Supplementation of Bread Flour by Moringa Leave

(*moringa oleifera*)

A Dissertation Submitted to Sudan University of Science and Technology in Partial Fulfillment for the Degree of B.Sc. in Food Science and Technology.

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DEDICATION

To our family’s,
friends
and teachers.....

With respect and love.
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English Abstract

This study was carried out to evaluate the effect of supplementation with different levels of moringa leaves powder (10, 20, 30%) on rheological properties of wheat dough and nutritional quality of bread. Proximate composition of moringa leaves, gluten quality and falling number of wheat flour were determined. Moreover, the rheological quality of different formulation of moringa supplemented dough and nutritional quality of the produced bread were also determined.

Supplementation with moringa leaves improved the properties of wheat flour, particularly, water absorption and gluten quality. However, there were decreases in falling number, energy, extensibility and resistance as compared with wheat dough without moringa leaves. On the other hand, the nutritional analysis of the bread showed significant improvements (P≤0.05) on protein, ash and fat content of bread due to supplementation with moringa leaves. Therefore, it is possible to produce bread with high protein and acceptable sensory characteristics.
ملخص الأطروحه

أجريت هذه الدراسة لتقييم أثر التدقيق بمستويات مختلفة (10، 20، 30%) من مسحوق اوراق المورونقا على الخصائص الفيزيوكيميائية، والقدرة الغذائية للخبز .

أجري التحليل التجريبي لعينة التهم جودة وكمية الفلترات، وكمية السقوط، ثم دراسة الخصائص الفيزيوكيميائية الجعيفة تبعياً معاملة، وبدون معالمة باستخدام الفلترات، والاكستنشاف في حبيبات.%

أظهرت النتائج فروقاً معنوية (p<0.05) في خصائص حبيبة الدقيق المعالج والخز، حيث أن ارتفاع محتوى السقوط العناصر، ونسبة مسحوق المورونقا تقلل من نسبة محتوى السقوط، ونسبة المغذية، وبدون معالمة معالجة (Ratio Number Max) للأوراق النباتية، انخفضت نسبة امتصاص الماء ونسبة جودة الفلترات، ونسبة مسحوق المورونقا بزيادة نسبة امتصاص الماء ونسبة جودة الفلترات .

قد أجريت هذه الدراسة لتقييم تأثير المكملات باستخدام بذرة أوراق المورونقا بمستويات مختلفة (10، 20، 30%) على الخصائص الفيزيوكيميائية، وجودة القمح، والقدرة الغذائية للخبز .

تتم تحديد النتائج للفلترات، وكمية الفلترات، وكمية السقوط، ونسبة مسحوق المورونقا، ونسبة مسحوق المورونقا بزيادة نسبة مسحوق المورونقا في الورق، والرمل، والدهون، والضفائر، والجبيل، وبدون معالمة معالجة (Ratio Number Max) للأوراق النباتية، انخفضت نسبة امتصاص الماء ونسبة جودة الفلترات، ونسبة مسحوق المورونقا بزيادة نسبة امتصاص الماء ونسبة جودة الفلترات .

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CHAPTER ONE
INTRODUCTION

Cereals are the major source of energy for most people of the world. They provide 50% of the calories of human diet (Mitchell, et al., 1976).

Among cereals, wheat (*Triticum aestivum* L.) is the most worldwide cultivated crop. Used for bread making and baking, its production needs fertile, well-drained soil with rain during growth period and sunny droughts at ripening time (Boumans, 1985). In Sudan, Wheat consumption in Sudan has been sharply increasing recent years. The increase in consumption was due to both population growth and rising per capita consumption of food in addition to incorporation of wheat into addition food products. It is considered an important source of protein for the most people of developing countries.

Among cereals, Wheat is unique because it contains gluten which has the characteristic of being elastic when mixed with water and retains the gas developed during dough fermentation and baking. Wheat produced in different parts of the world differ greatly in their intrinsic protein qualities and quantities; the quantity is influenced mainly by environmental factors, but the quality of protein is mainly a heritable characteristic.

Wheat is favored for bread baking, which is means to present wheat flours in attractive palatable and digestible forms. Bread is made by baking fermented dough which formulated from different main ingredients including wheat flour, water, yeast and salt.

The leaves of *moringa oleifera* are a good source of Protein, Vitamin A, B and C and minerals such as calcium and iron (Dahot, 1988). The leaves-, fruit-, flowers-, and immature pods of this three
are edible and they from a parts of traditional diets in many countries of the tropics and sub-tropics areas (Sidduraju and Becker, 2003; Anhwange et al., 2004).

The use of moringa leaves powder for supplementation of bread is of potential. Moringa natural, available and cheap source of protein.

Objectives of this Study area:

1. To investigate the effect of Moringa leaves supplementation on nutritional quality
2. To determine the effect of moringa leaves powder on the dough rheological properties of both Moringa leaves powder and wheat flour.
3. To study the effect of moringa leaves flour on the quality of bread produced.
4. To study the effect of moringa leaves on the sensory characteristic of bread.
CHAPTER TWO

LITERATURE REVIEW

2.1 Importance of Cereals

The demand for cereals as food and feed is increasing due to population explosion and short falls in cereal production in several developed countries. It is well established that the majority of the people in the developing countries depend mainly on cereal grains as their stable food due to limited income and high prices of animal foods. Cereals generally provide almost 50% of the total caloric for the people of the world (Henry and Kettlewell, 1996).

