Physicochemical characteristics of wheat flour supplemented with pearl millet (*Pennisetum glaucum* L.) and lupin (*Lupinus termis*) flours and biscuit quality

by

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DEDICATION

To my father who has implanted in me the love of learning and who gave me maximum and endless help and support;

To my mother who taught me to widen of the alphabet and surrounded me with her love and tenderness;

To my brothers and sisters who blessed me to achieve this work;

And to my dear friends

Love and respect

Amani
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Physicochemical characteristics of wheat flour supplemented with pearl millet (Pennisetum glaucum L) and lupin (Lupinus termis) flours and biscuit quality

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ABSTRACT: The aim of this study was to examine the effect of supplementation of biscuit wheat flour (BWF) with debittered lupin seed flour (DLSF) and decorticated pearl millet flour (DMF) on quality of composite flours and biscuits. Chemical composition, minerals, anti nutritional factors and in vitro protein digestibility of BWF, DLSF and DMF were determined. The results showed that the DLSF has high protein, Ca and Fe content compared to DMF and BWF which contained 54.91%, 11.75% and 10.83% protein for DLSF, DMF and BWF, respectively. DLSF, DMF and BWF contained 26.2 mg/100g, 2.07 mg/100g and 4.86 mg/100g Ca, respectively. Fe was 5.52 mg/100g, 3.51 mg/100g and 1.20 mg/100g for DLSF, DMF and BWF, respectively. The results also revealed that DMF had high phytic acid, tannins, Polyphenols and in vitro protein digestibility followed by DLSF. BWF had the lowest phytic acid, tannins, Polyphenols and in vitro protein digestibility.

DLSF and DMF were added to BWF in the ratios 25% (12.5 DLSF + 12.5% DMF); 50% (25% DLSF + 25% DMF), and zero percent BWF (50% DLSF + 50% DMF) was also used. The composite flours were tested for rheological properties. Proximate composition, organoleptic test, nutritive value and quality characteristics of the biscuits were studied. Farinograph characteristics showed that increasing the ratio of
DMF and DLSF lead to increase in the water absorption and decrease of dough stability, and decrease in development time except at 50% (25% DLSF + 25% DMF) which gave the highest value. Incorporation of DMF and DLSF have significantly decreased (P ≤ 0.05) the spread ratio of biscuits. Addition of 25% (12.5% DLSF + 12.5% DMF) to wheat flour produced acceptable biscuits. Various nutritional parameters (protein, fat, ash, fiber, minerals and protein digestibility) increased with the level of substitution.
الخصائص الفيزيوكيميائية لدقيق القمح المدعوم بدقيق الدخن (Lupinus termis) و (Pennisetum glaucum L.)

البسكيوت المنتج

أطروحة ماجستير

إعداد

أمانى محمد الجاك

المستخلص: هدف هذه الدراسة إلى معرفة تأثير تدعيم دقيق القمح الخاص بالبسكيوت (BWF) بدقيق الدخن منزوع المرارة (DMF) ودقيق الدخن المفتوح (DLSF) على جودة الدقيق. تم تقييم المكونات الكيميائية. المعايير، مضادات التهيج، وقابلية هضم البروتينات والكالسيوم والحمض. أظهرت النتائج أن BWF وDLSF تحتوي على نسبة عالية من البروتين، الكالسيوم والحديد مقارنة مع DMF. وكان محتوى البروتين 54.91% في DLSF و DMF بواقع 10.83% ل BWF و 7.5% ل DMF. DLSF على التوالى. وتحتوي BWF و DMF، DLSF على التوالى. وكذلك كانت نسبة ب Rouge DLSF في التوالى. وأظهرت نسبة DMF، DLSF في التوالى. وكانت نسبة DLSF، BWF في التوالى. وأظهرت نسبة BWF و DMF في التوالى. وكان محتوى بروتين في DLSF و DMF بواقع 10.83% و 7.5% ل BWF و DMF. كان محتوى البروتين 54.91 في DLSF و DMF بواقع 10.83% و 7.5% ل BWF و DMF. وكانت نسبة DLSF، BWF في التوالى. وأظهرت نسبة BWF و DMF في التوالى. وكان محتوى بروتين في DLSF و DMF بواقع 10.83% و 7.5% ل BWF و DMF. كان محتوى البروتين 54.91 في DLSF و DMF بواقع 10.83% و 7.5% ل BWF و DMF. كان محتوى البروتين 54.91 في DLSF و DMF بواقع 10.83% و 7.5% ل BWF و DMF. كان محتوى البروتين 54.91 في DLSF و DMF بواقع 10.83% و 7.5% ل BWF و DMF. كان محتوى البروتين 54.91 في DLSF و DMF بواقع 10.83% و 7.5% ل BWF و DMF. كان محتوى البروتين 54.91 في DLSF و DMF بواقع 10.83% و 7.5% ل BWF و DMF. كان محتوى البروتين 54.91 في DLSF و DMF بواقع 10.83% و 7.5% ل BWF و DMF. كان محتوى البروتين 54.91 في DLSF و DMF بواقع 10.83% و 7.5% ل BWF و DMF. كان محتوى البروتين 54.91 في DLSF و DMF بواقع 10.83% و 7.5% ل BWF و DMF. كان محتوى البروتين 54.91 في DLSF و DMF بواقع 10.83% و 7.5% ل BWF و DMF. كان محتوى البروتين 54.91 في DLSF و DMF بواقع 10.83% و 7.5% ل BWF و DMF. كان محتوى البروتين 54.91 في DLSF و DMF بواقع 10.83% و 7.5%
البكويت. وقد أعطت إضافة 25% (12.5% + DLSF%) إلى دقيق القمح
أعلى درجة قبول للبكويت عند المحكومين. كما أظهرت زيادة نسب الإضافة ارتفاعاً في نسبة
الرمال، البروتين، الدهون، الألياف، العناصر المعدنية وقابلية هضم البروتين.
# LIST OF CONTENTS

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dedication</td>
<td>i</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>ii</td>
</tr>
<tr>
<td>Abstract</td>
<td>iii</td>
</tr>
<tr>
<td>Arabic abstract</td>
<td>v</td>
</tr>
<tr>
<td>List of contents</td>
<td>vii</td>
</tr>
<tr>
<td>List of tables</td>
<td>xii</td>
</tr>
<tr>
<td>List of figures and plates</td>
<td>xiv</td>
</tr>
<tr>
<td><strong>CHAPTER ONE: INTRODUCTION</strong></td>
<td>1</td>
</tr>
<tr>
<td><strong>CHAPTER TWO: LITERATURE REVIEW</strong></td>
<td>4</td>
</tr>
<tr>
<td>2.1 Chemical composition and nutritive value of wheat</td>
<td>4</td>
</tr>
<tr>
<td>2.1.1 Moisture content</td>
<td>4</td>
</tr>
<tr>
<td>2.1.2 Ash content</td>
<td>5</td>
</tr>
<tr>
<td>2.1.3 Protein content</td>
<td>5</td>
</tr>
<tr>
<td>2.1.4 Fat content</td>
<td>6</td>
</tr>
<tr>
<td>2.1.5 Fiber content</td>
<td>6</td>
</tr>
<tr>
<td>2.1.6 Anti nutritional factors</td>
<td>7</td>
</tr>
<tr>
<td>2.1.6.1 Phytic acid</td>
<td>7</td>
</tr>
<tr>
<td>2.1.6.2 Tannins</td>
<td>9</td>
</tr>
<tr>
<td>2.1.6.3 Polyphenols</td>
<td>9</td>
</tr>
<tr>
<td>2.1.7 <em>In vitro</em> protein digestibility</td>
<td>10</td>
</tr>
<tr>
<td>2.1.8 Minerals</td>
<td>11</td>
</tr>
<tr>
<td>2.1.8.1 Calcium and magnesium</td>
<td>11</td>
</tr>
<tr>
<td>2.1.8.2 Iron</td>
<td>11</td>
</tr>
<tr>
<td>2.1.8.3 Sodium and potassium</td>
<td>12</td>
</tr>
<tr>
<td>2.1.8.4 Phosphorus</td>
<td>12</td>
</tr>
<tr>
<td>Section</td>
<td>Title</td>
</tr>
<tr>
<td>---------</td>
<td>-------</td>
</tr>
<tr>
<td>2.2</td>
<td>Chemical composition and nutritive value of millet</td>
</tr>
<tr>
<td>2.2.1</td>
<td>Moisture content</td>
</tr>
<tr>
<td>2.2.2</td>
<td>Ash content</td>
</tr>
<tr>
<td>2.2.3</td>
<td>Protein content</td>
</tr>
<tr>
<td>2.2.4</td>
<td>Fat content</td>
</tr>
<tr>
<td>2.2.5</td>
<td>Fiber content</td>
</tr>
<tr>
<td>2.2.6</td>
<td>Anti nutritional factors</td>
</tr>
<tr>
<td>2.2.6.1</td>
<td>Phytic acid</td>
</tr>
<tr>
<td>2.2.6.2</td>
<td>Tannins</td>
</tr>
<tr>
<td>2.2.6.3</td>
<td>Polyphenols</td>
</tr>
<tr>
<td>2.2.7</td>
<td>In vitro protein digestibility</td>
</tr>
<tr>
<td>2.2.8</td>
<td>Minerals</td>
</tr>
<tr>
<td>2.2.8.1</td>
<td>Calcium and magnesium</td>
</tr>
<tr>
<td>2.2.8.2</td>
<td>Iron</td>
</tr>
<tr>
<td>2.2.8.3</td>
<td>Sodium and potassium</td>
</tr>
<tr>
<td>2.2.8.4</td>
<td>Phosphorus</td>
</tr>
<tr>
<td>2.3</td>
<td>Chemical composition and nutritive value of lupin</td>
</tr>
<tr>
<td>2.3.1</td>
<td>Moisture content</td>
</tr>
<tr>
<td>2.3.2</td>
<td>Ash content</td>
</tr>
<tr>
<td>2.3.3</td>
<td>Protein content</td>
</tr>
<tr>
<td>2.3.4</td>
<td>Fat content</td>
</tr>
<tr>
<td>2.3.5</td>
<td>Fiber content</td>
</tr>
<tr>
<td>2.3.6</td>
<td>Anti nutritional factors</td>
</tr>
<tr>
<td>2.3.6.1</td>
<td>Phytic acid</td>
</tr>
<tr>
<td>2.3.6.2</td>
<td>Tannins</td>
</tr>
<tr>
<td>2.3.6.3</td>
<td>Polyphenols</td>
</tr>
<tr>
<td>2.3.7</td>
<td>In vitro protein digestibility</td>
</tr>
<tr>
<td>2.3.8</td>
<td>Minerals</td>
</tr>
</tbody>
</table>
2.3.8.1 Calcium and magnesium ........................................ 24
2.3.8.2 Iron ................................................................. 24
2.3.8.3 Sodium and potassium ........................................... 24
2.3.8.4 Phosphorus ....................................................... 25
2.4 Biscuits ................................................................. 25
  2.4.1.1 Flour ........................................................... 26
  2.4.1.2 Sweeteners .................................................... 26
  2.4.1.3 Shortening ..................................................... 27
  2.4.1.4 Milk and milk derivatives ................................. 27
  2.4.1.5 Leavening agent ............................................. 27
  2.4.1.6 Salt ............................................................. 28
  2.4.1.7 L – cystein ..................................................... 28
  2.4.2 Biscuit making process ........................................ 28
  2.4.2.1 Mixing .......................................................... 28
  2.4.2.2 Shaping and baking ....................................... 29

CHAPTER THREE: MATERIALS AND METHODS .................. 29

3.1 Materials .............................................................. 30
  3.1.1 Food materials .................................................. 30

3.2 Methods ............................................................... 30
  3.2.1 Preparation of millet for processing ......................... 30
  3.2.2 Lupin flour preparation ....................................... 30
  3.2.3 Formulation of composite flour ............................... 31
  3.2.4 Analytical methods ............................................ 31
    3.2.4.1 Moisture determination .................................. 31
    3.2.4.2 Ash determination ........................................ 32
    3.2.4.3 Crude Protein determination ............................ 32
    3.2.4.4 Fat determination ........................................ 33
3.2.4.5 Crude fiber determination............................................ 34
3.2.4.6 Anti nutritional factors Determination .......................... 34
3.2.4.6.1 Phytic acid content ........................................... 34
3.2.4.6.2 Tannins content .............................................. 36
3.2.4.6.3 Polyphenols ................................................. 37
3.2.4.7 Determination of in vitro protein digestibility ............... 38
3.2.4.8 Determination of minerals content............................... 38
3.2.4.8.1 Potassium and sodium contents ......................... 38
3.2.4.8.2 Phosphorus content.............................. 39
3.2.5 Rheological properties of dough .................................. 40
3.2.5.1 Farinograph of dough .......................................... 40
3.2.5.1.1 The titration curve ........................................ 40
3.2.5.1.2 The standard curve ....................................... 40
3.2.5.2 Gluten quality and quantity ................................. 41
3.2.6 processing of biscuits ............................................ 42
3.2.7 Evaluation of biscuit ............................................. 43
3.2.7.1 Physical characteristics of biscuit sample ................. 43
3.2.7.2 Sensory evaluation of biscuit................................ 43
3.2.8 Statistical analysis .................................................. 43

