EFFECTS OF DRYING METHODS ON NUTRIENT CONTENTS OF *Moringa oleifera* (Lam.) LEAVES

A PROJECT REPORT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF BARCHELOR OF SCIENCE (Hons.) DEGREE IN BOTANY, IN THE DEPARTMENT OF BIOLOGICAL SCIENCES, USMANU DANFODIYO UNIVERSITY, SOKOTO.

BY

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CERTIFICATION

This project report entitled: ‘’Effects of drying methods on nutrient contents of ‘’*Moringa oleifera*” leaves by (Zainab Sani Yabo/1011308004) has been read and approved by the undersigned as meeting the requirement for the award of Bachelor of Science (Hons.) Degree in Botany in the Department of Biological Sciences, Usmanu Danfodiyo University, Sokoto.

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DEDICATION

I dedicated this work to my husband Alhaji Musa Usman Nasko, my late aunt Hajiya Balaraba Yabo and to my brothers and sisters who contribute immensely to my education. May their work be rewarded accordingly.

ACKNOWLEDGEMENTS

My greatest gratitude to Allah most merciful, most beneficent who all praise and love is from and unto him alone. I will forever give him all my praise and affection for seeing me through the tedious journey of achieving this academic pursuit

May the peace and blessing of Allah be upon our Holy prophet Muhammad (S.A .W) and his household (Amin).

I feel deep sense of gratitude to my supervisor Dr. H.M.Maishanu for his constructive criticism and guidance during the period of writing this project. My appreciation also goes to Malam Ahmad of agric laboratory for his immense suggestion and guidance during the period of conducting my practicals.

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May you all live long to enjoy the fruit of your labour and may Allah reward u with Jannatul Firdausi. (Amin).

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ABSTRACT

The study was carried out to determine the effect of drying methods on the nutrient contents of *Moringa oleifera* at the Agric. Chemical Laboratory (Usmanu Danfodiyo University Sokoto) and The Energy Research Field of Sokoto Energy Center, Sokoto. Fresh leaves were collected and cleaned then dried using different drying methods viz. shade drying, solar drying, oven drying and sun drying. The treatments were analyzed for proximate and mineral contents using standard methods. Statistical analysis indicates that moisture was lowest in solar drying (2.67%). Shade drying produces the lowest lipid content (2.33%). High protein content was recorded under shade drying (28.50%). Overall, shade drying was noted to preserve the nutrient contents of *Moringa oleifera* better. In view of economic importance of *Moringa*, there is need to educate the local populace on the best method of preserving this vegetable.

CHAPTER ONE

1.0 INTRODUCTION

Moringa oliefera Lam. commonly referred to simply as *“Moringa”* belongs to the kingdom Plantae, Order Brassicales, Family Moringacacae, Genus Moringa and Species *Moringa oliefera*.

Moringa oliefera is native to the Indian subcontinent and has become naturalized in the tropical and subtropical areas of the world. It is the most widely cultivated species of the Genus *Moringa,* which is the only genus in the Family Moringacacae. It is an exceptionally nutritious vegetable tree with a variety of potential uses. *Moringa oliefera* trees are well naturalized in the northern parts of Nigeria where the leaves are popularly known as ‘zogala’ and widely consumed by populace (Pallavi and Dipika, 2010).

The plant is described as a fast-growing plant and drought resistant crop variety. It can survive in less fertile soil (Fahey, 2005, Anwar *et al.*, 2007). The tree itself is rather slender, with drooping branches that grow to approximately 10-12m in height. The "*moringa*" tree is grown mainly in semi-arid, tropical and subtropical areas. While it grows best in sandy soil, it also tolerates poor soil, including coastal areas. *Moringa oliefera* tree has a wide-open typically umbrella-shaped crown and usually, a single stem which tends to be deeply rooted. The wood is soft and its bark is light (Anwar *et al.*, 2007).

The *moringa* leaves are excellent, concentrated source of proteins, vitamins and minerals. Out of the 120 vegetable species tested for their nutrient content, antioxidant activity, and the facility with which they are grown and processed, *moringa oliefera* leaves were top ranked by the World Vegetable Centre (AVRDC) (Moyo, *et al.*, 2011). However, seasonal variation and varieties has been reported to have effects on the nutritional content. This is similar to the reports of Rodrigues, *et al.* (2011) on the effects of meteorological conditions on antioxidant flavonoids in Portuguese cultivar of white and red onions.

The *Moringa oliefera* leaves either fresh or processed into dried powder, can be used as an everyday food item in a multitude of ways: in ready-made meals, juices, breads, pasta, fritters, condiments, tea and instant soups. It can be used in households, school cafeterias, dispensaries, maternity wards, rehabilitation centers as well as in restaurants and supermarkets (Armelle and Melanie, 2010). *Moringa* o*liefera* leaf is an exceptional resource for developing countries. Processed or fresh, the *Moringa oliefera* leaves are not only a new, promising source of income and employment, but also outstanding, nutritionally rich vegetables for families and markets (Foidl, *et al.*, 2001).

The *Moriga oliefera* plant leaves contain very high level of nutrients. The *Moringa oliefera* tree however, is a deciduous plants and it sheds its leaves in the dry season.

Food provides the body with chemical substances known as nutrients, which in turn furnish the body with energy, regulate body processes and promote growth and repair of body tissues. When food is selected wisely and consumed in sufficient quantity, it provides all the nutrients which the body needs in the proportion required to function properly (FAO, 1988).

Some of the nutrients supplied by food are called essential nutrients because they cannot be synthesized in the body, at least in the amounts needed, and they enable the body to maintain good health. Other nutrients used by the body are known as non-essential nutrients. They, too, come from chemical substances supplied by food, or from their breakdown products which may be synthesized into nutrients in the body. The body's supply of essential nutrients comes preformed in food; non-essential nutrients are, generally speaking, constructed in the body from chemical substances supplied in the food (FAO, 1988).

All studies of the interaction of nutrients in humans indicate the need for a balanced diet. Clinical reports show that Individuals with a deficiency in one nutrient, such as a vitamin, often have deficiencies in other nutrients as well. The presence or absence of one essential nutrient may also affect the availability, absorption, metabolism or dietary need for other nutrients. There are six main types of nutrients: Carbohydrates, Proteins, Fats, Vitamins, Minerals, Water (FAO, 1988).

Except for water, each of these classes of nutrients is made up of several different chemical substances, some of which are essential nutrients. Water is, of course, also essential for human survival. The energy nutrient, that is carbohydrates, proteins and fats, are converted in the body to simpler compounds that may be reassembled into body compounds or may he oxidized, releasing energy. This energy is expressed in terms of kilocalories or kilojoules (FAO, 1988). Carbohydrates, fats, proteins and vitamins are organic chemical substances. That is, their chemical structures contain carbon. Minerals and water are inorganic substances, almost all of which do not contain carbon.

Carbohydrates include starches, sugars and many other compounds. The important classes of carbohydrate are polysaccharides (many of which are starches), disaccharides and monosaccharide (which are sugars). In the presence of sunlight, through the process known as photosynthesis, green plants are able to synthesis carbohydrates by trapping water from the ground and carbon dioxide from the air. In this process, oxygen from the carbon dioxide is released and returned to the atmosphere. When carbohydrate is synthesized in a green plant, much of it is stored in the plant cells as cellulose and starch (which are polysaccharides) and glucose (a monosaccharide) (FAO, 1988).

Dietary fibre, another form of carbohydrate, is important in proper bowel function. Meals must include fibrous roughage supplied mostly by vegetables. Finally, foods that are usually considered for their carbohydrate content, for example cereals, also supply significant quantities of protein, and the B vitamins (FAO, 1988).

Proteins are very large molecules made up of many amino acids linked together. Some amino acids are known as essential amino acids because they cannot be synthesized in the body in large enough amounts to meet the body’s needs. The other amino acids are considered non-essential because the body is able to synthesize sufficient amounts when amino groups are available in the body.

In general, proteins supply essential amino acids which the body uses in making new tissue and repairing tissue proteins damaged in the continuous wear and tear of the body processes. These functions account for increased protein requirements during such periods of growth as infancy, childhood, adolescence and pregnancy (FAO, 1988).

The term lipid is used to refer to a fat, oil or other fat- like substance found in food and used in the body. However, the term fat is more generally used and understood. Fats, like carbohydrates, are made up of carbon, hydrogen and oxygen. Fats contain more carbon and lees oxygen than carbohydrates and thus have greater energy value. One of the ways humans store energy in their bodies for future use is in the form of fat. Some plants, in addition to storing energy as carbohydrate, also store fat in their nuts, seeds, seed germs and fruits. In eastern Africa; foodstuffs of this group help to supply needed dietary fats (FAO, 1988).

