# EFFECT OF BIOLOGICAL AND HEAT TREATMENTS ON THE NUTRITIONAL, PHYTOCHEMICAL PROPERTIES OF SESAME FLOUR AND SENSORY ACCEPTABILITY OF ITS COOKIES

BY

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## DECLARATION

I hereby declare that this project has been written by me and is a record of my own research work. It has not been presented in any previous application for a higher degree at this or any other University. All citations and sources of information are clearly acknowledged by means of reference.

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**Date**

## CERTIFICATION

This is to certify that the content of this project entitled '**Effect of Biological and Heat treatments on the Nutritional, phytochemical properties of sesame seed flour and sensory acceptability of its Cookies**.' was prepared and submitted by **OGBONNAYA CHIEMERIE GLORY** in partial fulfilment of the requirements for the degree of **BACHELOR OF TECHNOLOGY (B.TECH) IN FOOD SCIENCE AND TECHNOLOGY**. The original research work was carried out by her under our supervision and is hereby accepted.

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## DEDICATION

I dedicate this work to GOD Almighty for His mercies, grace, Protection, favour and blessings during the period of my project; To my family, my amazing parents, Mr & Mrs CHIJIOKE OGBONNAYA and siblings for their love, care and unending support, I will love to also thank my supervisors in this project Dr ATINUKE O. IDOWU and Dr S.S. SOBOWALE for guiding me through this project work.

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**ABSTRACT**

The desire for healthy and safe choice of food is increasing with the recent use of functional foods that can serve as healthier choices to the consumers. Incorporation of sesame flour into snacks may improve and provide healthier options for consumers. Due to the anti-nutrients present in sesame seeds, a number of treatments have been conducted on the seeds to reduce its anti-nutrients contents and improve the nutrient composition of the seeds .The objective of this work was to assess the effect of biological and heat treatments on nutritional, phytochemical properties of sesame seed and sensory acceptability of cookies produced from the composite flour. Five samples (full fat, defatted, germinated and fermented, germinated, fermented and cooked, and germinated, fermented and roasted) were used for this study. Proximate, functional, physico-chemical, and mineral analysis were conducted on the flour samples and sensory analysis was carried out on the cookies produced from the flour samples. The data obtained were subjected to statistical analysis using Analysis of Variance (ANOVA). The values (%) of moisture, ash, crude protein, crude fat, crude fibre, and carbohydrates contents ranged from 3.31-3.76, 0.23-4.53, 15.84- 40.80, 17.95-55.25, 0.37 - 1.09, 18.42 -33.88. The values (%) obtained for mineral contents ranged from 0.080 to 4.440, 0.029 to 0.845, 0.034 to 0.653, 0.190 to 0.383, 0.089 to 0.493, 0.101 to 0.260 for calcium, magnesium, potassium, phosphorus, sodium, and iron respectively. The results obtained for the sensory analysis were comparable with that of the control sample.

In conclusion, the heat and biological treatment carried out on sesame seed improved its nutrient content and reduced anti-nutritional factors leading to better nutrient bioavailability. The incorporation of sesame seeds flour into cookies improved their nutritional quality with acceptable sensory attributes. This could lead to improved healthy eating habits in children and adults.

Keywords: sesame, cookies, improved nutrition, biological treatment, sensory evaluation.

# CHAPTER ONE

## 1.0 INTRODUCTION

### 1.1 Background to the study

Sesame (*Sesamum indicum L.)* a self-pollinating plant having a straight, pubertal stem with branching and is known as one of the most important underutilized oilseed plant(fazal *et al*,2011). It has been considered an element in animal feed and human foods as a whole seed, oil, and meal *(*Hahma *et al., 2009*). Oilseeds crops and pulses constitute an available source of dietary protein (Tacon, 1997), Sesame seed is one of the world's important oil crops (*Natureloc et al*, 2022). Its primary marketable products are the whole seeds, seed oil and meal. While sesame seeds have been grown in tropical regions throughout the world since prehistoric times, traditional myths hold that their origins go back even further. (Natureloc *et al, 2022*). According to Assyrian legend, when the Gods met to create the world, they drank wine made from sesame seeds. These seeds were thought to have first found in India and were mentioned in early Hindu legends. In these legends, tales were told in which sesame seeds represent a symbol of immortality. From India, sesame seeds were introduced throughout the Middle East, Africa and Asia. Sesame seeds were one of the known crops processed for oil as well as one of the earliest condiments like humus (Mediterranean dipping spread), gomasio (Japanese condiment with sesame seed), etc. (Zhong *et al., 2*016).

Sesame seeds are oval seeds measuring up to 3mm and these seeds come in different colours, depending upon the variety, including white, yellow, black and red. Sesame seeds are highly valued for their high content of sesame oil, an oil that is very resistant to rancidity (Aderonke *et al.*, 2013). Sesame is one of the fifteen (15) known species of herbaceous plants of the genus 'Sesamum' native to Africa and Asia and is the most widely planted species for its nutritious seeds and oil.

Historians believe that the origin of the sesame seed is the Indian subcontinent. The seed has been called the "Queen of oilseed crops" because of the high yield of oil and the quality of seed, oil and meal. Sesame oil is a non-drying oil, highly stable, and rarely turns rancid in hot climates (Venkata *et al.,* 2013). It is very rich in protein, a polyunsaturated fat used in cooking and cooking oils seen in *ogiri* condiment production from sesame seed (Olagunju *et al.,* 2013). Raw sesame seeds contain anti-nutrients like phytate and oxalate, usually found in

the seed hulls (Akanji *et al.,* 2003), these anti-nutrients can affect the mineral bioavailability of nutrients in food. Fermentation brings about a number of biochemical, nutritional and organoleptic changes in the raw materials, including the breakdown of certain constituents, the reduction of anti-nutritional factors in growing legumes and the synthesis of B vitamins (Mudgil & Barak, 2017). Sesame seeds could be fermented and ground to make an oily paste called ogiri, which can serve as a flavouring condiment (Uaboi *et al.,* 2008). The paste possesses a very strong pungent smell with some ammonical odour. The fermented seed has a pleasant aroma in soups and sauces and can also contribute to the protein and essential fatty acid intake in consumers, to sustain and optimize the production process.

The introduction of sesame flour into the processing of confectionaries to get snacks rich in protein content and avoid the heart disease risk of animal-based proteins. This also helps to harness the phytochemicals present in the crop, studies have shown that phytochemicals can lead to a reduction in the bioavailability of some of nutrients, Oxalic and phytic acids are phytochemicals considered to be anti-nutritional factors as they are predominantly found as oxalates and phytates bound to minerals like calcium and potassium (Akter *et al.,* 2020). Studies have associated excessive oxalate consumption with increased urinary excretion of oxalate (hyperoxaluria) and calcium oxalate kidney stone formation, and excessive phytate consumption with decreased bioaccessibility and bioavailability of certain minerals and reduced utilization of dietary protein *(*Akter *et al.,* 2020). Composite flour is a mixture (binary or ternary) of wheat flour and flour from the plants of oil seed (Shittu *et al.,* 2007) composite f lour is important because it helps with the utilization of local crops. (Hugo et al., 2003). Cookies are confectionary products dried to a low moisture content (Okaka, 2009) in comparison with biscuits, they are chewy and consumed all over the world as snacks in nations where protein and caloric malnutrition abound (Chinma and Gernah, 2007).

1.2 Statement of the problem

Legumes contain anti-nutritional factors such as tannins, phytic acid and trypsin inhibitors as well as their ‘hard-to-grind’ and ‘hard-to-cook’ properties which reduces their utilization as well as nutritional quality and processing (Gwala *et al.,* 2019*;* Qaku and Dlamini., 2020). In some parts of Africa, grains are mostly processed using traditional processing techniques in the bid to partially achieve adequate nutrition and food security, the lack of machinery in developing countries has resulted in the continued use of fermentation and germination (Adebiyi *et al.,* 2016).

Germination is a low-cost, biological processing technology that can reduce anti-nutrients as to other biological processes like fermentation that improve nutrients and reduce anti-nutrients in food sources, phenolic contents and functional properties for different food applications. Therefore, sprouted grains are a new source of functional ingredients for the creation of health-improving foods. However, compositional changes in legumes during germination, have been studied only in some grains to a limited extent. This work goes a step further to amplify these nutrients by passing the sesame seeds through a number of biological processes (fermentation, germination) and thermal processes (cooking and roasting) and comparing them with the normal ways the seeds are processed and observing the rise and fall of nutrients and anti-nutrients present in the seed making sesame free of allergens and anti-nutrients.

### 1.3 Aim and objectives of this study:

The objective of this work is to assess the effect of biological and heat treatments on nutritional, phytochemical properties of sesame seed and sensory evaluation of cookies produced from composite flour. The objectives of this study are:

1. To investigate the effect of biological and heat treatment on the proximate, functional and physico-chemical properties of sesame flour.
2. To determine the mineral content and the anti-nutrient content in the treated sesame flour.

## 1.4 Scope of the study

This work centres on improving the nutritional value of sesame seed by passing it through a number of biological processes that helps detoxify the seeds of the natural toxicants present in the seed and improve its nutrient value and biological availability of the vitamins and minerals present in the processed seeds

## 1.5 Significance of the study

According to Ranjithkumar *et al*., (2020), Sesame is easy to grow and well-suited for planting in crop rotation. This crop is one of the plants where the oil content in seed is high. This seed is not only in use for culinary purposes, also in various applications such as industrial, engineering, and pharmaceutical. The ethno-botanical and medicinal uses of this commercially important, nutritionally rich oilseed need to be explored for better utilization. The significance of this study is to improve the bioavailability of nutrients in sesame seeds by detoxifying it of its natural toxicants inherent in them using thermal and biological processes.

