.73 mg/100g ,respectively. This result similar to the finding of James *et al.*, (2008) had reported Zinc(5.9 mg/100g) and iron(2.9 mg/100g). Potassium content of groundnut was higher 868.7 mg/100g. This result is slightly higher than Nzikou *et al*.,(2009) they reported potassium content of 851 mg/100g. Magnesium and calcium content of groundnut was 294.24 and 129.42 mg/100g, respectively. However, this result is lower than that by James *et al.*, (2008) they reported magnesium content of (308 mg/100g)and calcium of 131 mg/100g. Phosphorus content of groundnut was 213.52 mg/100g. This result is lower than the finding by James *et al.*, (2008)which, was 647.25 mg/100g groundnut.

Table 2: Minerals content of wheat, sesame and groundnut

Raw materials	Minerals/mg/100g					
	Mg	**Zn**	**Ca**	**Fe**	**P**	**K**
Wheat	130.18±3.04[c]	2.07±0.27[b]	35.48± 0.81[c]	3.08± 0.28[b]	321.95±3.86[b]	362.24±4.67[c]
Sesame	351.71±0.20[a]	5.51±0.31[a]	862.31±8.83[a]	9.43± 0.21 [a]	380.70±11.56[a]	385.68±5.24b
Groundnut	294.24±4.57[b]	5.31±0.35[a]	129.42±1.14[b]	2.73± 0.11[b]	213.52±3.39[c]	868.71±2.17[a]

Values are mean ±SD of triplicate independent analysis.

Values in the same column carrying different suberscribe letter are significant different at ($P<0.05$).

4.3 Chemical composition of breads

The chemical compositions of different breads are revealed in (Table 3). There were significant ($p < 0.05$) differences in components of breads including , ash, protein, fat, fiber, total carbohydrate and total energy. There was no significant ($p < 0.05$) differences in the moisture content between bread supplemented with 10% sesame and the one supplemented with 10% groundnut. Also no significant ($p < 0.05$) differences in moisture between bread supplemented with 5% groundnut and the control. The highest moisture content was 26.98% obtained in bread supplemented with 5% sesame. While the lowest moisture content of 24.44% was recorded in the bread control.

The protein content of breads significantly ($P \leq 0.05$) increased with the sesame and groundnut supplementation. Its levels were and it was 7.20, 8.69, 9.48, 10.21 and 10.70% for bread control, bread supplemented with 5% sesame, bread supplemented with 5% groundnut, bread supplemented with 10% sesame and bread supplemented with 10% groundnut, respectively. The protein was higher in bread supplemented with groundnut than sesame supplemented bread because legumes are rich in protein than sesame.

The result presented in (Table 3) showed significant ($p < 0.05$) increases in fat of bread supplemented with groundnut and sesame. The highest fat content was 3.38% in bread supplemented with 10% groundnut. While the lowest fat content was 1.32% in control bread. The variation in fat content could be due to supplementation with of groundnut which contains the highest level of fat as compared to sesame and wheat.

The fiber content of breads increased with increasing levels of sesame and groundnut supplementation. 10% supplemented groundnut bread had the highest value of fiber of 0.88%, followed by 10% sesame bread (0.84%) and finally 5% groundnut (0.58%) and 5% sesame (0.53). While the lowest value of fiber (0.35) recorded in control bread.

The ash content of breads was in the range of 1.59-0.74% (Table 3).

10% supplemented groundnut bread had the highest value of ash of 1.59%, followed by 5% groundnut bread (1.35%) and finally 10% sesame bread (1.23%). The ash was higher in bread supplemented with groundnut than sesame.

The carbohydrates significantly ($P<0.05$) decreased in bread supplemented with groundnut and sesame as compared to the control bread make from wheat. The carbohydrate content were 65.10 to 61.55, 61.04, 59.69 and 57.54 % for control bread fallowed by bread supplemented with 5% groundnut, bread supplemented with 5% sesame , bread supplemented with 10% sesame and bread supplemented with 10% groundnut, respectively.