CHAPTER FOUR : RESULTS AND DISCUSSION...................... 44

4.1 Proximate composition of flour samples ......................... 44
4.1.1 Moisture content ................................................ 44
4.1.2 Ash content ...................................................... 44
4.1.3 Protein content .................................................. 46
4.1.4 Fat content ....................................................... 47
4.1.5 Fiber content ..................................................... 48
4.1.6 The anti nutritional factors ..................................... 48
4.1.6.1 Phytic acid .................................................... 48
4.1.6.2 Tannin ................................................................. 50
4.1.6.3 Polyphenols .......................................................... 50
4.1.7 In vitro protein digestibility ......................................... 51
4.1.8 Mineral content ......................................................... 53
4.1.8.1 Calcium and magnesium ....................................... 53
4.1.8.2 Iron ................................................................. 55
4.1.8.3 Sodium and potassium .......................................... 55
4.1.8.4 Phosphorus ........................................................ 56
4.2. Rheological properties of dough .................................... 57
4.2.1 Farinogram of biscuit wheat flour with decorticated millet flour and debittered lupin seed flour ......................... 57
4.2.2.1 Gluten quality and quantity of biscuit wheat flour with decorticated millet flour and debittered lupin seed flour .......... 60
4.3. Chemical characteristics of biscuits containing different levels of decorticated millet flour and debittered lupin seed flour ............... 62
4.3.1. Proximate composition .......................................... 62
4.3.2 In vitro protein digestibility ...................................... 66
4.3.3 Mineral content of biscuits ....................................... 66
4.4. Physical characteristics of wheat biscuits supplemented with lupin and millet flour ................................. 70
4.4.1. Biscuit thickness and diameter of biscuit pieces .......... 70
4.4.2. Biscuit spread ratio ............................................. 72
4.5. Sensory evaluation of biscuits ..................................... 72

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS .. 76
5.1. Conclusions ............................................................ 76
5.2. Recommendations ................................................... 76
References .................................................................. 78
Appendices .................................................................. 99
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table No</th>
<th>Title</th>
<th>Page No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Formulation of composite flour for rheological tests and biscuit production</td>
<td>31</td>
</tr>
<tr>
<td>2</td>
<td>Proximate composition (%) of biscuit wheat flour, debittered lupin seed flour and decorticated millet flour</td>
<td>45</td>
</tr>
<tr>
<td>3</td>
<td>Anti-nutritional factors of biscuit wheat flour, debittered lupin seed flour and decorticated millet flour</td>
<td>49</td>
</tr>
<tr>
<td>4</td>
<td><em>In vitro</em> protein digestibility of biscuit wheat flour, debittered lupin seed flour and decorticated millet flour</td>
<td>52</td>
</tr>
<tr>
<td>5</td>
<td>Mineral content (mg/100g) of biscuit wheat flour, debittered lupin seed flour and decorticated millet flour</td>
<td>54</td>
</tr>
<tr>
<td>6</td>
<td>Farinograph results of biscuit flour with decorticated millet flour and debittered lupin seed flour</td>
<td>58</td>
</tr>
<tr>
<td>7</td>
<td>Gluten content (%) and gluten index (%) of biscuit wheat flour, debittered lupin seed flour and decorticated millet flour</td>
<td>61</td>
</tr>
<tr>
<td>8</td>
<td>Proximate composition (%) of biscuit prepared from biscuit wheat flour containing different levels of debittered lupin seed flour and decorticated millet flour</td>
<td>63</td>
</tr>
<tr>
<td>9</td>
<td><em>In vitro</em> protein digestibility (%) of biscuit prepared from biscuit wheat flour containing different levels of debittered lupin seed flour and decorticated millet flour</td>
<td>67</td>
</tr>
<tr>
<td>10</td>
<td>Mineral content (mg/100g) of biscuit prepared from biscuit wheat flour containing different levels of debittered lupin seed flour and decorticated millet flour</td>
<td>69</td>
</tr>
<tr>
<td>11</td>
<td>Spread ratio of biscuit prepared from biscuit wheat flour containing different levels of debittered lupin seed flour and decorticated millet flour</td>
<td>71</td>
</tr>
<tr>
<td>12</td>
<td>Sensory evaluation of biscuit prepared from biscuit wheat flour containing different levels of debittered lupin seed flour and decorticated millet flour</td>
<td>73</td>
</tr>
</tbody>
</table>
LIST OF FIGURES AND PLATES

Fig (1): The structure of phytates.................................. 8
Plate (1): Biscuit made from DLSF and DMF with BWF…. 74
CHAPTER ONE
INTRODUCTION

Biscuits are consumed extensively all over the world as snack food and on a large scale in developing countries where protein and caloric malnutrition are prevalent particularly among women and children. Biscuits can serve as a vehicle for important nutrient if made readily available to the population. The increasing importance of snack foods such as cookies in today’s eating habit has not been fully exploited. This could be due to the high cost of wheat in tropical areas leading to importation. This leads to economic drain and increased prices of baked goods in these countries. The main problem facing the bakery industry in Sudan is the non-availability of wheat flour, so any effort made to substitute part of the wheat by other kind of available flours, e.g. sorghum, will contribute to lowering the cost (Elkhalifa and El-Tinay, 2002). Wheat imports have exerted a heavy burden on the Sudan meagre and deteriorating foreign exchange resources and creating a negative trade balance (Abdelrahman, 2000). Thus much research involving the use of non-wheat flour has been carried out to substitute wheat in baked products in developing countries (UNECA, 1985). These flour mixes used are generally referred to as composite flours (Akubor, 2004a).

Lupins are dicotyledons, belonging to the grain- legume (pulses) family leguminosae. More than 500 lupin species have been described. Whereas 12 species occur in Europe and Africa, roughly 200 – 300 species inhabit North and South America. It has been speculated that lupins originated from South America (Wink, 1993). The economically significant species include L. albus with a white flower, and L. angustifolius, a narrow-leafed lupin with a white flower that originally had a blue flower. Modern varieties generally have a white flower. Having been selected for low
alkaloid content, they are known as sweet white lupins or Australian sweet lupins. The yellow-flowered lupins, *L. luteus*, is not widely grown and is generally used as animal feed (Petterson *et al*, 1997). Lupin is a valuable ancient leguminous plant, which grows well in different soils and climates (Morrow, 1991; Dervas *et al*, 1999). Lupins are a good source of protein and lipids and offer the advantage of having no lectins and a very low content of protease inhibitors (Petterson, 1998). Lupin-Kernel has been used as a bakery additive (Doxastakis, *et al*, 2002). Partly to take advantage of its potential to improve the amino acid balance by increasing the proportion of lysine. Other potential advantages include reducing mixing time, increased water holding capacity and proving distinctive flavor and yellowish coloring that have proved popular with some parts of the bread market. The water retention capacity of lupin flour has also been used to retard staling in cookies and cake. Therefore, the supplementation of cereal flour with grain legumes flour is a good way combating malnutrition problems in developing countries.

Cereal grains provide a major source of energy, protein and dietary fiber in human nutrition (Dukes *et al*, 1995). Cereal grains are the most important calorie source in Sudanese diet (Abdelrahman, 2000). For example wheat can provide more than half of the calorie requirements in a healthy daily diet. Wheat also is a major source of protein and contributes more than 25% of the protein consumed in the human diet (Dukes *et al*, 1995). The protein content in sorghum and in millet are nearly equal and comparable to that of wheat and maize (FAO and ICRISAT, 1996). Millet are indigenous African cereals that, unlike wheat or rice, are well adapted to African semi-arid and sub tropical agronomic conditions. Millet grow under difficult ecological conditions and tolerate poor soils and a certain degree of drought better than any other cereal crops (Obilana, 2003). There are nine species of millet
cultivated around the world and pearl millet is most widely grown species in Africa (FAO, 2004). Pearl millet is ranking second crop after sorghum in the Sudan. It’s the preferred stable food crop for majority of the inhabitants of western Sudan (Abuelgasim and Hassans, 2006). Pearl millet is a good source of protein, minerals and energy. Except of lysine deficiency, pearl millet has well-balanced protein, with higher threonine and lower leucine contents than sorghum protein. Tryptophan levels are generally higher in pearl millet than in other cereal (Chung and Pomeranz, 1985).

The objectives of this study were:
1- To utilize of debittered lupin flour and decorticated millet flour in biscuits making.
2- To study the effect of incorporation of debittered lupin flour and decorticated millet flour on the nutritive value and quality of biscuits produced.
CHAPTER TWO
LITERATURE REVIEW

2.1 Chemical composition and nutritive value of wheat

A wheat kernel consists of three principal parts: germ, bran and endosperm. The wheat germ (about 2 – 4% of the kernel weight), wheat bran (about 7 – 8% of the kernel weight) consists of the several distinct layers which are rich in non – starch polysaccharides (Maes and Delcour, 2001). The endosperm is located inside the bran layers and is composed of the starchy endosperm about (81 – 84 % of the kernel weight) and an outer layer called the aleurone about (5 – 8% of the kernel weight) (Posner, 2000). The germ is a rich source of oil, tocopherol, sugar, protein and B-vitamins (Hoseney, 1992). Wheat contributes approximately 30% of the total cereals grown in the world and is a major stable source of mineral elements for people in many countries (Mckevith, 2004). Wheat proteins are known to be low in some amino acids that are considered essential for the human diet especially lysine (the most deficient amino acid) and thereonine (the second limiting amino acid) (Abdel – Aal and Sosulski, 2001). Wheat is rich in soluble dietary fiber (Muralikrishna and Rao, 2007), wheat provides moderate source of biotin (10 – 100 µg/100g) and together with rye of folic acid (FA) 30 – 90 µg/ 100g (Truswell, 2002).

2.1.1 Moisture content

Chinma and Gernah (2007) mentioned that, the moisture content of wheat flour was 8.50%, while Sudha et. al (2007) reported that, the moisture content of wheat flour was 11.2%. Elagib (2002) stated that, the
moisture content of three Sudanese wheat cultivars ranged between 6.23 – 7.49% and 8.83% for Australian wheat flour. However the moisture content of Australian wheat flour (72 – 75% extraction) was 13.45% as reported by Abdalla (2003).

2.1.2 Ash content

Ash content of wheat is directly related to the amount of bran in the wheat, and hence has a rough inverse relationship to flour yield. The ash content of hard white winter wheat flour (72% extraction rate) was 0.52% as showed by (Abdelghafor, 2007). Sudha et al., (2007) found that, the ash content of wheat flour was 0.45%, while Suleiman (2005) mentioned that ash content of wheat flour was 1.70. Mohamed (2000) found that, the ash content of four local commercial wheat cultivars ranged from 0.38 – 0.50 %, While Hassan (2005) studied the ash content of three Sudanese wheat cultivars Sasaraib, El-Nielain and Deberia, (72% extraction rate) were 0.53, 0.43 and 0.62% respectively. Mohamed (2007) showed that, the ash content of special wheat flour was 0.71%.

2.1.3 Protein content.

Proteins are one of the three major food components, along with carbohydrates and lipids. Proteins are necessary for the build up and survival of cells and are a major component in enzymes and many hormones responsible for regulatory and immune functions (GNDP Editorial Team, 2004). Protein is a key specification for wheat and flour purchasers since it is related to many processing properties such as water absorption and gluten strength. Protein content also is related to finished product attributes as texture and appearance low protein content is desired for crisp or tender products, such as snack and cookies. High protein content is desired for product with chewy texture such as pan bread.
Wheat protein 8-12% comprise up to 80% gliadins and glutenins (gluten proteins) which have high content of proline and glutamine (Mariotti et al. 2001, 2002; Morens et. al, 2003). Protein content of 43 wheat cultivars sown in China during the 2005 – 2006 ranged from 8.7 – 13.9% observed by Tang et. al (2008). Sudha et. al (2007) reported that, the protein content of wheat flour was 10.3%. Ahmed et. al (2004) Stated that, the protein content of three Sudanese wheat cultivars, Elnelain, Debaira, Wadilnel and Australian wheat flours were 9.37, 10.57, 11.17 and 13.16% respectively. Mohamed (2007) found that the protein content of special wheat flour was 11.87%.

2.1.4 Fat content

Lipids are minor component of the wheat grain and are more concentrated in the germ and aleurone than in the endosperm. Tri – acyl glycerols or non polar lipids constitute 60 – 70% of wheat lipids, whereas other lipid components in wheat include phospholipids, glycolipids, sterols, tocopherol and fat-soluble vitamins (Chung, 1991). Wheats in general are relatively low in lipids (Bock, 1991). The fat content of wheat flour was 1.90 as mentioned by (Chinma and Gernah, 2007); however AbdAlrahman (2005) reported that, the fat content of special wheat flour was 1.67%. Hassan (2005) studied that the fat content of wheat flour of three Sudanese wheat cultivars, Sasaraib, El-Nielain and Debeira (72% extraction rate) were 1.17, 0.92 and 0.87% respectively. Mohamed (2000) found that the fat content of four local commercial wheat cultivars (72% extraction rate) ranged from 1.33 – 1.43%.

2.1.5 Fiber content

Dietary fiber plays a very important role in the human diet. Dietary fiber, consisting of indigestible cellulose, hemi cellulose, lignin, gum and mucilage, provides a variety of health benefits. Soluble fiber is known for
its hypocholesterolemic effect and insoluble fiber is known for reduction in risk of colon cancer. B-Glucan is known for reduction in the risk of colon cancer and is known to reduce the absorption of glucose in the digestive system (Pomeranz, 1988; Potty, 1996). The fiber content of the wheat flour was found to be 1.10% as reported by (Chinma and Gernah, 2007); while Suliman (2005) found that, the fiber content of wheat flour (72% extraction) was 2.35%. Ali (2008) showed that, the fiber content of seven imported wheat and local commercial wheat cultivars (72% extraction rate) ranged from 1.08% to 1.24%, whereas the fiber content of four local commercial wheat cultivars (72% extraction) varied from 0.40 – 0.48% (Mohamed, 2000).