## 1.6 Definition of Terms

### 1.6.1 Germination

Germination is defined as the onset of growth. The term is most commonly associated with plants, describing the process of a seed sprouting into a seedling. The term germination can also be applied to spores or buds. Germination mobilizes reserve nutrients required for growth and therefore may help in the removal of some of the unwanted components of dry seeds which are thought to function as reserve nutrients (e.g. phytates and raffinose oligosaccharides).

### 1.6.2 Roasting

Roasting is the act of cooking without water, the act of cooking something in an oven or over an open air (dry air).Roasting of sesame seed is a significant step in processing of sesame as it causes important physical, chemical, structural and sensorial changes.

### 1.6.3 Cooking

This is the act of preparing food in water under high temperature. It can be classified into so many other terms like simmering, boiling, steaming etc.

# CHAPTER TWO

# 2.0 LITERATURE REVIEW

## 2.1 Sesame

### 2.1.1 Origin of Sesame

Sesame (*Sesamum indicum L.*) is one of the ancient seed oil crops and is mainly grown and cultivated under rainfall conditions in tropical and subtropical region *(*Pathak *et al.,* 2014*;* Oyinloye *et al.,* 2016*).* It has a high oil content (50 %,) *(*Kanu *et al.,* 2007), protein contents (30-60%) (Demirhan and Özbek, 2013) and carbohydrates among the oil seed crops (Raja *et al*., 2007; Wei *et a*l., 2015). It is categorized as an underutilized oil seed with respect to protein extraction and food formulation. Sesame is an annual crop of the Lamiae's order and Pedaliaceae family (Ghosh *et al.* 2005*;* Rajeswari *et al,* 2010). Sesame is one of the oldest crops known to humans. There are archeological remnants of sesame dating to 5,500 BC in the Harappa Valley in the Indian subcontinent. (Singh *et al.,* 2018). Assyrian tablets from 4,300 B.C. in a British museum describe how they ate bread and drank sesame wine together before the gods battled to restore order to the universe (Grichar *et al.,* 2012). Sesame was a major oil seed in the ancient world because of its ease of extraction, great stability, and drought resistance *(*Kapadiya, *et al.,* 2015). It was produced in Texas on a limited scale during the 1950s and early 1960s, first in Northeast Texas and later shifting to the High Plains, where consistent yield increases resulted from irrigation and more favorable climate conditions (Couch *et al.,* 2017).

The sesame was cut with a binder, hand-shocked, and manually fed into a machine when dry. Due to a change in guest worker laws in the mid-1960s, hard labour from Mexico became unavailable, and the sesame crop disappeared (Langham *et al.,* 2002). Sesame returned to Texas in 1987 and has spread to Oklahoma and Kansas with varieties that did not require binding and shocking. The sesame could be swathed into a windrow, allowed to dry, and then picked up with a pick-up attachment on a combine. Since that time, new varieties have been developed that can be left standing in the field to dry down and combined directly (Langham *et al.,* 2007).

In Nigeria, the white cultivar is mostly cultivated in the states of Benue (Oturkpo), Nassarawa (Doma), Jigawa (Malammadori), and Taraba, whereas the black cultivar is mainly grown in Katsina, Kano (Dawanau), and Jigawa (near Hadejia*)* (Makinde and Akinoso, 2013). Sesame (*Sesamum indicum Linn)* is an oilseed legume rich in protein and essential amino acids (Idowu *et al*., 2021). Sesame is the richest source of most of the inorganic nutrients, it is also consumed for its medicinal qualities. Sesame seed is rich in protein compared to other seeds' protein, because of the higher essential amino acids content. Sesame protein is more nutritious compared to all the other oilseed proteins *(*Pathak *et al,* 2014*;* Idowu *et al.,* 2021*).* According to several studies, seeds not only contain nutritionally essential bio-compounds, but they are also substantial sources of other Phyto-compounds with anti-nutritional effects (Samtiya *et al,* 2020*).*

2.1.2 Harvesting of sesame

The time to start preparing for harvest is when the crop stops flowering, which is 50-60 days before harvest. In general, any combine (high capacity sesame combine harvester) can harvest sesame, but not any combine "should" harvest sesame. There are a few tips to improve harvest efficiencies. As with any other crop, a well-tuned combine eases anxiety and pressure at harvest. Sesame must be dry above the cutter bar before combining. A few green capsules will not affect moisture significantly, but those capsules will not release the seed. Sesame seeds are very small. Start with a clean machine and make a pass to have good seed flow. A smooth cutting cutter bar will reduce loss as the crop is cut by the platform knife and moved by the reel to the auger. A coarse serrated knife and a knife guard with a square cutting edge will also reduce loss. There will be seed on the ground from the header striking the sesame. However, 33.4 seeds per square foot on every square foot represents a mere loss of 10 lbs./ac *(*Langham *et al,* 2010). Specific recommendations are developed mainly to reduce seed losses during harvesting and improve the quality grade of products. The indeterminate growth habit of sesame with its subsequent uneven ripening of the capsules creates difficulties for mechanical harvesting. It is important that the crop be completely dry before harvesting, as sap from green material passing through the header can discolour and taint the seed, creating off flavours in subsequent processed products. Physiological maturity normally occurs 90 - 110 days after planting and normally dries down in 130 - 160 days, depending on variety and climatic condition. Sesame is usually mature for harvesting between 90 and 130 days after planting.

Harvesting is done when many leaves have dropped off, and most of the remaining ones have turned yellow and the lowest capsules on the stem are about to split open. When the plants are sufficiently dry the bundles are threshed on a tarpaulin spread on the ground. The plants are beaten gently with sticks and seeds are collected, winnowed and bagged for storage or sale. Make bundles and stalked upright for drying. One week after harvesting, threshing and winnow the seeds. The plants are cut with a cutlass or sickle and should be immediately bundled, tied upright and left in the sun for one week or until they are sufficiently dry for threshing. Delays in harvesting should be avoided to prevent seed loss through shattering, Time of harvesting depends on the variety. Harvest as soon as the crop matures (e.g. from late October to December. If harvesting is delayed, shattering of the capsules will result in seed loss, contamination should be avoided during harvest. This can be achieved avoiding uprooting during harvesting but harvest by cutting the plants with a sickle or knife, the harvesting starts when 75% of the fruit capsules are ripened. While harvesting, it is better to cut than pull in order to avoid impurities: The crop dries above where it will be cut stems tend to change from green to yellow to red in colour and the leaves begin to fall off. Physiological maturity occurs 80-90 days after planting and normally, dries down in DAP 95-100, depending on variety and climatic conditions. For storage, the seeds must have 10% moisture content. Sesame seeds need to be threshed without further contact with soil. Winnow sesame seeds avoid contamination with soil, and any kind of source of humidity.

### 2.1.3 Varieties of Sesame Seeds

The varieties of sesame seeds include:

1. Brown Seeds- Known to be rich in oil around 45-50%, the brown sesame seeds are used for extraction of oil which is extensively used in India.
2. White Seeds- The white seeds which are exported from India is known for their nutty flavour and is used as a condiment for confectionary purposes, it is mostly found sprinkled over burger buns and cakes.
3. Black Seeds- The black seeds are rich in flavour and are mostly used as seasoning in salads, meat processing and vegetables, and also for nutraceuticals purposes.
4. Red Sesame Seeds-The red seeds are rich in aroma so they are mainly used in dishes to enhance the mouth feel.

**Table 2.1. Characteristics of sesame seed**

| Variety | Maturity (Days) | Seed Colour | Seed Size (mm) |
|---|---|---|---|
| NCRI BEN-01M | 102-115 | White | 3 |
| NCRI BEN-02M | 102-115 | Light | 3 |
| NCRI BEN-032 | 125-140 | Brown | 2 |
| E-8 | 80 | White | 3.6 |

***Source: [*Olaleye *et al*., 2002*.]***

### 2.1.4 Morphology of sesame seeds

Sesame is an annual or occasionally perennial plant that may reach a height of 50-250 cm. It has a wide range of morphologies. The sesame plant comes in two varieties: branched and unbranched. The leaves can be alternating or opposite, and they come in a variety of shapes and sizes *(*Kronenberg, 2003. The bell-shaped white to pale-rose flowers appear 6 to 8 weeks after planting on the leaf axils and last for many weeks. Opposite leaves facilitate multiple flowering. Sesame seeds are usually pollinated by insects. The fruit is a deeply grooved capsule (1 to 3 inches long) containing 50 to 100 seeds or more. Sesame's growth is indeterminate, meaning the plant will produce leaves, flowers, and capsules as long as the weather permits. Sesame seeds come in different variety of colours and sizes. The seeds with a lighter colour are thought to be of better quality. It grows in subtropical and tropical regions, and is well adapted to withstand dry conditions. Sesame seed plants thrive on poor soil and in climates that are unfavourable for other crops.