Total energy of breads were significant ($p< 0.05$) decreased by groundnut and sesame supplementation the highest energy bread was 304.61kcl. While the lowest energy bread gave 296.05kcl recorded in bread with 5% sesame.

Children 1- 10 years old would need to ingest at least 464.47 -853.55g , 459.38 - 878.23g, 443.27 - 847.43g, 452.25 - 864.59g and 448.34 - 857.12g of this control bread ,5% sesame, 5% groundnut, 10% sesame and 10% groundnut supplemented bread, respectively, to meet the daily energy requirements of 1,360 – 2,600 kcal as recommended by FAO/WHO/UNU (1985).

Table 3: Chemical composition of bread

Bread blends	Moisture content (%)	Protein content (%)	Fat content (%)	Fiber Content (%)	Ash content (%)	Carbohydrate content (%)	Energy Kcal
Control bread	24.44±1.37[a]	7.20±0.50[d]	1.32±0.10[d]	0.35±0.04[b]	0.74 ± 0.25[c]	65.10 ± 1.08[a]	304.61±5.11[a]
Bread supplemented with 5% sesame	26.98±0.98 [a]	8.69±0.29[c]	1.91±0.06[c]	0.53±0.01[b]	0.86±0.11[bc]	61.04± 1.24[b]	296.05 ±4.10[a]
Bread supplemented with 5%groundnut	24.52±1.04 [a]	9.48±0.17 [bc]	2.52±0.09[b]	0.58±0.10[b]	1.35 ±0.12[a]	61.55 ±0.96[b]	306.81±4.25[a]
Bread supplemented with 10%sesame	25.68±1.10 [a]	10.21±0.41[ab]	2.34±0.29[b]	0.84±0.16[a]	1.23±0.13[ab]	59.69±1.01[bc]	300.72±6.00[a]
Bread supplemented with 10%groundnut	25.92±0.67 [a]	10.70±0.05[a]	3.38±0.12[a]	0.88±0.03[a]	1.59 ±0.21[a]	57.54 ±0.77[c]	303.34±3.59[a]

Values are mean ±SD of triplicate independent analysis.

Values in the same column carrying different suberscribe letter are significant different at (P<0.05).

4.4 Mineral content of bread

Analysis of variance showed significant differences ($p < 0.05$) in minerals content between different bread. 10% groundnut supplemental bread had the highest contents of Mg, P, Zn and K which were 138.19, 261.6, 2.43 and 353.4 (mg/100g), respectively. While the bred make with 10% sesame has the highest contents of Ca and Fe at levels of 78.11 and 2.52 (mg/100 g), respectively. Therefore, supplementation groundnut increased Mg, P, Zn and K in breads. Whereas, supplemented with sesame increased level of Ca and Fe in bread.

Table 4: Mineral content of bread

Bread blends	Minerals					
	Mg	Zn	Ca	Fe	P	K
Control bread	82.50±3.34[d]	0.69±0.076[c]	18.11±0.76[c]	1.00±0.05[bc]	213.03±3.74[cd]	197.5±0.97[d]
Bread supplemented with 5% sesame	115.31±3.15[c]	1.43±0.16[b]	63.27±0.53[b]	1.44±0.15[b]	237.69±1.61[b]	217.66±3.51[cd]
Bread supplemented with 5%groundnut	124.21±1.7[b]	1.27±0.17[b]	23.84±1.76[c]	0.86±0.13[c]	211.25±10.54[c]	230.50±5.19[bc]
Bread supplemented with 10%sesame	128.70±2.13[b]	2.26±0.18[a]	78.11±1.67[a]	2.52±0.41[a]	253.06±2.81[ab]	251.02±0.58[b]
Bread supplemented with 10%groundnut	138.19±1.65[a]	2.43±0.22[a]	27.80±1.59[ab]	1.02±0.06[bc]	261.68±9.98[a]	353.4±24.7a

Values are mean ±SD of triplicate independent analysis.

Values in the same column carrying different suberscribe letter are significant different at ($P<0.05$).