2.3.2 Wheat Classification

Generally bakers classify wheat by the hardness of the kernel, that is, by whether the kernel is hard or soft. Hard wheat kernels are high in protein; soft wheat kernels are low in protein. Hard wheat kernels feel harder than soft ones because protein in these kernels forms large, hard chunks. Strong flours usually have a high water absorption value and require a longer mixing time to fully develop, but they are tolerant of overmixing. The strength of flour depends largely upon the gluten it contains, which gives to bread its elastic quality and its ability to absorb water (Blackman and Payne, 1987). Strong flours are typically used in yeast-raised products, like breads, rolls. Soft wheat flours typically from weak gluten that tears easily, and are sometimes called weak flours, and this is desirable for many cakes, cookies, and pastries. (Kipps, 1970) reported that wheat is a group classify according to, color, texture and year seasons as follows:
2.32.1 Hard Red Spring Wheat

This class of wheat is noted for its high protein content and excellent bread making characteristics. It is used extensively for blends with weaker wheat throughout the world. Hard red spring and hard red winter wheat contain an average of about 11 to 15 percent protein, (Kipps, 1970).

2.32.2 Hard Red Winter Wheat

The grain is hard and generally high in protein content. As bread wheat, it ranks second only to hard red spring wheat in quality, protein content usually averaging 11 – 12%, (Kipps, 1970).

2.32.3 Soft Red Winter Wheat

Most of the wheat of this region has grain of low-protein content, which produces flour most satisfactory for pastries, such as cakes, cookies and pies. Soft wheat contains 8 to 11 percent protein and the soft red winter wheat varieties were in general high in starch and low in protein, (Kipps, 1970).

2.32.4 Durum Wheat

The kernels of this wheat are the hardest known and for this reason are often called “hard” wheat, the hardness of durum wheat semolina, combined with its high protein content, yellow color and nutty taste makes it suitable for making pasta of consistent cooking quality. The high gluten content also results in a dough that is stiff and extrudes easily through metal discs to make more than 350 shapes of pasta, (Kipps, 1970).

2.32.5 White Wheat
The white wheat is mainly used for pastry purposes, but some of them go into shredded wheat and bread,(Kipps,1970).

2.2–3 Nutrition Value of Wheat

Wheat and wheat foods are major source of nutrients for people in many regions of the world. Wheat is a source of carbohydrate, proteins, vitamins and minerals when consumed as a major component of the diet.

Consist mainly of starch and significant proportion of many minerals and vitamin. Nutrients are generally found in the highest concentrations in the germ and in the aleurone cells surrounding the starchy endosperm. Significant quantities of minerals and vitamins are lost when whole wheat is milled to produce white endosperm flour because the outer layer of bran are removed along with aleurone cells and germ. extraction flour of(72-75)% contains from as little as 20%to about 60%of the BBvitamins originally present in whole-wheat flour (FAO,1970).

2.4 Importance and use of wheat in the world

Wheat (Triticum spp) continuos to be one of the world most important grains, especially as food—, where the unique properties of its products can be utilized to advantage (Inglett,1974).

The cultivation of wheat, reach far back in history, and the crop was predominant in antiquity as a source of human food. Wheat is a major cereal produced, imported and exported, its most important use is in the manufacture of all breads, biscuits and pastry products.

Whilst, all the cereals can be ground into flour or meal, only wheat and rye ….. contain the type of protein that will enable them to be baked into bread (Cowley and Howarth, 2006).
It contains gluten protein, which enables leavened dough to rise by forming minute gas cells that hold carbon dioxide during fermentation (Quisenberrg and Reitz, 1967).

The soft wheat is used extensively for crackers, pastries and cookies and hard wheat is use usually to make bread (Wilson, 1998).

Bread and cereals contain protein and complex carbohydrate and B group vitamins and iron (Inglett, 1974).

2.5 Importance, production and consumption of wheat in Sudan

In many African, eating habits have changed in favor for wheat away from other cereals since the 1970s, when food aid in the form of wheat was introduced (Pomeranz, 1988).

In Sudan, wheat has become the staple food of the majority of Sudanese societies than sorghum, and wheat is getting more important as one of the main cereal food, and varieties grown are mainly used for bread making (El–Faki al., 1978).

Wheat in Sudan is grown under irrigation during the dry and comparatively cool winter season which extends from November to February (Ishag and Ageeb, 1991). Wheat production was confined to the northern Sudan along with the Nile bank; the growing area extended southward to the warmer central and Estern Sudan (Ageeb, 1994).

In term of cultivated area, in average, 96% of the area cultivated with wheat fell within the irrigated sector during the period between 2008 and 2013 and it recorded a high share of 98% during the 2014/2015 season (Al-Feel and Al-Basheer, 2012).

Technologies development and policy strategy help wheat production to increase and follow the growth in wheat consumption.
2.6 Wheat kernel structure

Wheat kernel is the seed of the plant, has three main parts: the endosperm, the bran, and the germ, while whole wheat flour contains all three parts of the kernel, white flour is milled from the endosperm only the bran consists of several layers of protective outer coverings, it comprises 13-17% of the weight of wheat kernel, the endosperm composes 80 – 85% of the grains weight and the germ composing 2-3 % of wheat kernel weight (Internet report, 2001).

2.7 Wheat composition

The composition of wheat flour varies considerably according to the class of wheat, its origin and the proportion of outer part removed by particular milling process.

2.7.1 Moisture content

Moisture content of wheat is to only of economic significance, but is important in regard to its keeping qualities and its behavior on storage.

Basdi et al. (1978) mentioned that moisture & content of Sudanese wheat flour, Moisture content of different Sudanese wheat cultivar varies from about 6.33 to 8.87% (Ahmed, 1995).

2.7.2 Ash content

High extraction flour generally has high ash content. (Zeleny,1971) mentioned that ash content of whole wheat flour ranged between 1.4 and 2 %.

Reported that Ash content of whole flour of several Sudanese cultivars ranged between (1.03 and 1.24%) (Badi et al., 1978) and (Ahmed 1995).

2.7.3 Protein content
Wheat is considered superior compared to other cereals because of its nutritional value of wheat grain protein. Blackman and Payne (1987) reported that wheat is an important source of protein for people of the developing countries. The endosperm contain about 80 percent of the total amount of proteins in the whole kernel.

Haldor et al. (1982) reported that protein content of whole wheat flour ranges between 10 and 16% while (Ahmed, 1995) reported that the protein content of four Sudanese wheat cultivars (Condor, Debra, Elneilein and Nasser) ranges between 8.21 and 12.26%.