### 2.1.5 Storage and utilization of sesame

Sesame seed small scale processing are recommended from the moment it's been harvested. The primary objective of drying is to achieve easy removal of hulk and steady drying of the pods, in order to avoid afflation contamination. Harvested plants should be kept in the field for a few days to allow them to dry in the sun and air, before removing the pods. Then drying should continue until the moisture content is reduced to 10%. Normally, this can be achieved by drying the pods in the sun for 6-7 days, taking care to cover them if it rains: too long exposure of the pods to the sun could affect both seed quality and seed germination. Sesame seed is easily threshed and relatively delicate, so drum speed should be reduced to about half of that required for cereals, and the concave clearance made as wide as possible. Seed damage during harvesting affects both the viability of the seed, storage and the quality of the oil. Since sesame is a small flat seed, it is difficult to move much air through it in a storage bin. Therefore, it is recommended that the seed be harvested as dry as possible, and stored at a moisture of about 6%. More importantly, during oil processing, moist seeds lead to low yields and clog the screw or cage, a part of the press. Moist seeds are prone to fungal infestation, as mould spores are present in all crops. A standing rule is that the moisture content of the seed should be close to 10 per cent (Kurki, 2013). The high lipid content of sesame oil (50% oil) is part of the attraction for its use in baking and its high protein content (up to 25% protein by weight). Sesame oil carries a premium relative to other cooking oils and is considered more stable than most vegetable oils due to the antioxidants in the oil

(Idowu *et al*., 2021). The antioxidants inhibit the development of rancidity in the oil. In the food industry, where synthetic antioxidants are used extensively, there is an increasing demand for more natural products. Sesame is commercialized in a number of forms. Most sesame is processed directly into oil but can also be sold at various stages of processing, for various uses, such as meal, paste, confections, and bakery products. In Nigeria, sesame is grown for its seed, and the primary use of the sesame seed is as a source of oil for cooking, compared with other vegetable oils (soybean, sunflower, coconut, and olive), sesame oil is more stable against oxidative rancidity due to the presence of distinctive tocopherols and lignans, for example, p-hydroxyphenyl-propane. It is also common to find roasted sesame seeds sold (either sole or with groundnuts) and eaten as snack. With the growing demand for organically grown food, there is a market for sesame products produced under organic conditions. During sesame seed oil extraction process, the remaining meal, e.g. extraction by-products is a high protein material suitable for feeding to livestock. Although at this time sesame oil is used almost exclusively for human food consumption, it has potential for a variety of industrial uses, as do most vegetable oils. The young leaves may also be eaten in stews, and the dried stems may be burnt as fuel with the ash used for local soap making. Sesame seeds should be stored in an airtight container. Unrefrigerated seeds can be kept in a cool, dry place for up to three months. If you refrigerate the seeds, they will last up to six months; frozen ones will be good for up to one year. Sesame oil, on the other hand, is remarkably stable and will keep for years without turning rancid, even in hot climates. (Bennet, 2011).

**Table 2.2. Food products made from sesame seeds and their origins**

| Food | Country |
|---|---|
| Sesame cakes, wine and brandy | Biblical Babylon |
| Breadsticks, crackers, salads and cooking oil | worldwide |
| Roasted seed | India |
| Substitutes for olive oil | Europe |
| On bread | Sicily |
| Cakes | Greece |
| Soup, spice, seed oil | Africa |
| Salad and fish oil | Japan |
| Confectionery | China |
| Sesame seed buns, chips | United states |

***Source: Food, Industrial, Nutraceutical, and Pharmaceutical Uses of Sesame Genetic***

2.1.6 Processing of sesame into different foods and cosmetics

There are many foods with sesame as an ingredient. Oil is normally extracted from the seed, and sometimes the remnant is used to make a traditional soup called *Miyartaushe* with its leaves, as well as being utilized as a component in the production of other dishes (Idowu *et al,* 2021). Europeans use it as a substitute for olive oil. Sesame oil is an excellent salad oil and is used by the Japanese for cooking fish. Aqua hulled sesame seeds undergo a special hulling process which produce clear white seeds. These seeds are washed, dried and used on hamburger buns. This special process makes the seeds to stick to the bun while maintaining a white colour after baking. The seeds are also used on bread and then eaten in Sicily. In Greece, the seeds are used in cakes, while in Togo and Africa the seeds are used as a main soup ingredient. Mechanically hulled sesame seed enriches bakery and candies and is also the base for the creamy, sweet wholesome tahini. Sesame flour has high protein content, high levels of methionine and tryptophan and 10-12% sesame oil. Sesame seeds contain three times more calcium than a comparable measure of milk. 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 flavour 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. Other products with sesame seed as an ingredient include sesame crackers, honey puffed kasha, sesame blue chips, unhulled sesame seed and sesame seed candy. Many recipes contain sesame seeds as an ingredient such as sesame seed sprouts, sesame spread, tanferine and sesame, sesame seed cookies, hummus, sesame seed bagels, sesame granola, sesame broccoli rice, sesame mustard sauce, ginger sesame chicken, sesame pastry, sesame seed sauce and sesame green beans. Sesame meal is excellent feed for poultry and livestock.

Vitamin E contained in Black sesame oil acts as antioxidant, thus it is useful as sunscreen lotion. (Ambikar *et al.*, 2014)

Black Sesame oil can act as moisturizer and emollient for the body. Besides vitamin E, black sesame oil also contains linoleic acids, stearic acids, and palmitic acids. Sesame oil slows down skin aging. The oil has an antioxidant called sesamol which effectively prevents the appearances of wrinkles and fine lines. Sesame oil is fairly thick and sticky, it is easily absorbed by the skin. Black sesame oil helps to repair damaged skin and improve blood circulation. (Ambikar et al., 2014).

**Table 2.3. Utilization of sesame seeds**

| Input | Products | Description and Uses |
|---|---|---|
| Seeds | Confectionery | Fried seeds may be bound together with sugar syrup to give sweetmeats |
| Seeds | Biscuits | The whole seeds can be baked into biscuits. |
| (Hulled) seeds | Bakery | Popular in northern Europe either incorporated into breads or as Decorative toppings. May be used hulled or whole. |
| Seeds, sometimes Roasted. | oil | Particularly used in oriental cuisine. The flavor is quite strong and rarely compatible with traditional Western style cooking but also used as a salad oil |
| Oil | Medicinal treatment | Ulcers and burns |
| Oil | Margarine | Once an important use, now other cheaper vegetable oils are available |
| Oil | Aerosol | Reported use as a synergist for pyrethrum sprays |
| Low-grade oil | Various | Soaps paints, lubricants, and illuminants. Local uses, of no Importance in international trade. |

***Source:*** **[Tunde-Akintunde *et al.*, 2012]**

2.1.7 Nutritional value of sesame

Sesame seed has a nutritional composition of about 50-52% oil, 17-19% protein and 16-18% carbohydrate (Tunde-Akintunde and Akintunde, 2004). Its seed contains about 42-54 % quality oil, 22-25 % protein, 20-25 % carbohydrates and 4-6% ash. The hull contains large quantities of oxalic acid, crude fibre, calcium and other minerals. When the seed is properly dehulled, the oxalic acid content is reduced from about 3 % to less than 0.25 % of the seed weight (Akinoso *et al.,* 2010). Sesame seed contains antioxidants which inhibit the development of rancidity in the oil. In the food industry, where synthetic antioxidants are used extensively, there is an increasing demand for more of these natural products (Bennet, *2011*). The nutritional benefits derived from sesame seeds are based on the variety being utilized. Sesame seeds contain all the essential amino acids, vitamins and minerals, sesame meal also contains rich amounts of fiber, ash, and carbohydrates which can be extremely nutritious for livestock feed. It is also used in paints, cosmetics, perfumes and insecticides (Babaji *et al.,* 2005). Several unsaturated fatty acids such as linoleic and oleic acids are present in sesame seeds and are mainly responsible for oil quality (Uzun *et al.,* 2008).

**Table 2.4: Nutrient composition of sesame seeds**

| **Nutrient composition of sesame seeds** | |
|---|---|
| **Nutrient** | **Quantity (%)** |
| Moisture | 04.0-05.3 |
| Protein | 18.3-25.4 |
| Oil | 43.3-44.3 |
| Saturated Fatty Acids (% in oil) | 14.0 |
| Monounsaturated Fatty Acids (% in oil) | 39.0 |
| Polyunsaturated Fatty acids (% in oil) | 46.0 |
| Ash | 05.2-06.2 |
| Glucose | 03.2 |
| Fructose | 02.6 |
| Phytosterols | 0.4 |

**Source: (Nutritional, Medicinal and Industrial Uses of Sesame (Sesamum indicum L.) Seeds, 2010)**

### 2.1.8 Some processing methods of sesame seeds

#### 2.1.8.1: Germination

Germination is defined as the onset of growth. The term is most commonly associated with plants, describing the process of a seed sprouting into a seedling. The term germination can also be applied to spores or buds Germination mobilizes reserve nutrients required for growth and therefore may help in the removal of some of the unwanted components of dry seeds which are thought to function as reserve nutrients (e.g. phytates and raffinose oligosaccharides). Over 70% of raffinose oligosaccharide can be removed during germination of dry beans. Phytic acid has been suggested to be the source of phosphorus and inositol. Germination can lower the phytates in dry beans to a variable degree depending on the type of bean and germinating conditions. Germination also seems to help reduction in haemeaglutinin activity due to proteolysis of lecterns.

