SOMALI REGION PASTORAL & AGRO-PASTORAL RESEARCH INSTITUTE (SoRPARI)

FOOD SCIENCE AND NURTITION RESEARCH DIRECTORATE

RESEARCH REPORT SUBMITTED TO SOMALI REGION PASTORAL AND AGRO-PASTORAL RESEARCH INSTITUTE (SoRPARI)

MACRO AND MICRO-NUTRIENT ANALYSIS OF DIFFERENT SESAME VARIETIES PRODUCED/ADAPTED UNDER SoRPARI IN SOMALI REGIONAL STATE



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Executive Summary

The study was conducted in Somali Regional state with objective to analyze the macronutrient and micronutrient (minerals) content of different sesame varieties produced in Somali reginal state. Five different types of samples such as *Idaan, Adi, Barsan Local* and JLM control as control sample were collected. The collected sesame samples were individually grounded to a fine powder (30 mesh size), packed in air tight polyethylene plastic bags and were stored at 4°C until further analysis. Proximate composition such as crude Protein, crude Fat, crude fiber, moisture content, carbohydrate, total energy, different minerals like Calcium, Iron, Zinc and Total phosphorous were determined by AOAC. Based on the result all locally adapted those sesame varieties adapted by the Somali region research institute were better in both macro and micro nutrients especially when it comes fiber, protein, total ash, moisture content as compared to the control sample with brand name *JLM control* which is purchased from Jigjiga local market. Fat content is exceptional which means the control sample has high amount fat as compared to samples. There is significant different in different components of sesame between different varieties at $p<0.05$. Significance difference were also observed at $p<0.05$ in minerals content such as Calcium, zinc, iron and Total Phosphorous. Overall, from the finding we conclude that, almost all locally adapted and the control sesame varieties have better in nutritional content especially moisture, ash, protein fat, and fiber and very poor in carbohydrate content. Therefore, all actors should engage in mass production of sesame with improved varieties so as to get more income and currency from abroad.

Key words: Sesame, macronutrient composition, micronutrient composition, oil content.

CHAPTER ONE

1. INTRODUCTION

1.2. Background

Sesame (Sesamum indicum L.) is herbaceous annual plant belonging to the Pedaliaceae family [1]. Sesame seed is also known as benniseed (Africa), benne (Southern United States), gingelly (India), gengelin (Brazil), sim-sim, semsem (Hebrew) and tila (Sanskrit) [2]. It is one of the world's important and oldest oilseed crops [3, 4] and has been used extensively for thousands of years as a seed of worldwide significance for edible oil, paste, cake, confectionary purposes and flour due to its highly stable oil contents, nutritious protein (rich in methionine, tryptophan and valine) and savory nutty roasted flavor [4, 5].

It is cultivated widely in India, Burma, Indo-China, Japan and some parts of Africa, the Mediterranean and, more recently, in the USA, Mexico and other Latin American countries [6]. The seeds of different varieties have various colors, such as creamy white, dark red, brown, and yellow [7]. Among the important uses of sesame seed is the production of high quality odorless vegetable oil, which can substitute for olive oil [6]. The oil has found many uses in industry e.g. for manufacture of soap, cosmetics, perfume and pharmaceutical products [6]. The oil contains, in addition to phytosterol and tocopherol, two compounds which are not found in any other oil, namely sesamolin; this, upon hydrolysis, yielded sesamol, which is responsible for the antioxidant behavior of sesame seed crop oil [6].

Oilseeds cover a total of 7.63% (about 855,000 hectares) of the grain crop area and 3.83% (6.6 million quintals) of yield production to the national grain production. For instance, Neoug (Niger seed), sesame and linseed covered 2.8%, 2.48% and 1.61% of grain crop area, respectively; and about 1.11%, 1.27% and 0.91% of the grain production, respectively [8]. Study reports indicate that Ethiopia is among the six producers of sesame seed, linseed and niger seed in the world [9]. The major sesame seed producing regions are situated in the North West and South West Ethiopian in Humera, North Gondar and Wollega [9-11]. The major sesame producing areas are situated in the low land of Tigray, Gambella, Benshangul Gumuz, Somali, Amhara, Southern and Oromia regions of Ethiopia [9].

Most of the sesame traded in the world is light seeded, but seed coats of local varieties can vary from white to buff, tan, gold, brown, reddish, gray and black [12]. Some of the variations in the seed are hundred seed weight that can range 0.11 - 0.46 g [13], protein 19% - 30% [14, 15], oil 34.4% - 59.8% [14], carbohydrates 6.4% - 21.0% [16]. In Ethiopia, improved sesame seed varieties were developed through researches that have good disease resistance, improved yields, different oil composition, size and color [8, 17, 18]

Sesame contains important minerals and vitamins such as Ca, P, and Fe, niacin and thiamin [16] [19, 20]. It has also some potential of nutraceutical compounds such as phenolic and tocopherols with antioxidant activity that have significant effect on reducing the blood pressure, lipid profile and degeneration of vessels and an impact in reducing chronic diseases [21-23]. On the other hand, other chemical components such as anti-nutritional factors such as phytate, trypsin, α-amylase inhibitors, lectin, and tannins are in existence in sesame seeds and can limit their utilization in the food system [24-27].

1.2. Statement of the problem

Sesame (SesamumindicumL.) is one of the most ancient oilseed crops known to mankind and cultivated plant and thought to have originated from Africa and India. Sesame is one of the most important oilseeds crops worldwide. It is an important oilseed crop grown for local consumption and export in Ethiopia and it is the first in area of production and as export oil crop among oilseed crops in Ethiopia [28]. In Ethiopia, the production of sesame is both by small- and large-scale farmers; and it is an important crop and export commodity. Oilseed crops are major sources of lipids for human nutrition as well as for several industrial purposes[29]. They are defined as those seeds that contain considerably large amounts of oil. The most commonly known oilseeds (conventional oil seeds) are groundnut, soybean, palm kernel, cotton seed, olive, sunflower seed, sesame seed, linseed, etc. [30].

The demand for vegetable oil has been increasing as most indigenous plants and seeds are rich in essential nutrients and also have a wide range of medicinal values [40]. Sesame (Sesamum indicum L.) is an oilseed herbaceous crop of the Pedaliaceae fam is produced by only a few developing countries in the world due to its high demand for labor farming and harvesting [44]. About 96% of the world sesame production is contributed from Asia and African countries. Considering a 10-year average report (from 2008 to 2018), the top ten sesame producers are Myanmar, India, Tanzania, Sudan, China, Nigeria, Sudan (Former),

Ethiopia South Sudan, and Burkina Faso, in the same order (http://www.fao.org/faostat/en/#data/QC/ visualize, accessed on 12th August 2021).

Study reports indicate that Ethiopia is among the six producers of sesame seed, linseed and niger seed in the world [7]. The major sesame seed producing regions are situated in the North West and South West Ethiopian in Humera, North Gondar and Wollega [8-10]. The major sesame producing areas are situated in the low land of Tigray, Gambella, Benshangul Gumuz, Somalia, Amhara, Southern and Oromia regions of Ethiopia [7]. Sesame production is increasing in the country due to increase in demand and price. Thus, sesame cultivation is expanding to new potential growing areas [45].

Sesame is an important annual oilseed crop being cultivated as an ingredient for human food oil, meal, and animal feeds [41, 42]. The sesame seed oil contains saturated fatty acid, unsaturated fatty acids, proteins, and various minor nutrients such as vitamins and minerals, lignans, such as sesamin, sesamol, sesamolin, and tocopherols [34, 36, 37]. The seeds are also very rich in iron, magnesium, copper, calcium, and vitamin B1 (thiamine) and E (tocopherol), and phytosterols [38, 39, 41]. Sesame seed oil is renowned for its stability because it strongly resists oxidative rancidity even after long exposure to air [35].

