NUTRITIONAL ANALYSIS OF *SESAMUM RADIATUM* SEEDS

by

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DECLARATION

I declare that this thesis entitled "Nutritional Analysis of *Sesamum radiatum* Seeds" is the resulted my own research except that cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree

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APPROVAL

"I hereby declare that i have read this thesis and in our opinion this thesis is sufficient in terms of scope and quality for the award of the degree of Bachelor of Applied Science (Natural Resources Science) with Honours"

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Nutritional Analysis of *Sesamum Radiatum* Seeds

ABSTRACT

Presence of valuable chemical compositions in plant has been attracts researcher and consumer to use it for research and healing treatment. *Sesamum radiatum* is an annual herbaceous plant which is commonly distribute at the tropical and subtropical areas in Asia but native to Africa .*Sesamum radiatum* is family Pedaliaceae. Its common name is Benniseed and Black Benniseed. The purpose of this study was to determine moisture, ash, fat, protein, carbohydrates and food energy content from the *Sesamum radiatum* seeds using various analytical and biochemical method. This study also was conducted to determine mineral content (Ca, Mg, K, Na, Cu) from *Sesamum radiatum* seeds using atomic absorption spectrophotometer (AAS). Thus, studies has revealed *Sesamum radiatum* content 4.24% moisture, 6.27% ash, 43.48% fat, 20.60% protein, 25.41% carbohydrates and 577.36 Kcal/g food energy content. The seeds also were found to be good sources of minerals where Potassium (111.8 mg/L) Calcium (175.1 mg/L), Magnesium (57.35 mg/L), Sodium (3.043 mg/L) and Copper (0.346 mg/L). This plant has show high nutritive value which can be exploited as a good source of food and supplements.

Analisis Nutrisi Benih *Sesamum Radiatum*

ABSTRAK

Kehadiran komposisi kimia berharga pada tumbuhan telah menarik penyelidik dan pengguna untuk menggunakannya untuk rawatan penyelidikan dan penyembuhan. *Sesamum radiatum* adalah tumbuhan herba tahunan yang lazimnya dijumpai di kawasan tropika dan subtropika di Asia tetapi berasal dari Afrika. *Sesamum radiatum* adalah keluarga Pedaliaceae. Nama biasa ialah Benniseed dan Black Benniseed. Tujuan kajian ini adalah untuk menentukan kelembapan, abu, lemak, protein, karbohidrat dan kandungan tenaga makanan dari benih radiamum *Sesamum radiatum* menggunakan pelbagai kaedah analisis dan biokimia. Kajian ini juga dijalankan untuk menentukan kandungan mineral (Ca, Mg, K, Na, Cu) dari benih *Sesamum radiatum* dengan menggunakan spektrofotometer serapan atom (AAS). Oleh itu, kajian telah mendapati kandungan *Sesamum radiatum* mengandungi 4.24% kelembapan, abu 6.27%, lemak 43.48%, protein 20.60%, karbohidrat 25.41% dan kandungan tenaga makanan sebanyak 577.36 Kcal/g. Biji-bijian juga didapati sebagai sumber mineral yang baik di mana kalsium (175.1 mg / L) Potassium (111.8 mg / L), Magnesium (57.35 mg / L), Natrium (3.043 mg / L) dan Copper (0.346 mg /L). Tumbuhan ini mempunyai nilai khasiat yang tinggi dan boleh dieksploitasi sebagai sumber makanan dan makanan tambahan yang baik.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABREVIATION

AOAC	Association of Analytical Communities
AAS	Atomic Absorption Spectroscopy
Ca	Calcium
Cu	Copper
FAO	Food and Agriculture Organization
H_2SO_4	Sulphuric acid
H_3BO_3	Boric acid
HCL	Hydrochloric acid
K	Potassium
Kcal/g	kilocalorie per gram
Mg	Magnesium
mg	milligram
mg/L	milligram per liter
MUFA	Monounsaturated fatty acids
Na	Sodium
NaOH	Sodium hydroxide
PUFA	Polyunsaturated fatty acids
SD	Standard Deviation

SFA	Saturated fatty acids
SIRIM	Scientific and Industrial Research Institutes of Malaysia
TNB	Tenaga Nasional Berhad
WHO	World Health Organization

CHAPTER 1

INTRODUCTION

1.1 Background of study

There are various types of plant in the world. Some are already known and being exploited in medicine and some remain unknown. Nowadays nutritional analysis in the plant has been used worldwide and attracts researcher and consumer to use it for research and healing treatment. According to the concept Ayurveda which is using natural resources as ethno medicine in India can be considered complete medicinal system which link it with science (Ravishankar & Shukla, 2007). This is because medicinal plant presence of chemical element which can be found in any parts of the plant from leaves to the root which is beneficial and effective for curing of human diseases.

Sesamum radiatum is believed have medicinal value and widely utilised as traditional medicine in Africa and Asia (Konan, Datté, & Yapo, 2008). The nutritional value describes mainly the percentage of major nutritional bio-molecules such as proteins, carbohydrates, fats and fibre along with the presence of major minerals and their food value (Frazier & Whesthoff, 2007).