4.1.6. Anti-nutritional factors

2.1.6.1 Phytic acid

Phytic acid (myo-inositol 1, 2, 3, 4, 5, 6 hexakis-dihydrogen phosphate; IP6) is the major storage form of phosphorus in plants (60-90% of total seed phosphorus). It is a ubiquitous seed constituent, comprising 1 – 3% of all nuts, cereals, legumes and oil seed (Graf, 1986). While phytate implies the mono to dodeca anions of phytic acid and is a general term used to describe hexa phosphate esters of inositol (Mago, 1982; and Marfo et al, 1990). Phytate has ability to form chelates with polyvalent metal ions, such as those of iron, calcium, zinc copper and magnesium (Fig 1) (Buri et al, 2004). The complex of phytic and mineral elements in the form of phytate, leads to marked reduction in bioavailability of these nutrient elements (Raboy, 2001). Recent information showed that the phytates possess potential ability to lower blood glucose, reduce cholesterol and triacylglycerols, and reduce the risk of cancer and heart disease (Burgess and Gao, 2002; Cornforth; 2002;
Fig: (1) The structure of phytates
Jenab and Thompson, 2002). Anjum et al (2002) and Guttieri et al (2006) showed that the phytate concentration in the bran was much higher than in whole wheat flour and straight grade flour in all genotypes. The phytate in wheat grain is predominantly in the aleurone, which remains attached in the bran (Brinch-Pederson et al, 2002). Ali (2006) determined that, the phytic acid of wheat flour (72% extraction rate) was 126 mg/100g. However Giami et al, (2005) showed that, the phytic acid in wheat flour was 18.6 mg/100g. Levels of 40-50 mg/100g of grain in Spelt and Common flour (wheat species) obtained by Grela (1996). Phytate content of wheat ranged from 0.73 – 1.28 mg/100g (Erdal et al, 2002).

2.1.6.2 Tannins

Tannins are group of polyphenolic compounds that bind to proteins and either inhibit their activity in the case of digestive enzymes or complex with proteins. Tannins can also form cross linkages between protein and other macromolecules and render them unavailable for digestion (Griffiths, 1991), and are located primarily in the pericarp and testa tissues (Klopfenstein and Hosency, 1995). Grela (1996) found that, tannin content of spelt and common wheat were 200 mg/100g, whereas Ali (2006) gave values 15 mg/100g for wheat flour.

2.1.6.3 Polyphenols

Cereal polyphenols are important phytochemicals with one or more aromatic rings with hydroxyl groups in different patterns (Towo et al, 2003). Polyphenols considered anti nutrients because by inhibits several digestive enzymes, lower protein digestibility as well as starch digestibility and hinder mineral adsorption. Polyphenols compounds in plants are complex groups of substances with wide range of molecular mass and are found either free or bound to protein or dietary fiber (Bravo
Polyphenols exhibit an fence mechanism against animal as well as bird predators and also microbes for plants. Besides they are reported to improve aortic fragility and elasticity by attenuating elevation of blood pressure and they increase vasorelaxation (Mizutani et al., 1999). They exhibit significant antioxidant activity (Sripriya et al., 1996), and other potential health beneficial properties, such as anti-inflammatory, antiviral, anti-cancer and platelet aggregation inhibitory activity. Limited information on health benefits of wheat polyphenols has been reported (Malleshi et al., 2003; Zielinski and Kozlowski, 2000). Phenolic compounds are concentrated in the aleurone and bran portions of wheat (Onyeneho and Hettiarachchy, 1992; Ramarathnam et. al, 1989). The polyphenols content of whole wheat flour bread was 315 mg/100g obtained by Dhingra and Jood (2001).

### 2.1.7 In vitro proteins digestibility

The biological utilization of protein in any food product is primarily dependent on digestibility (Rathi, et al 2004), also Hahan et al (1984) reported that, the native value of protein referred as protein quality depend on its content of amino acid and digestibility. Wheat protein (66% retention) is lower nutritional quality than milk (74%), soy (71%), pea (70%) and lupin (74%) proteins (Mariotti et al., 2001, 2002; Morens et al., 2003). The protein digestibility of Spelt and Hard red spring (HRS) wheat flour were similar 86.4%, while for bread from Spelt and (HRS) wheat cultivars were 87.4% and 87.7% respectively observed by Abdel- Aal and Sosulski (2001). This result is similar to that reported by Adel- Aal and Hucl (2002) who gave averaging 86.7% for selected ancient wheat cultivars. Wheat flour bread had 74.0% protein digestibility (Dhingra and Jood, 2001). However Siddiq (1999) found that, the in vitro protein digestibility of wheat flour bread was 45.55%.
2.1.8 **Minerals**

The mineral contents are often more influenced by ecological conditions in the area where the crop is grown than by genetic factors as reported by Buerkert *et al* (2001). The distributions of mineral elements vary greatly in different parts of the grain, with most of them located in the germ and aleurone layer (Anjume *et al*, 2002). Wheat seriously deficient in calcium 26 – 55 mg/100g, whereas phosphorus level 334 – 427 mg/100g were high relative to human requirements (800 mg/day) (Grela, 1996; Abdal- Aal *et al*, 1995; Ranhotra *et al*, 1996).

2.1.8.1 **Calcium and magnesium**

Araujo *et al* (2008) determined that, the calcium and magnesium content of 54 wheat cultivars varied from 11 – 196 mg/100g and 19 – 51 mg/100g respectively. Tang *et al*, (2008) gave range from 95 – 150 mg/100g for magnesium and 23.7 – 49.2 mg/100g for calcium for 43 wheat cultivars. The calcium content of biscuit wheat flour was 4 mg/100g studied by Eltoum (2004). Lovis (2003) obtained a value of 25 mg/100g magnesium.

2.1.8.2 **Iron**

Zhao *et al* (2009) determined that, the iron content among 150 lines of bread wheat ranged from 2.89 – 5.08 mg/100g, these results were similar to those reported in another study (2.16– 3.38 mg /100g; Tang *et al*, 2008). Baysal (1988) found that, the iron content of wheat flour, 72% and 85% extraction rate, were 1.0 mg/ 100g and 2.4 mg/100g respectively. Lower value obtained by Ali (2006) as 0.82 mg/100g.
2.1.8.3 Sodium and potassium

Potassium content of 54 wheat cultivars were collected in Brazilian cites ranged from 76 to 319 mg /100g (Araujo et al., 2008), whereas Tang et al (2008) reported that, the potassium contents of 43 wheat cultivars sown in China during the 2005 – 2006 crop season, ranged from 243.8 – 446.1 mg /100g. Ali (2006) obtained values (7.25 and 3.44 mg/100g for potassium and sodium respectively). Taha (2000) reported that, the amount of sodium and potassium for two Sudanese wheat cultivars (Condor and Debeira 72 % extraction) were 0.15% and 0.11%, 1.81% and 1.80% respectively.

2.1.8.4 Phosphorus

The phosphorus content of Hard White Winter Wheat flour (72% extaction rate) was 0.105% observed by Abdelghafor (2007), while Taha (2000) gave values 0.22% and 0.14% for two Sudanese wheat cultivars. Arujo et al, (2008) gave range from 89 – 715 mg phosphorus/ 100g. Tang et al, (2008) showed that the phosphorus content of 43 wheat cultivars varied from 227.9 – 353.5 mg/100g. Whereas Pomeranz and Dikeman (1982) mentioned that the phosphorus content of 25 wheat cultivars varied from 0.381 – 0.549%.

2.2 Chemical composition and nutritive value of millet

The Pearl millet consists of 71 – 76.2% endosperm, 15.5 – 21% germ and 7.2 – 10.6% pericarp (Abdelrahman et al., 1982, 1984). The germ of pearl millet is much larger in percentage of the total kernel than is the germ of sorghum 17.4% compared with 9.8% in sorghum (Sullivan et al., 1990). Abdelrahman et al. (1984) studying American pearl millet cultivars, proportion of bran (including pericarp and aleurone) is comprised between 7.0% and 12% of the grain weight and corresponds,
respectively to 9% and 6% of total protein and lipid content of the grains. The endosperm texture of the millet kernels consists of largely flour portion and crumbles to fine grits when the seed coat is partially or fully peeled off (Malleshi and Hadimani, 1991). The seed coat of the millet is an edible component of the kernel and is a rich source of photochemical, such as dietary fiber and polyphenols, and also a very good source of minerals, especially calcium (Hadimani and Malleshi, 1993). The seed coat normally imparts dark color; chewy texture and characteristic mostly dour of the food products and these factors largely hinder their acceptability by non-traditional millet consumers. Pearl millet is nutritionally better than most other cereals, it has high levels of calcium, iron, zinc, lipid and high quality proteins (Kloopenstein and Hoseney, 1995). Ihekoronye and Ngoddy (1985) reported that, millet grain made up of protein 9 – 10%, fat 3 – 4%, fiber 2%, carbohydrate 75 – 85%, ash 1 – 2% and energy 414 kcal. It is a good source of thiamine, vitamin B, calcium, phosphors, magnesium and iron. Some of health benefits associated with regular intakes of millet foods, such as the hypocholesterolemic, hypoglycemic and anti ulcerative characteristics (Mc Donough et al, 1986; Ravindran, 1991) and reduce the risk of diabetes mellitus (Gopala, 1981) and gastrointestinal tract disorders (Tovey, 1994).

2.2.1 Moisture content

The moisture content of two pearl millet cultivars Campela and IKMP-5 was 7.8 – 9.3 % respectively as reported by Lestienne et al (2007). Abdelrahman (2004) reported that, the moisture content of eight pearl millet cultivars ranged from 7.7% to 8.9%. Elyas et al, (2002) gave lower value of 6.4%. Eltayeb (2006) stated values of 5.4% and 6.48% for two Sudanese pearl millet cultivars Gazera and Gadrif respectively.
Ahmed (1999) found that the moisture content of dehulling two pearl millet cultivars were 9.7 and 8.5%. While Idris (2001) reported that, the moisture content of decorticated millet (70.1 and 63.7% extraction rate) were 9.60% and 9.50% respectively.

2.2.2 Ash content:-

Abdelrahman et al (2005a) stated that, the ash content of two pearl millet cultivars were 1.8 and 1.6%, while Ali et al (2003) reported that, the ash content of two pearl millet cultivars were 2.1 and 2.4%. Elyas (1999) reported 1.2 and 2.1% for two pearl millet. Ash content of decorticated pearl millet was 1.8% as reported by Almeida- Dominguez et al (1993). While Idris (2001) determined the ash content of decorticated millet (70.1 and 63.7% extraction rate) as 1% and 0.9% respectively. Viswanath et al (2009) reported that, the ash content of finger millet (whole, 3, 5 and 7% flour fraction) were 2.7, 0.9, 0.5 and 0.5 respectively.

2.2.3 Protein content:-

Ali et al (2004) reported that, the protein content of six genotypes of pearl millet ranged from 11.4% to 16.3%. Abdalla et al (1998a) stated that, the protein content of ten pearl millet genotype varied from 8.5 to 15.1%. Lestienne et al (2007) found protein content for whole two pearl millet as 8.73 and 10.11% while for decorticated (12% decortications rate) as 7.60 and 8.80%. Eltayeb (2006) determined that, the protein content of whole pearl millet was 11.4 and 14.40% decreased to 10.7 and 12.30% by debranning for two pearl millet cultivars. Idris (2001) found that the protein content of decorticated pearl millet (70.1 and 63.7% extraction rate) were 13.5 and 13.0% respectively. Protein content of decorticated finger millet 6.3% as investigated by (Shobana and Malleshi, 2007).
2.2.4 Fat content

The lipid content in millet grains was noticeably higher than in some other cereal species such as wheat or barley (about 1.8 or 2.1 g/100g Dry matter DM), respectively (Souci et al, 2000). Pearl millet has the highest oil content due to the large proportion of the germ to the endosperm (Osagie and Kates, 1984). The oil content of eight pearl millet varied from 4.0% to 7.7% according to Abdelrahman (2004). Ali et al (2003) found that, the oil content were 7.8% and 6.7% for two pearl millet, these results were lower than that reported by abdelrahman et al (2005a) who found 11.7% and 12.8% for two pearl millet. Lestienne (2007) studied the lipid content of two raw millet cultivars Gampela and IKM-5 (5.58% and 5.77 g/100g DM respectively) while for (12% decortication rate) were (5.08 and 5.19 g/100g). Idris (2001) showed 4.50% for whole pearl millet, while for decorticated (70.1 and 63.7% extraction rate) were 4 and 3.25% respectively. Shobana and Malleshi (2007) reported that, the decorticated finger millet contained 0.9% fat. Viswanath et al (2009) found that, the oil content of finger millet (whole, 3, 5 and 7% flour fraction) were 1.2, 1.1, 1.0 and 0.9% respectively.

2.2.5 Fiber content

Abdelrahman (2004) stated that, the fiber content of eight pearl millet cultivars were between 2.1 to 3.2%. Values 1.42% and 2.2% fiber content were reported for two pearl millet cultivars (Eltayeb, 2006). Elyas et al, (2002) gave values of 2% and 2.3% for two pearl millet cultivars. Fiber content of pearl millet 1.5% to 1.7% for high protein in bread line and 1.25% to 1.3% for normal protein varieties (Singh et al, 1987). Idris (2001) found 1.10% for whole pearl millet while for decorticated at (29.90% and 36.26% decortication rate) were 0.75 and 0.55%
respectively. Viswanath et al (2009) gave 22.5%, 9.9%, 6.0% and 4.2% for (whole, 3%, 5% and 7% flour fraction) respectively.

2.2.6 Anti-nutritional factors

2.2.6.1 Phytic acid

Pearl millet is known to contain a considerable amount of phytic acid representing more than 70% of the total phosphorus in the grain (Chauhan et al, 1986). Simwemba et al (1984) showed that, phytate content of pearl millet grain was 752 mg/100g in germ against 86 and 278 mg/100g for endosperm and bran respectively. Taking these values with those reported by Abdelrahman et al (1984) for the proportion of the different grain structures, about 60% of the phytates appeared to be located in germ, 30% in the endosperm and 10% in the bran fraction. Simwemba et al., (1984) mentioned that, the phytic acid ranged from 179 to 306 mg/100g. Phytic acid of eight pearl millet cultivar varied from 422.3 mg/100g to 1101 mg/100g Abdelrahman (2004), while Badau et al (2005) gave range from 2.91% to 3.30% for ten pearl millet cultivars. Phytate content were 720 and 800 mg/100g changed by decortication at (12% of extraction) to 691.2 and 736 mg/100g for two pearl millet observed by Lestienne et al (2007). Altayeb (2006) showed that, the phytic acid of two pearl millet were 952.51 and 987.19 mg/100g, decreased by debranning to 101.76 and 100.47 mg/100g.