The term mineral means an element or compound in a solid, crystalline and inorganic form. In nutrition, minerals are commonly referred to as mineral elements or, in the case of those present or required in small amounts, a- trace elements or trace minerals. Although the analysis of mineral ash shows the presence of more, there are only 22 mineral elements essential to good human nutrition. They are classified as: Macronutrient elements which include: calcium, chloride, magnesium, phosphorous, potassium, Sulphur, sodium. Micronutrient elements which include: arsenic, chromium, cobalt, copper, fluoride, iodine, iron, manganese, molybdenum, nickel, selenium, silicon, tin, vanadium and zinc (FAO, 1988).

Collectively about 4 to 5 percent of body weight is in the form of minerals, compared with 14 to 16 percent of protein and 12 to 20 percent of fat. Mineral elements have many essential roles to play in body metabolism or as constituents of body tissue. Many of them are indirectly involved in the growth process. Most minerals are obtained from foods in which they exist as salts and organic compounds. Highly refined foods and foods such as sugar contain few minerals (FAO, 1988).

Drying as a form of processing ensures the availability of perishable products all year round (Habou *et al.*, 2003). Drying method is used in Nigeria for preserving leafy vegetable and example of such vegetables is leaf of *Moringa oleifera*. Drying leafy vegetable increase their shelf life upon storage (Eklou *et al.*, 2006). The need for well established data on the nutrients composition of food is of great importance in identifying and solving nutritional problem in the society.

Drying agricultural produce by sun drying is widely used in most of the developing countries of the tropical region. However, solar drying is an elaboration of sun drying and was the most hygienic method of drying (Bala and Woods, 1994). The leaves of *Moringa oleifera* are preserved traditionally using sun drying (open air) and this is associated with possible contamination by microorganisms, infestation by insects and rodents. Their quality can be diminished and even become inedible (Diamante and Munro, 1993).

1.1 STATEMENT OF THE RESEARCH PROBLEM

The need to meet nutritional requirements through adequate food supplies and proper selection of diet has been a basic determinant of stability and progress, since human being require food to pursue essential functions such as growth, development and reproduction (Onimawo, 2001). Hunger and malnutrition are highly prevalent in the developing countries. FAO (2001) reported that absolute number of food-unsecured in developing world increased from 780 million to 798 million. In Nigeria, about 7.8 million people were undernourished in 1995-1997 and increased 9.1 million in 1999-2001 (SCN, 2004).

1.2 JUSTIFICATION

The justification of this research is based on the fact that *Moringa oleifera* leaves can be a source of income and employment to some individuals. It is also used for many purposes including medicine, food, oil, industrial purpose e.t.c. Leafy vegetables are very much prone to attack by pathogens especially fungi if not adequately preserved. The best drying method if applied will go a long way in ensuring the food security of the local people.

1.3 AIM AND OBJECTIVES

The main aim of this research work is to investigate the effect of different drying methods on the proximate and other nutrient composition of *Moringa oliefera* leaves. The specific objectives are:

1. To determine the effects of various drying methods on the proximate composition of the leaves of *Moringa oleifera.*
2. To determine the effects of various drying methods on the mineral composition of the leaves of *Moringa oleifera*.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 BOTANY OF *Moringa oleifera*

Moringa oliefera, commonly referred to as the drumstick tree is a plant from the *Moringacae* family, which can be found widely throughout the tropics in Africa, South America and India (Fahey, 2005, Anwar *et al*., 2007). There are about 13 species in the *Moringacae* family, of which *Moringa oliefera* is the species most widely known. The tree is often called “multipurpose” due to the fact that all parts including the leaves, pods, seeds, flowers, fruits and roots are edible.

Moringa can be described as a “much branched plant” of around 10 meters in height, with grey thick bark and a thin crown (Anwar *et al*.,2007). The tree requires an annual rainfall of between 250mm and 3oomm and survives in a temperature range of 25 to 40^{0}C which makes it suitable for tropical climates (HDRA, 2002).

Moringa is concidered as one of the world's most useful trees, as almost every part of the *Moringa* tree can be used for food, medication and industrial purposes (Khalafalla *et al.,* 2010). People use its leaves, flowers and fresh pods as vegetables, while others use it as livestock feed (Anjorin *et al.,* 2010). This tree has the potential to improve nutrition, boost food security and foster rural development (Hsu, 2006).

Recently, a high degree of renewed interest was placed on the nutritional properties of *Moringa* in most countries where it was not native (Reyes, *et al*., 2006; Oduro *et al*., 2005). This could be due to the claims that it increases animal productivity as it has nutritional, therapeutic and prophylactic properties (Fahey, 2005). Studies from other countries indicate that the leaves have immense nutritional value such as vitamins, minerals and amino acids (Anwar *et al.,* 2007). As such, the leaves have been used to combat malnutrition, especially among infants and nursing mothers. In addition, nutrition plays a crucial role in both humans and livestock as short-term alternative to chemoprophylaxis.

Moringa oleifera leaves contain more vitamin A than Carrot, more vitamin C than oranges and more potassium than bananas. The protein quality of *Moringa* leaves compares very well with that of milk and eggs (Gardener and Ellen, 2002). The leaves and stem of *Moringa oliefera* are known to have large amount of calcium oxalate crystals which are decreased by processing, making them more available to the body (Gardener and Ellen, 2002). The leaves are cooked and used as spinach. In addition, its leaves are commonly dried prior to pulverization as powder for fortification and supplementation especially in complementary infant feeds. The dried and pulverized powder is added to pap, cereals and drinks to improve nutrition (Gardener and Ellen, 2002).

A study was done in Pakistan to examine the physico-chemical characteristics of *Moringa oleifera* seeds and seed oil from a wild provenance of Pakistan. The *Moringa* seeds harvested from the forests of Kohat district of NWFP exhibited an oil yield of 34.80%. Protein, Fiber, Moisture and Ash contents were 31.65, 7.54, 8.90 and 6.53%, respectively the wild *M. oleifera* seed oil was found to contain oleic acid up to 73.22% followed by palmitic, stearic, behenic and arachidic acids 6.45, 5.50, 6.16 and 4.08%s respectively and fell in the category of high oleic oils. The results of different quality attributes of *M. oleifera* oil from a wild provenance of Pakistan reviewed that it could be employed for edible and commerce (Anwar and Bhanger, 2003, Dahot and Memo, 1987, Farooq and Rashid,2007, Fuglie and Lowell, 2001, Monica, 2005, Trees For Life, 2005). Other studies have reported variable Protein contents ranging between 16,22.42, 23.27, 27.4 and 40% (Gidamis *et al*., 2003; Sarwatt *et al*., 2004; Nouala *et al*., 2008; Sanchez-Machado *et al*., 2009).

2.2 USES OF *Moringa oleifera*

Moringa oliefera is the most nutrient-rich plant yet discovered. This humble plant has been making strides in less-developed societies for thousands of years and significant nutritional researches has been conducted since the 1970s (Bakare,1985, Ademoroti,1996, and Oyeleke,1984). *Moringa* provided a rich and rare combination of nutrients, amino acids, antioxidants, anti-aging and anti-inflammatory properties used for nutrition and healing. Moringa is sometimes called "Mother's best friend" and "Miracle Tree". Since 1998, the World Health Organization has promoted Moringa as an alternative to imported food supplies to treat malnutrition (Johnson, 2005).

2.2.1 NUTRITIONAL USES

Moringa has been in use since centuries for nutrition as well as medicinal purposes. These include Vitamin C, which fights a host of illness including colds and flu; Vitamin A, which act as a shield against eye disease, skin disease, heart ailments, diarrhea and many other diseases; Calcium which builds strong bones and teeth and helps prevent osteoporosis; Potassium which is essential for the functioning of the brain and nerves, and Proteins, the basic building blocks of all our body cells. Another important point is that *Moringa* leaves contain all the essential amino acids, which are the building blocks of proteins. It is very rare for a vegetable to contain all of these amino acids. *Moringa* contains these amino acids in a good proportion too. These leaves could be a great boom to people who do not get protein from meat. *Moringa* even contains argenine and histidine, which are important for infants who are unable to make enough protein for their growth requirements. Experts tell us that 30% of children in sub-Saharan Africans are protein deficient. *Moringa* could be an extremely valuable food source (Babu *et al.*, 2000).

Given its nutritional value it can be utilized in fortifying sauces, juices, spices, milk, bread and most importantly instant noodles. Many commercial products like zija soft drink, tea and neutron ceuticals are available all over the globe (Khawaja *et al*., 2010).