Thus, this research is conduct to determine moisture, ash, fat, protein, carbohydrates and food energy content from seed of *Sesamum radiatum.* This research

also determines mineral content (Ca, Mg, K, Na, Cu) from seeds of *Sesamum radiatum* using Atomic Absorption Spectrophotometer (AAS).

1.2 Problem Statement

Sesamum radiatum has been used by the people especially in Africa as their food whether eating fresh or cooked while leaves also uses as medicine. Limited study had been done on *Sesamum radiatum* and mostly the study focusing on content and use in leaves of this plant where it is used as traditional medicine. Despite of that, there is no research had been reported about the nutritional analysis seed of *Sesamum radiatum*. This research will be conducted to reveal the presence of nutrition in the seed of the plant.

1.3 Objectives

1. To determine moisture, ash, fat, protein, carbohydrates and food energy content from seed of *Sesamum radiatum*
2. To determine mineral content (Ca, Mg, K, Na, Cu) from seeds of *Sesamum radiatum* using Atomic Absorption Spectrophotometer (AAS)

1.4 Scope of study

This research is focused on nutritional analysis of *Sesamum radiatum* . This study was conducted on the seed of the plant as the sample. The selected nutrient that determine

were moisture, ash, fat, protein, carbohydrates and food energy content from seed of *Sesamum radiatum.* This research also determine mineral content (Ca, Mg, K, Na) from seeds of *Sesamum radiatum* using Atomic Absorption Spectrophotometer (AAS) and was held at Laboratory Faculty of Earth Science of University Malaysia Kelantan, Jeli Campus.

1.5 Significance of study

The whole plant is usually consumed by local farmer as their staple food. There are few studies had been conducted on the leaves of this plant but their nutritional values on seed have not been explored yet. Thus, this study was conducted as a good approach for further study on the nutritional value which focusing on the seed. Next, this study will help medical technology using natural product can be improved in future and been utilized by human in taking the minerals that human not capable make it by themselves.

CHAPTER 2

LITERATURE REVIEW

2.1 Seed

Seed are generally known as embryo of plant that surrounded by a protective coat. Embryo of plant is miniature undeveloped which is after germination the early development they stored food in the seed. In other word, seed is the products which plant reproduction business occurs and where nurturing the developing plant happens. Seeds is a combination of many different enzymes and structural protein (Yang et al.,2013). Besides, size of seed carry different quantity of nutritional value which large seed often contain high nutritional value (Vander wall,1995) .

Seed protein and leaf protein usually has different value (Edelman & Colt, 2016). Seed protein is made up of hundreds of different enzymes and structural protein (Yang et al., 2013). According to Larkins and Holding (2009) , protein is can be found abundantly in family of storage protein. As example, in corn kernels its zein, which consists of up to 60% of the endosperm protein; while in the rice grains consist over 80% glutelins in the seed protein (Shyur et al., 1988). Glutelins is major protein inside wheat flour.

Mineral sources are important in our body. As example, metal ions serve as cofactor in enzymatic reactions and essential in maintaining protein structure. Enzymes activities also require present of zinc (Azia et al., 2015).

2.2 *Sesamum radiatum*

Sesamum radiatum is an annual herbaceous plant which is commonly distribute at the tropical and subtropical areas in Asia but native to Africa (Ashri, 1998). *Sesamum* is the main genus in the family Pedaliaceae which consist of 17 genera and 80 species (Nimmakayala, 2011). Its common name is Benniseed and Black Benniseed. According to Dabir (2000), in Nigeria , there are three species that frequently use by the local people for different purpose in their daily life which are *S. alatum, S. indicum* and *S. radiatum* .

As stated by the official website of NParks Flora and Fauna, Singapore, *Sesamum radiatum* is type of flowering seed plants (dicotyledon). Its maximum high is 1.2 m. The shapes of the leaves are oblong to lanceolate and have opposite leaf arrangement towards the base. This plant also has pink flower attached to the stem by a short stalk with tubular shape which occur individually in leaf axil (the upper angle between a leaf stalk or branch and the stem or trunk from which it is growing).

In recent studies show that the aqueous extract of the *Sesamum radiatum* leaves is high with phenols, lignans and flavonoid give compelling myorelaxant effect in guinea-pig (Konan, et al., 2008). This plant also help to combat constipation which is also known as laxative plant (Kerharo & Adams,1974). This study may exert beneficial health effects to our life using this plant which can be found easily as it is also have been introduced to Malaysia.

In this research, *Sesamum radiatum* was found in Universiti Malaysia Kelantan area. To be specific, figure 2.1 showed the area is in TNB building in Universiti Malaysia Kelantan, Jeli Campus area where it is growing extensively.