2.7.4 Fat content

The germ contains 6–11 lipids, the bran 3–5% and the endosperm 0.8–1.5% (Kent, 1975).

The germ is readily separated from the endosperm by milling; it is an important dietary supplement providing a rich source of vitamin E. The fats limit the keeping quality of wheat flour (Anon, 1987). Fat content of the whole white flour of Sudanese wheat Cultivars Depra, Elneelain, Condor, Sasarib., were found to be in the range of 2.15 to 2.35 and 1.33 to 1.93%, respectively.

2.7.5 Crude fiber content

The fiber content increase with the amount of branny matter present. Fiber is the indigestible carbohydrate in food which acts like a brome to sweep out the digestive.

Egan et al. (1981) found that the fiber percentage in whole wheat flour ranges between 1.8 and 2.5% and of white flour (72% extraction rate).

2.8 Botanical Description and Background of Moringa Oleifera Trees
Kingdom: plantae
Family: moringaceae
Genus: moringa
Species: moringaoleifera
The name of moringa are miracle tree, Horseradish Tree, Ben oil Tree …etc

The Moringaceae is a single-genus family of oilseed trees with 14 known species. Of these, Moringaoleifera, which ranges in height from 5 to 10 m, is the most widely known and utilized (morton.1991; sengupta and Gupta, 1970).

Today moringa is widely cultivated in central Africa and south America, Srilanka, India, Mexico, Malaysia and the Philippines.

Moringaoleifera is esteemed as a versatile plant due to its multiple uses.

The leaves, fruit, flowers, and immature pods of this tree are edible and they form a part of traditional diets in many countries of the tropics and sub-tropics (Siddhuraju and Becker, 2003; Anhwange et al., 2004).

The leaves of moringaoleifera are a good source of Protein, Vitamin A, B and C and minerals such as calcium and iron (Dahot, 1988). The origin of moringaoleifera is South Africa. It is widely spared in India, The east and west Indies, the other tropical countries and Europe.

The tree was introduced to Sudan during British rule as ornamental tree in Gezira province and Kordofan (Elsham, M. 2002).
Moringa oleifera which is locally known as Rawag is the most widely known and utilized species of the genus Moringaceae (Wickens, 1988).

The moringa tree originated in India, people brought it to Africa from Asia who used it as source of food and for medicinal purposes.

The moringa tree likes sun shine and can grow best on dry sandy soil and can withstand drought condition. It grow quickly from seeds or cuttings, can reach a height of twelve feet within the first year and regenerates itself even after the most severe pruning (Mustafa, et al. 1999).

The following plates (1,2,3,4 and 5) show Moringa tree, Moringa pods, Moringa seeds, Moringa leaves, Moringa d leaves powder respectively.

Plate 1: Moringa Tree
Plate 2: Moringa Pods

Plate 3: Moringa seeds
Plate 4: Moringa leaves

Plate 5: Moringa leaves Powder
2.9 History Background of moringa

*Moringaoleifera* is the best known of the thirteen species of the genus moringaceae. Moringa was highly valued in the ancient world. The Romans, Greeks and Egyptians extracted edible oil from the seeds and used it for perfume and skin lotion. In 19th century, plantations of Moringa in the West India exported the oil to Europe for perfumes and lubricants for machinery. People in the Indian sub-continent have long used Moringa pods for food. The edible leaves are eaten throughout West Africa and parts of Asia (Adedapo et al., 2009).

2.10 Etymology of moringa:

Moringa derives from the Tamil word, murungai or Malayalam word, murinna (alternately muringa). Numerous other common names for moringa exist in different languages worldwide.

*Moringaoleifera* is the most widely cultivated species of the genus Moringa, which is the only genus in the family Moringaceae. English common names include: moringa, drumstick tree (from the appearance of the long, slender, triangular seed-pods), horseradish tree'2' (from the taste of the roots, which resembles horseradish), ben oil tree, or benzoic tree'2' (from the oil which is derived from the seeds).

2.11 Developing the moringa value chain in Sudan:

It is a sun-loving, fast-growing tree, which tolerates poor soils and long spells of dry weather. Rich in vitamins, minerals and protein, it is a versatile source of food for humans, while as fodder it benefits livestock farmers by increasing milk and meat production. It yields edible oil and biofuel, and is used to purify water and combat land degradation. It is even said to work health and cosmetic wonders such as preserving the
youthful appearance of the human skin. And while its long slender pods gave it its unpretentious name of the "drumstick tree", it is frequently – and more fittingly – called the "miracle tree" and the "tree of life" (Aljozoli, 2007)

Native to the southern foothills of the Himalayas in north-western India, *moringaoleifera* is the most widely grown species of the genus Moringa. This robust tree is cultivated in arid, semi-arid as well as tropical and subtropical regions, and it grows best in dry sandy soil. It is occurs as a wild plant and is cultivated in Central America and the Caribbean, South America, Oceania, and many African countries (Aljozoli, 2012).

2.12 Nutritional value of Moringa tree

Moringa tree have been used to combat malnutrition, especially among infant and nursing mothers. Three non-governmental organizations in particular-three for life, church world service and Educational concerns for Hunger Organization -have advocated Moringa as "natural nutrition for the tropics. " Leaves can be eaten fresh, cooked, or stored as dried powder for many months without refrigeration, and reportedly without loss of nutrition value. Moringa is especially promising as a food source in the tropics because the tree is in full leaf at the end of the dry season when other foods are typically scarce (Aljozoli, 2012).

The leaves are the most nutritious part of the plant, being a significant source of B vitamins, vitamin C, provitamin A as beta-carotene, vitamin K, manganese, and protein, among other essential nutrients. When compared with common foods particularly high in certain nutrients per 100 g fresh weight, cooked moringa leaves are considerable sources of these same nutrients. Some of the calcium in moringa leaves is bound as crystals of calcium oxalate though at levels 1/25th to 1/45th of that
found in spinach, which is a negligible amount. The leaves are cooked and used like spinach and are commonly dried and crushed into a powder used in soups and sauces.