2.2.2 TRADITIONAL USES

Moringa has been used in the traditional medicine passed down for centuries in many cultures around the world for skin infections, anemia, anxiety, asthma, black heads, blood impurities, bronchitis, catarrh, chest congestion, cholera, conjunctivitis, cough, diarrhea, eye and ear infections, fever, glandular, swelling, headaches, abnormal blood pressure, hysteria, pain in joints, pimples, psoriasis, respiratory disorders, scurvy, semen deficiency, sore throat, sprain, tuberculosis, for intestinal worms, lactation, diabetes and pregnancy. The healing properties of *Moringa* oil have been documented by ancient cultures. *Moringa* oil has tremendous cosmetic value and is used in body and hair care as a moisturizer and skin conditioner. *Moringa* oil has been used in skin preparations and ointments since Egyptian times (Fuglie *et al*, 2001).

2.2.3 PLANT GROWTH ENHANCER

Lab experimentation had shown that *Moringa* spray had a wide range of beneficial effects on plant crops. Effects of spray indicated acceleration growth of young plants. Plants were firmer, more resistant to pests and disease.They also have longer life-span, heavier roots, stems and leaves, produced more fruits, larger fruit, increase in yield 20-35%. Even if a fraction of these results could be reproduced in the field, it could be a great help in increasing food supplies for millions of hungry people (Foild, *et al.*, 2001).

2.2.4 ANIMAL FEED FORTIFICATION

M**o***ringa* leaves added to cattle feed increased their daily weight gain by up to 32 percent. Feed of milk cows was supplement with 15 to 17 kilograms of fresh *Moringa* leaves daily; and the cattle milk production increased by 43 percent. Feed supplemented with 2kg dry matter and milk production increased by 58 percent. Also feed supplement with 3kg dry matter per day and milk production increased by 65 percent. Imagine what would be possible if milk production in developing countries could be increased in this way. It could prevent untold sufferings of people with protein deficiency (Foidl, *et al*, 2001).

2.2.5 WATER PURIFICATION

Powdered seeds act as a natural flocculent, able to clarify even the most turbid water, seed powder can be used as quick and simple method for cleaning dirty water. The powder joins with the solids in the water and sinks to the bottom. Using Moringa to purify water replaces chemicals such as aluminum sulphate which are dangerous to people and the environment and are expensive. Twenty liters of water may be purified by adding 2grams of powder to one cup of clean water poured into a bottle and shaken for 5 minutes (Gassenschmidt *et al.,* 1995).

2.3 NUTRITIONAL VALUES OF DRIED LEAVES POWDER

This research focuses on the leaves of the plant as they have the highest amount of crude protein content as identified by a study carried out in Germany. Makkar and Becker (1996) discover that the crude protein content of leaves, soft twigs and stems are respectively 260, 70 and 60g per kg, pointing out the high amount of crude protein in the leaves. They also demonstrate that the leaves have a superior percentage of true protein at about 87% compared to 60 and 53% in twigs and stems respectively (Makkar and Becker 1996).

The leaves have also been subject to other various studies using individuals with special nutritional needs. For instance, two research studies which analysed the impact of *Moringa* dry leaf powder on iron values of lactating women and undernourished HIV positive children show no adverse symptoms of the plant (Idohoz-Dossou, *et al*. 2011, Tété-Bénissan, *et al*. 2012). These studies apply the leaves as a supplement for human consumption, enabling them to be considered as tolerable for infants as no side effects have been identified.

The leaves are described as “feathery with a green to dark green elliptical leaflet about1-2cm long.” (Paliwal, *et al*., 2011) Various small technological procedures are used to obtain a uniform dry powder.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 STUDY AREA

The research was conducted at the Agric. Chemical Laboratory (Usmanu Danfodiyo University Sokoto) and The Energy Research Field of Sokoto Energy Center, Sokoto. The area lies within 11.3^0 to 13.50^0 N and 4^0 to 6.50^0 E above sea level, covering an area of 55.842 kilometer square. It lies within the Sudan Savanna ecological zone characterize by long dry season (October to May) and short rainy season (June to September).The mean annual precipitation in the area ranges from 300-600mm, and minimum and maximum temperature are 27^0 C around April and 40^0 C around April respectively (Singh and Babaji, 1990).

3.2 SAMPLE COLLECTION AND PREPARATION

The leaves of *Moringa oleifera* were collected at biological garden Usmanu Danfodiyo University, Sokoto, Nigeria (UDUS) , at a time from the same tree to avoid the effect of soil variation on the micro nutrient content of the leaves. The leaves collected were washed with water to remove dust and some portion was dried to a constant weight using the four drying methods.

3.3 DRYING METHODS

The drying methods used in the present study were (i) sun drying (ii) Shade drying (iii) Oven drying and (iv) solar drying.

3.3.1 SUN DRYING

The leaves were placed on a sheet of cloth and placed under direct sunlight on a roof away from animals, traffic and dust. The leaves were turned occasionally to ensure even drying. The leaves were brought indoor at nights as the temperature during night falls down. Sudden temperature change could put moisture back into the leaves and lengthen the drying time. The leaves took four days to dry in the sun (Pallavi and Dipika, 2010).

3.3.2 SHADE DRYING

The leaves were spread on a sheet of cloth and kept in a well-ventilated room at a temperature 25 ± 2^0C for days. Natural current of air was used for shade-drying the leaves. It took about six days for the leaves to dry completely and become crisp and brittle to touch.

3.3.3 SOLAR DRYING

The leaves were loaded in the dryer. The leaves shielded from direct incidence of solar radiation. Heated air from the solar absorber and the air is directed to the drying chamber. Air flow is by natural or forced convection. This type of chamber are monitored by periodic inspection because of the temperature variance (Amedorme *et al*., 2013).

3.3.4 OVEN DRYING

The leaves were oven dried (60^0 C) using hot air oven (Stuart Scientific, England) for 24h to obtain a completely dried sample (Hassan *et al*., 2007).

3.4 CHEMICAL ANALYSIS

The dried leaves were analyzed for proximate composition (moisture, Protein, Carbohydrate, Nitrogen, Fat, Fiber and Ash), mineral composition (Calcium, Potassium, Magnesium and phosphorus). The proximate analysis off the dried *Moringa oliefera* leaves were determined.

3.4.1 PROXIMATE ANALYSIS

The proximate analysis of the sample for total ash, crude fibre and ether extract were carried out using the methods described in AOAC (1990). The nitrogen was determined by Micro Kjeldahl's method described by Pearson (1976) and the nitrogen content was converted to protein by multiplying by 6.25. Carbohydrate was determined by method of difference.

3.4.2 DETERMINATION OF CRUDE MOISTURE

PROCEDURE

The two grams of the four samples were added to the empty moisture dish and placed into an air oven. The three samples were dried in the hot air drying oven at 110°c for 24hours. The samples were then kept in a desiccator and allowed to cool after which the crucible with the dry samples were then weighed and returned to the oven for further 24hours to make sure that the drying was completed. The weights were taken again, for each sample (Bakare, 1985). The moisture was determined using the following formula:

$$\frac{\% = \text{Moisture} = W_1 - W_2 \times 100}{W_1 - W_0}$$

Where

Wo = Weight of empty dish

W_1 = Weight of sample fresh

W_2 = Weight of sample dry

3.4.3 DETERMINATION OF CRUDE NITROGEN

The determination of total nitrogen was done by the micro-kjeldahl's procedure.

PROCEDURE

Exactly 0.5grams of each sample was weighed, and placed in a dry 500m1 micro-kjeldahl's flask to which 20m1 of distilled water were added. The flask was swirled for a few minutes and then allowed to stand for 30minutes. One (1) tablet of mercury catalyst and l0ml of concentrated H_2SO_4 were added through a pipette. The flask was heated continuously at low heat on the digestion stand. When the water has been removed and frothing has ceased, the heat were increased until the digest were cleared. The mixture was boiled so that the H2SO4 condenses about half way up to the neck of the flask. The flask was allowed to cool and 50m1 of water was added to the flask slowly. Then l0ml of aliquot of digest were added into the distillation apparatus. The distillation flask was then attached to the distillation. The condenser was kept cool below 30°c allowing sufficient cold water to flow through and regulate heat to minimize frothing and prevent suck back. Thereafter 40m1 distillate was collected and the distillation was stopped. Nitrogen were determined in the distillate by titration with 0.01 (M) molar standard HCl using a 25m1 burette graduated at 0.01 ml intervals, the colour change at the end point, were from green to pink (ASA Monograph 1982). Then percentages of nitrogen content in the sample were calculated using the below formula:

$$N\% = \frac{TVx\ 0.0lx\ 0.014x\ 50\ x100}{0.5\ x\ 10}$$

Where

N% = Percentage of nitrogen

TV = Titration value

0.01 = Molar standard of HC1

0.014 = Nitrogen concentration

50 = Distilled water

10 = m/g of aliquot

0.5 = Weight of sample

3.4.4 DETERMINATION OF CRUDE PROTEIN

To estimate crude protein, it involves the determination of total Nitrogen. The amount of crude protein were obtained by multiplying the nitrogen content by a factor of 6.25.