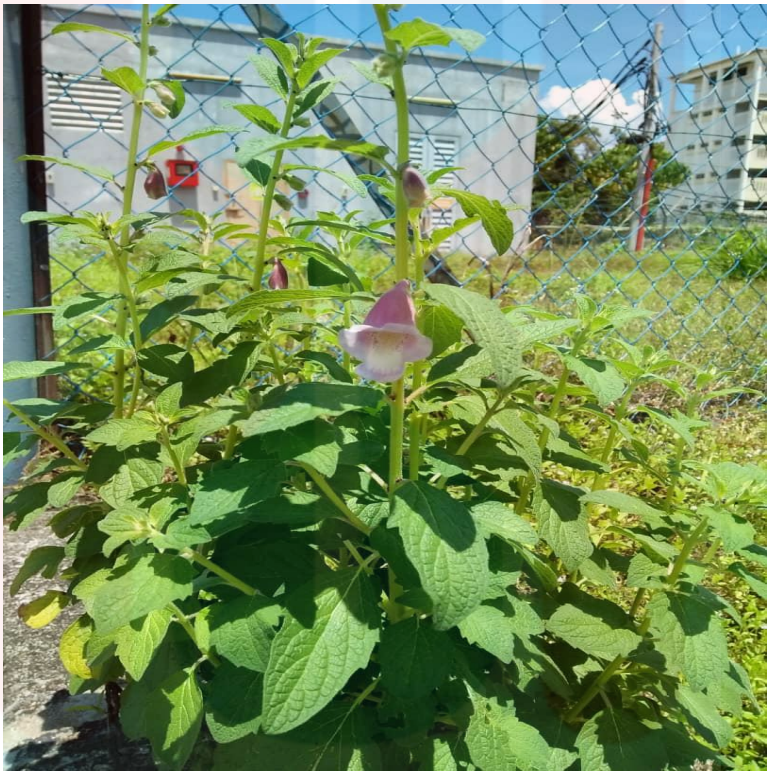

Figure 2.1 : *Sesamum radiatum* plant and its habitat area

(Sources : © Umi Raihanah 2018)

2.3 Nutritional value

Nutritional value is content of minerals, vitamin, protein and carbohydrates present in the product or natural sources. Good nutrition content not necessary to have high nutrient value but it is related to optimal body requirement so it will promote durability in life (Brandit & Mølgaard, 2001). There two types of nutrients which are macronutrients and micronutrients. Macronutrients are needed in large amount to provide

energy in our body while micronutrients are essential in small amount which act as body supplement.

According to Nanloh, Kagaru and Uzoma (2015) research on nutritional analysis and anti nutritional analysis of *Sesamum radiatum* leaves concluded that this plant contain valuable nutrition that not harmful and consumable by human as food or ethno-therapeutic. As a result, they found that their leaves contain 18.3% crude protein, 4.1% crude fibre and 1.3% crude fat. In fact, some nutrients in this plant are higher compared to commonly consumed plant in Nigeria.

2.4 Selected Nutrient

2.4.1 Moisture

Moisture defined as the total of water content when plant's extract powder is dried in oven. The dry matter from the plant sample remains after removal of moisture is known as total solid (Bradley, 2010). Determination of moisture content in plant will be followed (AOAC,1999) method. This method will using oven-drying and let the plant material in desiccators cool down until it achieves constant weight. *Sesamum indicum* is also in the same family with *Sesamum radiatum* which is Pedaliaceae , so according to the research by Blessing, Garuba et al.(2010), found that *S. indicum* seeds moisture is 5.60± 3.74 b and has significant different at the root and leaves.

2.4.2 Ash

Ash is defined as the mineral content that is remaining behind after process of incineration of plant sample extract in powder form (Pomeranz & Meloan,1994). Ash also can be defined as the inorganic matter in fuel. Ash can be analyses or measured by biomass combustion usually use furnace in laboratory.

Ash content in herbaceous are higher than wooden plant. In addition, different parts of plant have different ash content and composition. As example leaves contain higher ash content compared to other part. Plant material usually made up of carbohydrates, protein, tannins, oil etc. so the element in ash content can be found are silicon, potassium, magnesium etc.. This happen when oxides reacting with the carbon dioxides (Malcom, 2016).

Apparatus usually used for ash is crucible which will be heat in the furnace in higher temperature (500-600 ºC) for 24 hours. There many types crucible can be used such as quartz, platinum, steel, porcelain, Pyrex etc.

2.4.3 Fat

Fats provide energy and gaining the satisfied after consuming the meal to human . Fat can comes from variety sources like food, plant and animal. According to anonymous (2017), stated that fat is non-volatile substances that comes from plant or animals which are insoluble in water and oily to touch. It is usually solid at room temperature and liquefies at higher temperature. There are four categories of fats which are

monounsaturated fats, polyunsaturated fats, saturated and transfatty acids. The differences between the categories are their stated in the room temperature. Monounsaturated fats and polyunsaturated fats usually liquid stated in room temperature which mean less risk of healthy problem compare to trans fats.

Fat is also major source or storehouse of energy and usually found in the seed of plant such as olive oil. Fatty acid is comprised into three groups which are saturated fatty acids (SFA), Monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA). All this type of fatty acids may give different impact on health depend on intakes of individual (FAO,2008). In official website which is organized by Australian Government National Health and Medicinal Council said that eating a lot of saturated fat will increase risk of heart disease and high level of cholesterol while unsaturated fat help in reduce that risk. As example, intakes of omega-3 fats and some nuts (cashews and almond) can help control the cholesterol in the blood.