2.2.6.2 Tannins

Mc Donough et al (1986) reported that, the testa layer of the millet is highly pigmented and contributes for the bulk of Polyphenols and tannin content of the millet. Ahmed (1999) found that, the tannin content of whole pearl millet were 0.25% and 0.33% for two pearl millet cultivars, while for dehulled were 0.10% and 0.15%. Elyas (1999) found
0.12% and 0.24% for two pearl millet cultivars. Tannin content of 1.52 g/100g was reported for CO7 pearl millet cultivar Nithya et al (2006). Values of 0.22% and 0.17% for two pearl millet decreased to 0.08% by debranned studded by (Eltayeb, 2006).

2.2.6.3 Polyphenols

Polyphenols are high concentration in the grains with a brown pericarp and pigmented testa (Ejeta et al, 1989). The polyphenol content of finger millet is concentrated in the seed coat (Chethan and Malleshi, 2007) also Viswanath (2009) observed the seed coat and whole flour contained higher amount of polyphenols 12.6% and 7.3% respectively, while for various millet fractions (3, 5 and 7%) were ranged from 3.6 to 2.3%. Abdelrahman (2004) showed that, the polyphenols ranged from 306.65 to 669.39 mg/100g for eight pearl millet cultivars. Chethan and Malleshi (2007) gave range from 0.3 to 2.3% for 7 finger millet varieties and it was found that the brown varieties contain (1.2 – 2.3%) higher proportion of polyphenols than did white varieties (0.3 – 0.5%). The noticeable difference between white and brown varieties could be due to the presence of the red pigments such as anthocyanins, which are generally polymerized phenolic present in brown cultivars. Nithya et al (2006) mentioned that the polyphenols content of pearl millet was 300 g/100g. Ahmed (1999) found that dehulling reduced polyphenols from 303.7 to 235 mg /100g and from 443.5 to 326 mg /100g for two pearl millet cultivars. Shobana and Malleshi (2007) gave 265 mg/100g polyphenols reduced to 67 mg/100g by decortication for finger millet.

2.2.7 In vitro protein digestibility

Digestibility values of the pearl millet varieties were higher than that of sorghum and comparable to that of maize and in vitro protein
digestibility of uncooked two pearl millet 91% and 89% while for cooked were 87% and 85% (Ejeta et al, 1987). Ali et al (2003) reported that, 68.1% and 75.9% for two millet cultivars, while Eltayeb (2006) observed that, the in vitro protein digestibility of two pearl millet cultivars 66.0% and 63.20% while for debranned increased from 66 to 74.60% for Gazira variety and from 63.20 to 70.2% for Gadarif variety. Ahmed (1999) reported values 72.70% and 70.4% increased by dehulling to 69.1% and 78.6% for two pearl millet Ugandi and standard varieties respectively.

2.2.8 Minerals

In pearl millet a greater concentration of minerals is located in the covering layers and germ than the endosperm portion of the kernel (Varriano- Mariston and Hoseny, 1980).

2.2.8.1 Calcium and magnesium

Calcium content of ten pearl millet cultivars ranged from 53.6 to 122 mg/100g as investigated by Badau et al (2005). Arora et al (2003) found that, the calcium content of pearl millet seeds was 39.6 mg/100g. Calcium content was 1.42 and 1.5 mg/100g for two pearl millet cultivars (Eltayeb, 2006). Serna- Saldivar et al (1991) gave range 71 - 156 mg/100g for magnesium. Nithya et al (2006) gave values 120 mg/100g and 140 mg/100g for magnesium and values of calcium 33 mg/100g for two pearl millet cultivars. Where Abdelrahman et al (2005a) gave 53 and 54 mg/100g for calcium and gave 75 and 93 mg/100g for magnesium for two pearl millet cultivars. Calcium content of various millet fraction content ranges from 140 to 340 mg/100g for finger millet obtained by Viswanath et al (2009).
2.2.8.2 Iron

Iron content of two pearl millet cultivars were 1.87 mg/100g and 3.41 mg/100g reduced by decortication at 12% of extraction from 3.41 to 2.32 mg/100g and from 1.87 to 1.37 mg/100g as observed by Lestienna (2007). Whereas Altayeb (2006) obtained values 5.84 mg/100g and 6.50 mg/100g. Iron content of two pearl millet cultivars Gazira and Gadarif decreased to 5.15 and 4.10 mg/100g by debranning respectively. Nithya et al (2006) determined that, the iron content of two pearl millet cultivars were 8.6 and 8.8 mg/100g. Iron content of ten pearl millet cultivars varied from 16.3 – 18.3 mg/100g investigated by (Badau et al, 2005). Abdelrahman (2004) gave range of 7.5 to 11.7 mg/100g for eight pearl millet cultivars. Iron content of different milled fraction content range from 3 to 2 mg/100g for finger millet (Viswanath et al, 2009).

2.2.8.3 Sodium and potassium

Potassium content of two pearl millet cultivars were 29 and 30 mg/100g (Nithya et al, 2006). Potassium and sodium content of eight pearl millet cultivars were varied from 370.5 to 547.5 mg/100g, and from 13 to 19.4 mg/100g respectively Abdelrahman (2004). While Abdalla et al (1998a) gave range from 0.007 to 0.011% for potassium and from 0.004 to 0.13% for sodium for ten pearl millet cultivars. Abdelrahman et al (2005b) gave 15.21 mg/100g and 370.47 mg/100g for sodium and potassium respectively.

2.2.8.4 Phosphorus

Phosphorus content of pearl millet seed cultivar was 348 mg/100g investigated by (Arora et al, 2003). Abdalla et al (1998b) reported values of 0.99, 0.88 and 0.55% phosphorus content for three cultivars. Badau et al (2005) gave range of 30.4 to 68.1 for ten pearl millet cultivars.
Whereas Abdelrahman (2004) gave range of 551.6 to 1290 mg/100g for eight pearl millet cultivars. Shobana and Malleshi(2007) obtained that, the phosphorus content for native and decorticated finger millet were 211 mg/100g and 109 mg/100g respectively.

2.3 Chemical composition and nutritive value of lupin

Lupin grain is rich in protein (30 – 40 %) and lipids (5 – 10%) made up largely of unsaturated fatty acids (Peterson et al, 1997). The carbohydrate chemistry of lupin is different to most legumes with negligible level of starch and high levels (up to 500 g/kg) of soluble and in soluble non starch polysaccharides and oligosaccharides (Van Barneveld, 1999). The thick seed coat (testa, 15 – 25 % grain weight) of the lupin consists mainly of cellulose and hemicelluloses (Gladstones et al, 1998). Its removal is the first step in processing the grain for human food, but it dose have feed for ruminants (Peterson, 2000). The importance of lupin (Lupinus ssp) as valuable source of nutrient to be used in human or animal nutrition (Farrel et al, 1999; Depenna et al, 2003; Hall and Johnson, 2004), has increased in recent years. This is due to its high content of protein, mineral, dietary fiber and fat in certain species, as well to its low level of non nutritional components such as trypsin inhibitor, lectins or alkaloids in sweet varieties (Gueguen and Cerletti, 1994; Dupon et al, 1994; VanBarneveld, 1999). Lupin fiber has good cholesterol – lowering properties, improving stool transit times and adding a feeling of satiety due to its water holding properties. Thus lupin grain has potential as a fiber source in a full range of bakery products bread, muffins, cookies, pasta, noodles and even dessert (Chrk and Johnson, 2002; Rayas – Duarte et al, 1996). In addition to these nutritional properties, lupin also features beneficial functional properties such as antioxidant, antimicrobial or hypocholesterolemic effect (Tosaliki

2.3.1 Moisture content

Viveros et al (2007) stated that, the moisture content for Lupinus albus var multtolupa was 6.15%. Doxastakis et al (2002) showed that, the moisture content of dehulled lupin flour was 7.8%. Sathe et al (1982) observed that, the moisture content for Lupinus mutabilis was 6.9% and 7.7% for L. albus cv Multolupa. Moisture content of debittered lupin seed flour was 6.0% for L. termis (Siddiq, 1999).

2.3.2 Ash content

The ash content of raw L.albus var multitalia was 3.8% (Prandini et al, 2005). Lqari et al (2002) found that ash content of L. angustifolius was 2.1%. Dehulled full fat lupin flour with 1.47% ash content (Doxastakis et al, 2002). Elamin (1996) reported that, the ash content of debittered kernels for 30 and 60 min were 1.37%; 1.29% and 1.26%; 1.29% respectively for tow Sudanese lupin cultivars.

2.3.3 Protein content

The protein content of the white lupin (Lupinus albus), Australian sweet lupin (Lupin angustifolius) and yellow lupin (L. luteus) were 40.2, 38.3 and 37.3% respectively (Glencross et al, 2003). Khalil et al (2006) mentioned that, protein content of raw L. albus L. var Giza (Egypt) was 36.8%. Viveros (2007) gave 38.8% protein content, thesis results lower than obtained by Elamin (1996) who found that, the protein content of whole lupin seed were 49.88% and 50.37%, while for debittered kernel for 30 and 60 min was found to be 59.33%, 57.42% and 56.91%; 56.03% respectively for two Sudanese lupin cultivars. Highest values 61.7% protein for debittered lupin seed flour study by (Siddiq, 1999).
2.3.4 Fat content

The fat content of raw lupin flour was 14.64% (Porres et al, 2006). Whereas Viveros et al (2007) found that, the fat content of _L. albus_ var _multolupa_ was 9.98%. Doxastakis et al, (2002) reported that the fat content of dehulled full fat lupin flour was 15.1%. Elamin (1996) found that, the oil content was 10.4%, ranged from 10.02 to 10.51% and 9.92 to 10.87% for raw whole seed, debittered whole seed (for 30 and 60 min) respectively, and varied from 11.54 to 12.12% and from 12.34 to 12.54% for debittered kernel for 30 and 60 min respectively.

2.3.5 Fiber content

Lqari et al (2002) mentioned that the fiber content of defatted lupin flour was 9.9%. However the crude fiber of 13 lupin cultivars ranged from 13 – 17.3% (Wasilewko and Buraczewska, 1999). (_Lupinus albus_ var _multitalia_) with 9.58% crude fiber content (Prandini et al, 2005). Crude fiber of roasted lupin at 80 – 90 °C for 10, 20, 30 and 40 min were 3.9, 3.5, 3.2 and 3.3% respectively as was reported by Ballester et al (1986). Siddiq (1999) obtained 1.5% crude fiber.

2.3.6 Anti nutritional factors

2.3.6.1 Phytic acid

Eltayeb (2004) found that, phytic acid content of two Sudanese lupin cultivars _Lupinus termis_ cv _Dongola_ and _Golo_ were 124 mg/100g and 209 mg/100g respectively, soaking of the whole seeds significantly decreased phytic acid for both cultivars and was found to be 58 and 70.3 mg/ 100g for Dongola and Golo respectively. Khalil et al (2006) found phytate for _L. albus_ var _Giza_ was 420 mg/ 100g. Elamin (1996) observed that, the phytic acid content of two Sudanese lupin cultivars was 0.9%,
and 0.83% for whole seed, phytic acid decreased for both cultivars and varied from 0.15% to 0.60% and 0.08 to 0.47% by boiling in water for 30 and 60 min followed by dehulling respectively.

2.3.6.2 Tannins

Tannin content of raw *L. albus* var *multitalia* was 61 mg/100g as reported by Prandini (2005). Petterson and Mackintosh (1994) found that, the tannin content in sweet lupins ranged from 0.17 – 1.20%. Eltayeb (2004) showed that, the tannin content of two Sudanese lupin cultivars were 92 and 95 mg/100g, soaking of seed followed by cooking and dehulling significantly decreased tannin content and was found to be 10.4 and 21 mg/100g. Tannin content was very low 0.02% for boiling of lupin seed followed by soaking and dehulling study by Elamin (1996).

2.3.6.3 Polyphenols

Polyphenols content in the defatted lupin flour was below 0.1% (Lqari *et al*, 2002). *L. albus* var *multitalia* with 639 mg/100g Polyphenols (Prandini *et al*, 2005).

2.3.7 *In vitro* protein digestibility

The protein digestibility of raw lupin was 91.8% as mentioned by Khalil *et al* (2006). Lqari *et al* (2002) found that, the *in vitro* protein protein digestibility (IVPD) of defatted lupin flour was 80%. Elamin (1996) reported that, the IVPD of raw *lupinus termis* cv *Rubatab* and cv *Dongola* was 73.9 and 73% respectively, while IVPD of debittered kernel of *Rubatab* and *Dongola* were 77.4 and 76%, 81 and 80% for 30 and 60 min respectively. Hassan *et al* (2005) observed that, the IVPD of raw *Lupin termis* cv *Dongola* and *Golo* were 72.6 and 74.8%, increased
by soaking whole seeds and was 89.4%. Lower values obtained by Ahmed and Nour (1990) who reported 55% IVPD.

2.3.8 Mineral

2.3.8.1 Calcium and magnesium

Calcium and magnesium content of raw lupin flour were 138.9 and 14.50 mg/100g respectively (Porres et al., 2006). Wasilewko and Buraczewska (1999) showed that, Ca content of yellow lupin, white lupin and Blue lupin cultivars varied from 240 – 430 mg/100, 330 – 390 mg/100g and 290 – 350 mg/100g respectively, whereas Mg content ranged from 260 – 360 mg/100, 170 – 210 mg/100g and 190 – 280 mg/100g respectively. Petterson (2000) gave range from 0.22 mg /100g in L.albus to 0.24 mg /100g in both L. angustifolius and L. luteus for calcium in whole seed.