#### 2.1.8.2: Fermentation

Fermentation is a biochemical process in which complex organic substances is turned into simple substances with the help of bacteria, yeasts and other microorganisms. The word fermentation is derived from the Latin verb, "fervere", which means to boil. (Skowron,*et al* 2022). During fermentation most of the changes are of catabolic nature and help hydrolysis of components such as the proteins and carbohydrates this hydrolysis leads to reduction of certain unwanted components such as the rafinose oligosaccharides, phytic acid has also been reported to be hydrolyzed during fermentation to a variable degree depending on the type of crop as well as fermentation. The reduction is due to the action of the enzymes present in the crop and the microorganisms responsible for the fermentation.

2.1.8.3: Roasting

Roasting is the act of cooking without water, the act of cooking something in an oven or over an open air (dry air).Roasting of sesame seed is a significant step in processing of sesame as it causes important physical , chemical, structural and sensorial changes( Rababah *et al*,2017)

2.1.8.4: Cooking

This is the act of preparing food in water under high temperature. It can be classified into so many other terms like simmering, boiling, steaming etc.

2.1.9. Sesame seed and anti-nutrients present in them and how they can be removed

Plants just like humans have a survival mechanism to store food within their seeds, so as to harvest them in time of need and reproduce, the stored foods such as the storage protein (Oligosaccharides) can pose a great threat during processing and lead to anti-nutrient development. This kind of mechanism in plant can also be seen in tree, which give secretions that repel ants and save its leaves from being eaten. This understanding can be related to formation of anti-nutrients in seeds and nuts. The anti-nutrients present in the seed just to mention a few are allergens, phytate, protease inhibitor etc.

**A.** Soaking: Rafinnose oligosaccharides, tannin, trypsin and chymotrypsin inhibitors.
**B.** Cooking: Trypsin and chymotrypsin inhibitors, saponin, phytates, allergens
**C.** Germination**:** Rafinnose oligosaccharides, phytates, heamagglutinin, trypsin inhibitors
**D.** Fermentation**:** Rafinnose oligosaccharides, phytate

2.1.9 LIGNANS IN SESAME

The term lignan was coined by Haworth in 1936 to describe a group of phenylpropanoid dimers in which C6-C3 units are linked by the central carbon of their propyl side chains (Dar & Arumugam (2013). Lignans are currently known for their role in conferring health benefits such as lowering the cholesterol and blood glucose levels in humans (Amin & Thakur (2014). Based on the way in which oxygen is incorporated into the skeleton and the cyclization pattern, sesame lignans individually as well as in combination have been found to exhibit varied biological activities. The main lingans are sesamin and sesamolin and sesaminol

- **Sesamin:** This is a type of lignan with a number of beneficial health effects in humans. It has been found to play a significant role in lipid and glucose metabolism, hypertension, anti-inflammation and free radical scavenging Zhang *et al* (2021)
- **Sesamolin:** This compound is known to increase both the hepatic mitochondrial and the peroxisomal Fatty acid oxidation rate (Morris, 2002). It has induced apoptosis in human lymphoid leukaemia Molt 4B cells, inhibited mutagenesis induced by $H_2O_2$ [Grougnet *et al*., 2012] and suppresses ROS generation in neurons against excitotoxicity or lipopolysaccharide (LPS)-induced neurotoxicity [Park *et al,* 2010].
- **Sesaminol:** This compound also has the property of inhibiting the membrane lipid peroxidation (Nishant *et al*., 2008), the microsomal peroxidation induced by ADP-Fe3+/NADPH and the oxidation of LDL induced by copper ions. Sesaminol has been shown to increase the availability of tocopherols in biological systems by synergistic effects in raising liver and plasma concentrations of vitamin E. It was also found to inhibit oxidative damages in DNA Dar & Arumugam (2013). Sesaminol glucosides present in defatted sesame flour were proved to decrease susceptibility to oxidative stress and inhibit allergen absorption in vitro (Li& liu, 2022).

2. 2.1 Sesame seed flour

2.2.2 Composite Flour

In most developing countries, wheat flour is mainly used in making bread, buns, noodles, biscuit and others. Although it is well known that no other crop can achieve the baking properties of wheat, composite flours became the subject of numerous studies. Composite flour may be considered firstly as blends of wheat and other flours for the production of many products like snacks, porridges, pasta and many other products (Chandra *et al.*, 2015).

Composite flours are quite different from the ready mixed flours in the sense that ready-mixed flour may contain non-perishable constituents of the recipe for a certain baked product, whereas composite flour may contain a mixture of different tubers rich in starch, protein sources or cereals. Possible sources are cassava, yam, millet, maize, soy, peanut, sorghum and flours from other sources which substitute wheat to form composite flour. The composite flours from cereals such as maize are known to be rich in protein (Chandra *et al*, 2015)

2.2.3 Ingredients used in making cookies

- **Flour:** Flour is the main ingredient in cookie dough formula which provides the matrix around which other toughening or tenderizing ingredients in varying proportions are mixed to form a dough. Flour derived from soft wheat is perfect for producing a wide range of confectionery and baked products including cookies, pastries, cakes, steamed buns and snack foods. Soft wheat is a unique blend of white, soft-grained wheat varieties (Pareyt and Delcour, 2008).
- **Sugar (sucrose):** Sugar is an important ingredient of short-dough cookies. It contributes to texture, flavour, sweetness and colour in cookies. The quantity, granulation and type of sugar used influence the quality of cookies. Sucrose, a disaccharide and non-reducing sugar, is the common sugar used in cookie preparation. It is a major and important ingredient of most cookies (Pareyt and Delcour, 2008).
- **Shortening:** The term "shortening" refers to the ability of a fat to lubricate, weaken, or shorten the structure of food components (Pareyt and Delcour, 2008). Fat functionality is very versatile in baked products which include providing of flavour and mouth feel and also contributes to the appearance, palatability and texture of the cookies (Zoulias *et al*., 2002).
- **Cookies Baking:** Baking is a unit operation which uses heat to alter the eating quality of foods. A secondary purpose of baking is preservation by destruction of microorganisms and reduction of the water activity at the surface of the food, baking involved simultaneous heat and mass transfer; heat is transferred into the food from hot surfaces and air in the oven and moisture is transferred from the food to air that surrounds it and then removed from the oven (Fellows, 2000). Cookies baking changes the physical and/or (bio-) chemical properties of the various flour constituents, sugar, and fat present in the cookie dough ingredients, but the ingredients themselves have a marked influence on the relative occurrence and rates of these transformations (Pareyt and Delcour, 2008).

# CHAPTER THREE

# 3.0 MATERIALS AND METHODS

## 3.1 Materials

Sesame seeds were obtained from Ketu market, mile 12, Lagos. Nigeria. The flour, sugar, butter and flavors used in cookie production were obtained from Mowe, ibafo market, Ogun state, Nigeria.

## 3.2 Equipment and Instruments

Air oven dryer, refrigerator, blender, weighing balance, stainless steel trays, pot, cooking stove, gas cylinder, bucket, colander sieve, roasting pan, metal sieve, nylon bags, jute sack bag, bowl, paper tape, cooking spoon, plastic bowl plates, fume cupboard, digestion box, kjedahl distillation machine, measuring cylinders, beakers, conical flask, biurets, separating funnel, retort stand, muffle furnace, Muffle furnace (Vulcan 3-550), funnels, reagent bottles, distilled water bottles, Analytical balance, Porcelain crucibles, Volumetric flasks (2000ml), 50ml polyethylene centrifuge tube, Precision balance (0.0001g accuracy) [Denver], Vortex mixer [Genius 3], Weighing paper, Centrifuge [5810R machine], Atomic Absorption Spectrophotometer [Buck 211], Inductively Coupled Plasma –Optical Emission Spectrophotometer (ICP/OES) [Perkin Elmer].

### 3.2.1 Chemicals and reagents

The chemicals and reagents were obtained from the Laboratory of Food Science and Technology, Mountain Top University, Km 12 Lagos-Ibadan expressway, behind MFM Prayer City Ibafo, Ogun State, Nigeria. All reagents used were of analytical grade.

## 3.3 Sample Preparation

### 3.3.1 Preparation of Sesame flour

#### 3.3.1.1 Preparation of full fat sesame seed flour

Sesame seeds (3500kg) were thoroughly sorted and cleaned with water to eliminate damaged seeds, metals, stones, chaff, and other debris. It was sun-dried for two days. The seeds were

divided into five samples (700 grams each), the full fat sesame seed sample was milled into flour using a blender and packed in an air-tight bag.

3.3.1.2 Preparation of defatted sesame seed flour

Defatted sesame seed flour was obtained by extracting oil from the full fat sesame seed flour using soxhlet extraction with N-hexane as the solvent.

3.3.1.3**:** Preparation of germinated and fermented sesame seed flour

The sesame seeds was soaked for 6 hrs and then germinated using the methods described by (Coulibaly *et al.*, 2011) for two days at 28$^{o}$C and fermented as described by (Onweluzo and Nwabugwu, 2009). The germinated seeds were washed and covered with water in a ratio of 1:2, the sample was left to ferment for 2days and then was rinsed and dried before milling into powder

3.3.1.4: Preparation of germinated, fermented and roasted sesame seed flour

The germinated and fermented seeds described in section 3.3.1.3 were oven dried at 45 $^{o}$C and roasted at 120 $^{o}$C

3.3.1.5 Preparation of germinated, fermented and cooked sesame seed flour

The germinated and fermented seeds described in section 3.3.1.3were cooked using a water bath at 90 $^{o}$C.