The study that have been conducted analyzed that fat content of date seeds among fifteen fatty acids found that oleic was the predominant (44.92–48.38%). For *Boufgous* and *Bousthammi seeds oil* shows that unsaturation fat is ranged between 53.98% and 57.23% (Bouhlali et al., 2017) . With the high value fat content in seed especially unsaturated type give a great potential as a good nutritional elements to human being and supported that plants seed are contain good sources of fats, protein, minerals and carbohydrate (Bello et al., 2008).

2.4.4 Protein

Proteins play crucial role in the body. Most of the cell, body's tissue and organs activity required proteins for the structure and function. Protein is known are large and complex molecules. According to (Caetano A. et al. (2009) proteins are defined as enzymatic chemistries and help in metabolic pathway, signal transduction, regulate gene expression and make up the actual molecular and cellular function. Protein also help human fight with any infectious.

Plants obtain protein naturally from the soil and it is important in whole aspect of plant growth and development. As example electron transport, catalyzing chemical reaction and facilitating membrane transport (Vince & Zoltán, 2011).

Good sources of protein can be found in seafood, dairy product, meat and poultry, eggs and vegetables. Babji et al. (2010) stated that protein in plant has low quality than protein in animal due to the little content of certain amino acids. In contrast, there is a study by Gayathri and Rachel (2015) illustrated that some plant showed high protein content by their leaf's extract just like *Costus igneus* have 1.30% protein.

2.4.5 Carbohydrate

Carbohydrate is defined as a source of energy or as building material in the plant (Weinmann, 1946). Carbohydrate can be found in plant stem, corms, stolon and rhizomes. As example, research conducted by Gayathri & Rachel (2015) show that most

medicinal plant contain high amount of carbohydrate such as *Terminalia chebula* (80.58%), *Aloe vera* (80.24%) and so on.

In human nutrition aspect, foods with high content of carbohydrate provide full range of minerals nutrient and bioactive compound (Nantel, 1999). According to National Institute of Diabetes and Digestive and Kidney Diseases USA (2017) generally explained that, carbohydrates have two types which are simple carbohydrates and complex carbohydrates. Simple carbohydrates can be found in fruits, vegetables and milk while complex carbohydrates can be found in cereals, starchy vegetables and rice.

2.4.6 Mineral content

Minerals have various roles and consider essential in the body function such as enzyme function, bone formation, water balance and oxygen transport. According to anonymous (2018) stated that minerals are inorganic nutrient that important for physiochemical development to human and animal life. There are 16 basis of minerals that are needed by human whether in small amount or large. As example potassium, chloride, sodium, calcium, phosphorus, magnesium, iron, manganese, copper, iodine, selenium and molybdenum (Wendy and Elaine, 2015)

Risk of diseases like cardiovascular, osteoporosis or hypocalcaemia can be reducing if body takes optimal quantity into the body (Ryan-harshman, 2005). So avoiding this matter it requires intakes of plant or supplement. After all, the most easiest way to get all this nutrient such as vitamins, minerals content and protein is natural product which are inexpensive, quickly to cooked and fresh (Gupta , 1998).

There are many ways to analyze mineral content. As example using atomic absorption spectroscopy (AAS) and inductively coupled plasma optical emission spectrometry (ICP-OES). All this involved different chemical dilution and technique which is depend on specific element we need, characteristic of element, concentration deal and its mineral phase (Ihnat, 2003).

2.5 Food energy content

Food energy value is defined as the amount of energy in food made accessible to a human‘s body. The chemical constituents of the food are made up of a carbohydrate, fat, protein and alcohol where they undergo the metabolism process when human ingested some food (Canadian Food Inspection Agency, 2014).

Martin and Coolidge (1978), proposed that energy value is estimated in kcal/g by multiplying the percentages of crude protein, crude lipid and carbohydrates with the factor of 2.44, 8.37 and 3.57 accordingly.

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CHAPTER 3

MATERIAL AND METHODS

3.1 Material

Figure 3.1 showed the collection of *Sesamum radiatum* seeds which collected from Universiti Malaysia Kelantan area and was used in this research.

Figure 3.1: The collection of *Sesamum radiatum* seeds

(Sources : © Umi Raihanah 2018)

3.2 Chemicals

Deionised water, ethanol, petroleum ether, boric acid (H_3BO_3), methyl red indicator solution, 40 % Sodium hydroxide (NaOH), 20% Hydrochloric acid (HCl), 0.1 M Hydrochloric acid (HCl), concentrated of sulphuric acid (H_2SO_4).

3.3 Equipment and Apparatus

Evaporating dish, Soxhlet extraction, refrigerator, electronic and precision balance, sterile bottles, oven, desiccators ,crucible, muffle furnace, extraction thimble, extraction flask, cotton, fume hood, digestion tube, FOSS Kjeltec^{TM} 8200 Auto Distillation Unit, FOSS Tecator^{TM} Digestor, beaker, measuring cylinder conical flask, volumetric flask, glass rod, Atomic Absorption Spectrophotometer (AAS) from Perkin Elmer PinAAcle 900F model, filter paper, dropper, beaker and gloves were used.