2.3.8.2 Iron

Wasilewko and Buraczewska (1999) mentioned that, the Fe content in lupin cultivars varied from 3.9 – 12.8 mg/100g. Mytyka et al., (1997) found Fe content of yellow lupin, white lupin, sweet blue lupin and bitter blue lupin were 8.1, 4.3, 6.4 and 6.0 mg/100g respectively. Hassan et al (2005) reported that, the Fe content of L.termis cv Dongola 3.6 mg/100g, soaking of whole seeds followed by cooking and dehulling decreased the total Fe and was found to be 3.2 mg/100g. While L. temis cv Golo was 1.8 mg/100g, soaking of seeds followed by cooking and dehulling increased Fe content and was found to be 5.1 mg/100g

2.3.8.3 Sodium and potassium

Potassium level in whole seeds range from 0.89 mg/100g in L. angustifolius to 1.08 mg/100g in L. luteus (Petterson, 2000). Wasilewko and Buraczewska, 1999) found potassium content of white lupin, yellow
lupin and blue lupin ranged from 11.5 – 12.4 g/kg, 12.3 – 14 g/kg and 10.3 – 12.3 g/kg respectively, while sodium content ranged from 9.6 – 13.4 mg/100g, 7.9 – 11.1 mg/100g and 11.9 – 11.2 mg/100g respectively. Elamin (1996) determined the potassium content to be 0.49%, 0.52% and 0.52% and 0.71%, however sodium content were 5.75 mg/100g, 6.21 mg/100g and 6.48 mg/100g, 6.90 mg/100g for debittered kernel for 30 and 60 min for two Sudanese lupin cultivars respectively. Hassan et al (2005) found that, the potassium content of L. termis var Dongla was 18.2 mg/100g increased in the range between 19.6 and 27.1 mg/100g by soaking whole seed followed cooking and then dehulled.

2.3.8.4 Phosphorus

Pores et al (2006) obtained that the phosphorus content of raw lupin flour was 332.15 mg /100g. Petterson and Mackintosh (1994) reported that the P content of lupinus vucika range from 0.3 – 0.36%. Wasilewko and Buraczewska (1999) gave value ranged from 440 – 890 mg/100g of lupin cultivars. Elamin (1996) found that, the P of whole seed were 0.21% and 0.30%, and was 0.21% for debittered kernel for 60 min for two Sudanese lupin cultivars. Hill (1977) reported that, the level of P ranged from 0.18 % to 0.58% of whole seed and 0.59% for kernel of L. albus.

2.4 Biscuits

Biscuits are the most popular bakery item consumed nearly by all levels of society Sudha et al (2007). In the United States of American called cookies and crackers as reported by (Wade, 1988).
2.4.1 Biscuit ingredients

In cracker, cookie and biscuit production the characteristic texture of product depends primarily on the properties of the gluten in flour used. For biscuits, the texture, flavor and color of the final product also depend on the raw materials used, such as shortening, sugar, milk solids and leavening and flavoring agents (Van – Wakeren and Popper, 2002).

2.4.1.1 Flour

Kernel texture in wheat has been found to be directly controlled by one or two major genes. Generally good biscuit making wheat are those with soft endosperm texture, lower protein content, more break flour and smaller particle size. Study by (Labuschagne et al, 1997).

2.4.1.2 Sweeteners

Sweeteners provide many functional properties in addition to enhancing taste. The addition of sugar as coating, gives presweetened cereals high sweetness levels. Topical application provides an immediate, intense flavor. Sucrose is most often used because it can be crystallized to either a white "frosted" surface or a hard, clear glaze. A topical sweetener system can act as flavor carries, deliver added nutrients and bind dry ingredients, such as nut to cereals surface (Kner, 1997), as well as provide desirable texture. Sugar also compete with starch for available moisture, which can affect optimal starch hydration and expansion of the product (Kner, 1997). Sucrose, glucose and fructose are generally used in making of cookies. Cookies with glucose were the softest and most moist, expanded vertically (Nishibori and Kawakishi, 1992).
2.4.1.3 Shortening

Fats and oils have been important baker ingredients for centuries. Indeed, shortening is a baker's term: fat in bakery item "shortens" (tenderizes) the texture of the finished product. Shortening plays an important part in the efficient processing of many bakery products. Shortening makes the final quality of bakery product are: tenderness, moist mouth feel, lubricity, flavor and structure (Stauffer, 1998).

2.4.1.4 Milk and milk derivatives

Dairy milk products used to improve the Millard reaction (color and taste formation) in crackers. These products contain protein and sugars that react with each other during backing to form a variety of dark, flavored substances (Van – Wakeren and Popper, 2002).

2.4.1.5 Leavening agent

A chemical leavening system contains two functional components: a leavening base and acid. Sodium bicarbonate (NaHCO₃ or NBC) is the most widely used leavening base and is chemically neutralized by acid according to the following reaction:

\[ HX + NaHCO_3 \rightarrow NaX + H_2O + CO_2 \]

where HX is the acid

Leavening and gas bubble formation occur in the stage. During mixing, air is incorporated in to dough. This provide gas cell nuclei for gas to enter during later processing steps. Some CO₂ (carbon dioxide) is formed by reaction of soluble acid NBC during mixing and holding. Heat from the oven causes less soluble acids and bicarbonate to dissolve and react to generate more CO₂. Retention of air bubbles in dough and the baked products is critical to maintain a leavened product and depend on many forces that destabilize and expand the product during baking (Cepeda et al, 2000; Dally and Navarro, 1999; LaBell, 1999 and Mckinney, 2000). Addition of NBC makes a rapid increase in width and also affects the
thickness. Use of ammonium bicarbonate (leavening agent) as also source of carbon dioxide, enhance the spread as well as open the structure to provide some lift.

2.4.1.6 Salt
Salt (sodium chloride) has marked strengthening effect on gluten; the salt level in the dough is often 1 – 1.5%.

2.4.1.7 L-cysteine
Addition of L-cysteine cleaves disulfide bonds, decreasing gluten elasticity (Bloksma and Bushuk, 1988). Elkhalifa and El-Tinay (2002) reported that, addition of cysteine lead to increase in water absorption, decrease in dough development time and decrease in dough stability, while the mixing tolerance index increased, also improvement of physical and sensory characteristics, of biscuits made from wheat and sorghum blend.

2.4.2 Biscuit making process
2.4.2.1 Mixing
There are two basic methods of mixing dough. The first method is known as multi-stage methods. It is done in many stages using different ingredients during mixing process. Usually requires initial introduction to the mixer of shortening, sometimes the syrup, then the addition of granulated sugar and some of all other dry ingredients. Mixing is continues at a low or medium speed until the all component became homogenous and the mixture has taken up air in the form of bubbles. The second method is creaming method, the beneficial effect of the creaming mixing process as fat – coating that delays solubization and hydration of sugar and flour, and the incorporation of small air bubbles which assist in leavening and establishing the structure of the finished cookie (Matz,
1968). Mixing biscuit dough should be no more than enough to allow the dough to be gently sheeted and biscuits to be cut.

2.4.2.2 Shaping and baking

There are two ways to shape the dough, roll and cut or drop. The rolling and kneading results with flakiness biscuit, no sticky and has sufficient developed gluten. After rolling the biscuit dough is cut into shapes usually round with a biscuit cutter, about 2 – 3 inches in diameter. The dropping method, drops the dough in an irregularly shape into grease baking sheet by your lightly floured finger tips. The dough is more sticky (Phillips, 2003). Baking is heating or cooking by hot air, and also by oven floor and trays. Moisture at the surface of the food is evaporated by the hot air, and this lead to dry crust in products such as bread and many biscuits (Kordylas, 1991; Fellows and Hampton, 1992). The cooking temperature for most ovens range between 120 and 260 °C (Kordylas, 1991).
CHAPTER THREE
MATERIALS AND METHODS

3.1 Materials
3.1.1 Food materials

Pearl millet seeds cultivar (Red) were purchased from Khartoum North local market. The wheat flour (Special wheat flours) was obtained from Sayga mills. Lupins seeds were purchased from Khartoum local market. Baking materials were obtained from local market as well.

3.2. Methods
3.2.1. Preparation of millet for processing

The millet seeds were carefully cleaned and freed from any foreign materials and broken seeds. The clean seeds were decorticated using mechanical dehuller, and then ground by a commercial mill to pass through a 0.4 mesh sieve. The flour was packaged in polyethylene bags and stored using covered plastic container in a freezer until needed for investigation.

3.2.2. Lupin flour preparation

The lupin grains were cleaned and freed from any foreign materials and broken seeds and then boiled for 60 min. The boiled grains were soaked in tap water for three days at ambient conditions and the water was changed at 8 hr intervals, and then de-hulled manually and dried in an air oven at 60°C for 24 hr. The dried lupin were then cooled, milled by commercial mill and sieved at a particle size of (0.4 mm) to obtain lupin flour. The flour was packed in polyethylene bags and stored using covered plastic container in freezer, and then samples were taken for use.
3.2.3. Formulation of composite flours

The millet and lupins flours were added to biscuits flour as shown in Table (1) below.

Table (1): Formulation of composite flour for rheological test and biscuit production.

<table>
<thead>
<tr>
<th>Flour blend</th>
<th>Wheat flour</th>
<th>Millet flour</th>
<th>Lupin flours</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (control)</td>
<td>100%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>B</td>
<td>75%</td>
<td>12.5%</td>
<td>12.5%</td>
</tr>
<tr>
<td>C</td>
<td>50%</td>
<td>25%</td>
<td>25%</td>
</tr>
<tr>
<td>D</td>
<td>-</td>
<td>50%</td>
<td>50%</td>
</tr>
</tbody>
</table>

3.2.4. Analytical methods

The determination of moisture, ash, crude protein, fat, and crude fiber were carried out according to the standard official methods of analysis (AOAC, 1984).

3.2.4.1 Moisture content determination

Two grams of well–mixed samples were weighed accurately in clean preheated moisture dish of known weight by using sensitive balance. The uncovered sample and dish were kept in an oven provided with a fan at 105°C and left to stay over night. The dish was covered and transferred to a desiccator, and weighed after reaching room temperature. The dish was heated in the oven for another two hours and was re-weighed. This was repeated until constant weight was obtained. The loss of weight was calculated as percent of weight and expressed as moisture content.
Moisture content (%) = \( \frac{W_1 - W_2}{\text{Sample weight}} \times 100 \)

Where:

- \( W_1 \) = Weight of sample + dish before oven drying.
- \( W_2 \) = Weight of sample + dish after oven drying.

### 3.2.4.2 Ash content determination

A crucible was weighed empty, and then accurately two grams of samples were put in it. The sample and the crucible were placed in a muffle furnace at 550 °C for 3 hr or more until white grey or reddish ash was obtained. The crucible was removed from furnace and placed in a desiccatior to cool, then was reweighed. The process was repeated until constant weight was obtained.

\[
\text{Ash content (\%)} = \left( \frac{W_2 - W_1}{W_s} \right) \times 100
\]

Where:

- \( W_1 \) = weight of empty crucible
- \( W_2 \) = weight of crucible + sample after ashing
- \( W_s \) = weight of dry sample

### 3.2.4.3 Crude protein determination

Crude protein was determined according to the method of AOAC (1984) using micro-Kjeldahl nitrogen digestion and distillation method as follows:
Twenty mille gram of oven dried sample was weighed into 100 ml Kjeldahl flask, and 0.4 g of catalyst mixture (96% anhydrous sodium sulphate + 4% cupric sulphate) was added with 3.5 ml of concentrated sulphuric acid. The sample and contents were heated on an electric heater for two hour (hr). The sample was cooled, diluted and placed in the distillation apparatus. Amount of 20 ml NaOH 40% were added, and distilled for 7 min. The ammonia evolved was received in 10 ml of 2% boric acid solution, contained in a conical flask attached to the receiving end. The trapped ammonia was titrated against 0.02 HCL using a universal indicator (methyl red + bromocresol green). The protein (%) was calculated using the following equation:

\[
\text{Crude protein (\%) = \frac{(ml \text{ HCl} - ml \text{ HCl Blank}) \times 0.02 \times 14 \times F \times 100}{\text{Dry sample weight} \times 1000}}
\]

Where:

- 0.02 = normality of HCl.
- 14 = nitrogen molecular weight.
- 1000 = to convert from g equivalent to mg.
- F = Factor (5.7 for wheat flour, 6.25 for other grains)

3.2.4.4 Crude fat determination

Two gram of oven dried ground sample were weighted. Extraction of the fat from each sample was carried out by Soxhlet using n. hexan as a solvent for 8 hr. After recovery of the solvent, the fat was dried in the oven at 105 °C for two h, then allowed to cool in a desicator, and finally weighed to a constant weight. The percentage of the crude fat was calculated using the following equation:
Crude fat (%) = \( \frac{W_2 - W_1}{\text{Dry sample weight}} \times 100 \)

Where:

- \( W_1 \) = The weight of the empty extraction flask.
- \( W_2 \) = The weight of the extraction flask with the extracted oil.

### 3.2.4.5 Crude fiber determination

Two g of dry defatted sample were weighed. One hundred and fifty ml of the \( \text{H}_2\text{SO}_4 \) (conc. 7.3 ml/L) were added and then heated to boiling. The mixture was boiled for 30 min and then filtered. The residue was washed three times with hot water. The 150 ml of pre-heated KOH (12.89 g/L) were added and heated to boiling for 30 min and then filtered. The residue was washed three times with hot water, dried under suction and then in an oven at 105 °C overnight and then weighed (\( W_1 \)). The residue was ashed in a muffle furnace at 550 °C for three hours till a light grey ash was formed, and then weighed (\( W_2 \)). The percentage of the crude fiber was calculated using the following equation:

\[
\text{Crude fiber (\%)} = \left( \frac{W_1 - W_2}{\text{Dry sample weight}} \right) \times 100
\]

Where:

- \( W_1 \) = The weight of oven dry sample after treatment by \( \text{H}_2\text{SO}_4 \) and KOH
- \( W_2 \) = The weight of the treated sample after ashing.