3.4.5 DETERMINATION OF CARBOHYDRATE OR NFE

The Nitrogen Free Extraction (NFE) referred to as soluble carbohydrate was not determined directly but obtained as a difference between crude protein, sum of crude ash, lipid and crude Fibre (Bakare, 1984).

FORMULA:

NFE = 100% - (% Ash + % Crude lipid + Crude fibre % Crude protein).

3.4.6 DETERMINATION OF CRUDE ASH

PROCEDURE

Ash dry sample was determined by direct incineration in a muffle furnace at 600^0c after charring, till grayish white residue formed described by AOAC (2006) the empty crusible was initially weight and 2 grams of the sample was added to it and weight gained.

FORMULA:

$$\%Ash = \frac{w_2 - w_0}{W_1 - w_0} \times 100$$

3.4.7 DETERMINATION OF CRUDE FIBER

PROCEDURE

Two gram of the grounded sample were weighed and put into 1litre control flask. Then 2200ml at 1.25% H_2SO_4 were added and boiled gently for 30minute using cooling finger to maintain a constant volume.

It was then filtered through a poplin cloth. The residue were washed thoroughly with hot water and rinsed once with 10% HCL and twice with industrial methylated spirit. It were then rinse finally three times. With petroleum ether (BP40-60^{o}c) and allow to dry. The residue were kept overnight at 105^{o}c in the oven, and was cooled in a desiccator. The two samples were weighed again and ashed at 550^{o}c for 90minute in a muffle furnace cooled and weighed again.

FORMULA:

$$\% \text{ Fibre} = \frac{W_1 - W_2}{2} \times 100$$

3.4.8 DETERMINATION OF CRUDE LIPID

PROCEDURE

2 grams was collected from each sample and was put into a bottle then 20ml of N-Hexane added to the sample, the bottle was tightly closed and was left for 24hours

The empty petri- dish was weighed (w_1) initially and after 24hours the sample was poured into the weighed petri-dish and it was placed under the fan for the N-Hexane to evaporate, then petri-dish was weighed (w_2) again to determine the Lipid content.

FORMULA:

$$\frac{W_2 - w_1}{2} \times 100$$

3.5 MINERAL ANALYSIS

The mineral elements determined in this study were: Sodium (Na), Potassium (K), Calcium (Ca), Magnesium (Mg), and Phosphorus (P) using EDTA method (Ademoroti, 1996).

3.5.1 CALCIUM AND MAGNESIUM DETERMINATION

PROCEDURE

Calcium and Magnesium were determined by E.D.T.A. Method. Calcium was obtained by pipetting 1m1 aliquots of the samples solution into filtration flask. Three drops each of KCN, NH_2,OH and

Triethanolalamine were added together with 0.3g of Murexide and it were then filtrated with E.D.T.A solution to the end point from Pink to Purple.

FORMULA:

$$\% \, Ca = \frac{TV \times 0.01 \times 1000}{20m1}$$

Where:

% Ca = Percentage of Calcium

TV = Titre value of calcium

0.01 = Standard E.D.T.A concentration

1000 = Unit measurement

20 = Aliquot sample

FORMULA:

$$\% Mg = \frac{TV \times 0.01 \times 1000}{20}$$

3.5.2 PHOSPHORUS DETERMINATION

PROCEDURE

Phosphorus (P) was determined using spectrophotometer. Then 4 of the sample was pipette into a 50m1 volumetrically flask. Then 45m1 of distilled water and 2m1 of ammonium molybdate Solution were added and mixed properly. After that, 1m1 of $5NC1_2$ $2H_2O$ dilute solutions were added and mixed again, after 5 minutes the measure was taken on the electro photometer at 660m wavelength.

FORMULA:

$$P = \frac{Abs \times CF \times DF \times DF}{\text{Atomic weight of phosphorus}}$$

Where:

Abs = Absorbent reading of the spectrophotometer

CF = Conversion factor (0.61)

DF= Dilution factor (25)

DF= Dilution factor (25)

3.5.3. SODIUM AND POTASSIUM ESTIMATION

PROCEDURE

Potassium and Sodium were obtained by using the flame photometer. The flame photometer was set up by inserting appropriate filter usually by 768 mu for K and 589 mu wave lengths for Na respectively. This instrument was set to 100 transmittance by taking 2-10 ppm of K and Na solution. The standard curve was prepared by plotting transmittance reading against concentration of standard K and Na solution.

CHAPTER FOUR

4.0 RESULTS

The results of comparative nutrient analysis of four samples are represented in the table one below:

4.1 PROXIMATE ANALYSIS

Table 1 shows the proximate composition of *Moringa oleifera* leaves from different drying methods. The moisture content was in the range of 2.67 to 13.67%. Moisture content was significantly ($P>0.05$) higher (13.67%) for shade dried treatment. Solar dried treatment was found to be significantly ($P<0.05$) lower than other treatments. The Protein content in the four treatments was in the range of 3.20-28.50%. Shade dried treatment was significantly ($P>0.05$) higher (28.50%) than solar dried treatment (3.20%), oven dried treatment (6.80%) and same dried treatment (14.30%). The Fiber content of the four treatments varied from 3.00-10.50% shade and sun dried treatment were found to be significantly ($P<0.05$) lower than solar and oven dried treatments.

The Lipid composition of the treatment was in range of 2.33-6.50% solar and sun dried treatments were statistically (P>0.05) higher than the other treatments but not significantly different from each other, with 6.00% and 6.50% respectively.

Table 1: Proximate composition of *Moringa oleifera* at different drying methods.

Parameters (%)	Shade Drying (Treatment A)	Solar Drying (Treatment B)	Oven Drying (Treatment C)	Sun Drying (Treatment D)	SEM
Moisture	13.67^{a}	2.67^{d}	5.67^{c}	8.50^{b}	0.39
Ash	9.33^{b}	12.00^{a}	9.50^{b}	9.17^{b}	0.23
Lipid	2.33^{c}	6.00^{a}	4.83^{b}	6.50^{a}	0.27
Fiber	3.00^{c}	7.17^{b}	10.50^{a}	3.00^{c}	0.30
Nitrogen	4.56^{a}	0.52^{d}	1.09^{c}	2.29^{b}	0.01
Protein	28.50^{a}	3.20^{d}	6.80^{c}	14.30^{b}	0.04
Carbohydrate	56.50^{d}	71.67^{a}	68.37^{b}	67.03^{c}	0.30

Means with the same letter (s) on the same row are not significantly different (P<0.05), while means with different letter(s) are significantly different (P>0.05). Triplicate determination (n=3). SEM = Standard Error of Mean.

4.2 MINERAL ANALYSIS

The results of comparative nutrient analysis of four samples are represented in the table two below:

Table 2 shows the mineral composition of *Moringa oleifera* leaves at different drying methods. Shade dried, solar dried, oven dried and sun dried treatment in potassium (5800.00, 3500.00, 3800.00 and 3000.00 mg/kg) are significantly different from each other. However, shade dried treatment is significantly ($P>0.05$) higher and sun dried treatment is significantly ($P<0.05$) lower. It can also be seen that in calcium, shade dried, solar dried, oven dried and sun dried treatments (0.77, 1.83, 1.10 and 0.97mg/kg) are significantly different from each other. However, solar dried treatment is significantly ($P>0.05$) higher and shade dried treatment is significantly ($P<0.05$) lower.

Shade dried treatment was significantly ($P>0.05$) higher for sodium with (142.50mg/kg), while solar, oven and sun dried treatment are not significant ($P<0.05$) with 120.00mg/kg, 125.00mg/kg and 125.83mg/kg respectively.

Table 2: Mineral composition in (mg/kg) of *Moringa oleifera* leaves under different drying methods

Parameters (mg/kg)	Shade Drying (Treatment A)	Solar Drying (Treatment B)	Oven Drying (Treatment C)	Sun Drying (Treatment D)	SEM
Sodium (Na)	142.50[a]	120.00[b]	125.00[b]	125.83[b]	1.65
Potassium (K)	5800.00[a]	3500.00[c]	3800.00[b]	3000.00[d]	66.07
Calcium (Ca)	0.77[d]	1.83[a]	1.10[b]	0.97[c]	0.04
Magnesium (Mg)	1.03[a]	0.40[c]	0.73[b]	1.03[a]	0.04
Phosphorus	3.30[a]	3.20[b]	3.10[c]	3.13[c]	0.03

Means with the same letter (s) on the same row are not significantly different ($P<0.05$) while means with different letter(s) are significantly different ($P>0.05$). Triplicate determination (n=3). SEM = Standard Error of Mean.