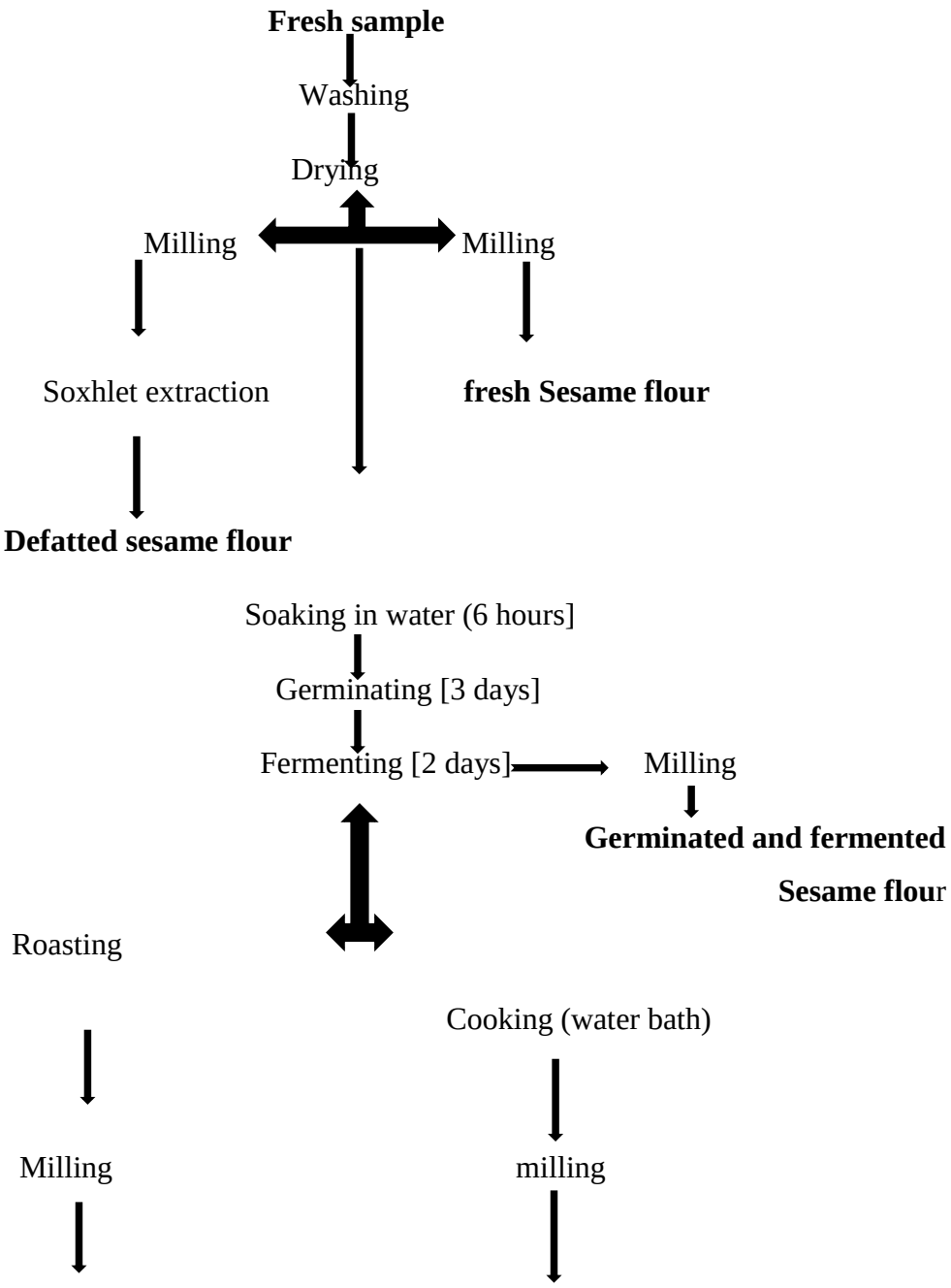


**Figure 3.1: Flowchart of sesame flour preparation**

### 3.3.2 Formulation of flour blends

Wheat flour and one of each of the sample (full fat, defatted, germinated and fermented, germinated, fermented and roasted, germinated, fermented and cooked) were produced and blended in the ratio 80:20 and 100 percent wheat as control to produce cookies respectively.

The formulation is in the table below:

**Table 3.1. Cookies Formulation**

| Samples (%) | | wheat flour (%) |
|---|---|---|
| FR | 20 | 80 |
| GR | 20 | 80 |
| RS | 20 | 80 |
| CK | 20 | 80 |
| DF | 20 | 80 |
| F | 0 | 100 |

Where

FR = full fat sesame seeds flour

GR = fermented and germinated sesame seeds flour

RS = fermented, germinated and roasted sesame seeds flour

CK = fermented, germinated and cooked sesame seeds flour

DF = defatted sesame seeds flour

F = 100% wheat flour

### 3.3.3 Formulation of cookies

The formulation for 300 g flour for cookies production was formulated according to Banureka & Mahendran (2009). The raw materials used include wheat flour (240 g) and sesame flour (60 g), sugar (150 g), margarine (150 g), sodium bicarbonate (0.5 g), milk (35 g), vanilla flavour (15 ml). These were weighed appropriately and two stage creaming up method was used. All the ingredients except flours were mixed thoroughly in a Kenwood mixer (a 3-speed hand mixer), it was then transferred to a bowl. The flours and sodium bicarbonate were added with continuous mixing for 15min. until smooth dough was obtained. A piece of this dough was cut, placed on a clean platform then rolled out using rolling pin until the desired uniform texture and thickness of 0.44 cm was obtained. Cookies cutter was used to cut the sheet of the dough into required shapes and sizes. These were transferred on to a greased (with margarine) baking tray. The baking was done at 200$^{o}$C and baked for 15 – 20 mins. After baking, the hot cookies were removed from the pan and placed on a clean tray to cool down.

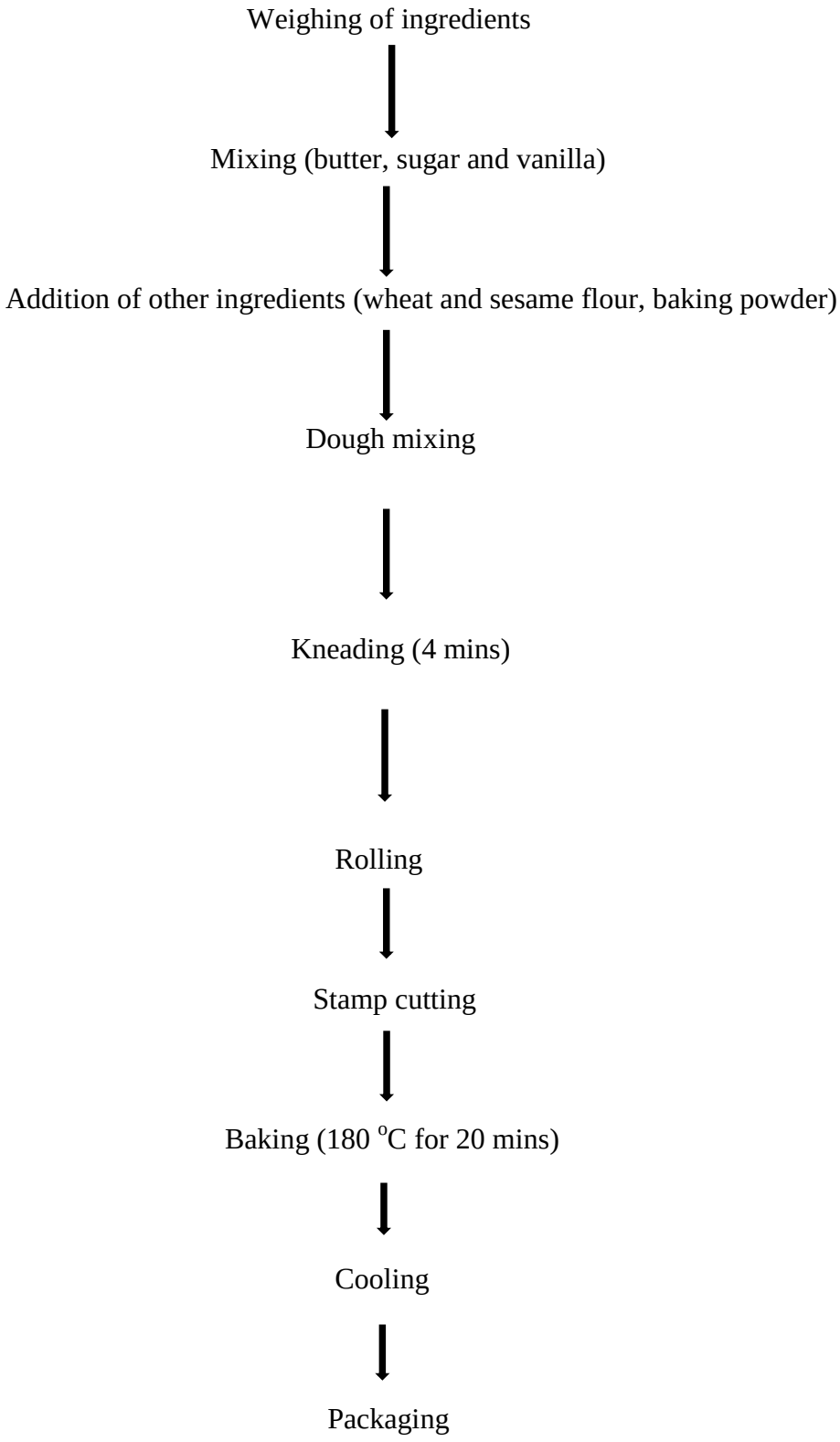


**Figure 3.2: Flow chart for preparation of cookies**

### 3.4 Proximate Analysis

Proximate analysis was determined according to the official method of analysis described by the Association of Official Analytical Chemists (AOAC 2012).