### 3.2.4.6 Anti-nutritional factors determination

#### 3.2.4.6.1 Phytic acid

The phytic acid content was determined by the method described by Wheeler and Ferrel (1971). Two grams of milled dried sample were weighed in 125 ml conical flask. The sample was extracted with 50 ml of
3% trichloroacetic acid (TCA) for 3 hr with mechanical shaking. The suspension was centrifuged for 5 min. And 10 ml aliquot of the supernatant were transferred to 50 ml boiling tube; 4 ml of FeCl₃ solution (made to contain 2 mg ferric ion per ml in 3% TCA) were added to the aliquot. The tube was heated in a boiling water bath for 45 min. One or two drops of 3% sodium sulphate in 3% TCA) were added. The tube cooled and centrifuged for 10 – 15 min. The clear supernatant was decanted. The precipitate was washed twice by dispersing well in 25 ml 3% TCA, heated for 10 – 15 min in a boiling water bath, then centrifuged again. Washing was repeated once more with water, the washed precipitate was dispersed in few ml of water and 3 ml of 1.5N NaOH were added and the volume completed to approximately 30 ml with water. Then the tube was heated in a boiling water bath for 30 min and hot filtered using Whatsman No. 2; the precipitate was washed with 60 ml hot water, the washings were decanted. The precipitate was dissolved from the filter paper with 40 ml 3.2 N HNO₃ (hot) into 100 ml volumetric flask. The paper was washed with hot water. The washing was collected in the same flask then completed to volume. Then 0.5 ml aliquot was taken from the above solution and transferred into 10 ml volumetric flask, then 2 ml of 1.5N potassium thiocyanate (KSCN) were added and the volume was completed to 10 ml with distilled water. The density of color was read immediately at 480 nm using Spectrophotometer (Corning, 259) within one minute.

**Calculation**

A standard curve of different Fe(NO₃)₃ concentrations was plotted to calculate the ferric ion concentration. The phytate phosphorus was calculated from the ferric ion concentration assuming 4:6 iron: phosphorus molar ratio.
Phytic acid (mg/100g) = $\frac{1.5 \times A \times C \times 20 \times 10 \times 50 \times 100}{1000 \times S}$

Where:

A = optical density
C = concentration corresponding to optical density
S = weight of sample.

### 3.2.4.6.2 Tannin content

Quantitative estimation of tannin was carried out using the modified Vanillin - HCL methanol (Price et al, 1978). The Vanillin - HCL reagent was prepared by mixing equal volumes of 8% concentrated HCL methanol and 1% Vanillin in methanol. The two solutions of the reagent were mixed just prior to use. It was discarded if a trace of color appeared. 0.2 g of the ground grain was placed in a small conical flask. Then 10 ml of 1% concentrated HCL in methanol were added. The conical flask was capped and continuously shook for 20 min and the content centrifuged at 2500 rpm for 5 minutes. One ml of the supernatant after centrifugation was pipetted into a test tube and 5 ml of the Vanillin – HCL reagent was added. Absorbance at 450 nm was read on spectrophotometer (Corning, 259) after 20 min incubation at 30 °C, a blank sample was carried out with each run of sample. A standard curve was prepared expressing the result as catechin equivalent, i.e. catechin (mg per ml) which gives color intensity equivalent to that given by tannin after correcting for blank. The concentration of the condensed tannins was determined from the standard curve, Tannin concentration was expressed as catechin equivalent as follows.
Tannin (%) = \( \frac{C \times 10 \times 100}{200} \)

Where:

- \( C \) = Concentration corresponding to the optical density.
- 10 = Volume of the extract (ml)
- 200 = Sample weight (mg).

### 3.2.4.6.3 Polyphenols

Total polyphenols were determined according to Pursson Blue Spectrophotometric method (Price and Butler, 1977). This method was employed to estimate the total polyphenolic content of pearl millet grain. Sixty mg of ground grain were shaken manually for one minute with 3 ml of methanol in a test tube. The mixture was filtered, then the tube was quickly rinsed with additional 3 ml of methanol and the content poured at once into the funnel. The filtrate was mixed with 50 ml of water and analyzed within one hr. Three ml of 0.1M FeCl\(_3\) in 0.1N HCL were added to 1 ml of filtrate followed immediately timed addition of 3 ml of 0.008 MK\(_3\)Fe(CN)\(_6\) which was freshly made. The absorbance was read at 720 nm on a Spectrophotometer (Corning, 259) after 10 min from the addition of the 3 ml of 0.1M Fe Cl\(_3\) and 30 ml of 0.008 MK\(_3\)Fe(CN)\(_6\). Catechin was used to make the standard curve following the same steps in the sample procedure.

The polyphenol content was calculated as follows.

\[
\text{Polyphenol (mg/100g)} = \frac{C \times 56 \times 100}{60}
\]

Where

- \( C \) = Concentration corresponding to optical density.
56 = Volume of extract.
60 = Weight of sample (mg).

3.2. 4.7 Determination of the in vitro protein digestibility

In vitro protein digestibility was carried out by the method of Monjula and Johan (1991). A known weight of sample containing 16 mg nitrogen was taken in triplicate and hydrolysed with 1 mg pepsin in 15 ml of 0.1M HCL at 37 °C for 18 hr. The reaction was terminated by the addition of 15 ml of 10% (w/v) trichloroacetic acid (TCA). The mixture was then filtered quantitatively through Whatman No.1 filter paper. The TCA soluble fraction was assayed for nitrogen micro- Kjeldahl method. Digestibility was calculated using the following formula:

Protein digestibility (%) = \(\frac{(N \text{ in supernatant} - \text{enzyme } N)}{N \text{ in sample}} \times 100\)

3.2. 4.8 Determination of minerals content

Minerals of sample were extracted according to Pearson's (1981). The sample was burned in a muffle furnace at 550 °C, then the sample was placed in a sand bath for 10 min after addition of 10 ml of 5 N HCL, then the solution was carefully filtered in a 100 ml volumetric flask and finally distilled water was added to make up to mark. The extracts were stored in bottles for further analysis. Minerals, Ca, Mg, Fe, were determined using Atomic Absorption Spectrophotometer (AA 6800).

3.2. 4.8.1 Potassium and sodium contents

potassium and sodium contents of extracted sample were determined according to AOAC (1984) method using flame photometer (corning 400). One milliliter of the extract was taken and diluted in a 50 ml conical flask with distilled water, The standard solutions of the KCL and NaCL were prepared by dissolving 2.54, 3.33 g of KCL and NaCL,
respectively each in 1000 ml distilled water. Ten ml of this solution were taken and diluted to one liter to give a 10 ppm concentration. The flame photometer was adjusted to zero using distilled water as a blank and to 100 degree using standard solution.

**Calculation:**

\[
K \text{ or Na (mg/100g)} = \frac{F. R. \times D. F. \times 100}{10^3 \times S \times 10}
\]

Where:

- F.R = Flame photometer reading
- D.F = Dilution factor
- S = Sample weight

---

### 3.2. 4.8.2 Phosphorous content

The determination of phosphorous content was carried according to the method of Chapman and Pratt (1982). Two ml of the extracted samples were pipetted into a 50 ml volumetric flask. Ten ml of ammonium molybdate- ammonium vanadate reagent [(22.5 g of WH₄)₆MO₇O₄₄ H₂ O in 400 ml distilled water + 1.25 g ammonium vanadate in 300 ml boiling water + 250 ml conc. HNO₃, then diluted to 1 liter] were added. The content of the flask were mixed and diluted to volume. The density of the color was read after 30 minutes at 470 nm using a spectrophotometer (Corning, 259). A standard curve of different KH₂PO₄ concentration was plotted to calculate the ion phosphorous concentration.

**Calculation:**

\[
\text{phosphorous (mg/100g)} = \frac{\text{Curve reading} \times \text{ash dilution} \times 1000}{10^3 \times \text{oven dry weight of sample}}
\]
3.2.5 Rheological properties of dough

3.2.5.1. Farinograph of dough

The rheological properties of dough prepared from wheat flour (control) and the blends were determined by using bra-bender farinograph according to the ICC standard method No 115/1 (2000).

3.5.1.1 The titration curve

Bra-bender farinograph was operated as described in ICC method (2000). The titration curve was used for the assessment of the water absorption for each flour sample. A sample of 300 g was weighed and transferred into a clean mixer. Farinograph was switched on 63 rpm for one minute, then distilled water was added from a special burette until 500 units consistency is reached, the correct water absorption can be calculated from deviation, where 20 units deviation correspond to 0.5% water, if consistency is higher than 500 farinograph units (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.

3.2.5.1.2. The standard curve

After measuring, the mixer was cleaned and the farinograph was prepared as above, the flour was added into the mixer, and the water quantity, which is determined by the titration curve, was fed at once. When appreciable drop on the curve was noticed the instrument was run for further 12 min then shut off.

The significant readings taken from fariongraph are:
(a) Water absorption (%): The percent of water that results in a dough consistency of 500 farinograph units (FU). It prescribes the quantity of water, which has to be added to the flour during production.
(b) Dough developing time: This is defined as the time (in min) between the addition of water and the torque curve before weakening begins.

(C) Arrival time: The differences between zero minutes and the point at which the top of the curve first intersects the 500 FU line.

(d) Departure time: The time from zero to the point where the top of the curve leaves the 500 FU line.

(e) Dough stability: The difference between the time where curve first intercept (arrival time) and leaves (the departure time) the 500 FU line.

(f) Degree of softening: The difference between the line of consistency and the medium line of the torque curve 12 min after development time (measure in FU).

(g) Farinograph quality number: The farinograph quality number measures the length of the curve in (mm) from beginning to the point at which the curve has decreased by 30 farinograph units from the 500 FU.

3.2.5.2. Gluten quality and quantity

Gluten quantity and quality were determined according to ICC standard method No 155 (2000). Ten grams of samples were mixed with 4.8 ml of 2% sodium chloride solution for 20 seconds in test chamber. The dough was washed with 2% NaCl for 10 min. When the glutomatic stop, the gluten ball was carefully centrifuged through special sieve. The percentage of wet gluten remaining on the sieve after centrifugation was defined as gluten index. The part of the gluten remaining on the sieve and the part, which passes through it, were collected and weighed and were defined as wet gluten content. Then the wet gluten was dried by glutork heater to give the dry gluten.
**Calculation:**

\[
\text{Wet gluten (\%)} = \frac{\text{weight of wet gluten}}{\text{Weight of sample}} \times 100
\]

\[
\text{Dry gluten content (\%)} = \frac{\text{Weight of dry gluten}}{\text{Weight of sample}} \times 100
\]

\[
\text{Gluten index (\%)} = \frac{\text{Total wet gluten (Wt)} - \text{passed gluten (Wt)}}{\text{Total wet gluten (wt)}}
\]

**3.2.6. Processing of biscuits**

Biscuits were prepared using the method of Vatsala and Harids Rao (1991). Formula used in biscuit processing was as follows:

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Quantity (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biscuit flour</td>
<td>100</td>
</tr>
<tr>
<td>Sugar powder</td>
<td>30</td>
</tr>
<tr>
<td>Shortening</td>
<td>30</td>
</tr>
<tr>
<td>Skim milk powder</td>
<td>2</td>
</tr>
<tr>
<td>Sodium chloride</td>
<td>1</td>
</tr>
<tr>
<td>Sodium bicarbonate</td>
<td>0.4</td>
</tr>
<tr>
<td>Ammonium bicarbonate</td>
<td>1.5</td>
</tr>
<tr>
<td>Glucose</td>
<td>2</td>
</tr>
<tr>
<td>L- cysteine</td>
<td>0.02</td>
</tr>
<tr>
<td>Water (ml)</td>
<td>15</td>
</tr>
</tbody>
</table>

The ingredients were weighed for 250 g of flour, sugar powder, skim milk and glucose were creamed in Hobart N-50 mixer with a flat beaker for 3 min at 61 rpm. Salt, ammonium, bicarbonate and cysteine were dissolved separately in part of the required water and added to the cream.
Mixing was done for 8 min at 125 rpm to obtain homogenous cream. Finally flour was added and mixed for 3 min at 61 rpm and then the dough was heated to a thickness of 4 mm with the help of two rulers placed at two sides of the dough. The sheeted dough was cut into round shape using 4.985 mm diameter cutter. The cut dough was transferred to an aluminum tray. The biscuits were baked in an electric oven maintained at 200°C for (11 min). The baked biscuits were cooled for about (20 min), packed in plastic bags and stored at room temperature for further analysis.

3.4.7 Evaluation of biscuit
3.2.7.1 Physical characteristics of biscuits sample

Biscuit diameter and thickness were determined. The spread ratio for all samples of biscuits was calculated by using 6 pieces according to the following equation:

\[
\text{Spread ratio} = \frac{\text{Diameter}}{\text{Thickness}}
\]

3.2.7.2 Sensory evaluation of biscuits

Fifteen panelists from the Food Research Center and Faculty of Agriculture University of Khartoum were carried the test as prescribed in Appendix (I).

3.2.8 Statistical analysis

The data were statistically analysed using analysis of variance and least significant difference according to Statistical Analysis System (SAS, 2002).
CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Proximate composition of flour samples

4.1.1 Moisture content

The moisture content of biscuit wheat flour (BWF) gave higher value 9.76%, while debittered lupin seed flour (DLSF) and decorticated millet flour (DMF) gave lower values (7.72% and 6.12% respectively) as shown in Table (2). There was significant difference (P ≤ 0.05) in their moisture content. The moisture content of biscuit wheat flour (BWF) was lower than range of 11.22 – 12.11% for four wheat cultivars reported by Hendawey (2009), and higher than three Sudanese wheat cultivars, (Elnelain, Debaira, Wadi Elneel) and Australian wheat reported as  6.23, 6.83, 7.49 and 8.83% respectively Elagib (2002). The results obtained are in agreement with the range from 7.41% to 11.87% for eight wheat cultivars determined by Ali (2008). The moisture content of DLSF was higher than the values reported by Viveros et al (2007) and Siddiq (1999). This result was in agreement with 7.7% for L. albus cv multolupa mentioned by Sathe et al (1982). The moisture content of DMF was 6.12% which is lower than the values of 9.60% and 9.50% moisture content for decorticated millet flour at (70.1% and 63.7 extraction rate) respectively reported by Idris (2001), and in agreement with 6.4% for millet cultivars reported by Elyas et al (2002).