4.5 Physical characteristic of bread

Characteristic of bread made from wheat flour supplemented with different levels of sesame and groundnut was shown in (Table 5)

Loaf volume of bread ranged between 441.67 to 416.67 cc. The highest loaf volume was in bread supplemented with 5% sesame and 5% groundnut. While the lowest loaf volume of was in bread with 10% sesame and groundnut.

The results shown no significant difference ($P<0.05$) in loaf volume of control bread, bread with 5% sesame and bread with 5% groundnut.

The results of loaf bread weight increased significantly ($P<0.05$) by increases of levels of sesame and groundnut. The results of loaf weight are correlated well with the increases in protein content, due to supplementation with sesame and groundnut.

As in Table 5. There was no significant ($P<0.05$) differences in loaf specific volume of between different breads. Although there is decrease in loaf specific volume by increased levels of sesame and groundnut supplementation (Table 5).

Table 5: Physical characteristic of loaf bread samples

Bread blends	Physical characteristic		
	Loaf Volume (cm^3)	Loaf weight (g)	Loaf specific volume (cm^3lg)
Control bread	435.00±5.00[a]	118.17±0.21[b]	3.68±0.046[a]
Bread supplemented with 5% sesame	441.67±2.89[a]	118.20±1.15[b]	3.73±0.055[a]
Bread supplemented with 5%groundnut	433.33±2.89[a]	115.87±1.06[c]	3.45±0.464[a]
Bread supplemented with 10%sesame	416.67±7.64[b]	121.80±0.46[a]	3.42±0.08[a]
Bread supplemented with 10%groundnut	416.67±2.89[b]	122.43±0.78[a]	3.42±0.050[a]

Values are mean ±SD of triplicate independent analysis.

Values in the same column carrying different suberscribe letter are significant different at ($P<0.05$).

4.6 Microbial quality of bread

Food is safe when it does not contain pathogenic microorganism (Coliform Staphylococcus and Salmonella). The results presented in (Table 5) reveald That pathogenic microorganism did not exist in all types of bread. However, there are limited yeasts and moulds 10% groundnut supplemented bread.

Since all types of processed bread were free from pathogenic microorganism. Breads are safe for human consumption.

Table 6: Microbial quality of bread

Bread blends	**Total count (cfu/ml)**	**Yeastand mould (cfu/ml)**	**Total Coliform (cfu/ml)**	**Staphylococcus (cfu/ml)**	**Salmonella (cfu/ml)**
Control bread	Nill	Nill	Nill	Nill	Nill
Bread supplemented with 5% sesame	Less than 10	Nill	Nill	Nill	Nill
Bread supplemented with 5%groundnut	Nill	Nill	Nill	Nill	Nill
Bread supplemented with 10%sesame	Nill	Nill	Nill	Nill	Nill
Bread supplemented with 10%groundnut	Less than 10	Less than 10	Nill	Nill	Nill

Values are mean ±SD of triplicate independent analysis.

Values in the same column carrying different suberscribe letter are significant different at ($P<0.05$).

4.7 Sensory characteristic of bread

Sensory characteristics of different bread display at given in (Table7). The scores of colour, odur, taste, crumb texture, crumb grain and general acceptability were no significantly ($P<0.05$) difference between control and other supplemented breads. There for it is possible to produce acceptable Bread supplemented with up to 10% sesame and groundnut.

Table 7: Sensory characteristic of bread

Bread blends	Colour	Odour	Taste	Crumb Texture	Crumb Grain	General Acceptability
Control bread	1.60± 0.83[a]	2.13 ± 0.74[a]	1.80±0.78[a]	2.20±0.94[a]	2.00±1.00[a]	1.80 ±1.09[a]
Bread supplemented with 5% sesame	2.13±0.74[a]	2.47 ± 0.92[a]	2.60 ±0.99[a]	2.33±0.72[a]	2.20±0.68[a]	2.40 ±0.91[a]
Bread supplemented with 10%sesamet	2.067 ±1.10[a]	2.20 ± 0.94[a]	2.13 ±1.13[a]	2.20±0.67[a]	2.20±0.78[a]	2.47 ±1.06[a]
Bread supplemented with 5%groundnut	2.00 ± 1.13[a]	2.13 ± 0.83[a]	2.13 ±1.13[a]	2.07±0.96[a]	2.27±1.16[a]	2.27±1.03[a]
Bread supplemented with 10%groundnut	2.33 ± 1.11[a]	2.40 ± 1.18[a]	2.20 ±1.15[a]	2.07±1.10[a]	2.40± 0.91[a]	2.33 ±1.18[a]