These days, there are several varieties and genotypes of sesame adapted to different geographical conditions. However, the cultivation of modern varieties is limited due to insufficient genetic information [43]. According to some studies the seed is believed to exist in 16 genera and 60 species, most of which exist in Africa [43]. Due to the high market demand and adaptability to several environmental factors, sesame production is increasing year to year in different countries [44]. In Ethiopia, sesame seed production and export alone are twice larger than all other oil seeds together. In Ethiopia, both black and white sesame seed varieties are cultivated but the oil yield, the dominant fatty acid constitutes of the oils and phenolic compounds of these sesame seed varieties cultivated in these districts have not been reported so far, though the country is one of the major sesame seed producers and exporters from Africa.

As sesame seed is nutritionally important in some parts of the world, few reports were documented about color, size and oil content of Ethiopian sesame seeds in the literature [17-19] and oil characteristics [28]. So, limited scientific research has been done on the physico-chemical composition of sesame varieties. The scientific information generated from this

research could serve as an important input for production, marketing, food industry, human nutrition and maximum utilization, particularly for the benefits of sesame growing areas. Therefore, the objective of this study was to investigate some, proximate, mineral compositions of different sesame varieties grown under SoRPARI potential areas and Somali Region in Ethiopia.

1.3. Objective

1.3.1. General Objective:

The general objective of the study is to evaluate the nutritional quality of different sesame varieties grown under SoRPARI and other local or marketed one.

1.3.2. Specific objective

The specific objectives of the research were;

- To assess the macronutrient composition of different sesame varieties grown under SoRPARI and other local or marketed one
- To assess the micronutrient composition of different sesame varieties grown under SoRPARI and other local or marketed one

1.4. Significance of the study

This study so important as it is the 1st in its nature to conduct such study on different sesame varieties macronutrient and micronutrient analysis that grown in Somali region. The outcome of the study is important to get up to date data on the nutritional composition of the different sesame varieties grown in SRS. The result obtained from this study is further be important for future researcher as baseline information to conduct their research. Based on the recommendation come out from this study, policy maker, government, non-Government organization and other interested institutions working on the area is expected to get up to date information form the study.

CHAPTER TWO

2. LITRATURE REVIEW

2.1. Introduction

Sesame (Sesamum indicum L.), otherwise known as sesamum or benniseed, member of the family Pedaliaceae, is one of the most ancient oilseeds crop known to mankind. Sesame plays an important role in human nutrition. Most of the sesame seeds are used for oil extraction and the rest are used for edible purposes [31]. Sesame is grown primarily for its oil-rich seeds. Before seeds were appreciated for their ability to add nutty flavour or garnish foods, they were primarily used for oil and wine [32]. After the extraction of oil, the cake is mostly used for livestock feed or often as manure. Its colour varies from cream-white to charcoal-black but it is mainly white or black. Other colours of some sesame seed varieties include, yellow, red or brown [33]. In Nigeria, the notable colours for sesame seed are white, yellow and black [34]. The lighter varieties of sesame which are considered to be of higher quality are generally more valued in the West and Middle East, while both the pale and black varieties are prized in the Far East. (www.wikepedia-sesame). There are numerous varieties and ecotypes of sesame adapted to various ecological conditions [35].

The major world producers include India, Sudan, China and Burma (who contribute about 60% of the total world production) [31]. It is also one of main commercial crops in Nigeria, Sudan and Ethiopia (www. nutrition and you). Study reports indicate that Ethiopia is among the six producers of sesame seed, linseed and niger seed in the world [9]. The major sesame seed producing regions are situated in the North West and South West Ethiopian in Humera, North Gondar and Wollega [9-11]. The major sesame producing areas are situated in the low land of Tigray, Gambella, Benshangul Gumuz, Somali, Amhara, Southern and Oromia regions of Ethiopia [9]. Sesame is an important crop to Nigerian agriculture: it is quite extensively cultivated especially in Northern Nigeria. It yields in relatively poor climatic conditions, and it is widely used within Nigeria. Moreso, it is an important component of Nigeria's agricultural exports [36].

Sesame seed is rich in fat, protein, carbohydrates, fibre and some minerals. The oil seed is renowned for its stability because it strongly resists oxidative rancidity even after long exposure to air [37]. The oil fraction shows a remarkable stability to oxidation. This could be attributed to endogenous antioxidants namely lignins and tocopherols [15].

The seed is rich in protein and the protein has disable amino acid profile with good nutritional value similar to soybean [38]. The chemical composition of sesame shows that the seed is an important source of oil (44-58%), protein (18-25%), carbohydrate (~13.5%) and ash (~5%) [39]. Sesame seed is approximately 50 percent oil (out of which 35% is monounsaturated fatty acids and 44% polyunsaturated fatty acids) and 45 percent meal (out of which 20% is protein) [32, 33].

Sesame seeds are small, almost oblate in shape and have a mild and delicious aroma and taste. Sesame seed is used whole in cooking and also yields sesame oil (www.wikepedia,sesame; [33]. It has a rich nutty flavour (although such heating damages their healthful polyunsaturated fats) and is used mainly as a food ingredient in whole, broken, crushed, shelled, powdered and paste forms. Its use is country based, in the US; it is used as some form of whole seed product for the confection and baking industries. A small percentage percent of total production is however processed into oil, meal or flour [33].

Sesame seeds are not only used for culinary purposes but also in traditional medicines for their nutritive, preventive and curative properties. Its oil seeds are sources for some phyto-nutrients such as omega-6 fatty acids, flavonoid phenolic anti-oxidants, vitamins and dietary fiber with potent anti-cancer as well as health promoting properties (www.nutrition-and-you). Sesame oil is an edible vegetable oil derived from sesame seeds used in various countries. It is used as a cooking oil in South India and Asia and often as a flavor enhancer in Chinese, Japanese, Korean, and to a lesser extent Southern Asia cuisine (www.wikepedia-sesame.oil).

It is stable and free from undesirable nutrition or flavor component. Beniseed oil has a natural oxidant which prevents aging and is vital for the production of liver cells [38, 40]. The oil also contains oleic (35.9-47%), linoleic (35.6-47.6), palmitic (8.7- 13.8%), stearic (2.1-6.4%), as well as arachidic acids (0.1-0.7%) [15, 39].

2.2. History

Sesame seeds are the seeds of the tropical annual Sesamum indicum. The species has a long history of cultivation, mostly for its yield of oil. The oil plant has been grown since the beginning of arable cultivation, and originates from the dry bush savannah of tropical Africa, and spread from there to India and China, where it is still widely cultivated [33]. The original area of domestication of sesame is obscure but it seems likely to have first been brought into

cultivation in Asia or India (www.nigeriamarkets.org). Archeological records indicate that it has been known and used in India for more than 5,000 years and is recorded as a crop in Babylon and Assyria some 4,000 years ago [39].

Sesame was cultivated during the Indus valley civilization and was the main oil crop. It was probably exported to Mesopotamia around 2500 BCE and was known in Akkadian and Sumerian as 'ellu'. Prior to 600 BC, the Assyrians used sesame oil as a food, salve, and medication, primarily by the rich, as the difficulty of obtaining it made it expensive. Hindus used it in votive lamps and considered the oil sacred.