4.1.2 Ash content

The ash content of BWF, DLSF and DMF were found to be 0.43, 1.4 and 1.2 % respectively as illustrated in Table (2). The higher value was
Table (2): Proximate composition (%) of biscuit wheat flour, debittered lupin seed flour and decorticated millet flour.

<table>
<thead>
<tr>
<th>Flour sample</th>
<th>Moisture</th>
<th>Ash</th>
<th>Protein</th>
<th>Fat</th>
<th>Crude fiber</th>
</tr>
</thead>
<tbody>
<tr>
<td>BWF</td>
<td>9.76±0.15(^a)</td>
<td>0.43±0.03(^c)</td>
<td>10.83±0.006(^c)</td>
<td>1.47±0.06(^c)</td>
<td>0.28±0.006(^c)</td>
</tr>
<tr>
<td>DLSF</td>
<td>7.72±0.11(^b)</td>
<td>1.4±0.1(^a)</td>
<td>54.91±0.006(^a)</td>
<td>10.60±0.06(^a)</td>
<td>3.6±0.6(^a)</td>
</tr>
<tr>
<td>DMF</td>
<td>6.12±0.01(^c)</td>
<td>1.2 ±0.1(^b)</td>
<td>11.75±0.006(^b)</td>
<td>5.37±0.06(^b)</td>
<td>1.27±0.06(^b)</td>
</tr>
</tbody>
</table>

- Values are means (± standard deviation)
- Mean values having different superscript letters in the same column are significantly different at (P≤0.05).

Where:

- BWF: Biscuit wheat flour
- DLSF: Debittered lupin seed flour
- DMF: Decorticated millet flour
shown by DLSF, however the BWF gave the lower value. Generally analysis of variance showed significant difference \((P \leq 0.05)\) in their ash content. The ash value for wheat flour falls within the range of 0.30 – 0.51\% for eight wheat cultivars (72\% extraction) showed by Ali (2008) and lower than the value reported by Hendawey (2009) who reported that, the ash content for four wheat cultivars ranged from 1.88 to 2.23\%. The level of ash content in DLSF was lower than the value of 3.74\% for \((L. albus \ var \ multolupa)\) reported by Viveros et al (2007), and was in agreement with Elamin (1996). The ash content of DMF was lower than the values of 1.58\% and 1.75\% for two pearl millet cultivars reported by Eltayeb (2006), and the result obtained was in agreement with 1.2\% reported by Elyas (1999).

4.1.3. Protein content

The debittered lupin seed flour had higher protein content 54.91\% followed by decorticated millet flour 11.75\%, while biscuit wheat flour had the least protein content 10.83\% as shown in Table (2). There was significant difference \(p \leq 0.05\) between BWF, DLSF and DMF in terms of protein content. The value for biscuit wheat flour falls within the range of 8.3 – 15.9\% for 16 wheat varieties (72\% extraction rate) studied by Bettge (2003), and lower than range of 11.75 – 13.15\% for four wheat cultivars reported by Hendawey (2009). The results obtained were lower than the reported by Chinma and Gernah (2007) who found that, the protein content of wheat flour was 10.25. The level of protein content in DMF was in agreement with the range of 11.4 – 16.3 reported by Ali et al (2004) and range of 8.5 – 15.1\% studied by Abdalla et al (1998a), and lower than the values of 13.50\% and 13\% for pearl millet at (70.1 and 63.7\% extraction rate) respectively reported by Idris (2001), and higher than values 7.60\% and 8.8 \% for decorticated two pearl millet at (12\%
decortication rate) reported by Lestienne et al (2007). The protein content of DLSF 54.91% was lower than 61.7% reported by Siddiq, (1999), and higher than the value determined by Porres et al, (2006) who showed that the protein content of L. albus var multlupa was 34.4%.

4.1.4. Fat content

The fat content of BWF, DLSF and DMF are given in Table (2). The DLSF had higher fat content which was 10.60%, followed by DMF 5.37% while BWF had the least fat content which was 1.47%. Statistical analysis revealed significant difference (P ≤ 0.05) between BWF, DLSF and DMF in terms of fat content. The higher value of fat content in DMF than in BWF may be due to the large proportion of the germ to the endosperm of pearl millet studied by Osagie and Kates (1984), also Souci etal (2000) noticed higher lipid content in millet than in some other cereal species such as wheat and barley. The fat content of BWF was similar to that reported in another study (0.85 to 1.73% Ahmed, 1995), and was higher than that observed in another study (0.70 to 1.25%, Ali, 2008) and lower than the value of 1.90% of wheat flour reported by Chinma and Gernah (2007). The fat content of DMF falls within the range of 4% to 7.75 as reported by Abdelrahman (2004), and higher than the results of Idris (2001) who showed 4% and 3.25% for decorticated pearl millet at (29.90 and 36.26% decortication rate respectively), and lower than the values of 7.8% and 6.7% for two pearl millet cultivars reported by Ali et al, (2003). The fat content of DLSF was lower than the values reported by Porres et al (2006) who found that the fat content of lupin flour was 14.64, and higher than value 9.98% obtained by Viveros et al (2007). The result obtained was in agreement with (Elamin, 1996).
4.1.5. Fiber content

Table (2) shows differences in fiber contents as 0.28%, 1.27% and 3.7% for BWF, DMF and DLSF respectively. There was significant difference ($P \leq 0.05$) observed between BWF, DMF and DLSF. The value for wheat flour was in a good agreement with those values reported by AbdAlrahman (2005) who showed that the fiber content for special wheat flour was 0.28%, and lower than reported by Chinma and Gernah (2007), Sulieman (2005), Ali (2008) and Mohamed (2000). The level of fiber content in DMF was in agreement with value 1.25 to 1.3% as obtained by Sigh et al (1987), but higher than value 0.75% and 0.55% for decorticated pearl millet at (29.90 and 36.26% decortication rate respectively) reported by Idris (2001), and lower than that observed by Abdelrahman (2004); Eltayeb (2006) and Elyas et al (2002). The level of fiber content in DLSF was higher than the values 1.5% reported by Siddiq (1999), and similar to that reported by Ballester et al (1986).

4.1.6 The anti-nutritional factors of flour samples

4.1.6.1. Phytic acid

Table (3) shows the phytic acid content of biscuit wheat flour, debittered lupin seed flour and decorticated millet flour which were significantly different ($P \leq 0.05$). DMF had higher phytic acid content 266.51 mg/100g, followed by DLSF 43.39 mg/100g, while BWF had least phytic acid which was 37.19 mg/100g. The phytic acid content of BWF was lower than that reported by Ali (2006), and higher than that reported by Giami et al (2005) and Erdal (2002). The result obtained was comparable to that reported by Grela(1996). Phytic acid of DMF was higher than 101.76 and 100.47 mg/100g of two debranned pearl millet shown by Eltayeb (2006).
Table (3): Anti-nutritional factors of biscuit wheat flour, debittered lupin seed flour and decorticated millet flour.

<table>
<thead>
<tr>
<th>Flour sample</th>
<th>Tannin (%)</th>
<th>Polyphenols (mg/100g)</th>
<th>Phytic acid (mg/100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BWF</td>
<td>0.01 (±0.006)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>21.07 (±0.01)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>37.19 (±0.00)&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>DLSF</td>
<td>0.02 (±0.006)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>63.20(±0.02)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>43.39 (±0.01)&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>DMF</td>
<td>0.11(±0.01)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>231.72 (±0.01)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>266.51 (±0.01)&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

- Values are means (± standard deviation)
- Mean values having different superscript letters in the same column are significantly different at (P ≤ 0.05).

Where:
- BWF : Biscuit wheat flour.
- DLSF : Debittered lupin seed flour.
- DMF : Decorticated millet flour.
the results obtained are in agreement with the range from 176 to 306 mg/100g mentioned by Simwemba et al, (1984). The phytic acid of DLSF was lower than the value 420 mg /100g of *lupinus_albus* var *Giza* observed by Khalil et al (2006) and which was a little lower than, that mentioned by Eltayeb (2004).

### 4.1.6.2 Tannin

The tannin content of biscuit wheat flour (BWF) debittered lupin seed flour (DLSF) and decorticated millet flour are given in Table (3). The statistical analysis showed that significant difference (*P* ≤ 0.05) among them in tannin content was found to be 0.01, 0.02 and 0.11% for BWF, DLS and DMF respectively. The value for BWF was lower than the value reported by Ali (2006) and Grela (1996). The value for DLSF was lower than that reported by Eltayeb (2004); Prandini (2005) and Petterson and Mackintosh (1994). The result obtained was in agreement with the value found by Elamin (1996). The value for DMF was in agreement with that reported by Ahmed (1999) and higher than that observed by Eltayeb (2006) who found that, the tannin content for debranned pearl millet was 0.08% , and lower than that determined by Nithya et al (2006).

### 4.1.6.3 Polyphenols

Table (3) shows the Polyphenols content of biscuit wheat flour, debittered lupin seed flour and decorticated millet flour . There was significant difference (*p* ≤ 0.05) between BWF, DLSF and DMF in Polyphenols content which was found to be 21.07, 63.20, 231.72 mg/100g respectively . The DMF has higher Polyphenols content, and BWF had the lower Polyphenols content. The level of Polyphenols content in (DMF) was lower than that reported by Eltyeb (2006) who
found that, the Polyphenols content reduced by debranning from 415.38 to 378.68 mg/100g and from 420.25 to 390 mg/100g for two pearl millet, and comparable to that, reported by Ahmed (1999) and higher than that reported by Shobana and Malleshi (2007) who found polyphenols content of decorticated finger millet to be 67 mg/100g. The value of BWF was very lower than that, reported by Dhingra and Jood (2001). The value of DLSF was higher than that obtained by Lgari et al (2002) and lower than that reported by Prandini et al (2005).

4.1.7 In vitro protein digestibility of the flours

The in vitro protein digestibility (IVPD) of biscuit wheat flour, debittered lupin seed flour and decorticated millet flour is presented in Table (4). The in vitro protein digestibility (IVPD) of BWF, DLSF and DMF were 74.47, 77.43 and 78.97% respectively. The higher in vitro protein digestibility of DMF is due to the amino acid profile of pearl millet which is comparable to that of wheat and have favorable amino acid balance with a high level of essential amino acids, coupled with the superior in vitro pepsin digestibility values. Pearl millet is a nutritious and well digested source of protein for humans (Ejeta et al, 1987). The higher IVPD in debittered lupin seed flour than biscuit wheat flour is due to the wheat protein lower nutritional quality than that of lupin protein (Mariotti et al, 2001; Mariotti et al 2002 and Morens et al, 2003). The value of IVPD of BWF was lower than that reported by Abdal- Aal and Sosulski (2001) and comparable to that, reported by Dhingra and Jood (2001) and higher than that, reported by Siddiq (1999). The value obtained in DLSF was lower than that reported by Khalil et al (2006) and Lqari (2002) and in agreement with those reported by Elamin (1996). The value for DMF is higher than those reported by Eltyeb (2006) and Ali et al (2003) and lower than observed by Ejeta et al (1987). The results
Table (4): *In vitro* protein digestibility (IVPD) of biscuit wheat flour, debittered lupin seed flour and decorticated millet flour.

<table>
<thead>
<tr>
<th>Flour sample</th>
<th>Protein (%)</th>
<th>IVPD (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BWF</td>
<td>10.83 (±0.006)c</td>
<td>74.47 (±0.006)c</td>
</tr>
<tr>
<td>DLSF</td>
<td>54.91 (±0.006)a</td>
<td>77.43 (±0.01) b</td>
</tr>
<tr>
<td>DMF</td>
<td>11.75 (±0.006)b</td>
<td>78.97 (±0.01) a</td>
</tr>
</tbody>
</table>

- Values are means (± standard deviation)
- Mean values having different superscript letters in the same column are significantly different (P ≤ 0.05).

Where:

- BWF: Biscuit wheat flour
- DLSF: Debittered lupin seed flour
- DMF: Decorticated millet flour
obtained in this study are in agreement with those shown by Ahmed (1999).

4.1.8 Mineral content of flour samples
4.1.8.1 Calcium and magnesium

The mean values for analysis of calcium and magnesium content for the flour samples are shown in Table (5). The Ca content of biscuit wheat flour, debittered lupin seed flour and decorticated millet flour were 4.86, 26.20 and 2.07mg/100g respectively. It is observed that debittered lupin seed flour (DLSF) has the highest value of Ca content, followed by biscuit wheat flour (BWF) however the decorticated millet (DMF) flour had the least Ca content. Mg content were found to be 32.4, 14.42 and 107.65 mg/100g for BWF, DLSF and DMF respectively, it shows that the decorticated millet flour had highest value of Mg content followed by biscuit wheat flour while debittered lupin seed flour had the lowest value. Generally the statistical analysis of variance showed significant difference (P \leq 0.05) among the flour samples in their Ca and Mg content. The value of Ca content of biscuit wheat flour was comparable to that reported by Eltoum (2004), and lower than the range mentioned by Tang et al (2008) and Araujo et al (2008), while value of Mg content was within the range of 19 – 51 mg/ 100g reported by Araujo et al (2008) and lower than the range of 95 – 150.1 mg/100g determined by Tang et al (2008) and higher than the value 25 mg/100g reported by Lovis (2003). The values of Ca and Mg content of DLSF were lower than the range of 240 – 390 mg Ca/100g and the range of 170 – 360 mg Mg/ 100g reported by Wasilewko and Buraczewska (1999), Mg content for DLSF was in agreement with 14.50 mg/100g reported by porres et al (2006). While Ca content for DLSF higher than
Table (5): Mineral content (mg/100g) of biscuit wheat flour, debittered lupin seed flour and decorticated millet flour

<table>
<thead>
<tr>
<th>Flour sample</th>
<th>Ca</th>
<th>Mg</th>
<th>Na</th>
<th>K</th>
<th>P</th>
<th>Fe</th>
</tr>
</thead>
<tbody>
<tr>
<td>BWF</td>
<td>4.86±0.005&lt;sup&gt;b&lt;/sup&gt;</td>
<td>32.4±0.06&lt;sup&gt;b&lt;/sup&gt;</td>
<td>75±0.001&lt;sup&gt;a&lt;/sup&gt;</td>
<td>150±0.001&lt;sup&gt;b&lt;/sup&gt;</td>
<td>440±0.006&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.20±0.05&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>DLSF</td>
<td>26.2±0.06&lt;sup&gt;a&lt;/sup&gt;</td>
<td>14.4±0.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>75±0.001&lt;sup&gt;a&lt;/sup&gt;</td>
<td>25±0.001&lt;sup&gt;c&lt;/sup&gt;</td>
<td>510±0.006&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.52±0.006&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>DMF</td>
<td>2.07±0.006&lt;sup&gt;c&lt;/sup&gt;</td>
<td>17.65±0.006&lt;sup&gt;a&lt;/sup&gt;</td>
<td>75±0.001&lt;sup&gt;a&lt;/sup&gt;</td>
<td>300±0.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>570±0.006&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.51±0.006&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

- Values are means (± standard deviation)
- Mean values having different superscript letters in the same column are significantly different at (P<0.05).