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The comparison in nutrition value between different items and moringa leaves is contain more Vitamin A than carrots, more calcium than milk, more iron than spinach, more Vitamin C than oranges, and more potassium than banana.

2.13 A cornucopia of vitamins, minerals and proteins

While moringa is regarded as one of the world's most valuable multi-purpose trees, it is its nutritional value that has received the greatest attention from researchers and food product developers. Leaves, pods, flowers and roots are all edible. Moringa leaves contain more vitamin A than carrots, more iron than spinach, more calcium than milk, more vitamin C than oranges, and more potassium than bananas, are rich in omega oils and antioxidants, and their protein quality rivals that of milk and eggs (Aljozoli, 2012).
As a source of nutritious food, moringa is seen as a particularly important crop for African countries plagued by drought, poverty and rudimentary agricultural infrastructure. During the last three decades, significant efforts have been made to promote the cultivation and processing of moringa in Africa to combat malnutrition, especially among infants and nursing mothers, and to contribute to food security in arid and semiarid environments, where moringa thrives during dry seasons when little else can grow and provide food.

Sudan is among the countries that face these challenges and at the same time are striving to develop capabilities to harvest the benefits of the tree of life.

Rural communities in Sudan have used moringa for hundreds of years, mostly as a food source, but also as a medicinal plant and to purify the turbid water of the Nile.

2.14 Traditional Uses of moringa:

For centuries, people in many countries have used Moringa leaves as traditional medicine for common ailments. Clinical studies have to suggest that at least some of these claims are valid, with such great medicinal value being suggested by traditional medicine, further clinical testing is very much needed. India: Traditionally used for anemia, anxiety—, asthma—, blackheads, blood impurities—, bronchitis—, catarrh, chest congestions, cholera—, Conjunctivitis, cough—, diarrhea—, eye & ear infections, fever—, glandular swelling—, headaches—, abnormal blood pressure—, hysteria—, pain in joints—, Pimples—, psoriasis—, respiratory disorders—, scurvy—, semen deficiency—, Sore throat—, sprain—, tuberculosis (Adedapo et al., 2009).
2.15 Modern Uses of moringa

Over the past two decades, many reports have appeared in mainstream scientific journals describing its nutritional and medicinal properties. Its utility as a non-food product has also been extensively described. Every part of Moringa tree is said to have beneficial properties that can serve humanity. People in societies around the world have made use of these properties (Adedapo et al., 2009).

2.16 Harvesting of Moringa

Two harvests of seed pods can produce in one year and the Moringa leaves tend to appear toward the end of dry season when few other sources of green leafy vegetables are available (Mustafa et al., 1999). Fruit or other parts of the plant usually harvested as desired according to some authors but in India fruiting may peak between March and April and again in September and October (Burkill, 1966).

2.17 Bread

All over the world, bread means food and life. It requires no further preparation once purchased. Bread, a nutritionally dense food, is high in complex carbohydrates, which give the body a sustained energy (Bennion, 1967). Herbs, 1995 reported that bread is a staple since prehistoric times. It has originated in Egypt about 3500 BC as reported by (Joswellman, 2003). The migration from countries site inward the urban has imposed the spread out of the habit of eating bread and thus increase the consumption (Deny, 1992). The large consumption of bread led to the development of a well-organized baking industry.

Bread acts as a vehicle for protein and vitamin-rich materials such as meat and cheese. In addition to that the solid state of bread facilities its transportation.
CHAPTER THREE

MATERIALS AND METHODS

3.1 Materials:

Wheat bread flour was obtained from sigamills (Khartoum).

Moringa leaves were obtained from different areas (Shambat, Omdurman). Other food materials (salt, oil, yeast, sugar) were purchased from the local market (Omdurman). All chemicals and reagents were of analytical grade.

3.2 Methods:

3.2.1 Preparation of Moringa leaf powder

Samples were collected from different areas (Shambat, Omdurman). The collected leaves were washed with tap water and dried at room temperature (60°C) for 3 ouars, then grinded and stored at 4°C. 3 samples (90% - 80% - 70%) wheat flour to (10% - 20% - 30%) Moringa.

3.2.2 Blends of Moringa leaf powder and Wheat Flour:

Five blends of wheat flour (WF) and Moringa leaf powder (MLP) were then formulated in the following ratios,

90: 10, 80:20 and 70:30 from which dough were prepared for production of the bread samples, with 100% WF control.

3.3 Making of bread

Bread preparation was carried out according to badi et al. (1978) method.
Control bread and mixed with dry ingredients (yeast, Salt, Sugar and Ascorbic acid) using Mono. Universal Dough Mixer, water was added (based on the Farinograph optimum absorption) and mixed, the dough was allowed to rest for 10 minute at room temperature (38±2°C), scaled to three portions of 120g each, molded into and transferred into the fermentation cabinet for 45 min. The fermented dough were then backed in Simon Rotary baking oven at 250ºc for 30 – 55 min.

3.4 Analytical Methods

3.4.1 Proximate Composition

The analytical work was carried out of Moringa Oleifera leaves powder, wheat flour and the composite flour were determined, with will mixing of the samples. The determination of moisture and ash were carried out on the samples according to AACC (2000) methods.

3.4.1.1Moisture content

**Determination of Moisture Content**

The main steps were as follows according to the method described by AOAC (2002).
Three grams of well-mixed samples were weighed accurately in clean preheated moisture dish of known weight by using sensitive balance. The uncovered dish with the sample were kept in an air oven provided with a fan at 130°C for 1 hour. The dish was then covered and transferred to desiccatior and weighed after cooled to room temperature. The loss of weight was calculated as percent of sample weight and expressed as moisture content:

$$\text{Moisture content \%} = \frac{W_{t1} - W_{t2} \times 100}{W_{t1} \times 100} \times \frac{1}{\text{Sample wt.}}$$

Where:
- $W_{t1}$ = Weight of sample + dish before oven dry.
- $W_{t2}$ = Weight of sample + dish after oven dry.