Study on sesame reported that one Assyrian legend records that when the Gods met to create the universe they were served with wine produced from sesame[41]. Some people believe that the seed originated from India as old Hindu legends signified the seed as symbolizing immortality. According to believers of this narrative, the seed was introduced from India to Asia, Africa and the Middle East. Oil produced from the sesame crop is regarded as one of the first edible oils known to man whiles the seed itself is one of the oldest condiments to be consumed.

Sesame seeds were introduced in to the United States of America by slaves from Africa during the later part of the 17th century and soon became

popular food ingredient in recipes from the South [41]. From archeological records, sesame was determined to be widely cultivated in Babylon and Assyria over 4,000 years and was also known to Indians in about 5,000 years ago [39].

2.3. Production of sesame seed

Global production of sesame seed is estimated by FAO at 3.15 mn tonnes per year (2001) having risen from 1.4 mn tonnes in the early 1960's. However only a small proportion of the global sesame harvest enters international trade. For the most part, the oil is expressed locally and used locally for cooking or the seeds themselves are eaten, particularly after being fried. Sesame is grown in many parts of the world on over 5 million acres (20,000 km2). The largest producer of the crop in 2007 was India, China, Myanmar, Sudan, Ethiopia, Uganda and Nigeria. Seventy percent of the world's sesame crop is grown in Asia, with Africa growing 26% [33].

The largest producers are China and India, each with an annual harvest around 750,000 tonnes followed by Myanmar (425,000 tonnes) and Sudan (300,000 tonnes). These figures are only rough estimates of the situation as sesame is a smallholder crop and much of the harvest is consumed locally, without record of the internal trade and domestic processing. Nigeria has a great market potential for sesame seed production for domestic and export markets noting that the production figures of the commodity has been on a steady increase since 1980, reaching 67000 MT by 1997 and was estimated to reach 139, 000 MT by the year 2010, according to the federal ministry of agriculture and natural resources [42]. This is agreement with the 2008 annual report of the Central Bank of Nigeria which states there has been a rise in production of sesame seed from 98,000,000 to 152,000,000 kg from 2003 to 2007 [43].

In Ethiopia, the major sesame producing areas are situated in the low land of Tigray, Gambella, Benshangul Gumuz, Somalia, Amhara, Southern and Oromia regions of Ethiopia [10]. Sesame production is increasing in the country due to increase in demand and price. Thus, sesame cultivation is expanding to new potential growing areas [44]. However, there are limited reports on the biochemical compositions and fatty acids profile of Ethiopian sesame genotypes and their implications on oil yield and quality improvement [45]. The quantity and quality of the chemical composition and fatty acid profile of sesame seeds have been shown to depend on ecological factors and varieties [46].

2.4. Varieties of sesame

Sesame seeds come in different colours depending on the variety. The colours range from creamy-white to charcoal black, but some cultivars can be yellowish, red or brownish [33, 47] revealed that the paler varieties of the seeds are regarded to be of superior quality and are preferred in the Middle East and the Western world whiles people from the Far East prefer the black cultivars. A study in Nigeria discovered that the commonest varieties of sesame seeds found in Nigeria are the white, yellow and black varieties (Fariku & Bitrus 2007)[34]. Several varieties and ecotypes of the seed however exist and have adapted to different ecological conditions around the world [48].

Table 2.1: Composition of the Four Main Varieties of Sesame Seeds

Variety	Origin	Purity	Admixture	Moisture	Oil content
Red	West Bangladesh	99%	1%	8% Maximum	40-42% Minimum
Brown	Bangladesh	99%	1%	7-8% Maximum	45-50% Minimum
Black	Assam (India)	99%	1%	8% Maximum	48% Minimum
White	Assam, Tripura (India)	99%	1%	8% Maximum	48% Minimum

Source: Orchid Exim (India) Pvt. Limited (2012) [49]



Figure 2.1: White sesame seeds



Figure 2.2: White sesame seeds



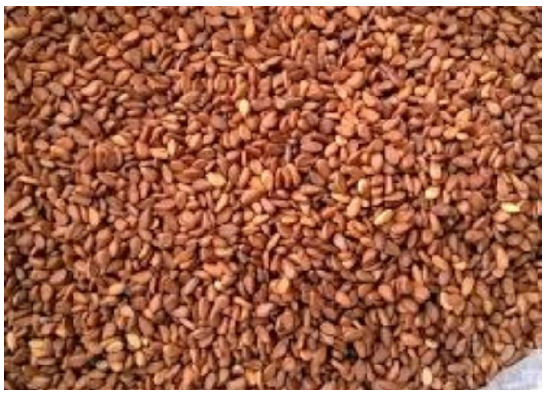


Figure 2.3: Brown sesame seeds Figure 2.4: Red sesame seeds

Source: Orchid Exim (India) Pvt. Limited (2012))[49]

2.5. Nutritional benefits of sesame seed

Sesame seed (Sesamum indicum L.) is an oilseed with a chemical composition of about 50-52% oil, 17-19% protein and 16-18% carbohydrate. 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 fiber, 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 [50]. 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 [51]. The nutritional benefits derived from sesame seeds are based on the variety being utilized.

Sesame seed (Sesamum indicum L.), from Northern Congo were reported to contain 5.7% moisture, 48.5% crude oil, 20% crude proteins, 7.78% carbohydrate (by difference), 9.4% crude fiber and 4.2% ash [35, 48]. The protein content of White Sudan sesame seed was high (~25%) similar to other foodstuffs rich in proteins such as almond, hazelnut protein the contents of which were respectively, 20% and 21% [39]. The ash content in raw sesame was relatively high (~5%) compared to other products of great consumption such as almond (3%), and the pistachio (2.7%) [39]. Other Sudanese local and improved varieties considered by [31] had protein content of 32.50 to 35.94 and 33.43 to 40.00 respectively.

The seeds also contained significant amount of important minerals with the Potassium concentration being the highest, followed by Phosphorus, Magnesium, Calcium and Sodium [35]. For White sesame seed (S. indicum L.) from Sudan, oil was 52.24%, protein 25.97%, fibre 19.33% and ash 4.685 [31]. The predominant mineral composition was calcium

followed by potassium, magnesium and phosphorus. All other elements were present in comparatively low concentrations [15]. Potassium is an essential nutrient and has an important role is the synthesis of amino acids and proteins. Calcium and Magnesium plays a significant role in photosynthesis, carbohydrate metabolism, nucleic acids and binding agents of cell walls. Calcium assists in teeth development Magnesium is essential mineral for enzyme activity, like calcium and chloride; magnesium also plays a role in regulating the acid-alkaline balance in the body. Phosphorus is needed for bone growth, kidney function and cell growth. It also plays a role in maintaining the body's acid-alkaline balance. The presence of these minerals also confirms the fat that sesame seed is of high nutritional benefit to its consumers.

Sesame contains high levels of essential vitamins and minerals and also serves as an importance source for B-complex vitamins like niacin, thiamine (vitamin B1), pyridoxine (vitamin B6), folic acid and riboflavin. 100g of the seed carry 97µg of folic acid, which is approximately 25% of the daily recommended intake. Folic acid being vital for DNA synthesis helps prevent neural tube defects when given to expectant mothers during pregnancy. Niacin is also another important B vitamin that is abundant in sesame seeds. The recommended daily intake is 4.5mg or 25% of niacin which can be obtained from just a 100g of sesame seed. The presence of niacin in the body contributes to the reduction of LDL cholesterol concentrations in the blood and helps boosts GABA activity in the brain, which is responsible of reducing anxiety and neurosis [49].