CHAPTER FIVE

5.0 DISCUSSION

From the result obtained, shade dried treatment is significantly higher than the other treatments. The value obtained may noted to be higher than the value (6.35%) reported by Mbah et al. (2012).Removal of moisture by heat generally improves the digestibility of foods, increases concentration of nutrients and can make some nutrients more available (Morris et al., 2004). Moisture contents of fruit and vegetables provide an enabling environment for growth of micro-organisms, thus it has to be reduced if vegetables and fruits have to be preserved or kept for long time to be used and this may inhibit autolytic enzymes (Ladan *et al.*, 1997). From the four different treatments, solar dried treatment was found to be most effective due to it low moisture content as it can decrease deterioration and can have long shelf life.

Potassium in shade dried treatment has found to be significantly higher than solar dried, oven dried and sun dried treatments. Higher potassium level in shade dried treatment. The higher lipid contents in solar and sun dried treatments could not be and added advantage over the fresh sample for use as a therapy and are vital for bone (Dzomeku *et al.*, 2006).

Lower protein values for solar and oven dried treatment from this research shows that macro nutrients value decreases when dried under heat. The result tallied with the assertion of Laden *et al.* (1997) that heat reduces the nutrients values of tomatoes. The significant decrease of macro nutrients upon drying may be attributed to the stability of the bonds involved in them. The intensity of heat applied due to efficiency of the dryers was found t be commensurate with the decrease in protein content. Morris *et al.* (2004) reported losses of these macro nutrients especially protein due to application of heat.

The higher lipid contents in solar and sun dried treatments could not be considered as a good source of lipid, which is in agreement with the fact that green leafy vegetables are ‘Heart friendly food’ (Pallavi and Dipika, 2010). The lipid content of shade and oven dried treatments were found to be lower and most effective in terms of lipid than solar and sun dried treatments. This enhances the storage life of the flour due to the reduction in chance of developing rancid flavor and may not be a good source of fat soluble vitamins. Lipid can be used as basis in determining, processing temperatures as well as the auto-oxidation which can lead to rancidity (affect flavor of food).

Higher fiber content for solar and oven dried treatments could be due to dehydration and concentration of dry matter. Fiber has useful role in providing roughage that aids digestion (Lisa, 1997). Higher fiber content in diets have been reported to have resulted in increased in the removal of carcinogen, potential mutagens and steroids. Solar dried treatment was statistically higher in carbohydrate content and can be a good source of energy for animals and human beings. However, sun dried, oven dried and shade dried treatments are statistically different to each other and statistically lower than solar dried treatment.

Solar and oven dried treatments in calcium were higher than that of shade and sun dried treatments. It is also of remarkable interest that the dried *Moringa* leaves have high deposit of mineral elements. Calcium was observed to be higher compared with other plant sources (Nkafamiya *et al.,* 2010). It is required for formation and maintenance of bones and teeth thus, preventing osteoporosis. It is also needed for normal blood clotting and nervous function. Also, it can be seen that in Sodium shade dried treatment is significantly higher than solar dried, oven dried and sun dried treatments. However, the three treatments (solar, oven and sun dried) were found to be statistically similar to each other and lower than shade dried treatment.

Shade dried, solar dried, oven dried and sun dried in Nitrogen are significantly different to each other. Shade dried treatment is statistically higher than the other three treatments. The results from this research work indicate that mineral element composition of *Moringa oleifera* vary with drying method. There is no known explanation regarding unusual observation. However, it may be due to environmental, genetic factors and the method of analysis employed. The higher Ash composition of solar followed by oven, shade and sun dried treatments (having lowest and comparable values) may indicate higher mineral elemental composition of leaves of *Moringa oleifera.*

Shade dried and sun dried treatments in Magnesium were found to be significantly higher and similar to each other, while solar dried and oven dried treatments are lower than sun dried and shade dried treatment. Also, it can be seen that in phosphorus shade dried is significantly higher ($P>0.05$) than sun dried, solar and oven dried treatment. The higher calcium and phosphorus in the dried treatment are vital for bone a similar observation was reported with tomatoes by (Ladan *et al*., 1997).

CONCLUSION

It can be concluded that drying generally improves the nutrient contents of *Moringa oleifera* leaves. There is no significant effects ($P < 0.05$) between the four treatments on the Nitrogen and Protein contents of *Moringa oleifera*. Oven dried treatment have higher content of Fiber, while shade dried treatment have higher content of Protein, Phosphorus, Potassium and Sodium. It is therefore recommended that *Moringa oleifera* leaves should be dried using shade drying method due to the higher retention of some essential minerals.

RECOMMENDATION

1. Further research should be carried out on the effect of drying methods on the Vitamins and anti-nutrients, since *moringa oleifera* is a cheap source of nutrients. It should be used in food supplementation, fortification and complementation (especially in infant feed).

2. There should be proper education in various communities on the economic and nutritional importance of shade drying, solar drying, oven drying and sun drying food preservation.

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APPENDIX 1

Calculation for the proximate composition (Which include, Moisture, Fiber, Ash Lipid, Protein, Nitrogen and carbohydrate) of *Moriuga oleifera*.