### 3.4.1.2 Ash content

**Determination of Ash**

The steps were as follows according to AOAC (2002).

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

% Ash content was calculated using the following equation:

$$\text{Ash content \%} = \frac{(W_{t1} - W_{t2}) \times 100}{\text{Sample wt.} \times (100 - m)} \times \frac{100 \times 100}{(W_{t1} - W_{t2}) \times 100 \times 100}$$

Where:
- $W_{t1}$ = Weight of crucible with ash sample.
- $W_{t2}$ = Weight of empty crucible.
- $m$ = % moisture
3.4.1.3 Oil content

Determination of fat content

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

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

3.4.1.4 Protein

Determination of Crude Protein

The determination of crude protein was carried out on the samples according to AOAC (1984) methods.

The steps were as follows:

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

The trapped ammonia was titrated against 0.02N HCl. The percentage (g/100) of protein was calculated by using an empirical factor to convert nitrogen into protein as follows:

\[
\text{Nitrogen content \%} = \frac{TV \times N \times 14.00 \times 100}{1000 \times \text{wt. of sample}} \times 6.25
\]

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

Where:
TV = Actual volume of HCL used for titration (ml HCL – ml blank).
N = Normality of HCL.
14.00 = Each ml of HCL is equivalent to 14 mg nitrogen.
1000 = To convert from mg to gm.
6.25 = Constant factor for sorghum and legumes.
5.7 = constant factor for wheat flour.

**3.4.1.5 Carbohydrate**

**Determination of Carbohydrates**

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

**3.5 Farinograph**

Brabenderfarinograph method was carried on wheat flour with and without chickpea according to AACC (2000).

Brabenderfarinograph was operated as described in AACC method (2000). Titration curve was used for the assessment of the water-
absorption for each flour sample. A sample of 300 gram (14% moisture) was weighed and transferred into a cleaned mixer. The farinograph was switched on 63 rpm for one minute, then the distilled water was added from especial burette (the correct water absorption can be calculated from the deviation, 20 units deviation correspond to 0.5% water, if the consistency, is higher than 500 F. U. more water is needed and vice-versa). When the consistency is constant, the instrument was switched off and the water drawn from the burette indicates water absorption of the flour in percentage.

The standard curve the measuring mixer was thoroughly cleaned. A sample of 300 g was weighed, and then introduced into the mixer; the farinograph was switched on such as before. The water quantity, which is determined by the titration curve, was fed at once. When an appreciable drop on the curve was noticed, the instrument was run further 12 minutes, and then shut off.

3.6 Extensograph

Extensograph method was used according to ICC (2001). The extensograph and farinograph were set and operated at 30°C. The dough for extensograph was prepared as for the farinograph, but the amount of water used for mixing was 2% less due to the addition of 2% salt and the dough was mixed for 5 min. only. Three pieces of dough (150 g each) were weighed, molded on the balling unit, rolled with dough roller into cylindrical test pieces, fixed in the dough holder, and stored in the rest cabinet for 45 min. The dough piece was placed on the balance arm of extensograph and stretched by stretching hook until it broke. During the period of stretching the behavior of the dough was recorded on a curve via extensograph. This test was performed at 45, 90, and 135 min intervals.
3.7 Bread Weight
The weight of the loaf was taken in g.

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

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

3.10 Sensory Evaluation of Loaf Bread
The loaves were sliced with an electric knife and prepared for sensory evaluation same day. The sensory evaluation of bread samples (aroma, taste, crumb texture, crumb color, crumb cell uniformity, general acceptability) was carried out by 10 semi trained panelists. The surrounding conditions were kept the same all through the panel test (see Appendix 2).

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

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Chemical composition of wheat flour, Moringaoleifera leaves powder:

Chemical composition of wheat flour, Moringaoleifera leaves powder and there blends were shown in table 1.

4.1.1 Moisture Content

Analysis of variance showed significant differences($P \leq 0.05$) among Moringaoleifera leaves powder, wheat flour and supplemented samples in moisture content.

Moisture content of Moringaoleifera leaves powder was 4.53%, moisture content of wheat flour was 10%. Results of supplemented samples were 9.79, 8.88, and 8.24, for 10, 20, and 30% respectively.

These results were in agreement with Jaffar and Hala, 2012) who reported that the moisture content of wheat flour was 10.7% and 10.80,
10.50, 10.71 for 2.5, 5, 7.5 for supplemented samples respectively, and 7.64 for moringa.

4.1.2 Ash Content

Analysis of variance showed significant differences ($P \leq 0.05$) in ash content among Moringa oleifera leaves powder, wheat flour samples was 0.393, respectively. And the results for supplemented samples were 2.95, 3.88 and 11.71% for 10, 20, and 30% respectively, results shows significantly increased in ash content 30% of Moringa leaves powder which gained the highest value 11.71%.

In table (4.1): These results were in agreement with (Jaffar and Hala, 2012) who reported that the ash content of wheat flour 0.70% and the results for supplemented samples were 0.91, 1.14, 1.41 for 2.5, 5, 7.5 respectively, for moringa 9.20.

4.1.3 Protein Content

Analysis of variance showed significant differences ($P \leq 0.05$) among Moringa leaves powder, wheat flour and levels of Moringa leaves powder in protein content.

Content of Moringa leaves powder was 5.37%, protein content of Moringa leaves powder incorporated wheat flour with different level 10, 20 and 30% was increased with increasing the level of Moringa leaves powder from 14.13, to 6.04 and 8.10 respectively. Compared with control was 13.7%, these due to Moringa leaves powder the highest percentage of protein content 5.37%.

In table (4.1): These results were in agreement with (Jaffar and Hala, 2012) who reported that the protein content of wheat flour 11.31% and
the results for supplemented samples were 12.48, 26.71, 28.13 for 2.5, 5, 7.5 respectively, for moringa 36.08.