2.5.1. Oil Content

Sesame oil is referred to as teel oil or benne oil and is a pale yellow, oily liquid and almost odourless with a bland taste. Sesame oil contains antioxidants, glycerides and four fatty acids namely palmitic, stearic, oleic and linoleic acids. Study done on the evaluation seventy promising Indian genotypes of sesame for oil content and fatty acids and reported that the seed oil content ranged from 46.2 to 56.8 per cent[52]. Another study done on the analysis of 410 germplasm lines of sesame and reported that average fat content was 53.1 per cent[53]. The fat consisted primarily of six fatty acids, of which oleic acid and linoleic acids were the main components (41.3 and 43.7%), respectively.

Study on the comparison of oil content and fatty acid composition of the total lipids in the cultivated sesame {Sesamum indicum L.) and three wild species (5. alatum Thonn, 5.

radiatum Schum and Thonn and S. anqusti folium {Olive Engl.)[54]. The wild species was found to contain less oil (30%) than the cultivated one (50%). Other research reported oil content to be negatively correlated with the intensity of seed colour. The darker seed had a lower oil content than lighter seed colour. This factor which converts seed colour is apparently also responsible for the decrease in oil content[55]. [56] noted that dark sesame seeds had significantly higher oil content than white ones. Oil content was 47.02 and 49.07 per cent in white and dark coloured seeds, respectively. There was also difference in the composition of fatty acids in black and white seeds.

Sesame seeds are important source of edible oil which was reported to be approximately 50 per cent. The oil content and fatty acid composition of determinate and indeterminate genotypes of sesame and noted that determinate genotypes had lower seed and oil yields but better fatty acid composition than indeterminate genotypes[55].

2.5.2. Protein content

Sesame seed is a rich source of protein and has high methionine, cystine and tryptophan content. In general, the legumes are deficient for these amino acids and hence sesame in combination with legume provides a balanced diet. [56] determined protein content and amino acid composition of two genotypes of sesamum indicum. The dark sesame seeds had significantly lower protein content than white colured seeds. Amin and Kothari introduced ten genotypes of sesame having protein content in the range of 24-28 per cent[55].

[57] determined quality characteristics of three Turkish varieties of sesame seeds (white, semi-red). They found that in defatted seeds, protein content varied from 42.70- 44.10 per cent, the maximum value was in the red colored sample. [58]compared the protein content of ten sesame local and introduced varieties of sesame. Local variety contained more protein (21.71-30.28%) and essential amino acids than introduced varieties. Some research found that application of nitrogen generally increased the protein content of sesame seeds from 19.4-20.9 per cent and reported that delay in sowing significantly increased protein content in the seeds[55].

[55]investigated the physical and biochemical properties of four different varieties of sesame seed i.e. white, brown, red and black, out of which seed meal from ones had highest protein content ranging from about 40 to 45 per cent. Application of organic waste compost on sesame cultlvars showed no variation in total protein. [55]determined the change in protein

content of five varieties of sesame grown under rainy season. [59]compared molecular weight and related hydrodynamic parameters of high molecular weight protein from a few oilseeds, arachin from groundnuts alpha-globulin from sesame, brassin from B. juncea and helianthin from sunflower.

Table 2.2: Nutrient profile of per 100 g value of whole dried sesame seed.

Principle	Nutritional Value	Percentage of RDA
Energy	575 Kcal	29%
Carbohydrate	23.45g	18%
Protein	17.7 g	32%
Total Fat	49.67g	166%
Cholesterol	0 mg	0%
Dietary Fibre	11.8g	31%
Vitamins		
Folates	97 µg	25%
Niacin	4.51 mg	28%
Pantothenic acid	0.050mg	1%
Pyridoxine	0.790 mg	61%
Riboflavin	0.247mg	19%
Thiamin	0.79 mg	66%
Vitamin A	9 IU	<1%
Vitamin C	0	0%
Vitamin E	0.25mg	<2%
Electrolytes		
Sodium	1 mg	1%
Potassium	468 mg	10%
Minerals		
Calcium	975mg	98%
Copper	4.082 mg	453%
Iron	14.55mg	182%
Magnesium	351mg	88%
Phosphorous	629mg	90%
Selenium	34.4µg	62.5%
Zinc	7.75mg	70%
Phytonutrients		
Carotene-ß	5 µg	
Crypto-xanthin-ß	0µg	
Lutein-zeaxanthin	0µg	

Source: USDA National Nutrition Database (2019) [60]

2.6. Uses of sesame

2.6.1. For culinary purposes

Sesame is utilized as an important ingredient in human food as well as animal feed. It is primarily grown for its oil. The major market for the seed is the U.S.A where the food

industry incorporates the seed into several baked foods and confections. Sesame oil is also considered to be the finest when compare with oils used for cooking. The oil is also seen to be highly stable when compared to others and this stability is largely attributable to the presences of antioxidants in it. The primary oil used for cooking the Eastern part of Nigeria comes from sesame. The crop is largely grown in that part of the country purposely for its rich oil [61]. Oil produced from sesame is odourless, good tasting and is straw-like in colour.

Sesame oil is among the few plant-based oils that needs no refining before it can be used for cooking. It requires less winterization as it is a naturalsalad [61]. The smoke point for light sesame oil is higher than that of dark sesame oil. This makes the former the most preferred oil for deep frying. The latter can however be effectively used

for stir frying meat and vegetables as well as making omelets. [62]. Sesame oil is widely used in a lot of East Asianand Mexican cuisines. Soap production, canning of sardines and beef, magarine production, shortening and confectionary production are the other areas where sesame oil is widely used[38].

The seed has a delicate nutty flavor and can be eaten whole as a nutritious foodstuff. Its unique flavor is enhanced when it is gently roasted at low temperature for a short period of time [33]. Sweet confections are commonly produced from ground sesame seeds. In the middle East and Asia honey or syrup is often added to sesame seeds to produce candy while in Japan paste and starch produced from sesame are used in making "goma-dofu".

Sprinkling the seeds on desserts and salads and its incorporation in ice cream-based preparations are additional uses of the sesame seed [61]. Various cultures have varied cultural uses of sesame. Whiles the industrial usage and processing of the seed has not yet been attained in Nigeria, it is nonetheless used locally in varied forms in Nigerian states where cultivation of the crop is common.

Products such as "Kantun Ridi" and "Kunun Ridi" are made from sesame. The locals after extracting the oil from the seed produce a cake('kulikuli) from the paste which is used with the sesame leaves to prepare a local soup known as "Miyar Taushe" [61]. The Japanese make "gomashio" from sesame seeds. This is largely made from roasted black or tan sesame varieties. The Greeks use sesame in the production of cakes whiles the Togolese use it as a main soup ingredient. The French and

Sicilians eat the seed on bread called "ficelle sésame"and sesame thread. Ground sesame known as “wangila” is a delicacy in Northern Angola and Congo and is often prepared with lobsters or smoked fish.

In Manipur (North Eastern State of India), black sesame is used in the preparation of a favorite side dish called 'Thoiding' and in 'Singju' (a kind of salad). Also in Tamil Nadu, India, a ground powder, Milagai Podi, made of sesame and dry chili is used to enhance flavor and consumed along with other traditional foods [61]. In Togo, the young leaves are eaten as vegetable [63].