Values are mean ±SD of triplicate independent analysis.

Values in the same column carrying different suberscribe letter are significant different at ($P<0.05$).

.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Groundnut contains higher protein, fat and minerals than wheat and sesame.

More over Incorporation of groundnut and sesame in wheat flour has improved the nutritional quality of bread in protein, minerals and fats with all types were increasing levels of supplementation the better.

Breads including those supplemented with different levels of groundnut and sesame acceptable as reveled by sensory evaluation.

5.2 Recommendations

It is recommended that:

1. Optimize the supplementation of bread with groundnut and sesame to further improve nutritional quality
2. Incorporation of groundnut and sesame on cereal based food such as biscuits, cakes, famine foods and infant.
3. More studies should done on bread supplemental with groundnut and sesame.

REFERENCES

AACC, (2000). The American Association of Cereal Chemists Approved Methods of the American Association.

Abdullah, I. A. (2003). Biscuit from composite flour of wheat and sorghum. M.Sc. thesis Faculty of Agriculture, University of Khartoum, Sudan.

Adams ML, Lombi E, Zhao FJ, McGrath SP. (2002). Evidence of low selenium concentrations in UK bread-making wheat grain. Journal of the Science of Food and Agriculture, 82: 1160–1165.

Akinoso, R., Aboaba, S. A. and Olayanju, T.M.A. (2010). Effects of Moisture Content and Heat Treatment on Peroxide Value and Oxidative Stability of Un-Refined Sesame Oil. AJFAND 10 (10): 4268- 42850

Alper, C. M. and Mattes, R. D. (2003).Peanut consumption improves indices of cardiovascular disease risk in healthy adults. J. Am Coll Nutr.22 (2): 41-133.

Anilakumar, K. R., Pal, A., Khanum, F., and Bawa, A. S. (2010). Nutritional, Medicinal and IndustrialUses of Sesame (Sesamum indicum L.)Seeds, Agriculture Conspectus Scientificus 75(4) :159-168

AOAC, (1990). Association of Official Analytical Chemists. Official Methods of Analysis, 15th edt. Inc, Suite 400, 2200 Wilson Boulevard Arlington, Virginia 22201, USA.

Arruda, I.M., Cirino, V.M., Buratto, J.S.and Ferrira, J.M.(2015). Growth and yield of peanut cultivars and breeding lines under water deficit.Agropec Trop Goiania 45(2): 146-154

Atasie, V.N., Akinhanmi, T. F. and Ojiodu, C.C. (2009). Proximate Analysis and Physico-Chemical Properties Of Groundnut(Arachis hypogaea L.). Pakistan Journal OF Nutrition 8(2):194-197

Ayoola, P.B., Adeyeye, A. and Onawumi, O. O. (2012). Chemical evaluation of food value of groundnut (Araachi hypogaea) seed. American journal of food and nutrition 2(3): 55-57

Bedigian, D. and van der Maesen, L.J.G. (2003). Slimy Leaves and Oily Seeds: Distribution and Use of Sesamum spp. and Ceratotheca sesamoides (Pedaliaceae) in Africa. In: Schmelzer, G.H. and Omino,B.A., eds.: Proceedings of the First PROTA (Plant Resources of Tropical Africa) International Workshop,Nairobi, Prota Foundation, Wageningen, The Netherlands, pp. 271-274.