### 4.1.4 Fat Content

Analysis of variance showed significant differences (P \leq 0.05) among *Moringa oleifera* leaves powder in wheat flour and its levels in *Moringa oleifera* leaves powder in fat content of Moringa leaves powder 7.51 and for wheat flour is 1.8 and its 3.14, 3.89 and 7.51 for 10, 20 and 30% respectively.

In table (4.1): These results were in agreement with (Jaffar and Hala, 2012) who reported that the fat content of wheat flour 2.22% and the results for supplemented samples were 2.79, 2.22, 2.37 for 2.5, 5, 7.5 respectively, for moringa 5.86.

### 4.1.5 Crude fibre content

Analysis of variance showed significant differences (P \leq 0.05) among *Moringa oleifera* leaves powder in wheat flour and its levels in *Moringa oleifera* leaves powder in fat content of Moringa leaves powder 5.58 and for the flour is 0.9 and its 10, 20 and 30% for 1.48, 2.82 and 3.58 respectively.

### 4.1.6 Carbohydrates Content

Carbohydrate content decrease with increase supplementation of moringa leaves powder levels. 72.6 for wheat flour, and 57.9 for moringa leaves, and 73.5, 78.40, 71.31 for the samples 10, 20, 30 respectively.

These results were in agreement with (Jaffar and Hala, 2012) who reported that the CHO content of wheat flour were 75% and the results...
for supplemented samples were 73.2, 59.4, 57.3 for 2.5, 5, 7.5 respectively, for moringa 41.22.
Table 4.1: Chemical Composition of Wheat Flour and Moringa Leaves Powder sample Blends

<table>
<thead>
<tr>
<th>Bread sample</th>
<th>Moisture content</th>
<th>Ash content</th>
<th>Oil content</th>
<th>Crude protein</th>
<th>Crude fiber</th>
<th>Available carbohydrates</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>10²</td>
<td>1³</td>
<td>1.8³</td>
<td>13.7³</td>
<td>0.9³</td>
<td>72.6³</td>
</tr>
<tr>
<td></td>
<td>±0.11</td>
<td>±0.09</td>
<td>±0.04</td>
<td>±0.12</td>
<td>±0.01</td>
<td>±0.09</td>
</tr>
<tr>
<td>B</td>
<td>4.53³</td>
<td>11.71³</td>
<td>8.70³</td>
<td>5.37³</td>
<td>11.82³</td>
<td>57.95³</td>
</tr>
<tr>
<td></td>
<td>±0.11</td>
<td>±0.15</td>
<td>±0.17</td>
<td>±0.15</td>
<td>±0.28</td>
<td>±0.45</td>
</tr>
<tr>
<td>C</td>
<td>9.79³</td>
<td>1.14³</td>
<td>3.14³d</td>
<td>14.13³</td>
<td>1.48³d</td>
<td>73.57³</td>
</tr>
<tr>
<td></td>
<td>±0.05</td>
<td>±0.11</td>
<td>±0.17</td>
<td>±0.17</td>
<td>±0.02</td>
<td>±5.72</td>
</tr>
<tr>
<td>D</td>
<td>8.88³</td>
<td>2.95³</td>
<td>3.89³</td>
<td>6.04³</td>
<td>2.82³</td>
<td>78.40³</td>
</tr>
<tr>
<td></td>
<td>±0.07</td>
<td>±0.07</td>
<td>±0.11</td>
<td>±0.09</td>
<td>±0.10</td>
<td>±5.07</td>
</tr>
<tr>
<td>E</td>
<td>8.24³</td>
<td>3.88³</td>
<td>7.51³</td>
<td>8.10³</td>
<td>3.58³</td>
<td>71.35³</td>
</tr>
<tr>
<td></td>
<td>±0.11</td>
<td>±0.13</td>
<td>±1.07</td>
<td>±0.10</td>
<td>±0.11</td>
<td>±4.03</td>
</tr>
<tr>
<td>Lsd₀.₀₅</td>
<td>0.1726*</td>
<td>0.2074*</td>
<td>0.8987³</td>
<td>0.2372³</td>
<td>0.2573³</td>
<td>7.042²*</td>
</tr>
<tr>
<td>SE±</td>
<td>0.05477</td>
<td>0.06583</td>
<td>0.2852</td>
<td>0.07528</td>
<td>0.08165</td>
<td>2.235</td>
</tr>
</tbody>
</table>

Values are mean ±SD
Mean(s) sharing same superscript(s) in a column are not significantly (P>0.05) different according to DMRT.

**Key:**
A ≡ wheat flour free addition (control)
B ≡ sample containing 10% Moringa + 90% wheat flour
C ≡ sample containing 20% Moringa + 80% wheat flour
D ≡ sample containing 30% Moringa + 70% wheat flour
4.2 Farinograph Results

Farinograph results of wheat flour supplemented with Moringa leaves are shown in table (4.3) fig (1,2,3,4)

The water absorption of incorporation of Moringa leaves powder with different levels ranged 66.6, 68.4 and 70.5 for 10, 20 and 30 % respectively.

The highest value observed in (30 %) moringa leaves powder it is obvious that water absorption increase with increasing the addition of Moringa leaves powder.

Dough development time increased with the increase of powder of Moringa leaves at 10, 20 and 30 % leaves from 5.5, 5.7, 7.2 respectively.