3.4 Collection of Plant Sample

The seeds was cleaned and dried in shade for few days at room temperature untill a constant weight is achieved. After that, the seeds were crushed using mortar and pestle into powder form and weighed.

3.5 Determination of Moisture Content

Standard method which is used by SIRIM (1991) for food analysis was used to estimate moisture content of *Sesamum radiatum* seeds. Evaporating dish will be dried for 3 hours in an oven at 105 ± 2º C. Next the dish was cooled to room temperature in a desiccators and weighed (W). 5 gram of *Sesamum radiatum* seeds was transferred into dish (W_1) and the dish was placed in oven at 105 ± 2º C for 5 hours. After drying was completed, the dish was removed and cooled at room temperature and weighed. The dish was heated once again at 105 ± 2º C for 1 hour and let cooled at room temperature in desiccators before dish being weighed. The process of heating for one hour was repeated and the dish was cooled in similar procedure before being weight (W_2).

This moisture content was calculated using formula (Skoog et al., 2000);

$$\text{Moisture \% by mass} = \frac{(W1 - W2)}{(W1 - W)} \times 100 \qquad (3.1)$$

Where ;

W = The mass in gram of empty dish

W_1 = mass in gram of the dish with material before drying

W_2 = mass in gram of the dish with material after drying

3.6 Determination of Ash Content

Ash content of *Sesamum radiatum* seeds was determined by using established method (AOAC,2002). Crucibles were placed into furnace as shown in figure 3.2 at about 550º C for 1 hour. The crucibles then removed from the furnace and allowed to cool down. Weight (W) was taken after the sample is cooling down. Next the 5 gram of sample were placed into crucible (W_1) and transferred into muffle furnace.

Figure 3.2: Crucible was placed inside the furnace

(Sources : © Umi Raihanah 2018)

Ignited about 550º C until the sample becomes grey ash. Left the crucible cool down at room temperature in a desiccators after taken out from the furnace then measure the weight (W_2)

The measurement will be used formula (AOAC, 1990);

$$\text{Ash \% by mass} = \frac{(W1 - W2)}{(W1 - W)} \times 100 \quad (3.2)$$

Where ;

W = The mass in gram of empty crucible

W_1 = mass in gram of the crucible with the material before ashing

W_2 = mass in gram of the crucible with the material after ashing

3.7 Determination of Fat Content

Fat content of *Sesamum radiatum* was followed the method describe FSA(1998) via soxhlet method. All the glassware was rinsed with petroleum ether, drained and dried in oven to constant weight which is about 1 hour at 100 ± 2ºC . Then the flask will be placed into desiccators and was allowed to cool at room temperature at 30 minute. The flask was weighed. 5g plant sample was transfer into an extraction thimble. The extraction thimble was transferred into soxhlet extractor. Sample was extracted at about 6-8 hours using petroleum ether as the extraction solvent. After completion of the extraction process, thimble containing sample was removed and the solvent was left until most of the solvent evaporate and condense. Placed the flask and its content in fume hood until all the petroleum ether evaporates. Next, dry the flask and its content in oven at 100 ± 2º C for 2 hours. Cool the flask in desiccators and then weighed. The fat content was calculated to the following formula (David & Jeff, 2003) :

$$\text{Fat \% by mass} = \frac{(m1 - m2)}{E} \times 100 \quad (3.3)$$

Where;

m_1 = weight of the dry empty vessel, in gram

m_2 = weight of the vessel in grams and fat residue after evaporating

E = sample weight in grams

3.8 Determination of Amount Of Protein

The amount of protein present in the *S. radiatum* seeds was calculated from the nitrogen concentration using Kjeldahl method (Magomya, Kubmarawa, Ndahi, & Yebpell, 2014). Sample of *Sesamum radiatum* seeds was added into 250 ml digestion tube. Kjeltab tablet and 12 ml of concentrated H_2SO_4 were added and placed in the digestion block. When solution turns clear its mean the sample has digested. The digestion product was leave cool and next was diluted with 80 ml of H_2O. Boric acid which was pre-added with methyl red indicator solution 25 ml and 40% NaOH of 50 ml was added into digestion tube. After that, the digested was distilled and titrated with 0.1 M HCL. The amount of nitrogen content was estimated based on the number of moles of acid that be used to neutralize the ammonium borate complex. The protein was calculated by multiplying a 6.25 factor with the percentages of nitrogen in the sample (Magomya et al., 2014).

3.9 Determination of Carbohydrate

Carbohydrates content was analyzed using a standard method (Tee et al.,1997).

Carbohydrate = 100% – (M_1 + M_2 +M_3 +M_4) (AOAC,2005) (3.4)

Where ;

M_1 = % Moisture

M_2 = % Ash

M_3 = % Crude Fat

M_4 = % Crude Protein

3.10 Determination of Food Energy Content

Food energy content was determined using standard formula **(**Food Regulations, 1985) as shown in equation below.