Begum S., Furumoto T., Fukui H. (2000). A new chlorinated red naphthoquinone from roots of Sesamum indicum. Biosci Biotech Biochem 64: 873-874

Boye, J., Zare, F., Pletch, A. (2010). Pulse proteins: processing, characterization, functional properties and applications in food and feed. Food Research International 43(2):414–431.

Chinma, C. E. and Gernah, D. I. (2007). Physicochemical and sensory properties of cookie produced from Cassava/Soybean/Mango Composite flours. Journal Food Technology 5(3): 256 – 260.

David, I. and Mişca, C. (2012). The monitoring of enzyme activity of protease on the bread dough. Journal of Agroalimentary Processes and Technologies 18(3): 236 - 241

Deme,T.,Haki,G.D., Retta, N.,Woldegiorgis,S.and Geleta, M.(2017).Mineral and nti-Nutritional Contents of Niger Seed(uizotia abyssinica (L.F.) Cass.,Linseed(Linumusitaissimum L.) andSesame (Sesamumindicum L.) Varieties Grown in Ethiopia.Journal food 6(27): 1-10

Dewettinck, K., Van Bockstaele, F., Kuhne, B., Van de Walle, Courtens, T. and Gellynck, X. (2008). Journal Cereal Science 48: 243-257.

Elhassan, S. EL. I. (2015).Formulation of Fermented Peanut Milk and Millet Blend as a Carrier For Bifidobacterium Longum BB536.MSc. Thesis Faculty of Agricultural Studies, Sudan University of Science and Technology,Sudan

Harrigan, W. F. (1998). Labrotary Methods in Food Microbiology. 3rd edition, Gulf Professional Publishing, USA.

JamesYaw, A., Richard, A., Osei, Safo., Hans Kofi, A., Ohemeng-Dapaah, Seth, O., and Adelaide1, A .(2008). Chemical composition of groundnut, Arachis hypogaea (L) landraces, African Journal of Biotechnology 7 (13): 2203-2208

Kafiriti, E. and Mponda, O. (2010). Growth and Production of Sesame. Soils, Plant Growth and Crop Production 11: 1-10

Kulp, K., Ranum, P.A, Williams, P.C. and Yamazaki, W.T. (1980). Natural levels of nutrients in commercial milled wheat flour. I. description of sample and proximate analysis. Jounral of Cereal Chemistry 57:54 – 58.

Kumar, P., Yadava, R. K., Gollen, B., Kumar, S., Vermav, R. K. and Yadav, S. (2011). Nutritional Contents and Medicinal Properties of Wheat. Life Sciences and Medicine Research 2011: 1-10

Liu, M. Y. (2013). Sesame Oil Attenuates Ovalbumin Induced Pulmonary Edema and Bronchial Neutrophilic Inflammation in Mice. BioMedical Research International 2013: 1 - 7

Lopes, RM., Agostini-Costa Tda S, Gimenes, MA., Silveira, D.(2011).Chemical composition and biological activities of Arachis species.J Agric Food Chem. 59 (9): 30 - 4321

Loumouamou, B., Silou, T. H. and Desobry, S. (2010). Characterization of Seeds and Oil of Sesame (Sesamum indicum L.) and the Kinetics of Degradation of the Oil During Heating. Research Journal of Applied Sciences, Engineering and Technology 2(3): 227-232.

Mohamed, E. A. (2002). Evaluation of four local wheat cultivars with special emphasis on protein fractions. M.Sc. thesis Faculty of Agriculture University of Khartoum, Sudan.

Mohamed, M. I. (2007). Physico-chemical properties of teff (Eragrostis teff (ZUCC.) Trotter.} Grains and their utilization in bread and biscuits making. M.Sc. thesis Faculty of Agric. University of Khartoum.

Nedumaran, S., Abinaya, P., Jyosthnaa, P., Shraavya, B., Rao, P. and Bantilan, C. (2015). Grain Legumes Production, Consumption and Trade Trends in Developing Countries. International Crops Research Institute for the Semi-Arid Tropics. pp. 64.