Dough stability decreased with the addition of Moringa leaves powder with all leaves from 4.4, 5.1 and 6.3 for control, 10, 20, 30% respectively.
Table 4.2: Farinograph readings of bread flour blends

<table>
<thead>
<tr>
<th>Bread sample</th>
<th>Water absorption (corrected for 500 FU)</th>
<th>Water absorption (corrected to 14%)</th>
<th>Development time (min)</th>
<th>Stability (min)</th>
<th>Degree of softening (10 min after begin)</th>
<th>Degree of softening (ICC/12 min after max)</th>
<th>Farinograph quality number</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>58.40±0.10</td>
<td>57.70±0.10</td>
<td>2.20±0.10</td>
<td>7.00±0.10</td>
<td>52.00±1.00</td>
<td>64.00±1.00</td>
<td>47.00±1.00</td>
</tr>
<tr>
<td>B</td>
<td>57.70±0.44</td>
<td>61.80±0.10</td>
<td>5.50±0.10</td>
<td>4.40±0.10</td>
<td>95.00±1.00</td>
<td>129.00±1.00</td>
<td>67.00±1.00</td>
</tr>
<tr>
<td>C</td>
<td>68.60±0.10</td>
<td>63.60±0.10</td>
<td>5.70±0.10</td>
<td>5.10±0.10</td>
<td>73.00±1.00</td>
<td>110.00±1.00</td>
<td>72.00±1.00</td>
</tr>
<tr>
<td>D</td>
<td>70.80±0.10</td>
<td>65.40±0.10</td>
<td>7.20±0.10</td>
<td>6.30±0.10</td>
<td>40.00±1.00</td>
<td>97.00±1.00</td>
<td>95.00±1.00</td>
</tr>
<tr>
<td>Lsd at 0.05</td>
<td>6.063**</td>
<td>0.1883**</td>
<td>0.1883**</td>
<td>0.1883**</td>
<td>1.883**</td>
<td>1.883**</td>
<td>1.883**</td>
</tr>
<tr>
<td>SE±</td>
<td>1.859</td>
<td>0.05774</td>
<td>0.05774</td>
<td>0.05774</td>
<td>0.5774</td>
<td>0.5774</td>
<td>0.5774</td>
</tr>
</tbody>
</table>

Values are mean ±SD

Mean(s) sharing same superscript(s) in a column are not significantly (P>0.05) different according to DMRT.

**Key:**
A ≡ wheat flour free addition (control)
B ≡ Moringa leaves
C ≡ sample containing 10% Moringa + 90% wheat flour
D ≡ sample containing 20% Moringa + 80% wheat flour
E ≡ sample containing 30% Moringa + 70% wheat flour
Fig. 1: Water absorption (corrected for 500 FU) of bread samples

Fig. 2: Water absorption (corrected to 14.0%) of bread samples

Key:
A ≡ wheat flour free addition (control)
B ≡ sample containing 10% Moringa + 90% wheat flour
C ≡ sample containing 20% Moringa + 80% wheat flour
D ≡ sample containing 30% Moringa + 70% wheat flour
**Fig. 3: Development time of bread samples**

**Fig. 4: Stability of bread samples**

**Key:**
- A = wheat flour free addition (control)
- B = sample containing 10% Moringa + 90% wheat flour
- C = sample containing 20% Moringa + 80% wheat flour
- D = sample containing 30% Moringa + 70% wheat flour
Fig. 5: Degree of softening (10 min after begin) of bread samples

Fig. 6: Farinograph quality number of bread samples

**KEY:**
A = wheat flour free addition (control)
B = sample containing 10% Moringa + 90% wheat flour
C = sample containing 20% Moringa + 80% wheat flour
D = sample containing 30% Moringa + 70% wheat flour
Fig. 7: Farinograph of dough prepared from control wheat flour

Fig. 8: Farinogram of dough prepared from 10% Moringa leaves powder
Fig. 9: Farinogram of dough prepared from 20% Morenga leaves powder

Fig. 10: Farinogram of dough prepared from 30% Morenga leaves powder
4.5 Extensograph results

The Extensograph results of the wheat flour with and its blends with Moringa leaves powder are shown in table (3) and fig (1,2,3,4).

Wheat flour with 10, 20, 30% moringa leaves powder energy decreased gradually with increasing the level moringa leaves powder.

Resistance of dough prepared from powder of moringa leaves decrease in at all levels (10, 20 and 30%) powder at 45 min.

The addition of moringa leaves powder showed decrease in extensibility at 45 min. Ratio number increase in one levels (10%) moringa leaves powder.
Table 4.3: Extensograph of bread samples

<table>
<thead>
<tr>
<th>Bread sample</th>
<th>Energy (cm²)</th>
<th>Resistance to extension (BU)</th>
<th>Extensibility (mm)</th>
<th>Maximum (BU)</th>
<th>Ratio number</th>
<th>Ratio number (max)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>45</td>
<td>90</td>
<td>135</td>
<td>45</td>
<td>90</td>
<td>135</td>
</tr>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>150 ±2.30</td>
<td>144 ±5.69</td>
<td>106 ±0.85</td>
<td>592 ±2.61</td>
<td>1028 ±2.30</td>
<td>868 ±1.11</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>53 ±5.14</td>
<td>40 ±4.74</td>
<td>32 ±1.11</td>
<td>441 ±1.45</td>
<td>367 ±1.29</td>
<td>270 ±2.46</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>32 ±2.39</td>
<td>19 ±1.67</td>
<td>15 ±1.05</td>
<td>185 ±2.37</td>
<td>70 ±4.79</td>
<td>134 ±0.95</td>
</tr>
<tr>
<td>D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>21 ±1.15</td>
<td>10 ±0.98</td>
<td>Nil</td>
<td>28 ±1.46</td>
<td>Nil</td>
<td>150 ±0.0</td>
</tr>
<tr>
<td>Lsd.6%</td>
<td>1.8529</td>
<td>13.5204</td>
<td>3.9556</td>
<td>2.9518</td>
<td>0.7453</td>
<td>0.2082</td>
</tr>
<tr>
<td>SE±</td>
<td>0.9631</td>
<td>5782</td>
<td>1.9735</td>
<td>0.7265</td>
<td>0.0699</td>
<td>0.0417</td>
</tr>
</tbody>
</table>

Values are mean±SD

Mean(s) sharing same superscript(s) in a column are not significantly (P>0.05) different according to DMRT.