Moisture content

$$\% \text{ moisture} = \frac{W_1 - W_2}{W_1 - W_0} \times 100$$

$$\% A_1 \text{ moisture} = \frac{31.75-31.48}{31.75-29.75} \times 100$$

$$= \frac{0.27}{2} \times 100$$

$$= 0135 \times 100$$

$$= 13.5\%$$

$$\% A_2 \text{ moisture} = \frac{34.43-34.15}{34.43-32.43} \times 100$$

$$= \frac{0.28}{2} \times 100$$

$$= 0.14 \times 100$$

$$= 14\%$$

$$\% A_3 \text{ moisture} = \frac{30.33-30.06}{30.33-28.33} \times 100$$

$$= \frac{0.27}{2} \times 100$$

$$= 0.135 \times 100$$

$$= 13.5\%$$

$$\text{Mean} = \frac{13.5 + 14 + 13.57}{3}$$

$$= 13.67\%$$

$$\% B_1 \text{ moisture} = \frac{51.00-50.75}{51.00-49.00} \times 100$$

$$= \frac{0.05}{2} \times 100$$

$$= 0.025 \times 100$$

$$= 2.5\%$$

$$\% B_2 \text{ moisture} = \frac{39.56-39.52}{39.56-37.56} \times 100$$

$$= \frac{0.04}{2} \times 100$$

$$= 0.02 \times 100$$

$$= 2\%$$

$$\% \ B_3 \text{ moisture} = \frac{44.75-44.68}{44.75-42.75} \times 100$$

$$= \frac{0.07}{2} \times 100$$

$$= 0.035 \times 100$$

$$= 3.5\%$$

$$\text{Mean} = \frac{2.5 + 2 + 3.5}{3}$$

$$= 2.67\%$$

$$\% \ C_1 \text{ moisture} = \frac{27.67-27.57}{27.67-25.67} \times 100$$

$$= \frac{0.1}{2} \times 100$$

$$= 0.5 \times 100$$

$$= 5\%$$

$$\% \ C_2 \text{ moisture} = \frac{36.23-36.09}{36.23-34.23} \times 100$$

$$= \underline{0.14} \times 100$$

$$2$$

$$= 0.07 \times 100$$

$$= 7\%$$

$$\% \ C_3 \text{ moisture} = \frac{31.42-31.32}{31.42-29.42} \times 100$$

$$= \frac{0.1}{2} \times 100$$

$$= 0.05 \times 100$$

$$= 5\%$$

$$\text{Mean} = \frac{5 + 7 + 5}{3}$$

$$= 5.67\%$$

$$\% \ D_1 \text{ moisture} = \frac{34.08-33.91}{34.08-32.08} \times 100$$

$$= \frac{0.17}{2} \times 100$$

$$= 0.85 \times 100$$

$$= 8.5\%$$

$$\% D_2 \text{ moisture} = \frac{28.32-28.16}{28.32-26.32} \times 100$$

$$= \frac{0.16}{2} \times 100$$

$$= 0.08 \times 100$$

$$= 8\%$$

$$\% D_3 \text{ moisture} = \frac{30.33-30.15}{30.33-28.33} \times 100$$

$$= \frac{0.18}{2} \times 100$$

$$= 0.09 \times 100$$

$$= 9\%$$

$$\text{Mean} = \frac{8.5 + 8 + 9}{3}$$

$$= 8.5\%$$

Ash content

$$\% \text{ Ash} = \underline{w_2-W_0} \times 100$$

$W_1 - W_0$

$$\% A_1 \text{ Ash} = \frac{29.93-29.75}{31.75-29.75} \times 100$$

$$= \frac{0.18}{2} \times 100$$

$$= 0.09 \times 100$$

$$= 9\%$$

$$\% A_2 \text{ Ash} = \frac{32.62-32.43}{34.43-32.43} \times 100$$

$$= \frac{0.19}{2} \times 100$$

$$= 0.095 \times 100$$

$$= 9.5\%$$

$$\% A_3 \text{ Ash} = \frac{28.52-28.33}{30.33-28.33} \times 100$$

$$= \frac{0.19}{2} \times 100$$

$$= 0.095 \times 100$$

$$= 9.5\%$$

$$\text{Mean} = \frac{13.5 + 14 + 13.57}{3}$$

$$= 9.33\%$$

$$\% \ B_1 \ \text{Ash} = \frac{49.25-49.00}{51.00-49.00} \times 100$$

$$= \frac{0.25}{2} \times 100$$

$$= 0.125 \times 100$$

$$= 12.5\%$$

$$\% \ B_2 \ \text{Ash} = \frac{37.79-37.56}{39.56-37.56} \times 100$$

$$= \frac{0.23}{2} \times 100$$

$$= 0.115 \times 100$$

$$= 11.5\%$$

$$\% \ B_3 \ \text{Ash} = \frac{42.99-42.75}{44.75-42.75} \times 100$$

$$= \frac{0.24}{2} \times 100$$

$$= 0.12 \times 100$$

$$= 12\%$$

$$\text{Mean} = \frac{12.5 + 11.5 + 12}{2}$$

$$= 12\%$$

$$\% \ C_1 \ \text{Ash} = \frac{25.86\text{-}25.67}{27.67\text{-}25.67} \times 100$$

$$= \frac{0.19}{2} \times 100$$

$$= 0.095 \times 100$$

$$= 9.5\%$$

$$\% \ C_2 \ \text{Ash} = \frac{34.23\text{-}34.23}{36.23\text{-}34.23} \times 100$$

$$= \frac{0.2}{2} \times 100$$

$$= 0.1 \times 100$$

$$= 10\%$$

$$\% \ C_3 \ \text{Ash} = \frac{29.60\text{-}29.42}{31.42\text{-}29.42} \times 100$$

$$= \frac{0.18}{2} \times 100$$

$$= 0.09 \times 100$$

$$= 9\%$$

$$\text{Mean} = \frac{9.5 + 10 + 9}{3}$$

$$= 9.5\%$$

$$\%\ D_1\ \text{Ash} = \frac{32.27-32.08}{34.08-32.08} \times 100$$

$$= \frac{0.19}{2} \times 100$$

$$= 0.095 \times 100$$

$$= 9.5\%$$

$$\%\ D_2\ \text{Ash} = \frac{26.50-26.32}{28.32-26.32} \times 100$$

$$= \frac{0.18}{2} \times 100$$

$$= 0.09 \times 100$$

$$= 9\%$$

$$\% D_3 \text{ Ash} = \frac{28.51-28.33}{30.33-28.33} \times 100$$

$$= \frac{0.18}{2} \times 100$$

$$= 0.09 \times 100$$

$$= 9\%$$

$$\text{Mean} = \frac{9.5 + 9 + 9}{3}$$

$$= 9.17\%$$

Lipid content

$$\% \text{ Lipid} = \frac{W_2 - W_1}{2} \times 100$$

$$\% A_1 \text{ Lipid} = \frac{37.71-37.65}{2} \times 100$$

$$= \frac{0.06}{2} \times 100$$

$$= 0.03 \times 100$$

$$= 3\%$$

$$\% A_2 \text{ Lipid} = \frac{29.36-29.32}{2} \times 100$$

$$= \frac{0.04}{2} \times 100$$

$$= 0.02 \times 100$$

$$= 2\%$$

$$\% \; A_3 \; \text{Lipid} = \frac{34.40 - 34.36}{2} \times 100$$

$$= \frac{0.04}{2} \times 100$$

$$= 0.02 \times 100$$

$$= 2\%$$

$$\text{Mean} = \frac{3 + 2 + 2}{3}$$

$$= 2.33\%$$

$$\% \; B_1 \; \text{Lipid} = \frac{44.44 - 44.32}{2} \times 100$$

$$= \frac{0.12}{2} \times 100$$

$$= 0.06 \times 100$$

$$= 6\%$$

$$\% \ B_2 \text{ Lipid} = \frac{44.37-44.26}{2} \times 100$$

$$= \frac{0.11}{2} \times 100$$

$$= 0.055 \times 100$$

$$= 5.5\%$$

$$\% \ B_3 \text{ Lipid} = \frac{32.69-32.56}{2} \times 100$$

$$= \frac{0.13}{2} \times 100$$

$$= 0.065 \times 100$$

$$= 6.5\%$$

$$\text{Mean} = \frac{6+5.5+6.5}{3}$$

$$= 6\%$$

$$\% \ C_1 \text{ Lipid} = \frac{33.62-33.52}{2} \times 100$$

$$= \frac{0.1}{2} \times 100$$

$$= 0.05 \times 100$$

$$= 5\%$$

$$\% \ C_2 \ \text{Lipid} = \frac{49.16-49.06}{2} \times 100$$

$$= \frac{0.1}{2} \times 100$$

$$= 0.05 \times 100$$

$$= 5\%$$

$$\% \ C_3 \ \text{Lipid} = \frac{26.74-26.65}{2} \times 100$$

$$= \frac{0.09}{2} \times 100$$

$$= 0.045 \times 100$$

$$= 4.5\%$$

$$\text{Mean} = \frac{5 + 5 + 4.5}{3}$$

$$= 4.83\%$$

$$\% \ D_1 \ \text{Lipid} = \frac{33.10-32.97}{2} \times 100$$

$$= \frac{0.13}{2} \times 100$$

$$= 0.065 \times 100$$

$$= 6.5\%$$

$$\% \ D_2 \text{ Lipid} = \frac{44.78-44.66}{2} \times 100$$

$$= \frac{0.12}{2} \times 100$$

$$= 0.06 \times 100$$

$$= 6\%$$

$$\% \ D_3 \text{ Lipid} = \frac{28.39-28.25}{2} \times 100$$

$$= \frac{0.14}{2} \times 100$$

$$= 0.07 \times 100$$

$$= 7\%$$

$$\text{Mean} = \frac{6.5 + 6 + 7}{3}$$

$$= 6.5\%$$

Fiber content

$$\% \text{ Fiber} = \frac{W_1 - W_2}{2} \times 100$$

$$\% \text{ } A_1 \text{ Fiber} = \frac{41.66-41.60}{2} \times 100$$

$$= \frac{0.06}{2} \times 100$$

$$= 0.03 \times 100$$

$$= 3\%$$

$$\% \text{ } A_2 \text{ Fiber} = \frac{41.65-41.60}{2} \times 100$$

$$= \frac{0.05}{2} \times 100$$

$$= 0.025 \times 100$$

$$= 2.5\%$$

$$\% \text{ } A_3 \text{ Fiber} = \frac{41.67-41.60}{2} \times 100$$

$$= \frac{0.07}{2} \times 100$$

$$= 0.035 \times 100$$

$= 3.5\%$

$$\text{Mean} = \frac{3 + 2.5 + 3.5}{3}$$

$= 3\%$

$$\% \ B_1 \text{ Fiber} = \frac{48.63 - 48.59}{2} \times 100$$

$$= \frac{0.13}{2} \times 100$$

$= 0.065 \times 100$

$= 6.5\%$

$$\% \ B_2 \text{ Fiber} = \frac{48.65 - 48.59}{2} \times 100$$

$$= \frac{0.15}{2} \times 100$$

$= 0.075 \times 100$

$= 7.5\%$

$$\% \ B_3 \text{ Fiber} = \frac{48.62 - 48.47}{2} \times 100$$

$$= \frac{0.15}{2} \times 100$$

$$= 0.075 \times 100$$

$$= 7.5\%$$

$$\text{Mean} = \frac{6.5+7.5+7.5}{3}$$

$$= 7.17\%$$

$$\% \; C_1 \text{ Fiber} = \frac{48.18-47.96}{2} \times 100$$

$$= \frac{0.22}{2} \times 100$$

$$= 0.11 \times 100$$

$$= 11\%$$

$$\% \; C_2 \text{ Fiber} = \frac{48.18-47.98}{2} \times 100$$

$$= \frac{0.2}{2} \times 100$$

$$= 0.1 \times 100$$

$$= 10\%$$

$$\% \ C_3 \ Fiber = \frac{48.16-47.95}{2} \times 100$$

$$= \frac{0.21}{2} \times 100$$

$$= 0.10.5 \times 100$$

$$= 10.5\%$$

$$Mean = \frac{11 + 10.5 + 10}{3}$$

$$= 10.5\%$$

$$\% \ D_1 \ Fiber = \frac{13.46-13.40}{2} \times 100$$

$$= \frac{0.06}{2} \times 100$$

$$= 0.03 \times 100$$

$$= 3\%$$

$$\% \ D_2 \ Fiber = \frac{13.45-13.38}{2} \times 100$$

$$= \frac{0.07}{2} \times 100$$

$$= 0.035 \times 100$$

$$= 3.5\%$$

$$\% \ D_3 \text{ Fiber} = \frac{13.44-13.39}{2} \times 100$$

$$= \frac{0.05}{2} \times 100$$

$$= 0.025 \times 100$$

$$=2.5\%$$

$$\text{Mean} = \frac{3 + 3.5 + 2.5}{3}$$

$$= 3\%$$

Nitrogen content

$$\% \text{ Nitrogen} = \frac{TV \text{x} 0.01 \text{x} 0.014 \text{x} 50 \text{x} 100}{0.5 \text{x} 10}$$