#### 3.4.1 Determination of crude protein content

The protein content of the sesame flour was determined according to AOAC, (2012). Ten (10) g of samples were weighed into a digestion flask and one kjeldahl tablet (catalyst) was added, twelve (12 ml) of conc.$H_2SO_4$ was added and digested for 4 h in a (baker) fume hood with (reactor 1001 digester) until a clear solution was obtained. The digest was cooled, and 30 ml of 4% boric acid was dispensed into a conical flask with 0.132 g of methyl red indicator and 0.198 g bromocresol green plus in a 200 ml alcohol.

The digest was diluted with 75 ml distilled water and dispensed into Kjeldahl distillation flask, the conical and the distillation flask was fixed in place and 50 ml of 4% NaOH was added through the glass funnel into the digest, in the kjeldahl auto distillation unit. The steam exit was closed and it was stopped when the solution of the boric acid and indicator reached 150 ml total volume. The distillate was titrated with 0.1 N HCl until an end point was reached (violet colour).

$$\%\, Total\ Nitrogen\ (gN/L) = \frac{(T-B)xNx14.007}{volume\ of\ sample} \times 100$$

T = Titration volume of sample (ml)

B = Titration volume of blank

N = Normality of acid to 4 place decimals

Therefore, the crude protein content was determined by multiplying percentage Nitrogen by a constant factor of 5.3 i.e.

% Crude protein = % N × 6.38

3.4.2 Determination of moisture content

Ten (10) g of each sample was weighed using analytical balance (Denver instrument company, TR-2102) into an evaporating dish. The weighed samples were put into the pre-set oven (memmert air oven model UN 55, (SCHWBACH, GERMANY) at 105 ℃ for 3 h. The samples were removed and cooled in a desiccator to room temperature and the weight was noted, they were then returned to the oven at 105 ℃ for 1 h, this was repeated until a constant weight was obtained for each sample. The differences in weight between sample before drying and sample after drying is the moisture loss (AOAC, 2012).

$$\%\ Moisture\ content = \frac{W_1 - W_2}{original\ weight\ of\ sample} \times 100$$

Where $W_1$ =weight of sample before drying

$W_2$ =weight of sample after drying

3.4.3 Determination of Ash content

Ash content was determined using the AOAC (2012) method. Ten (10) g of the sesame samples was weighed in dried ceramic crucibles till all the moisture was evaporated. The samples were then incinerated to ash in a muffle furnace for 6 h at 550 ℃. The crucibles were then removed, cooled in desiccator and the samples were weighed. The ash was and the percentage of ash was calculated as;

$$\%\ Ash\ content = \frac{Weight\ of\ ash}{original\ weight\ of\ sample} \times 100$$

3.4.4 Determination of crude fat content

This was determined by using the Rose Gottlieb method described by AOAC, (2012). Ten (10) g of sesame sample was weighed into a separating funnel, 1ml of ammonia solution and 10 ml of 95% ethanol and mixed thoroughly. 25 ml of peroxide-free-diethyl-ether was added

and shaken for 1 min. This was then followed by addition of 25 ml of petroleum ether and shaken vigorously to mix well. The mixture was then left to stand for one hr. to allow aqueous and organic phase to separate. The fat extract (organic phase) was collected and the solvent was removed by distillation. The fat in the flask was dried in the oven at 100 ℃ for 30 min. and the solvent was removed completely. The flasks were then cooled in a desiccator and were weighed for their mass of fat. The percentage fat was calculated by the following formula.

% Fat =$weigh\,t\ of\ extracted\ fat\ (g)$ -original weight of sample used (g) × 100

3.4. 5 Determination of Crude Fibre

The crude fibre was determined according to the method described *by* AOAC, *(*2012*).* Two (2) g of the sample was accurately weighed into flask and 200 ml of 1.25% $H_2SO_4$ was added. The mixture was heated under reflux for 30 min. The hot mixture was filtered through a fibre muslin cloth. The obtained filtrate was thrown off and the residue was returned to the fibre flask with 200 ml of 1.25% NaOH will be added and heated for another 30 min. The residue was removed and finally transferred into the crucible. The crucible and the residue was oven dried at 105 ℃ overnight to drive off the moisture. The oven dried crucibles containing the residue was cooled in a desiccator and later weighed to obtain the $W_1$. The crucible with $W_1$ was transferred to the muffle furnace for ashing at 550 ℃ for 4 hr. The crucible containing white or grey ash (Free of carbonaceous materials) was cooled in the desiccator and weighed to obtain $W_2$.

The difference in $W_1$ and $W_2$ give the weight of fibre.

$$\%\ fibre = \frac{W_1 - W_2}{original\ weight\ of\ sample} \times 100$$

$W_1 =$ Dried crucible + residue before ashing

W2 = Dried crucible + residue after ashing

3.4.6 Determination of carbohydrate content.

The determination of carbohydrate in the samples was determined by a difference method. That is the values or percentages of moisture, ash, protein, fat and fibre was summed up and then the results was subtracted from hundred which gives the carbohydrate content (AOAC, 2012*)*

CHO = 100 - % (ash + protein + fat + crude fibre + moisture)

3.5 Mineral analyses

Calcium (Ca), Magnesium (Mg), Sodium (Na) and Phosphorus (P) was determined according to AOAC, (2012). Sample (10 g) was transferred into a crucible, and heated over flame to volatize as much of the organic matter as possible, before transferring into a muffle furnace to burn at 450˚C for 5-7 hr. To the ash was added 10mL of dilute HCl, boiled for a few min., and made up to 100ml with distilled water. This was then used for the mineral analysis.

3.6 Functional Properties of the flour blends

3.6.1 Bulk density

This was determined using the method described by Wang and Kinsella, (2006). Ten (10) g of sample was weighed into a 50 ml graduated measuring cylinder. The sample was packed by gently tapping the cylinder on the bench top 60 times until there was no more decrease in volume. The volume of the compacted sample was recorded and the bulk density was calculated as follows.

Calculation:

$$Bulk\ density\ (\frac{g}{ml} or\ g/cm^3) = \frac{Weight\ of\ sample_1}{Volume\ of\ sample\ after\ tapping}$$

3.6.2 Water absorption capacity (WAC)

The water absorption capacity of the flours was evaluated according to method AOAC, (2012). One gram (1 g) of flour samples was each weighed into a centrifuge tube and 10 ml distilled water added. The content of the centrifuge tube was shaken for 30 mins in a KS 10 agitator. The mixture was kept in a water bath (MEMMERT) (37˚C) for 30 mins and centrifuged (ALRESA, DITACEN II) at 5000 rpm for 15 min. The resulting sediment ($M_2$) was weighed and then dried at 105 $^{o}$C to constant weight ($M_1$). The WAC calculated as follows:

$$\%\ WAC = M_2 - M_1 M_1 \times 100$$

3.6.3 Wettability

This was determined according to the method described by Wang and Kinsella, (2006). One (1) g of sample each was placed in a 25 ml graduated cylinder with a diameter of

1cm. A finger was placed over the open end and the cylinder was inverted and clamped at a height of 10cm from the surface of a 600ml beaker containing 500 ml distilled water. The finger was removed to allow the material to be dumped and the time required for the sample to become completely wet was recorded. A triplicate determination was made and the result was averaged

3.6.4 Foaming capacity

Determined as described by Okaka and Potter. A 2 g flour sample was added to 50 ml distilled water in a 100 ml graduated cylinder at 30 ºC and the suspension was mixed and shaken till foaming occurred (approx. 5 min); the volume of foam thus formed was expressed as FC using the following formula

$$FC = \frac{voi\ ume\ of\ foam\ after\ whipping\ Volume\ of\ foam\ beforwhipping}{Volume\ of\ foam\ before\ whipping} \times 100$$

The volume of foam was recorded one hour after whipping to determine foam stability as percent of the initial foam volume as follows

$$FS = \frac{Final\ foam\ volume\ after\ one\ hour}{Foam\ volume\ after\ whipping} \times 100$$

3.7 Physico-chemical Analysis

The physio-chemical analysis were determined according to the official method of analysis described by the Association of Official Analytical Chemists (AOAC 2012).

3.7.1 Determination of pH

The pH value of the samples was determined using a pH meter (JENWAY 3505) as described by AOAC (2012). The electrode was dipped in already weighed filtrate of sesame dilute the pH was recorded according to what was showed on the pH device.

3.7.2 Determination of titratable acidity

The titratable acidity was determined by the method described by AOAC (2012*)*. Ten (10) g of the sample was weighed and 30 ml of warm water was added. One (1) ml of phenolphthalein was added and titrated with 0.1 N alkali (NaOH) until a change in colour to pink was observed. The titration was repeated to get the average value.