Nzikou, J.M., M atos.L., Bouanga -Kalou.G., Ndangui. C.B., Pambou -Tobi. N.P .G., Kimbonguila. A., Silou.Th., Linder. M. and Desobry. S.(2009). Chemical Composition on the Seeds and Oil of Sesame (Sesamum indicum L.) Grown in Congo-Brazzaville, Advance Journal of Food Science and Technology 1(1): 6-11

Pathak, V. Shrivastav, Sh. (2015). Biochemical studies on wheat (Triticum aestivum L.). Journal of Pharmacognosy and Phytochemistry 4(3): 171-175

Perkowski, J., Stuper, K., Buśko, M., Góral, T., Kaczmarek, A. and Jeleń, H. (2012). Differences in metabolomic profiles of the naturally contaminated grain of barley, oats and rye. Journal of Cereal Science 56: 544 –551.

Prakask, K., and Naik, S. N. (2014). Bioactive Constituents as a Potential Agent in Sesame for Functional and Nutritional Application. Journal of Bioresource Engineering and Technology,1: 48 - 66.India

Prasad, p.v.v.,Kakani, V.G.and Upadhyaya,H.D.(2010).Growth and Production of Groundnuts.Soils, Plant Growth and Crop Production 11: 1-10

Price, R.K. and Welch, R.W. (2013).Cereal Grains. Encyclopedia of Human Nutrition, p. 307–316. Robertson, G.L 2006 Food Packaging and Practice, Second Edition, p. 550.

Senhofa, S., Straumite, E. and Klava, D. (2014). Quality changes of cereal muesli with seeds during storage. In: 9th Baltic Conference on Food Science and Technology, pp 123–126.

Sharma, I., Tyagi, B. S., Singh, G. Venkatesh, K. and Gupta, O. P. (2015). Enhancing wheat production- A global perspective. Indian Journal of Agricultural Sciences 85 (1): 3–13

Shukla, R.N., Mishra, Anand, A. and Gautam, A. K. (2016). Development of protein enriched biscuit fortified with green gram flour. Food Science Research. Journal 7(1): 112-118.

Singh, F.and Diwakar, B. (1993). Nutritive value and uses of Pigeonpea.International Crops Research Institute for the semi-Arid Tropics patancheru,Andhra pradesh 502324.India

Sudha, M. L., Vetrimani, R., Leelavathi, K. (2007). Influence of fiber from different cereals on the rheological characteristics of wheat flour dough and on biscuit quality. Journal of Food Chemistry 100:1365-1370.

Suleiman, A. E. (2005). Quality characteristics of wheat breads supplemented with chickpea (*Cicer arietenum*) flour. Journal of Agriculture Sciences 13 (2):292- 303.

Topping D. (2007). Cereal complex carbohydrates and their contribution to human health. Journal of Cereal Science, 46:220–229.

Tunde-Akintunde, T.Y., and Akintunde, B.O. (2004). Some physical properties of Sesame seed. Biosystems Engineering 88 (1), 127 – 129

Uauy C, Distelfeld A, Fahima T, Blechl A, Dubcovsky J.(2006). A NAC gene regulating senescence improves grain protein, Zn and Fe content in wheat. Science, 314: 1298–1301.

Wark, P. A., Lau, R., Norat, T. and Kampman, E. (2012). Magnesium intake and colorectal tumor risk: a casecontrol study and meta-analysis. The American Journal of Clinical Nutrition 96(3): 622-631.

Young, J. (2001). Functional bakery products: current directions and future opportunities. Food Industries Journal 4: 136-144.

Zebib, H., Bultosa, G. and Abera, S. (2015). Physico-Chemical Properties of Sesame (Sesamum indicum L.) Varieties Grown in Northern Area, Ethiopia. Agricultural Sciences 6: 238 - 246.

APPENDICES

Plate 1: Effect supplementation of groundnut flour and sesame flour to wheat flour on bread

A = Bread control

B= Bread supplemented with 5% groundnut

C= Bread supplemented with 10% groundnut

D= Bread supplemented with 5% sesame

E= Bread supplemented with 10% sesame