Calories from crude protein (Cp) = % protein × 4 kcal/g (3.5)

Calories from crude fat (Cf) = % fat × 9 kcal/g

Calories from carbohydrate (Cc) = % carbohydrate × 4 kcal/g

Energy content *(K cal*) = $Cp + Cf + Cc$

3.11 Determination of Mineral Content By Atomic Absorption (AAS) Method

For elements analysis of plant tissue, dry ashing procedure was choose. 1 gram of dried ground plant tissue was weighed and placed in the crucible. Next, transferred into muffle furnace. Ignited at about 550º C for 8 hours until the sample becomes grey ash. After that, let it cooled down then dissolve the ash in 5 ml of 20% HCL. Filter the solution with filter paper and syringe filter. The filtrate then transferred into 50 ml volumetric flask and diluted with deionised water until final volume of 50 ml. Atomic Absorption Spectrophotometer (AAS) was analyzed the elements from the digested plant extract such as calcium (Ca), magnesium (Mg), potassium (K) ,sodium (Na) and copper (Cu) (Adrian,1973).

3.12 Statistical Analysis

This analysis was carried out in triplicates and analyze its mean ±SD using a statistical packages program (SPSS 20.0).

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Proximate composition parameters

The detailed proximate composition of the *Sesamum radiatum* seeds are given in the table 4.1. The levels of different nutritional factors such as moisture, ash, fat, protein, carbohydrate and food energy content were using the different processing methods. The mean content from this research was 4.24% moisture, 6.27% ash, 43.48% fat, 20.60% protein, 25.41% carbohydrates and 577.36 Kcal/g food energy content.

.**Table 4.1**: Proximate nutritional composition of *Sesamum radiatum* seeds

Proximate Analysis (%)	**Triplicates Measurement**			**Average Result (Mean ± SD)**
	1st trial	**2nd trial**	**3rd trial**	
Moisture	4.23	4.40	4.08	4.24 ± 0.16
Ash	6.28	6.27	6.26	6.27 ± 0.03
Fat	43.16	43.08	44.21	43.48 ± 0.63
Protein	20.69	20.56	20.56	20.60 ± 0.08
Carbohydrate	25.64	25.69	24.89	25.41 ± 0.45
Food energy (Kcal/g)				577.36

Moisture content for *Sesamum radiatum* was obtained using oven drying methods which is the drying condition used in this method was standardized in term of temperature and time to obtain mean reading of the moisture content. The constant weight reading shows that the moistures or water content already been removed after drying process. According to Nzikou *et al*. (2009), *Sesamum indicum* seed was found to contain 5.7% moisture. The moisture content carried out by this study for *Sesamum indicum* is 1.46% different from the moisture content on *Sesamum radiatum* (4.24%). This showed *Sesamum indicum* has highest moisture content compared to *Sesamum radiatum.* In other plant like *Parkia biglobosa* seeds which commonly known as Africa locust bean (ALB) also has the moisture content ranged from 6.40% to 7.95% (Urua, *et al*., 2013). Moisture content for wheat, rice, corn kernels and soybeans are found to have 15% to 25% (Nutritiondata tools, 2014). According to Saura-Mas and Lloret (2007), moisture content in the plants are different whether it is within same species or different species due to the factors such as temperature, humidity of surrounding where the plant live and types of plant. This is because different plants have different morphological structures which lead to the differences rates of transpiration. In addition, others externalities like harvest time, storage conditions and climatic weather also influence the amount of moisture content for plant or food (Thomas & Krishnakumari, 2015)

From the research conducted, *Sesamum radiatum* was ignited at about 550°C for 9 hours and becomes grey ash which has 6.27% ash content. These value are lower than the values obtained from the ash content recorded for the *Sesamum indicum* which is in the ranged 6.36% to 7.27% (Jimoh *et al*., 2011). However in 2013 research conducted by Makinde and Akinoso found that ash content for *Sesamum indicum* seeds were in the

ranged 6.16 to 7.34%. Africa locust bean (*Parkia biglobosa)* which is sometimes described as meat or cheese substitute and one of the legumes types was also found has lower ash content 4.43% and have slightly difference value from two other location in Africa (Urua *et al*., 2013). *Solanum nigrum* from Congo was reported to have 7.18 % ash content (Dhello *et al*., 2006). Next in 2007 research conducted by Akubugwo, Obasi and Ginika found that *Solanum nigrum* have 8.05% ash content. According to Babayemi et al. (2010), ash content in the plant may vary due to the factors such as species of the plant; sources and the nature of the soil where the plants are grow. In fact in the same plant the value may be slightly different according to which part of the plant being analyzed. Besides, value of ash content also influence the value of mineral content which is needed in small scale in our body and usually high food quality from a low ash content

Nuts and seeds usually are low in carbohydrates but higher in fats. According to Dolson (2018), although nuts and seeds have high contained of fats but it is actually contain healthy fats which packed with magnesium, calcium, protein and phytonutrients which help the seeds to grow in its own. Fats determination was used soxhlet method as shown in figure 4.1 and their flask constant weight value after dry its in oven was taken. Fats content of *Sesamum radiatum* seeds in this research were found to have 43.48 % which is lower than the ranges of proximate composition for fats content in *Sesamun indicum* seeds which is 45.6% to 46.1% (Makinde & Akinoso,2013). High contain of fats indicate the high contain for oil extraction (Tashiro *et al*.,1990). In addition, *Moringga oleifera* seeds was found to have 45.84% fats content (Abiodun *et al*., 2012) was higher than the value melon seeds was reported which is in the ranged between 17.56% to 25.06% (Ebuchi & Avwobobe,2006). Pumpkin seeds were found to have high

fat content which is 38% in the form of crude lipid and also had great potential for good nutritional elements to human health (Elinge et al., 2012).