$$\% \ A_1 \text{ Nitrogen} = \frac{32 \text{x} 6 \text{x} 0.01 \text{x} 0.014 \text{x} 50 \text{x} 100}{0.5 \text{x} 10}$$

$$= \frac{22.82}{5} \times 100$$

$$= 4.564\%$$

$$\% \ A_2 \ \text{Nitrogen} = \frac{32.7x0.01x0.014x50x100}{0.5x10}$$

$$= \frac{22.89}{5} \times 100$$

$$= 4.578\%$$

$$\% \ A_3 \ \text{Nitrogen} = \frac{32.5x0.01x0.014x50x100}{0.5x10}$$

$$= \frac{22.75}{5} \times 100$$

$$= 4.55\%$$

$$\text{Mean} = \frac{4.564+4.578+4.55}{3}$$

$$= 4.564\%$$

$$\% \ B_1 \ \text{Nitrogen} = \frac{3.7x0.01x0.014x50x100}{0.5x10}$$

$$= \frac{2.59}{5} \times 100$$

$$= 0.518\%$$

$$\% B_2 \text{ Nitrogen} = \frac{3.6x0.01x0.014x50x100}{0.5x10}$$

$$= \frac{2.52}{5} x\ 100$$

$$= 0.504\%$$

$$\% B_3 \text{ Nitrogen} = \frac{3.7x0.01x0.014x50x100}{0.5x10}$$

$$= \frac{2.59}{5} x\ 100$$

$$= 0.518\%$$

$$\text{Mean} = \frac{0.518+0.504+0.518}{3}$$

$$= 1.54\%$$

$$\% C_1 \text{ Nitrogen} = \frac{7.9x0.01x0.014x50x100}{0.5x10}$$

$$= \frac{5.53}{5} x\ 100$$

$$= 1.106\%$$

$$\% C_2 \text{ Nitrogen} = \frac{7.8x0.01x0.014x50x100}{0.5x10}$$

$$= \frac{5.46}{5} \times 100$$

$$= 1.092\%$$

$$\% \ C_3 \ \text{Nitrogen} = \frac{7.7 \times 0.01 \times 0.014 \times 50 \times 100}{0.5 \times 10}$$

$$= \frac{5.39}{5} \times 100$$

$$= 1.078\%$$

$$\text{Mean} = \frac{11.106 + 1.092 + 1.078}{3}$$

$$= 1.095\%$$

$$\% \ D_1 \ \text{Nitrogen} = \frac{16.3 \times 0.01 \times 0.014 \times 50 \times 100}{0.5 \times 10}$$

$$= \frac{11.41}{5} \times 100$$

$$= 2.282\%$$

$$\% \ D_2 \ \text{Nitrogen} = \frac{16.2 \times 0.01 \times 0.014 \times 50 \times 100}{0.5 \times 10}$$

$$= \frac{11.34}{5} \times 100$$

$$= 2.268\%$$

$$\% D_3 \text{ Nitrogen} = \frac{16.5 \times 0.01 \times 0.014 \times 50 \times 100}{0.5 \times 10}$$

$$= \frac{11.55}{5} \times 100$$

$$= 2.31\%$$

$$\text{Mean} = \frac{2.282 + 2.268 + 2.31}{3}$$

$$= 2.287\%$$

Protein content

% protein = %Nitrogen x 6.25

$\%A_1$ Protein = 4.564x6.25

= 28.525%

$\%A_2$ Protein = 4.578x6.25

= 28.6125

$\%A_3$ Protein = 4.55x6.25

= 28.4375

$$\text{Mean} = \frac{28.525+28.6125+28.4375}{3}$$

=28.525%

$\%B_1$ protein = 0.518x6.25

= 3.2375%

$\%B_2$ Protein = 0.504x6.25

= 3.15%

$\%B_3$ Protein = 0.518x6.25

= 3.2375

$$\text{Mean} = \frac{3.2375+3.15+3.2375}{3}$$

=3.2083%

$\%C_1$ Protein = 1.106x6.25

= 6.9125%

$\%C_2$ Protein = 1.092x6.25

$= 6.825\%$

$\%C_3$ Protein $= 1.078 x 6.25$

$= 6.7375\%$

$$\text{Mean} = \frac{6.9125+6.825+6.7375}{3}$$

$=6.825\%$

$\%D_1$ Protein $= 2.282 x 6.25$

$= 14.2625\%$

$\%D_2$ Protein $= 2.268 x 6.25$

$= 14.4375\%$

$\%D_3$ Protein $= 2.31 x 6.25$

$=14.4375\%$

$$\text{Mean} = \frac{14.2625+14.175+14.4375}{3}$$

$=14.2967\%$

Carbohydrate Content

% CHO = 100-(% Ash+ Lipid + %Protein% Fiber)

$\%A_1$ CHO + 100-(9+3+28.525+3)

= 100-43.525

= 56.475%

$\%A_2$ CHO = 100-(9.5+28.6125+2.5)

= 100-42.6125

= 57.3875%

$\%A_3$ CHO + 100-(9.5+2+28.4375+3.5)

= 100-43.4375

= 57.5625%

$$\text{Mean} = \frac{56.475+57.3875+56.5625}{3}$$

=56.8083%

$\%B_1$ CHO + 100-(11.5+5.5+3.15+6.5)

= 100-28.2375

= 71.7625%

$\%B_2$ CHO = 100-(11.5+5.5+3.15+7.5)

= 100-27.65

= 72.35%

$\%B_3$ CHO + 100-(12+6.5+3.23+7.5)

= 100-29.2375

= 70.7625%

$$\text{Mean} = \frac{71.7625+72.35+70.7625}{3}$$

=71.625%

$\%C_1$ CHO + 100-(9.5+5+6.9125+11)

= 100-32.4125

= 67.5875%

$\%C_2$ CHO = 100-(10+5+6.825+10)

= 100-31.825

= 68.175%

$\%C_3$ CHO + 100-(9+4.5+6.7375+10.5)

$= 100\text{-}30.7375$

$= 69.2625\%$

$$\text{Mean} = \frac{67.58775+68.175+69.2625}{3}$$

$=68.3417\%$

$\%D_1$ CHO + 100-(9.5+6.5+14.2625+3)

$= 100\text{-}33.2625$

$= 66.7375\%$

$\%D_2$ CHO = 100-(9+6+14.175+3.5)

$= 100\text{-}32.675$

$= 67.325\%$

$\%D_3$ CHO + 100-(9+7+14.4375+2.5)