**Key:**
- A = wheat flour free addition (control)
- B = sample containing 10% Moringa + 90% wheat flour
- C = sample containing 20% Moringa + 80% wheat flour
- D = sample containing 30% Moringa + 70% wheat flour
Fig. 11: Extensograph of dough prepared from control wheat flour

Fig. 12: Extensograph of dough prepared from 10% Morenga leaves powder
Fig. 13: Extensograph of dough prepared from 20% Morenga leaves powder

Fig. 14: Extensograph of dough prepared from 30% Morenga leaves powder
4.6 Bread Specific Volume

Specific volume of control wheat flour and bread loaves containing moringa leaves powder are presented in Table and Plates.

Loaf specific volume of bread made from wheat flour with and without moringa leaves powder ranged between 4.19 to 1.55 cm$^3$/g. The highest specific volume 4.41 cm$^3$/g in 10% level.

Table 4.4: Specific volume of bread sample:

<table>
<thead>
<tr>
<th>Samples</th>
<th>Specific volume cm$^3$/g</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>4.19±0.106a</td>
</tr>
<tr>
<td>B</td>
<td>2.417 ±0.006a</td>
</tr>
<tr>
<td>C</td>
<td>1.906±0.0006a</td>
</tr>
<tr>
<td>D</td>
<td>1.55±0.006a</td>
</tr>
<tr>
<td>LSD 0.05</td>
<td>0.1196</td>
</tr>
<tr>
<td>SE±</td>
<td>0.0033</td>
</tr>
</tbody>
</table>

Mean±SD values bearing different superscript(s) within a column are significantly different (P≤0.05).

Key:
A = wheat flour free addition (control)
B = sample containing 10% Moringa + 90% wheaat flour
C = sample containing 20% Moringa + 80% wheat flour
D = sample containing 30% Moringa + 70% wheat flour
Fig. 15: Specific volume cm³/g
Plate 6: Bread samples containing moringa leaves powder.

A = wheat flour free addition (control)
B = sample containing 10% Moringa + 90% wheat flour
C = sample containing 20% Moringa + 80% wheat flour
D = sample containing 30% Moringa + 70% wheat flour
4.7 Sensory Evaluation:

Sensory evaluation of loaf bread from wheat flour with and without moringa leaves powder were shown in table (4).

The scores of aroma-, taste-, crust colour-, crumb texture-, crumb colour-, crumb cells uniformity-, general acceptability-. The aroma score range between 6 – 4 for three levels of moringa powder significant differences was obtained between these levels added decrease in score when moringa powder. These treatments was gained low score with compared with control (no significant differences (P≤0.05), particularly 10 % level of moringa.

Table 4.5: Sensory Evaluation

<table>
<thead>
<tr>
<th>Bread sample</th>
<th>Crust colour</th>
<th>Aroma</th>
<th>Taste</th>
<th>Crust texture</th>
<th>Crumb colour</th>
<th>General acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>18.00*</td>
<td>27.00^a</td>
<td>26.00^c</td>
<td>23.00^d</td>
<td>26.00^d</td>
<td>23.00^c</td>
</tr>
<tr>
<td></td>
<td>±0.41</td>
<td>±0.68</td>
<td>±0.96</td>
<td>±0.92</td>
<td>±0.70</td>
<td>±1.06</td>
</tr>
<tr>
<td>B</td>
<td>42.00^b</td>
<td>47.00^f</td>
<td>50.00^b</td>
<td>40.00^f</td>
<td>40.00^f</td>
<td>45.00^f</td>
</tr>
<tr>
<td></td>
<td>±0.77</td>
<td>±0.83</td>
<td>±1.05</td>
<td>±1.23</td>
<td>±0.90</td>
<td>±0.76</td>
</tr>
<tr>
<td>C</td>
<td>59.00^b</td>
<td>64.00^g</td>
<td>64.00^b</td>
<td>56.00^g</td>
<td>57.00^g</td>
<td>53.00^g</td>
</tr>
<tr>
<td></td>
<td>±0.70</td>
<td>±0.70</td>
<td>±0.70</td>
<td>±0.88</td>
<td>±0.68</td>
<td>±0.83</td>
</tr>
<tr>
<td>D</td>
<td>71.00^a</td>
<td>73.00^a</td>
<td>70.00^a</td>
<td>69.00^a</td>
<td>69.00^a</td>
<td>70.00^a</td>
</tr>
<tr>
<td></td>
<td>±0.80</td>
<td>±0.35</td>
<td>±0.62</td>
<td>±0.63</td>
<td>±0.63</td>
<td>±0.49</td>
</tr>
<tr>
<td>LSD0.05</td>
<td>0.5047^*</td>
<td>0.4869^*</td>
<td>0.6224^*</td>
<td>0.6885^*</td>
<td>0.5375^*</td>
<td>0.5929^*</td>
</tr>
<tr>
<td>SE±</td>
<td>0.1781</td>
<td>0.1719</td>
<td>0.2197</td>
<td>0.243</td>
<td>0.1897</td>
<td>0.2093</td>
</tr>
</tbody>
</table>

Values are sum of ranks±SD
Value(s) sharing same superscript(s) in a column are not significantly (P>0.05) different according to DMRT.

Key:
A ≡ wheat flour free addition (control)
B ≡ sample containing 10% Moringa + 90% wheat flour
C ≡ sample containing 20% Moringa + 80% wheat flour
D ≡ sample containing 30% Moringa + 70% wheat flour
Fig. 16: Organoleptic Quality of Bread Samples
CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

- Moringa leaves powder contain high levels of Oil, fiber and ash therefore it is more suitable for supplementation to improve cereal based foods.
- A dough supplemented with moringa leaves powder has better rheological properties.
- Bread made of wheat dough supplemented with 10% (w/w) moringa leaves powder has higher protein content comparing to control sample without any variation in acceptability.

5.2 Recommendations

It's recommended that:

1. Using Moringa leaves powder at level of 10% in bread making.
2. Studies required to treat the green color of moringa leaves powder inorder to be used at high level of concentration for supplementation.
3. Further research in Moringa leaves powder to be carried out to develop cereal base product.
REFERENCES


Ministry of Sciense& Communications, Council for Moringa Research & Technology.