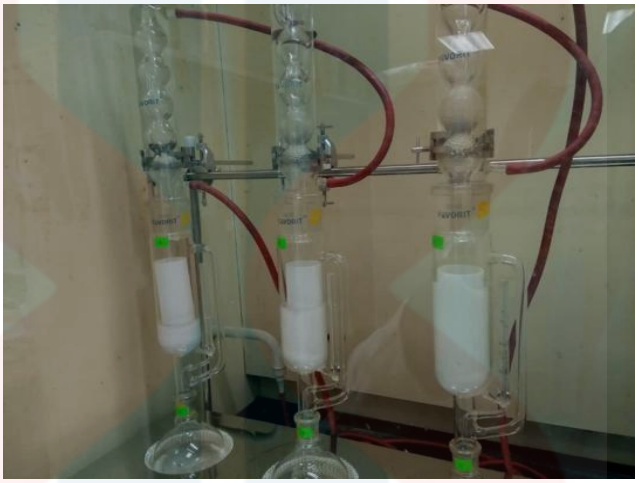

Figure 4.1: Fat extraction process using soxhlet extraction

(Sources: © Umi Raihanah 2018)

Protein determination was conducted using Kjedahl's method. This process consists of three crucial steps which are digestion, distillation and titration. Three samples and one blank sample were prepared during the process then the reading from the titration process taken and calculate into the equation. Thus, the crude protein for *Sesamum radiatum* was found to have 20.60% which is lower than the ranges 26.29% to 26.60% found in *Afzelia Africana* seeds (Ejikeme et al., 2010). According to Sarkar et al. (1994), soybean was reported has 28.2% crude protein. In addition, protein content of *Sesamum radiatum* seeds was found within the range 17% to 40% reported for legumes (Bojňanská *et al.*, 2012). According to Peter (2007), cereals consider as important sources of protein however, protein content in cereals which is 7% to 13 % is low compare to the *Sesamum*

radiatum seeds (Bojňanská, 2004) which is due to limitation amount of essential amino acid like lysine. In fact, protein content has relatively different value within and between species also due to the environment factor and genotype. The values of the crude protein is important in making the plant good for food supplements which help in improving protein malnutrition.

Carbohydrate content of *Sesamum radiatum* was found by differences showed that it contain 25.41% which is fall in between the ranged reported in Food Standard Agency and Institute of Food Research (2002) for oil seeds such as cotton seed (21.9%), flax seed/linseed (34.3%), peanut (12.5%), rape seed (8.3%) and sunflower seed. Carbohydrates are major nutrient which is crucial to our body and it is also provided nutritional energy value 17 Kcal/g and can be absorbed then serve as metabolic energy to people who consumed. Variety value in carbohydrates content may be due to the type of species, the organ, growth condition and photosynthesis process (Fanny *et al*, 2006).

Food energy portrayed the amount of energy in food component such protein, fat, carbohydrates and ash that human utilized as an input factor in energy balance equation. Food energy content in *Sesamum radiatum* seeds was found by energy content formula which contain of protein, fat and carbohydrate factor found to have 577.36 Kcal/g. Usually seeds are eaten in small quantities but it has a lot of nutrient content that needed by human body that keep them healthy. According to Blessing (2010), *Sesamum indicum* was reported to have 662.30 Kcal/g which revealed that species have higher food energy value which may due to high contain of carbohydrates in the seeds. For *Solenum nigrum* seeds was reported to have 43.54 kcal (Akubugwo *et al.*, 2007). In addition, food energy

is important to cover human needs like increase basal metabolic, the energy cost of physical activities and metabolic response to food.

4.2 Mineral composition of the *Sesamum radiatum*

Based on the table 4.2 shows that the analysis of the mineral element composition of *Sesamum radiatum* reveals the value of potassium, sodium, magnesium, calcium and copper by using the atomic absorption spectrophotometer (AAS). According to Karpiuk *et al*. (2016) the atomic absorption spectrophotometer (AAS) is the best technique to determine minerals due to their sensitivity, simplicity, high precision, rapid analysis, specificity, low detection limit, low cost and wide linear range.

The most abundant element that found in this seeds is calcium which is 175.1 mg/L. It can be consider as a good sources of calcium which is important for strong bone formation and maintaining teeth and bones keep strong (Bell *et al*.1996). Not only *Sesamum radiatum* seeds have high calcium content, *Terminalia catappa* oil seeds also found to have high calcium content which is 827.20 mg/100g (Matos *et al.* 2009) and 512.71 mg/g for *Myristica fragrans* seeds. However, *Moringa oleifera* seeds had the highest calcium value compared to *Sesamum radiatum* seeds which is 203.85 mg/L (Abiodun et al, 2012). According to Compaore et al. (2011), the difference value in the result is due to the factor geographical, soil composition, cultivation climate, the harvesting time of seeds and the extraction method that used.