%Titratable acid as lactic acid = $\frac{9 \times A \times N}{W}$

A = Volume of NaOH used

N = Normality of NaOH solution

W = Weight of sample used

3.8 Anti-nutritional factors analyses (physico-chemical analysis cont.)

3.8.1 Determination of oxalate

The method described by Underwood et al (1986) was used. One (1) gram of each sample was weighed into a 100 ml conical flask, 75 ml of 3 M $H_2SO_4$ was added and the solution was carefully stirred intermittently with a magnetic stirrer for about 1h and then filtered through Whatman No 1 filter paper. Exactly 25 ml of the filtrate was collected and titrated hot (80-90 $^oC$) against 0.1 M $KMnO_4$ solution to the point when a faint pink colour appeared and persisted for at least 30 s.

$$\text{Oxalate (mg/g)} = V_T \times 0.9004$$

Where, $V_T$ = Titre volume (mL)

3.8.2 Determination of phytate

The method described by *Bello (*2013*)* was adopted in the determination of phytate content. Fifty millilitres (50 ml) of the sample was diluted with 100 ml distilled water and filtered into a 250 ml beaker. Then, 10 ml of 0.3% ammonium thiocyanate solution was added as an indicator and titrated with standard iron (III) chloride solution which contained 0.00195g iron per ml. The endpoint was observed to be yellow which persisted for 5 min and phytate content was calculated as %phytic acid (g/100 g).

$$\%\text{Phytic acid} = \frac{\text{Titre value x 0.0019 x 100}}{2}$$

3.9 Sensory Evaluation

Samples of the product were evaluated using hedonic method. Fifteen (15) panellists were drawn from students of Mountain Top University, Km 12 Lagos-Ibadan expressway, behind MFM Prayer City Ibafo, Ogun State, Nigeria. They were served coded samples of the products and were asked to compare for appearance/colour, taste, texture, aroma/smell, and overall acceptability using a 9-point hedonic scale (9 – like extremely to 1- dislike extremely) (Appendix) described by (Omola *et al.*, 2014).

### 3.10 Statistical Analysis

All the data reported in this study were carried out in triplicate. In each case, a mean value and standard error will be calculated. The data was analysed using SPSS version 26 statistical software. Statistical parameters were estimated with analysis of variance (ANOVA).Differences between means were evaluated by the Duncan multiple range test and significance were accepted ($p \leq 0.05$).

# CHAPTER FOUR

## 4.0 RESULTS AND DISCUSSION

4.1 Proximate composition of sesame flour

The result obtained from the proximate analyses of different samples are illustrated in Table 4.1. The table shows that there was a significant difference ($p \leq 0.05$) in the moisture content of the different samples. The moisture content ranged from 3.31-3.76%, the variation in the values obtained for the moisture content might be due to the various treatments conducted on the flour sample. There was a significant increase in the moisture content of the flour that was germinated, fermented and cooked (CK). The high moisture observed in this sample could be as a result of the cooking process. High moisture content can affect the storability of the flour because it will be susceptible to mould growth. A significant moisture content reduction was observed in the germinated and fermented sesame sample GR, this can be due to modifications in germination. The food reserves are utilized to sprout the seeds and fermentation leads to hydrolysis of some macro nutrients (protein, carbohydrates) and converting them to simple sugars.

There was a significant ($p \leq 0.05$) difference in the protein content of the flour with values ranging from 15.84 to 40.80% this can be as a result of anti-nutrients present in the full fat sample, which were reduced in the germinated, fermented and roasted (RS) as well as the CK samples. The process of germination and fermentation reduces anti-nutrients present in sesame seed thereby releasing both micro and macro nutrients of sesame seeds. These values showed the importance of the heat and biological processes carried out on the sample.

A significant ($p \leq 0.05$) difference exists between the ash values of the sesame flour. The values ranged from 0.23 to 4.53% for ash content. The (RS) sample exhibited the highest ash content value. The high ash content of the roasted sample indicates the presence of some minerals. This increase could also be as a result of the sample's contact with the roasting medium.

The values obtained for the fat content ranged from 17.95 to 55.25%. An increase in the fat contents was observed for CK, having a value of 52.50% compared to that of full-fat sesame (FR) samples with a value of 40.75%. The values obtained for the fat contents are comparable to the fat content reported for sesame seeds by Bamigboye et al., (2010).

The values obtained for crude fibre ranged from 0.37 to 1.09 for the sesame flour samples. This result is similar to the results reported by Okafor et al. (2010). The high fibre content in

the (FR) and defatted sesame (DF) flour shows their role in digestion and easy bowel movement of the consumed meals.

There was a significant difference between the carbohydrate contents of the samples with values ranging from 18.42 to 33.88 %, with the FR sesame samples having the highest value and the RS and CK having the lowest. This can be a result of the hydrolysis of carbohydrate during fermentation and further cooking and roasting of the samples can reduce the carbohydrate content.

**Table 4.1. Proximate composition of sesame flour samples**

| Sample | MOISTURE% | ASH% | CRUDE PROTEIN% | CR. FAT% | Crude fibre% | Carbohydrat |
|---|---|---|---|---|---|---|
| FR | 3.31±0.20$^{b}$ | 4.53±0.61$^{c}$ | 23.55±0.15$^{d}$ | 40.75±0.25$^{d}$ | 1.09±0.05$^{a}$ | 26.49±0.29$^{b}$ |
| DF | 3.52±0.27$^{ab}$ | 2.65±1.36$^{b}$ | 40.80±0.10$^{c}$ | 17.95±0.05$^{e}$ | 1.02±0.04$^{a}$ | 33.88±1.27$^{a}$ |
| GR | 2.84±0.36$^{c}$ | 3.78±0.07$^{ab}$ | 15.84±0.00$^{e}$ | 55.25±0.25$^{a}$ | 0.58±0.07$^{c}$ | 21.71±0.07$^{c}$ |
| RS | 3.48±0.04$^{ab}$ | 4.47±0.49$^{a}$ | 24.16±0.03$^{a}$ | 49.10±0.20$^{c}$ | 0.37±0.04$^{d}$ | 18.42±0.05$^{e}$ |
| CK | 3.76±0.09$^{a}$ | 0.23±0.01$^{c}$ | 24.16±0.15$^{b}$ | 52.50±0.00$^{b}$ | 0.88±0.05$^{b}$ | 18.47±0.05$^{d}$ |

Mean values with different superscript in the same column are significantly different at {p≤0.05}

Where:

FR-Full fat sesame flour

DF-defatted sesame flour

GR –germinated and fermented sesame flour

RS-germinated, fermented and roasted sesame flour

CK-germinated, fermented and cooked sesame flour

## 4.2 Functional properties of flour blends

Table 4.2 shows the results for the functional properties of the sesame flour samples. There was a significant difference ($p \leq 0.05$) in the bulk densities of the different ratios of flour samples. Bulk densities ranged from 0.70 to 10.00 g/ml. The germinated and fermented sample (GF) showed the highest bulk density of 10.00g/ml, while the DF sample showed the lowest bulk density of 0.70 g/ml. This could be due to the particle size of the flour. The high bulk density of the GF sample could be attributed to the bulkiness of the sample, as a result of the high fat content. Samples FR and DF had similar bulk density. Bulk density is usually affected by the particle size and density of the flour and it is very important in determining the packaging requirement, materials handling and applications in food preparation (Wang *et al*., 2009).

The water absorption capacity determines the amount of water the flour will absorb during mixing. During mixing, DF sample will absorb the available water within the dough compared to other samples, this means that the flour is fit for baking as it will absorb enough liquid. There was a significant difference ($p \leq 0.05$) in the water absorption of the flour blends which ranged 0.05 to 1.81 g/g. RS sample had the lowest WAC of 0.05 g/g while DF sample had the highest WAC of 1.81g/g. There was no significant difference between the values obtained for samples FR and DF. The wettability increased as the water absorption decreased. The wettability ranged from 4.90 to 15.00 g/ml.

The foaming capacity was prominent in the FR and DF sample, while foam was not formed in samples: GR, RS and CK. The FR sesame sample having the lowest foam capacity of 4.05 g/ml and the defatted sample with the value of 9.90 g/ml, the high foaming capacity can be as a result of concentration of protein in defatted sesame sample being the first step in isolation of proteins in oil seeds. Foaming capacity is an indication of high protein content and samples with high foaming capacity is applicable to food products like ice cream, cakes, beer and so on.. The increase in oil production of samples; GR, RS and CK inhibited the formation of foam. This implies that the samples are not applicable to food products that require foam formation.