The dehulled seed can also be processed into a paste known as tahini and used for cooking and confectionery. Tahini is extensively used as a food ingredient in the Middle East and Mediterranean regions. Sesame is similarly used extensively either in its hulled or dehulled form in the bakery sector of Europe and North America as a garnish for products such as bread, cakes rolls, crackers, and pastry other products [48]. The process of dehulling the seed remains the major challenge for users who prefer the seedin this form as this has traditionally been done manually by rubbing the skinoff previousely soaked seeds with the hand. Mechanical devices have howeverbeen developed lately to ease the process of dehulling.

2.6.2. For medicinal purposes

Sesame is regarded in sections of Asia and Africa as folk medicine with every part of the crop being utilized for medicinal [64]. [65] noted that the oil from the seed beside being used for cooking, was alsoused as a tonic, diuretic, nutrient and aphrodisiac. It was also used in the

treatment of other medical condition as inflammations, asthma, lung diseases, dry cough, ulcers, urinary diseases, vertigo and migraine [65]. In that very year, Jadeja et al 2006 reported that the extracts from the seed was also used for treating haemorrhoids[66]. They also noted abdominal pain as another condition that crushed sesame seeds was adopted in treating [63, 66, 67] highlighted the presence of phenols and lignan glycosides in the seeds and the antihypertensive effect of sesamin (a lignan from sesame oil).

i. Treatment for respiratory diseases

Patil et al. (2008) noted the extensive use of the seed in Jalgaon district of Maharashtra as local medicines for the treatment of respiratory disorders. Locals add the seed to Trachyspermum ammi Linnand (a pungent seedlike fruit in India usually used as seasoning and for its medicinal properties) and use this for the treatment of asthma, lung diseases, dry cough and common cold[68]. Similarly, [63] reports how the immature leaves of the plant is used as medicine in the treating respiratory diseases and the soothing effect of the seed oil is used for treating chest complaints.

ii. Treatment for prostatic diseases

In their study of phytotherapy in Yaounde (the capital of Cameroon), [69]recommended sesame use for treating and preventing prostatic ailments. In this treatment, a spoonful of sesame oil is taken two times a day for a period of 2 to 3 months.

iii. A wound healer

[64] cited in their research that, civilizations as far as several thousands of years to date have used sesame seed oil as healing oil. [70]concurred with this assertion when he reported that the fruit from the plant when fried in mustard oil is effective in healing wounds. In another report published by [70]noted that natives of the Bodo tribe in Assam rely on parts of the plant such as roots, leafs, and fruit paste to heal wounds.

iv. Treatment for gynaecological problems

As highlighted by [71] sesame is also applied in the treatment of gynaecological problems in certain communities and the people of Haryana is a typical example. They blend partially ground seeds in “gud” and “ghee” and take it with milk during mensuration as relieve to amenorrhea.

v. Treatment for urinary troubles

In their study in Pakistan, [72] claimed that bed wetting among children can be cured by administering to them few grams of sesame slightly roasted in "ghee". Native of north-east Gujarat are also reported to use sesame to cure urinary problems [73]. And also, content that the acrid taste of sesame has a soothing and diuretic effect, and this is useful in urinary concretions, strangury and burning sensation.

vi. Aids for digestive problems

Intestinal disorders such as dysentery and diarrhea have also been considered ailments that sesame effectively treats. Inflammation of membranes in the mouth are treated with warm water leaves infusion used as gargles[64]. [63],in their study agreed with the use of sesame oil as a purgative.

vii. A relief for earaches and eye pains

The use of oil extracted from sesame for treating ear aches and secretions was proposed by [74]. The oil is often heated with "lahsun" (Allium sativaum Linn.) and drops of this is put in the ears prior to going to bed. [64] recounts how native from South Western Nigeria treat catarrhand eye pains with decoction of the leaves.

viii. A benefit for skin and hairs

Many researchers have confirmed the effectiveness of frequent application of sesame oil on scalp in the prevention of hair lost and promoting hair longevity[75]. [66] further states that sesame seed is a major source of hair oils extracts used for skin protection and rejuvenation. Skin eruptions and bruises are treated with decoction of sesame leaves in parts of South-Western Nigeria [47]. Some Asian immigrants in some American state as Georgia, Atlanta, were also noted by [76] to use black sesame for improving skin complexion and for use as blood tonic.

ix. Potency against ailments

[77] asserted the use of sesame oil as a local antidote for Bhallatak toxicity. Sesame has also been noted to be used as an aid to improving certain deficiencies. They also reports that sesame oil is added to toasted leaves of *Halophila ovalis*, *Hook.f.* and *Halophila gaudichaudii* and consumed over a period of three days to aid in the treatment of iron deficiency[77]. [64] reports the antiviral and antifungal properties of sesame and confirms how decoction of its leaves and roots are potent for fighting against ailments such as chicken pox and measles

(anti-viral) and similarly used as hair shampoo for treating Taenia capitis(antifungal).

2.6.3. For other purposes

Sesame is also used for so many purposes in different spheres of life. Industrial use of sesame in the personal care sector is extensively documented. Its oil is used in industrial formulation of perfumery and cosmetics. In the pharmaceuticals sector, sesame is widely used for the preparation of several drugs.

Likewise, paints, insecticides, and varnishes are other products that utilizes sesame [78]. [61]adds to this when they indicated the use of sesame oil as solvent in injected drugs or intravenous drip solutions and a cosmetics carrier oil. They also content that oil is used to coat grains meant for storage in a bid to ward off weevil attacks[61].

Inferior grades of the oil is also reported by [61]to be used in the manufacture of local soap, lubricants, and illuminants[61]. The oil is similarly the base ingredient for the production of paints and inks. Other products such as vermicides, bactericided, antiseptics, disinfectants insect repellants, and anti-tubercular agent employs the antioxidant lignans in sesame seed (sesamolin and sesamin) as their primary ingredient and this has proven to be helpful to both man and animal health [79]. Mixed with methanol and sodium hydroxide, sesame oil can serve as a substitute for diesel fuel [80].