Table 4.2 :Mineral composition of the *Sesamum radiatum*

Elements Analysis (%)	Triplicates Measurement			Average Result (Mean ± SD)
	1st reading	2nd reading	3rd reading	
Potassium (K)	113.4	111.5	110.5	111.8 ± 0.16
Sodium (Na)	3.045	3.046	3.039	3.043 ± 0.03
Magnesium (Mg)	57.42	56.78	57.84	57.35 ± 0.63
Calcium (Ca)	174.4	174.9	176.1	175.1 ± 0.08
Copper (Cu)	0.348	0.345	0.347	0.346 ± 0.45

Next, potassium is second most abundant element found in the *Sesamum radiatum* seeds with the concentration of 111.8 mg/L. In other research on *Afzelia Africana* seeds found that potassium content is 0.390% which is lower than the concentration found in cotton seeds (Ajuziogu et al., 2016) and abundantly found in *Terminalia catappa* seeds which is 928 mg/kg (Matos et al., 2009). Potassium play important role as principal cation in intracellular fluid and function in acid based balance, conduction of nerve impulse and others important function in our body (Soetan et al., 2010).

Magnesium (Mg) is an essential element for the nervous system. It helps in promoting sleep calming and proper digestion. Stress usually is caused from the deficiency of Mg where it increases sensitivity in physiological (Seelig,1994). The magnesium content of the *Sesamum radiatum* seeds is 57.35 mg/L. Magnesium can help

in resolving hypertension, cardiovascular diseases, osteoporosis and diabetes. According to Blessing et al. (2010), *Sesamum indicum* seeds was reported to have 0.49% concentration and 913.8 mg/100ml in *Monodora myristica* seeds (Stephen *et al*., 2014).

The sodium content of the *Sesamum radiatum* seeds is 3.043 mg/L which is lower than chia seeds which is found to have 3.68 mg/L (Paulina *et al.*, 2018). Next , *Solanum nigrum* seeds was reported to have 2.71 mg/100g (Akubugwo, 2007) and *Terminalia catappa* seeds 2.78 mg/kg (Matos et al., 2009). In fact, sodium and potassium are necessary to present in the plants as osmotic balance in the body.

The copper content is 0.346 mg/L found in the *Sesamum radiatum* seeds. According to Lippard and Jeremy (1994), copper is important in our body as constituent of several enzymes, such as cytochrome oxidase, catalase, tyrosine etc. Lack of this minerals can cause demineralization of bones, myocardial fibrosis etc. Besides, copper also act as activator of several enzyme system in plants (Raun, 2007). The present of mineral or element content in the plants might be due to the minerals composition of the soil in which the plants grow and climatology conditions (Blessing *et al*., 2010)

According to Sanchez et al. (1998), human risk factor can be lessening by consumed optimal intake of minerals or element such as potassium, magnesium, calcium, copper and others. In fact, there is increasing of interest in people and scientist to the needed of dietary minerals in improving the health issue even though only 4% to 6% is essential to our body.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The chemical composition of *Sesamum radiatum* was analyzed for content of moisture, ash, fat, protein, carbohydrates, food energy and minerals content. Based on this studies, there is significance different in the value due to types of plant, growth conditions, genetic factors, geographical variations and the method use. Fat content of *Sesamum radiatum* seeds is consider high and it is also rich in minerals element especially for calcium (Ca) and potassium (K). This seeds can be suggested as an alternative supplement to human body which is help to lower blood pressure by balancing out negative effect of salts due to present of high potassium content and also as cattle food for human to consume. It is concluded that *Sesamum radiatum seeds* has important nutritional value which is good for human diet.

This research also provides useful data on nutritional value in *sesamum radiatum* seeds. This seeds plant is suitable for a wide range of products, especially food based product or herb used which is safe for human consumption. From that, this plant can be commercial and prevent the food shortage in most developing countries due to the rapid growth of population, competition for fertile land and lack of agriculture's inputs.

5.2 Recommendations

This study was solely focus on nutritional analysis on Sesamum radiatum seeds. As recommendation for further research on *Sesamum radiatum* seeds, the most important is how the sample prepares, in order that the particle size must be lower so that the surface contact between the samples and extraction solvent is large and make it more efficient in extraction process. In this study, the sample preparation was used conventional method which is mortar and pestle and electric blenders to reduce the particles size. Besides that, to avoid the sample integrity is affected; every determination must be doing quickly without lengthy pauses during the process. All this assist in obtain the accurate data on the species that may be suitable for further research and development.

Next, future study that can be carried out is conducted the soil testing on the plant habitat. Soil testing like pH, salinity, acidity, nutrient and fertility can be measured or identified to justify their existence in certain condition and place influenced their nutrient content inside the plant.

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