**Table 4.2 Functional composition of sesame flour samples**

| Sample | WAC g/ml | Foam Capacity g/ml | Wettability g/ml | Bulk g/ml |
|---|---|---|---|---|
| FR | 1.75±0.02[a] | 4.05±0.05[b] | 4.90±0.10[e] | 0.764±0.01[d] |
| DF | 1.81±0.01[a] | 9.90±0.10[a] | 6.30±0.30[d] | 0.70±0.25[d] |
| GR | 0.60±0.10[c] | ND | 15.00±0.00[a] | 10.00±0.00[a] |
| RS | 0.05±0.01[d] | ND | 7.70±0.30[c] | 3.85±0.05[b] |
| CK | 1.18±0.02[b] | ND | 8.73±0.73[b] | 3.45±0.05[c] |

Mean value with different superscript in the same column are significantly different at {$p \leq 0.05$}

Where: ND = Not determine

FR –full fat sesame flour

DF -defatted sesame flour

GR –germinated and fermented sesame flour

RS -germinated, fermented and roasted sesame flour

CK -Cooked-germinated, fermented and cooked sesame flour

4.3 Physico-chemical composition

There was a significant ($p \leq 0.05$) decrease in the level of oxalate content in each treatment with values ranging from 1.40 to 3.30. The DF sample showed the highest value for oxalate content while the least value was found in the GR samples. The biological and heat treatments had a significantly reduced effect on the oxalate content. The pH values of the samples ranged from 4.59 to 6.41 with the full fat sample being the highest and RS being the lowest. The pH value of the FR samples is close to the neutral pH 7, so it would be applicable to neutral food products. The other samples with lower pH could be applicable to acidic food products. The values obtained for phytate ranged from 1.45 to 2.50. A significant decrease was observed in the phytate levels with the FR sample being the highest and the RS being the lowest. The total titratable acidity of the samples range from 0.27 to 2.37. The levels of total titratable acid shows that the germinated samples can be stored and persevered due to the acid levels in the samples.

**Table 4.3 Physico-chemical composition of sesame seed flour samples**

| Sample | pH | Oxalate | Phytate | TOTAL SUGAR(mg/dL) | TTA ( g/L) |
|---|---|---|---|---|---|
| FR | 6.41±0.09$^{a}$ | 1.90±0.10$^{b}$ | 2.50±0.50$^{a}$ | 42.91±0.31$^{b}$ | 0.27±0.15$^{c}$ |
| DF | 5.83±0.05$^{b}$ | 3.30±0.10$^{a}$ | 2.20±0.00$^{ab}$ | 43.98±0.20$^{a}$ | 1.33±0.21$^{b}$ |
| GR | 4.76±0.07$^{c}$ | 1.40±0.20$^{c}$ | 1.45±0.05$^{c}$ | 39.69±0.30$^{c}$ | 2.37±0.15$^{a}$ |
| RS | 4.59±0.04$^{d}$ | 1.90±0.10$^{b}$ | 1.65±0.65$^{bc}$ | 34.11±0.42$^{d}$ | 1.43±0.70$^{b}$ |
| CK | 4.72±0.02$^{c}$ | 1.85±0.05$^{b}$ | 1.95±0.15$^{abc}$ | 31.71±0.42$^{e}$ | 0.83±0.15$^{bc}$ |

Mean value with different superscript in the same column are significantly different at {$p \leq 0.05$}

Where:

FR-full fat sesame flour

DF-defatted sesame flour

GR –germinated and fermented sesame flour

RS-germinated, fermented and roasted sesame flour

CK-germinated, fermented and cooked sesame flour

4.4 Mineral composition

There was a significant difference ($p \leq <0.05$) in the mineral content of the sesame flour samples, the mineral content showed an increase in the treated (DF, GR,RS) sesame samples over the FR sesame sample, this could be as a result of anti-nutrients present in them that chelate minerals in the FR sesame samples. The increased mineral content in the treated samples could be attributed to the better bioavailability of the minerals as a result of the treatments. There was no significant difference for the GR, RS and CK samples for some of the mineral elements analysed. The FR sample had the lowest mineral content and the DF sample had the highest mineral content. The calcium content of the flour ranged from 0.08% to 4.44%, the magnesium content ranged from 0.029% to 0.845%, the phosphorous content ranged from 0.034% to 0.653, the potassium content ranged from 0.190% to 0.383%, the iron content ranged from 0.106% to 0.260%, the zinc content ranged from 0.042% to 0.494% and the sodium content ranged from 0.089% to 0.493%.

**Table 4.4 Mineral composition of sesame flour samples**

| Sample | Ca Mg/Kg | Mg Mg/Kg | K Mg/Kg | P Mg/Kg | Na Mg/Kg | Fe Mg/kg | Zn Mg/Kg |
|---|---|---|---|---|---|---|---|
| FR | 0.080±0.001$^{e}$ | 0.029±0.002$^{e}$ | 0.034±0.001$^{d}$ | 0.19±0.0038$^{d}$ | 0.089±0.002$^{e}$ | 0.106±0.002$^{c}$ | 0.042±0.002$^{c}$ |
| DF | 4.443±0.002$^{a}$ | 0.845±0.002$^{a}$ | 0.653±0.002$^{a}$ | 0.383±0.002$^{a}$ | 0.493±0.003$^{a}$ | 0.260±0.002$^{a}$ | 0.494±0.004$^{a}$ |
| GR | 3.089±0.004$^{b}$ | 0.364±0.002$^{c}$ | 0.347±0.003$^{b}$ | 0.237±0.002c$^{d}$ | 0.290±0.002$^{b}$ | 0.139±0.003$^{b}$ | 0.053±0.003$^{b}$ |
| RS | 0.295±0.007$^{d}$ | 0.551±0.001$^{b}$ | 0.319±0.002$^{c}$ | 0.277±0.054b$^{c}$ | 0.278±0.003$^{d}$ | 0.139±0.002$^{d}$ | 0.049±0.001$^{b}$ |
| CK | 2.934±0.003$^{c}$ | 0.360±0.003$^{d}$ | 0.347±0.003$^{b}$ | 0.293±0.003$^{b}$ | 0.28±0.0022$^{c}$ | 0.101±0.001$^{b}$ | 0.051±0.002$^{b}$ |

Mean value with different superscript in the same column are significantly different at {p≤0.05}

Where:

FR-full fat sesame flour

DF-defatted sesame flour

GR –germinated and fermented sesame flour

RS-germinated, fermented and roasted sesame flour

CK-germinated, fermented and cooked sesame flour

4. 5 Sensory Evaluation of Flour Blend

Table 4.5 shows the results of the sensory analysis of prepared cookies from the sesame flour samples. The values ranged from 6.38 to 8.69 for appearance, 6.25 to 8.50 for taste, 3.38 to 8.68 for texture, 6.63 to 8.44 for aroma, and 6.88 to 8.68 for overall acceptability. The flour blend containing the DF, CK and 100% wheat control samples had no significant difference in their appearance at ($p \leq 0.05$). Only the GR sample was significantly different, with a value of 6.38. There was a significant difference between values obtained for taste, the control sample exhibited the highest value in taste, which showed no significant difference when compared with DF and FR sesame sample and the germinated, fermented and cooked sample. The texture values showed no significant ($p \leq 0.05$) different between the DF sample and the control sample and the rest of the samples (FR, GR RS, and CK) this may be due to nature of sesame flour after germination and fermentation.

There was no significant difference at *(*$p \leq 0.05$) in the taste and aroma of the samples, with the exception of the germinated and fermented sample.

For the overall acceptability defatted sample was the highest, for the other samples FR sample CK and control samples, had was no significant difference ($p \leq 0.05$). The overall acceptability was affected likely by the texture. Incorporation of sesame seeds flour into cookies improved its nutritional quality with acceptable sensory attributes. This could lead to improved healthy eating habit in children and adults.

The results of the evaluation also showed that cookies made from the sesame flour samples is acceptable as the control. The highest score was the DF sample (8.81), followed by the control sample and CK sample with the score 8.69 and 8.44 and the least value was obtained from GR sample with the value as 6.88.

**Table 4.5. Sensory composition of sesame flour samples**

| Sample | Appearance | Texture | Aroma | Taste | Overall acceptance |
|---|---|---|---|---|---|
| FR | 7.88±0.96$^{b}$ | 8.25±0.68$^{bc}$ | 8.25±0.77$^{a}$ | 8.31±0.87$^{a}$ | 8.06±0.77$^{b}$ |
| DF | 8.69±0.48$^{a}$ | 8.94±0.25$^{a}$ | 8.44±0.51$^{a}$ | 8.25±0.45$^{a}$ | 8.81±0.40$^{a}$ |
| GR | 6.38±0.81$^{c}$ | 6.63±1.09$^{d}$ | 6.44±0.96$^{c}$ | 6.25±1.00$^{c}$ | 6.88±1.02$^{c}$ |
| RS | 7.50±1.26$^{b}$ | 7.80±0.94$^{c}$ | 7.06±1.34$^{b}$ | 7.00±1.03$^{b}$ | 7.31±0.70$^{c}$ |
| CK | 8.63±0.50$^{a}$ | 8.31±0.70$^{bc}$ | 8.31±0.60$^{a}$ | 8.13±0.50$^{a}$ | 8.44±0.63$^{ab}$ |
| F | 8.63±0.50$^{a}$ | 8.44±0.73$^{ab}$ | 8.13±0.81$^{a}$ | 8.50±0.63$^{a}$ | 8.69±0.60$^{a}$ |

Mean value with different superscript in the same column are significantly different at {p≤0.05}

Where:

FR-Full fat sesame flour

DF-defatted sesame flour

GR –germinated and fermented sesame flour

RS-germinated, fermented and roasted sesame flour

CK-germinated, fermented and cooked sesame flour

F-(100%) wheat

# CHAPTER FIVE

## 5.0 CONCLUSION AND RECOMMENDATION

### 5.1 Conclusion

The heat and biological treatment done on sesame seed improved the nutrient content and the oil yield in the flour sample. The protein content present in the flour sample increased with each of the treatments. Incorporation of sesame flour into snack can lead to improve healthy eating habit in children and adults.

### 5.2 Recommendation

During the study physical attributes of the cookies could not be evaluated due to time factor. However further work could be carried out on the mineral composition and physical attributes of the cookie samples

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