CHAPTER THREE

3. MATERIALS AND METHOD

3.1. Structure of the experiment work

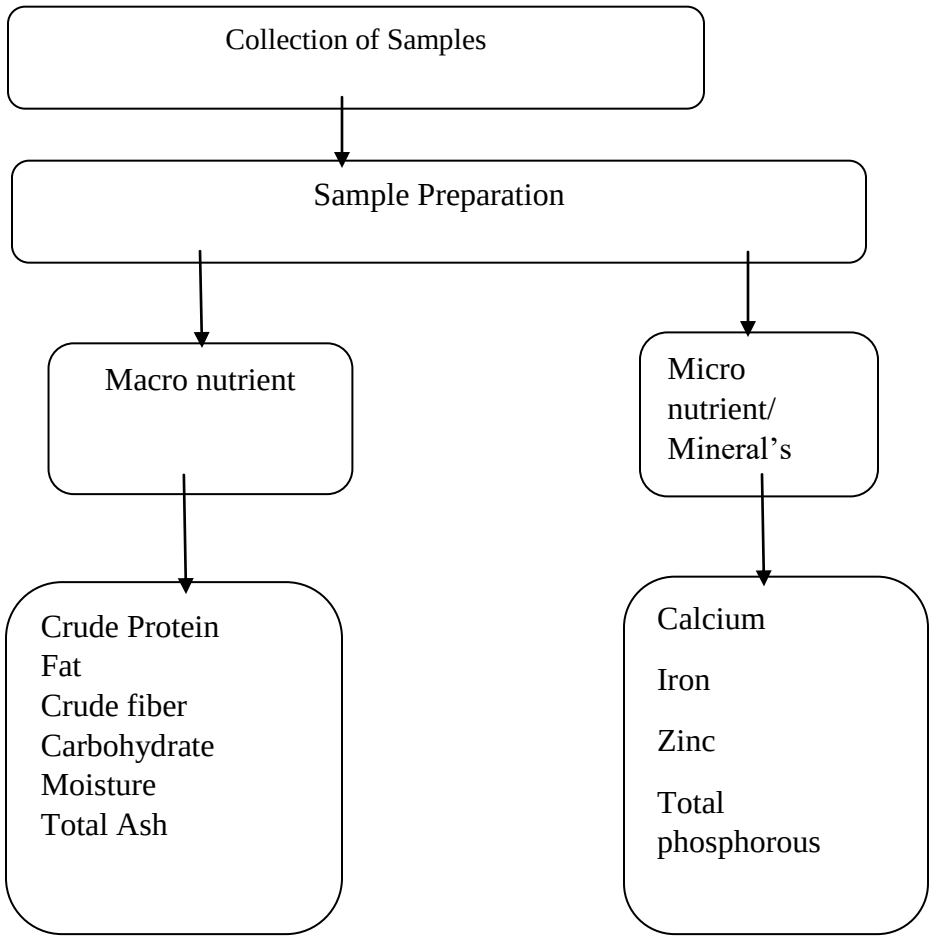


Figure 3.1: Structure of the experiment work

2.1. Materials and Equipment Used

Four different sesame varieties produced/adapted under SoRPARI were collected from Kelafo research sub center and one popular widely marketed variety as a control was purchased from the local market. The five varieties produced or adapted under SoRPARI that were used for this study includes Adi, Local, Barsan sesame, Iidan sesame whereas the control sesame sample was

purchased from Jigjiga City local market. Only whole sesame grains without any physical damage or insect infestation were selected for analysis. All equipment used in sample preparation was expected to be obtained from SoRPARI laboratories and missed equipment can be used from local institutes Further, after bringing to the laboratory, sesame samples were individually ground to a fine powder (30 mesh size), packed in air tight polyethylene plastic bags and were stored at 4°C until further analysis.

3.2. Proximate Composition

3.2.1. Moisture content

Moisture content (%) of the sesame seeds was determined according to the procedure described in the Association of Official Analytical Chemists, No. 930.15. Five gram of each sample was accurately weighed into a moisture dish and transferred into a hot air-oven at 103°C and then dried until a constant weight was attained. The final weight of each sample was taken after cooling it in desiccator (AOAC)[81]. The analysis was carried out in triplicate and the average value was recorded as moisture content.

$$\text{Moisture (\%)} = \frac{\text{(Initial moisture of the sample-Weight of Oven Dried sample)} * 100}{\text{Initial weight of the samples}}$$

3.2.2. Protein content

The crude protein content of sesame seed was determined from the nitrogen content by Kjeldahl method (AOAC)[81]. The percentage of crude protein was calculated from the % nitrogen as:

$$\text{Nitrogen (\%)} = \frac{\text{((Vs-Vb)*mMHCl*0.014008))} * 100}{\text{Weight of the sample}}$$

Where Vs = Volume (mL) of HCl required to titrate sample; Vb = Volume (mL) of acid required to titrate the blank; mM HCl = Molarity of acid; W = Weight of sample (g). Crude protein (%) = % nitrogen *F, where F (conversion factor), equivalent to 6.25 (AOAC)[81]. A blank was run through along with the sample and triplicate analysis was conducted for samples.

3.2.3. Determination of crude fiber

The crude fiber in the sample was determined by following the method described in the Association of Official Analytical Chemists, No. 962.09 (AOAC,)[81]. The percentage of fiber was calculated as:

Crude fiber (%) = (Weight of dried sample – Weight of Ash) * 100
Initial weight of samples

3.2.4. Determination of crude fat

The crude fat in the powdered samples was determined by Soxhlet extraction method described in the Association of the Official Analytical Chemists, No. 2003.06 (AOAC)[81]. The % fat in the sample was calculated as:

Fat (%) = (Wt. of flask containing the crude fat in the filter paper – Wt of flask plus paper) *100
Weight of sample

3.2.5. Determination of total ash content

The total ash content was determined by using direct method described in the Association of the Official Analytical Chemists, No. 923.03 (AOAC)[81]. The weight of ash was determined by subtracting the weight of dried empty crucible from the weight of crucible containing ash.

Ash (%) = Weight of Ash
Weight of initial Sample

3.2.6. Determination of total carbohydrate and gross energy values

The carbohydrate content of the sample was obtained by subtracting the sum of percentages moisture, fat, fiber, protein and ash from 100 % following a standard procedure reported [82].

Carbohydrate (%) = 100 – (% moisture + % fat + % protein + % fiber + % ash).

Gross energy values (kcal/100 g) of the samples were determined by multiplying the protein content by 4, carbohydrate content by 4 and fat content by 9 (AOAC):

Energy value (kcal/100 g) = (crude protein *4) + (Total carbohydrate *4) + (Crude fat * 9).

3.2.7. Mineral analysis

Mineral contents (Fe, Zn and Ca) of sesame seed were determined by Atomic Absorption Spectrophotometer (AOAC)[81] The powdered sesame seed sample (1.0 g) was taken in a glass tube. Twelve milliliters of HNO3 were added to the powdered sample and the mixture was kept for overnight at room temperature. Then, 4 ml HClO4 was added into the mixture and put in the fumes block for digestion. The temperature was gradually increased starting from 50°C until completion of digestion as indicated by the appearance of white fumes. The mixture was cooled down and the contents of the tubes were transferred into 100 ml volumetric flask and the volume

was made to 100 ml with distilled water. The wet digested solution was transferred to the plastic bottle and the digest was used for mineral determination. Phosphorus is determined by AOAC method No. 964.06, which was demonstrated as adequate recovery, reproducibility and has no bias. It is an alkalimetric ammonium molybdophosphate method appropriate for all concentrations of phosphate (AOAC)[83].

3.3. Statistical analysis

All the analysis were performed in duplicate (unless stated otherwise) and presented as mean ± standard deviation. Statistical significance of the data obtained was analyzed by One-way analysis of variance (ANOVA) followed by Duncan test by using Genstat version 18.0. The level of significance was considered at $P < 0.05$.

CHAPTER FOUR

4. RESULT AND DISCUSION

4.1. RESULT

4.1.1. Macronutrient content of different Sesame verities

Table 4. 1: Proximate composition of different Sesame Varieties

Varieties	Results in (%)/(100g)						
	Moisture	**Ash**	**C.Fiber**	**C.Protein**	**C.Fat**	**CHO**	**Energy**
JLM control	2.94 ± 0.2^{a}	4.15 ± 0.4^{a}	7.78 ± 0.3^{a}	21.70 ± 1.2^{a}	55.60 ± 2.6^{c}	7.83 ± 0.3^{b}	618.5 ± 2.9^{d}
Idaan	3.98 ± 0.32^{b}	6.93 ± 0.5^{d}	8.94 ± 0.4^{c}	25.65 ± 1.4^{e}	52.98 ± 2.5^{b}	1.52 ± 0.01^{a}	585.5 ± 2.2^{c}
Adi	4.00 ± 0.1^{b}	5.95 ± 0.6^{b}	12.18 ± 0.3^{e}	22.68 ± 1.3^{b}	47.87 ± 2.4^{a}	7.32 ± 0.2^{b}	550.8 ± 2.1^{a}
Barsan	4.00 ± 0.2^{b}	6.43 ± 0.4^{c}	9.40 ± 0.4^{d}	24.92 ± 1.5^{d}	47.78 ± 2.3^{a}	7.47 ± 0.2^{b}	559.6 ± 2.2^{ab}
Local	4.02 ± 0.4^{b}	6.82 ± 0.3^{cd}	8.44 ± 0.4^{b}	24.55 ± 1.3^{c}	48.50 ± 2.2^{a}	7.67 ± 0.3^{b}	565.4 ± 2.3^{b}

Key: Same letter in the same column is not significantly different from each other at $p<0.05$
CHO: Carbohydrate,
Energy: Energy in Calory unit obtained from consuming 100g of these sesame varieties

Table 4.1 above indicates the macronutrient contents of different sesame varieties under study. The JLM control variety has the lowest moisture content 2.94% while the "local" variety has the highest in moisture content 4.02%. Except the "JLM control" varieties which is significantly different as compared to the others four varieties under study, there is no significant difference in moisture content among the other four varieties at $P<0.05$.