$= 100\text{-}32.9375$

$= 67.0625\%$

$$\text{Mean} = \frac{66.7375+67.325+67.0625}{3}$$

$=67.041\%$

APPENDIX 2

Determination of Minerals (Ca, Na, U, Mg and P) in *Moringa oleifera.*

Calcium Content

$$Ca = \frac{TV \times 0.01 \times 1000}{20}$$

$$A_1\ Ca = \frac{1.3 \times 0.0 \times 1000}{20}$$

$$= 13/20$$
$$= 0.65\ mg/kg$$

$$A_2\ Ca = \frac{1.5 \times 0.01 \times 1000}{20}$$

$$= \frac{15}{20}$$

$$= 0.75mg/kg$$

$$A_3\ Ca = \frac{1.5 \times 0.01 \times 1000}{20}$$

$$= \frac{15}{20} x$$

$= 0.75$ mg/kg

Mean $= \frac{0.65 + 0.75 + 0.75}{3} = 0.72$mg/kg

B_1 Ca $= \frac{3.6 \times 0.01 \times 1000}{20}$

$= \frac{36}{20}$

$= 1.8$mg/kg

B_2 Ca $= \frac{3.7 \times 0.01 \times 1000}{20}$

$= \frac{37}{20}$

$= 1.85$mg/kg

B_3 Ca $= \frac{3.6 \times 0.01 \times 1000}{20}$

$= \underline{36}$
$= 20$

$= 1.8$mg/kg

Mean $= \frac{1.8+1.85+1.8}{3} = 1.82$ mg/ kg

$$C_1 \, Ca = \frac{2.1 \times 0.01 \times 1000}{20}$$

$$= \frac{21}{20}$$

$$= 1.05 \text{ Mg /Kg}$$

$$C_2 \, Ca = \frac{2.\,3 \times 0.01 \times 1000}{20}$$

$$= \frac{23}{20}$$

$$= 1.15 \text{ Mg/Kg}$$

$$C_3 \, Ca = \frac{2.0 \times 0.01 \times 1000}{20}$$

$$= \frac{20}{20}$$

$$= 1 \text{ Mg/ Kg}$$

$$\text{Mean} = \frac{1.05 + 1.\,15.1}{3} = 1.18 \text{ Mg/ Kg}$$

$$D_1 \, Ca = \frac{1.9 \times 0.01 \times 1000}{20}$$

$$= \frac{19}{20}$$

$$= 0.95 \text{ Mg/ Kg}$$

$$D_2 \text{ Ca} = \frac{1.9 \times 0.01 \times 1000}{20}$$

$$= \frac{19}{20}$$

$$= 0.95 \text{ Mg/ Kg}$$

$$D_3 \text{ Ca} = \frac{1.8 \times 0.01 \times 1000}{20}$$

$$= \frac{18}{20}$$

$$= 0.9 \text{ Mg /Kg}$$

$$\text{Mean} = \frac{0.95 + 0.95 + 0.9}{3} = 0.93 \text{ Mg/ Kg}$$

Magnesium Content

$$\text{Mg} + \text{Ca} = \frac{\text{TV} \times 0.01 \times 1000 -}{20} \text{ Ca}$$

$$A1\ Mg + Ca = \frac{3.5 \times 0.01 \times 1000}{20} - 0.65$$

$$= \frac{35}{2} = 1.75 - 0.65$$

$$A_1\ Mg = 1.10\ Mg/\ Kg$$

$$A_2\ Mg + Ca = \frac{3.3 \times 0.01 \times 1000}{20} - 075$$

$$= \frac{33}{20} - 1.65 - 0.75$$

$$= A2\ Mg = 0.90\ Mg/\ Kg$$

$$A_3\ Mg + Ca = \frac{3.6 \times 0.01 \times 1000}{20}$$

$$= \frac{36}{2} = 1.8 - 075$$

$$A3\ Mg = 1.05\ Mg/\ Kg$$

$$Mean = \frac{1.10 + 0.90 + 1.05}{3} = 1.02\ Mg/\ Kg$$

$$B_1\ Mg\ Ca = \frac{4.3 \times 0.01 \times 1000}{3} - 1.8$$

$$= \frac{43}{20} = 2.15 - 1.8$$

$$B1\ Mg = 0.35\ Mg/Kg$$

$$B_2\ Mg + Ca = \frac{4.5 \times 0.01 \times 1000}{20} - 1.85$$

$$= \frac{45}{20} = 2.25 - 1.85$$

$$B2\ Mg = 0.40\ Mg/Kg$$

$$B_3\ Mg + Ca = \frac{4.4 \times 0.01 \times 1000}{20} - 1.8$$

$$= \frac{44}{20} = 2.2 - 1.8$$

$$= 0.40\ mg/kg$$

$$Mean = \frac{0.35 + 0.40 + 0.40}{3} = 0.38\ Mg/Kg$$

$$C_1\ Mg + Ca = \frac{3.7 \times 0.01 \times 1000}{20} = 1.05$$

$$= \frac{37}{20} = 1.85 - 1.05$$

$$C1\ Mg + = 0.80\ Mg/Kg$$

$$C_2\ Mg + Ca = \frac{3.5 \times 0.01\ 1000}{20} - 1.15$$

$$C2\ Mg = 0.\ 60\ Mg/\ Kg$$

$$C_3\ Mg + Ca = \frac{3.6 \times 0.01 \times 1000}{20} - 1$$

$$= \frac{36}{20} \times 1.8 - 1$$

$$C3\ Mg = 0.80\ Mg/\ Kg$$

$$Mean = \frac{0.80 + 60 + 0.80}{3} = 0.73\ Mg\ /Kg$$

$$D_1\ Mg + Ca = \frac{3.9 \times 0.01 \times 1000}{20} - 0.\ 95$$

$$D1\ Mg = 1.0\ Mg/\ Kg$$

$$D_2\ Mg + Ca = \frac{3.8 \times 0.01 \times 100}{20} - 0.95$$

$$= \frac{38}{20} = 1.7 - 0.\ 95$$

$$D2\ Mg = 0.\ 95\ Mg/\ Kg$$

$$D_3\ Mg + Ca = \frac{4.0 \times 0.01 \times 1000}{20} - 0.9$$

$$= \frac{40}{20} \quad = 2 - 0.\ 9$$

D3 Mg = 1.1 Mg/ Kg

$$\text{Mean} = \frac{1.0 + 0.95 + 1.1}{3} = 1.02 \text{ Mg/ Kg}$$

Phosphorus Content

$$P = \frac{\text{Abs x CF x DF x DF}}{\text{Atomic weight of P}}$$

$$A_1\ P = \frac{0.266 \text{ x } 0.\ 61 \text{ x } 25 \text{ x } 25}{30.97}$$

$$= \frac{101.4125}{30.97}$$

$$= 3.27 \text{ Mg/ Kg}$$

$$A_2\ P = \frac{0.268 \text{ x } 0.61 \text{ x } 25 \text{ x } 25}{30.97}$$

$$= \frac{102.175}{30.97}$$

$$= 3.30 \text{ Mg/ Kg}$$

$$A_3\ P = \frac{0.269 \text{ x } 0.61\text{x } 25 \text{ x } 25}{30.97}$$

$$= \frac{0.04}{2} \text{ x } 100$$

$$= 3.31 \text{ Mg/ Kg}$$

$$\text{Mean} = \frac{3.37 + 3.30 + 3.31}{3} = 3.\ 30 \text{ Mg/Kg}$$

$$B_1\ P = \frac{0.261 \times 0.61 \times 25 \times 25}{30.97}$$

$$= \frac{99.50625}{30.97}$$

$$= 3.21 \text{ Mg /Kg}$$

$$B_2\ P = \frac{0.\ 263 \times 0.\ 61 \times 25 \times 25}{30.\ 97}$$

$$= \frac{100.26875}{30.97}$$

$$= 3.24 \text{ Mg/ Kg}$$

$$B_3\ P = \frac{0.260 \times 0.\ 61 \times 25 \times 25}{30.97}$$

$$= \frac{99.125}{30.97}$$

$$= 3.20 \text{ Mg/ Kg}$$

$$\text{Mean} = \frac{3.21 + 3.\ 24 + 3.\ 20}{3} = 3.\ 22 \text{ mg/kg}$$

$$C_1\ P = \frac{0.250 \text{ x } 0.\ 61 \text{ x } 25 \text{ x}25}{30.97}$$

$$= \frac{95.3125}{30.97}$$

$$= 30.8 \text{ Mg/Kg}$$

$$C_2\ P = \frac{0.252 \text{ x } 0.61 \text{ x } 25 \text{ x } 25}{30.\ 97}$$

$$= \frac{96.075}{30.97}$$

$$= 3.10 \text{ Mg/Kg}$$

$$C_3\ P = \frac{0.248 \text{ x } 0.61 \text{ x } 25 \text{ x } 25}{30.97}$$

$$= \frac{94.55}{30.97}$$

$$3.05 \text{ Mg/Kg}$$

$$\text{Mean} = \frac{3.08 + 3.\ 10 + 3.\ 05}{3} = 3.08 \text{ Mg/ Kg}$$

$$D_1\ P = \frac{0.\ 255 \text{ x } 0.\ 61 \text{ x } 25 \text{ x}25}{30.97}$$

$$= \frac{97.21875}{30.97}$$

$$= 3.14 \text{ Mg /Kg}$$

$$D_2 P = \frac{0.257 \times 0.61 \times 25 \times 25}{30.97}$$

$$= \frac{97.98125}{30.97}$$

$$= 3.16 \text{ Mg/Kg}$$

$$D_3 P = \frac{0.255 \times 0.61 \times 25 \times 25}{30.97}$$

$$= \frac{97.21875}{30.97}$$

$$= 3.14 \text{ Mg/Kg}$$

$$\text{Mean} = \frac{3.14+3.16+3.14}{3} = 3.15 \text{ Mg/ Kg}$$