The ash content of the five sesame varieties under study is in the range of 4.15 up to 6.93% as indicated in table 4.1 above. The "JLM control" has the lowest while the "Idaan" has the highest in ash content. The ash content is significantly different among the five sesame varities under study at $P<0.05$. But there is no significant difference in between "Idaan" and "Local" vartieties and the same is true for "Barsan" and "Local" varieties at $P<0.05$.

The "JLM control" sample is lowest in Crude fiber content (7.78%) while the "Adi" variety has the highest (12.18%) as shown in table above. The crude fiber content for all sesame varieties is

significantly different at P<0.05. When it comes to crude protein content, it in the range of 21.70% (For "JLM Control" sample) and 25.65% (for "Idaan" sample) as shown in table 4.1. above. The crude protein content is significantly different among all sesame varieties at P<0.05.

The fat content of "JLM control" sample is the highest (55.60%) while that of "Barsan" sample is the lowest which is 47.78% as shown in table above. There is no significant different in fat content among "Adi", "Barsan" and "Local" varieties of sesame under study at P<0.05. But there is significant difference in fat content between "JLM control" variety and that of "Idaan" variety at P<0.05. as indicated in table above.

With respect to carbohydrate content, "Idaan" variety has the lowest (1.52%) and while "JLM control" has the highest which is 7.87%. Except the "Idaan" sesame variety which has the lowest in carbohydrate content, there is no significant different in carbohydrate content among the others sesame varieties at P<0.05 as shown in table 4.1. above. Finally, when it comes to energy obtained from 100g of sesame varieties, it is in the range of 550.8Kcal (for "Adi" sesame variety) to 618.5Kcal (for "JLM Control" sample) as indicated in table above. There is no significant difference in energy for "Local" & "Barsan" varieties and as well in between "Barsan & "Adi" at P<0.05. But there is significant difference in between "Adi" & "Local" and "JLM control" & "Idaan" sesame varieties and vice versa at P<0.05. as shown in table 4.1. above.

4.1.2. Mineral content of different Sesame varieties

Table 4.2. Mineral's content of different sesame varieties

Sesame varieties	Result in (mg/100g)			
	Calcium (Ca)	Zink (Zn)	Iron (Fe)	Total phosphorous (TP)
JLM control	55 ± 2.5^{a}	4.087 ± 1.8^{d}	10.25 ± 1.5^{a}	620.0 ± 6.4^{ab}
Idaan	133 ± 4.5^{b}	3.992 ± 1.6^{c}	20.62 ± 2.4^{d}	600.0 ± 6.2^{ab}
Adi	104 ± 3.5^{b}	3.559 ± 1.5^{a}	17.66 ± 1.6^{c}	540.0 ± 5.6^{a}
Barsan	140 ± 4.9^{b}	5.208 ± 1.9^{e}	22.86 ± 2.5^{e}	590.0 ± 5.7^{ab}
Local	135 ± 5.7^{b}	3.690 ± 1.7^{b}	17.54 ± 1.8^{b}	640.0 ± 6.8^{b}

Key: Same letter in the same column is not significantly different from each other at p<0.05

The mineral contents of different sesame varieties are indicated in table 4.2. above. Calcium, Zink, Iron and phosphorous are the mineral considered in this research. The "JLM control" sample is the lowest in calcium content (550mg/Kg) while "Local" sesame variety has the highest which is 1350mg/Kg. The "JLM Control" sample is significantly different in calcium content from other four varieties of sesame at P<0.05. But there is no significant difference in calcium content among "Idaan", "Adi", "Local" and "Barsan" sesame varieties at P<0.05. With respect to zinc content, the "Adi" variety has the lowest (35.59mg/Kg) while the "Barsan" variety has the highest which is 52.08mg/Kg as indicated in table 4.2 above. There is significant difference in Zinc content among all sesame varieties at P<0.05.

When it comes to Iron content, the "Barsan" sesame verity has the highest (228.6mg/Kg) while the "JLM control" sample has the lowest which is 102.5mg/Kg. There is significant difference among all sesame varieties in iron content at P<0.05. Lastly, The total phosphorous content in the range of 5400mg/Kg (For "Adi" sesame variety) to 6400mg/Kg for "Local" sesame Varieties. There is significant difference in total phosphorous content among "Local" and "Adi" sesame varieties at P<0.05 as shown in table 4.2 above. But there is no significant difference in total phosphorous content in between "JLM control", "Idaan" and "Barsan" sesame varieties and the vice versa at P<0.05.

4.2. DISCUSSION

4.2.1. The Macronutrients content of Different Sesame Varieties

Table 4.1 above indicates the macronutrient contents of different sesame varieties under study. The JLM control variety has the lowest moisture content 2.94% while the "local" variety has the highest in moisture content 4.02%. Except the "JLM control" varieties which is significantly different as compared to the others four varieties under study, there is no significant difference in moisture content among the other four varieties at P<0.05. The difference in moisture content might be due to agro-ecology, farm management difference where the sample "JLM control" grew and that of the other four varieties that grew in Kelafo district. The moisture content of the studied sesame seeds was low, which corresponds to the moisture content of different sesame

varieties ranging from 4.16% to 7.80% [84, 85]. [6]reported the moisture content of sesame varieties from Werer Agricultural Research Center ranged from 4.4% to 4.8%. The relatively low moisture content of sesame seeds is helpful for the storage of sesame seeds. At low moisture, deterioration would occur relatively slowly [86]. Low moisture content has also an advantage on the reduction of oil spoilage, the so-called rancidity [6].

The ash content of the five sesame varieties under study is in the range of 4.15 up to 6.93% as indicated in table 4.1 above. The "JLM control" has the lowest while the "Idaan" has the highest in ash content. The ash content was significantly different among the five sesame varieties under study at $P<0.05$. The difference may as a result of being different varieties, soil condition in which they grown. Ash content was observed significantly ($p \leq 0.05$) different between sesame varieties. T-85 had the highest (6.19 g/100g) ash content and least was for bawnji (4.46 g/100g)[9]. [87] reported ash values to be between 1.4 and 6.6 g/100g for Saudi Arabia and foreign varieties (Lebanese, Indian and World collection), which is similar with the results of this study. Chemical composition of seeds can be affected not only by the genotype but also by agro-climatic conditions [88, 89]. High level of ash makes the oilseed a good source of mineral nutrition to the consumer [90][49].

The "JLM control" sample is lowest in Crude fiber content (7.78%) while the "Adi" variety has the highest (12.18%) as shown in table above. The crude fiber content for all sesame varieties is significantly different at $P<0.05$. The difference may be as a result of being different in varieties, farm management and some other reasons. Fiber contents were higher than the fiber contents of previously reported values fiver contents (5.24 to 7.70%) from Ethiopia sesame varieties [45], indicating the studied sesame varieties from Somali region could be useful source of fiber.

When it comes to crude protein content, it in the range of 21.70% (For "JLM Control" sample) and 25.65% (for "Idaan" sample) as shown in table 4.1. above. The crude protein content is significantly different among all sesame varieties at $P<0.05$. The difference might be due to varietal difference among sesame, farm condition and other components difference. The crude protein content in the studied sesame seeds was high, which was in agreement with that of sesame protein contents reported by [85] and by [84]Ogbonna and Ukaan (2008) (17.02%-21.00%), and [45]Amare et al. (2017) who reported the mean crude protein content (23.12%) of ten sesame seeds in Ethiopia. This result is consistent with range (18% - 25%) reported by [16]

but are lower than those reported by [42] for Sudan varieties and USA genotypes (32.5% - 40.0%) and by [43] for 13 sesame accessions of Nigeria (27.50% - 45.68%). [91] found protein content (19.81% to 24.45%) in Turkey's sesame genotype. The difference might be due to varietal difference among sesame, farm condition, agro-ecology difference, fertilizer management.

The fat content of "JLM control" sample is the highest (55.60%) while that of "Barsan" sample is the lowest which is 47.78% as shown in table above. There is no significant different in fat content among "Adi", "Barsan" and "Local" varieties of sesame under study at $P<0.05$. But there is significant difference in fat content between "JLM control" variety and that of "Idaan" variety at $P<0.05$. as indicated in table above. The crude fat contents of the studied sesame varieties were comparable to the mean crude fat content (47.33%) reported by [6]. Higher crude fat content (46.6% to 52.4%) in sesame seeds has also been reported in India [92]. [93]reported the oil content can range from 43.4% to 58.8% for 42 strains of sesame with the highest oil content found in white-seeded strain. [46, 94]reported oil content in Saudi and Indian sesame seeds ranging from 43.2% to 54.0%. Both the above results are consistent with the result of current study. Variation in the oil yield of sesame may be due to variation in variety, soil type, climatic, maturity of plant, the harvesting time of the seeds and the extraction method used [46, 94].

With respect to carbohydrate content, "Idaan" variety has the lowest (1.52%) and while "JLM control" has the highest which is 7.87%. Except the "Idaan" sesame variety which has the lowest in carbohydrate content, there is no significant different in carbohydrate content among the others sesame varieties at $P<0.05$ as shown in table 4.1. above. Finally, when it comes to energy obtained from 100g of sesame varieties, it is in the range of 550.8Kcal (for "Adi" sesame variety) to 618.5Kcal (for "JLM Control" sample) as indicated in table above. There is no significant difference in energy for "Local" & "Barsan" varieties and as well in between "Barsan & "Adi" at $P<0.05$. But there is significant difference in between "Adi" & "Local" and "JLM control" & "Idaan" sesame varieties and vice versa at $P<0.05$. as shown in table 4.1. above. Carbohydrate content had ranged (7.32% - 7.83%) between varieties studied which is inconsistent with range (8.31% - 11.69%) reported by [9] but are higher than the range 1.05% - 2.88% reported by [31] for Sudan varieties and USA genotypes. The highest carbohydrate values (27.90% - 45.15%) were reported in 13 sesame accession of Nigeria by [84]. Compositional

differences can exist among the different varieties of sesame seeds, and among the sesame variety grown in different countries. Further studies by [95][59] on some legume crops reported that there might be differences between varieties of the same species. The mean energy value of the studied sesame varieties was lower than energy value of sesame seeds reported by [6].

4.2.2. The mineral contents of different Sesame varieties

The mineral contents of different sesame varieties are indicated in table 4.2. above. Calcium, Zink, Iron and phosphorous are the minerals considered in this research. The "JLM control" sample is the lowest in calcium content (55mg/100g) while "Barsan" sesame variety has the highest which is 140mg/100g. The "JLM Control" sample is significantly different in calcium content from other four varieties of sesame at $P<0.05$. But there is no significant difference in calcium content among "Idaan", "Adi", "Local" and "Barsan" sesame varieties at $P<0.05$. This might be the fact that, being different varieties, different agro-ecolology, soil type, fertilizer and other farm management. The calcium content of this study is lower than 1450 mg/100g reported by [96] and [97] in some Indian sesame varieties. However, some Lebanese sesame varieties exhibited the lowest (228.3 mg/100 g) calcium content [98]. The current study results which are in the range 55 - 140 mg/100g is also lower than the research done on different sesame varieties which are in the range of 600 - 2000 mg/100g.

With respect to zinc content, the "Adi" variety has the lowest (3.559mg/100g) while the "Barsan" variety has the highest which is 5.208mg/100g as indicated in table 4.2 above. There is significant difference in Zinc content among all sesame varieties at $P<0.05$. This zinc content found is higher than the range (0 - 3.8 mg/100g) reported by [87] for Saudi Arabia and varieties (Lebanese, Indian, Nigerian and World collection). This might be the due to difference in variety, soil condition, farm management and agro-ecology.

When it comes to Iron content, the "Barsan" sesame verity has the highest (22.86mg/100g) while the "JLM control" sample has the lowest which is 10.25mg/100g. There is significant difference among all sesame varieties in iron content at $P<0.05$. The values were comparable with the Fe content of sesame varieties reported from Saudi Arabia (10.4 mg/100g Fe) [99]. This indicated that the studied sesame varieties could be considered to have normal amount of iron that can help consumers identify products with higher iron content [100]. Iron is an essential element for

human being by contributing to a wide variety of metabolic processes including oxygen transport, DNA synthesis and electron transport, transportation of oxygen around in the body [101]

Lastly, The total phosphorous content in the range of 540mg/100g (For “Adi” sesame variety) to 640mg/100g for “Local” sesame Varieties. There is significant difference in total phosphorous content among “Local” and “Adi” sesame varieties at $P<0.05$ as shown in table 4.2 above. But there is no significant difference in total phosphorous content in between “JLM control”, “Idaan” and “Barsan” sesame varieties and the vice versa at $P<0.05$. The P content was comparable with that reported elsewhere (501.99 - 762.79 mg/100 g) [102].

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATION

5.1. CONCLUSION

The study was conducted with aim of analyzing the macro and micronutrient content of the different sesame varieties. Five varieties of sesame were included in this study. The protein, fat, fiber and moisture content are up to the standard while the carbohydrate content is very low. The lower moisture content is the indication for shelf stability of the different sesame varieties. The higher fat content is the indication for the studied sesame varieties are good for oil production. In addition to this, with being higher in protein content, all sesame varieties are nutrient rich which is indicated in their calory content that are higher than 550kcal/100g of sesame. The higher ash content of all sesame varieties indicates, all varieties have good source of minerals. Except the calcium content, all sesame varieties have high amount of zinc, iron and total phosphorous.

5.2. RECOMMENDATION

Based on the finding and identified gaps, the following points are recommended;

- Further research should be done by expanding the area coverages and adding more samples from different areas of the region including the control samples.
- More parameters should be added in the future research that going to be done on different sesame varieties.
- Sesame is one of the nutrient dense crops. Community should use it by mixing with the different stables crop they use as regular food.
- Especial research should be done on the oil characterization of the different sesame varieties.
- More to be done on the different products that can be produce from sesame and as well the different use of sesame such as culinary, medicinal, industrial

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Appendix: Sample photo during sample preparation