Where:

- BWF: Biscuit wheat flour
- DLSF: Debittered lupin seed flour
- DMF: Decorticated millet flour
those studied by Petterson (2000). The value of Ca content of decorticated millet flour was higher than those reported by Eltayeb (2006), and lower than the range of 53.6 to 122 mg/100g studied by Badau et al (2005). Mg content of (DMF) was within the range of 71 – 156mg/100g mentioned by Serna-saldivar et al (1991), and higher than the range of 70.3 to 93.3 mg/100 g shown by Abdelrahman (2004), but lower than the results obtained by Nithya et al (2006).

4.1.8.2 Iron

The iron content of BWF, DLSF and DMF is illustrated in table (5). The results showed values 5.52, 3.51 and 1.20 mg/100g for DLSF, DMF and BWF respectively. There was significant difference (P ≤ 0.05) between flour samples in the iron content. The Fe content in DLSF fall within the range of 3.9 – 12.8 mg/100g studied by Wasilewko and Buraczewaska (1999) and slightly higher than 3.2 mg/100g reported by Hassan et al (2005). The Fe content of BWF was lower than those results shown by Zhao et al (2009), and Tang et al (2008). The result obtained was similar to that shown by Baysal (1988), and higher than that, obtained by Ali (2006). The value of Fe content in DMF was lower than those results investigated by Abdelrahman (2004); Badau et al (2005) and Nithya et al (2006), but and slightly higher than that studied by lestienne et al (2007).

4.1.8.3 Sodium and potassium

The value of sodium and potassium content in flour sample is presented in Table (5). The sodium content of biscuit wheat flour, debittered lupin seed flour and decorticated millet flour were the same and found to be 75 mg/100g. The analysis of variance showed no significant difference (p ≥ 0.05) between the flour samples in their Na
content. K content were found to be 150, 300 and 25 mg/100g for biscuit wheat flour (BWF), decorticated millet flour (DMF) and debittered lupin seed flour (DLSF) respectively. The analysis of variance showed significant difference \( (P \leq 0.05) \) among the flour samples in their K content. The value of Na content in (BWF) was higher than 3.44 mg/100g which was mentioned by Ali (2006), and lower than those results reported by Taha (2000). K content in BWF which was lower than the range of 350 – 450 mg/100g obtained by Hendawey (2009), and within the range of 76 to 316 mg/100g showed by Araujo et al (2008), but higher than that reported by Ali (2006). The Na content in DMF was higher than range of 13 – 19.4 mg/100g reported by Abdelrahman (2004). The K content in DMF was slightly lower than the values which were obtained by Abdelrahman et al (2005b), and higher than reported by Abdalla et al (1998a) who gave range from 0.007 – 0.013% (k) content. The Na content of DLSF was higher than those studied by Elamin (1996); Hassan et al (2005) and Wasilewko and Buraczewsk (1999).

4.1.8.4 Phosphorus

Table (5) shows the phosphorus content in decorticated millet flour (DMF); biscuit wheat flour (BWF) and debittered lupin seed flour (DLSF). The DMF had higher phosphorus content which was 570 mg/100g followed by DLSF was 510 mg/100g and BWF the least phosphorus content was 440 mg/100g. The statistical analysis revealed significant difference \( (P \leq 0.05) \) between flour samples in phosphorus content. P content in DMF was higher than reported by Eltayeb (2006) who found that the P content for two pearl millet (Gazira and Gadarif cultivars) were 183.45 mg/100g and 174.45 mg/100g respectively decreased by debranning to 123.61mg/100g and falls within the range of 551.6 – 1290 mg/100g reported by Abdelrahman (2004). The P content in
DLSF was in agreement with range of 440 – 890 mg/100g investigated by Wasilewko and Buracewska (1999), and higher than those studied by Porres et al (2006), Elamin (1996) and Petterson and Mackintosh (1994). The P content for BWF fall within the range of 89 – 715 mg/100g determined by Araujo et al (2008), and higher than range of 224 – 242 mg/100g investigated by Hendawey (2009).

4.2 Rheolgical properties of dough's
4.2.1 Farinogram of biscuit wheat flour with different levels of decorticated millet and debittered lupin seed flours.

The farinogram results of dough prepared from (BWF) with different levels of (DMF) and (DLSF) are presented in Table (6) and shown in Appendix (II – IV ). The water absorption (%) of dough prepared from biscuit wheat flour (A), (75% BWF + 12.5% DMF + 12.5% DLSF) (B) and (50% BWF + 25% DMF + 25% DMF) (C) were (62, 70.1, 68.1 %) respectively. The highest value of water absorption was observed in (B) whereas (A) control gave the lowest value. This result was in agreement with the result obtained by Ali (2006) who found the water absorption of wheat flour as 61.8% and higher than the value shown by Mohamed (2007), who found that, the water absorption of special wheat flour was 64.2%. Increasing level of DLSF in whole wheat flour (WWF) increased it's water absorption from 75.81% for (100% wheat flour) to 100.67% in (25% DLSF) as studied by Siddiq (1999). Doxastakis et al (2002) mentioned that, the amount of water absorption increased steadily with every increment of flour blend from 56.5% for 100% wheat flour to 60.3% and 63.5% at 5% and 10% lupin flour respectively. Lorenz and Dislaver (1980) reported that, the water absorption decreased as the amount of millet flour in the wheat flour blend increased. Idris (2001)
Table (6): Farinograph results of biscuit wheat flour with decorticated millet and debittered lupin seed flours.

<table>
<thead>
<tr>
<th>Flour blends</th>
<th>Water absorption (%)</th>
<th>Development time (min)</th>
<th>Stability time (min)</th>
<th>Degree of softening 10 min after begin (F.U.)</th>
<th>F. Q. N.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>62.0</td>
<td>8.0</td>
<td>14.1</td>
<td>9</td>
<td>156</td>
</tr>
<tr>
<td>B</td>
<td>70.1</td>
<td>7.2</td>
<td>6.6</td>
<td>10</td>
<td>125</td>
</tr>
<tr>
<td>C</td>
<td>68.1</td>
<td>18.2</td>
<td>10.2</td>
<td>81</td>
<td>200</td>
</tr>
</tbody>
</table>

- Values are means

Where:

A : Control biscuit sample
B : 75% biscuit wheat flour + 12.5% decorticated millet flour + 12.5% debittered lupin seed flour.
C : 50% biscuit wheat flour + 25% decorticated millet flour + 25% debittered lupin seed flour.
F.U: Farinogram units
F.Q.N : Farinograph quality number
found that, water absorption of millet increases with the rate of decortication. The development time (minute) is illustrated in Table (6) and found to be 8, 7.2 and 18.2 min for A, B, and C respectively. It is observed that C gave the highest value 18.2 min, but B gave the lowest value. These results are higher than reported by Hamad (2008) who found that the development time for two wheat cultivars was 4.3 and 3.5 min, and lower than the value 10.1 min for hard white wheat flour studied by Abdelghafor (2007), but comparable to the range of 4.0 to 7.8 min of three wheat cultivars reported by Bashir (2006). Dough development time was significantly ($P \leq 0.05$) increasing on addition of debittered lupin seed flour to whole wheat flour from 8.8 min for 100% wheat flour to 10.5, 11.5 and 11.4 min for 15, 20 and 25% DLSF respectively Siddiq (1999). Mohamed (2007) found that, the development time of the dough prepared from special wheat flour with 25, 50, 75% teff flour showed 3.8, 3.5 and 17 min respectively. These results are in general agreement with the findings of Anaka and Tipples (1979) who observed that the dough development time increased in flours with high protein content. The dough stability, which indicates the dough strength, was decreased from 14.1 min for A to 6.6 and 10.2 min for B and C respectively. The results showed weakening of dough on addition of DMF and DLSF. These results are in agreement with the range of 4 to 17.8 min, for three wheat cultivars reported by Bashir (2006). Similar results reported by Doxastakis et al (2002) who observed that, the dough stability of wheat flour decrease when addition of lupin, Soya and triticle flours. However Siddiq (1999) mentioned that the dough stability increased steadily with every increment of flour blends from wheat flour and lupin flour reported the range from 11.5 min for WWF to 16.8 min for 25% DLSF/75%WFF.
Abdelghafor (2007) showed that, the dough stability of Hard White Winter wheat flour was 17.8 min decreased by adding decorticated sorghum flour. The degree of softening (F.U) is presented in Table (6). The dough prepared from BWF (A) gave 9 F.U., while (B) and (C) were 10 and 81 F.U. respectively. The degree of softening obtained for the dough from biscuit wheat flour (A) was lower than the value reported by Abdelatif (2007) who reported that the degree of softening of biscuit wheat flour as 21 F.U.and that the value was increased sharply by adding decorticated pigeon pea. Mohamed (2007) showed that the degree of softening of special wheat flour increased as the levels of teff flours increased. The farinograph quality number (F.Q.N) of flour blends is given in Table (6). The C had high F.Q.N 200 followed by A 156, and B had least F.Q.N 125. Eltoum (2004) found that, the F.Q.N of biscuit wheat flour was 50. These values are lower than those obtained in this study. Abdelghafor (2007) found that the F.Q.N for hard white winter wheat flour 197 reduced gradually by increasing level of decorticated sorghum, while Mohamed (2007) reported that, the F.Q.N for special wheat flour was 86 decreased to 61 and 50 at 25% and 50% teff flours respectively, while 75% teff flour increased F.Q.N to 200. Abdelatif (2007) found that, the F.Q.N of BWF decreased by increasing level of decorticated pigeon pea.

4.2.2 Gluten quantity and quality of biscuit wheat flour, with decorticated millet flour and debittered lupin seed flour.

The wet gluten percentages of control and flour blends are presented in Table (7). The A had 32.03% while B gave lower value 30.27%, whereas the C gluten was not formed. This may be due to the lower quantity of wheat flour in the blend, which leads to low gluten in the blend, while D gluten was not formed due to the millet and lupin flours do not contain
Table (7): Gluten content (%) and gluten index (%) of biscuit wheat flour and flour blends

<table>
<thead>
<tr>
<th>Flour</th>
<th>Wet Gluten</th>
<th>Dry Gluten</th>
<th>Gluten Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>32.03 (±0.06)a</td>
<td>10.6 (±0.0.1)a</td>
<td>66.97 (±0.0.2)b</td>
</tr>
<tr>
<td>B</td>
<td>30.27(±0.06)b</td>
<td>10.1(±0.5)b</td>
<td>94.37 (±0.07)a</td>
</tr>
<tr>
<td>C</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>D</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

- Values are means (± standard deviation )
- Mean values having different superscript letters in the same column are significantly different ( p ≤ 0.05).

Where:

A : Biscuit wheat flour
B : 75% biscuit wheat flour + 12.5% decorticated millet flour + 12.5% debittered lupin seed flour.
C : 50% biscuit wheat flour + 25% decorticated millet flour + 25% debittered lupin seed flour.
D : 50% decorticated millet flour + 50% debittered lupin seed flour.
gluten. Analysis of variance showed significant difference ($P \leq 0.05$) between flour blends in their wet gluten. These results are comparable to that reported by Ahmed et al (2004) who found that the Australian wheat flour had 33.45% wet gluten, similar results were reported by Mohamed (2007) who found that, the substitution of biscuit wheat flour with teff flour decreased wet gluten of dough. Also Abdelatief (2007) found that, the wet gluten decreased by increasing level of decorticated pigeon pea.

The dry gluten of (A) was 10.6% reduced to 10.1% for (B). Statistical analysis showed significant difference ($P<0.05$) among the flour blends in their dry gluten. These results are higher than 7.40, 7.87% and 8.93% dry gluten for three Sudanese wheat cultivars Elneelain, Debaira and Wadi Elneel respectively and lower than 11.05 for Australian wheat flour studied by Ahmed et al (2004). Mohamed (2007) reported that, the dry gluten of special wheat flour decreased by increasing level of teff flour. Abdelatef (2007) observed that the dry gluten of wheat flour decreased by increasing level of decorticated pigeon pea flour.

The gluten index of flour blends shown in Table (7) was found to be 66.97% for (A) control increasing to 94.37%. The analysis of variance showed significant difference ($P \leq 0.05$) among flour blends in their gluten index. These results are similar to that studied by Hamad (2008) who reported that, the addition of guar gum powder to wheat flour caused significant increase ($P \leq 0.05$) in gluten index.

### 4.3 Chemical characteristics of biscuit containing different levels of DLSF and DMF

#### 4.3.1. Proximate composition.

Table (8) shows the proximate composition of wheat biscuits containing different levels of dibittered lupin seed flour and decorticated millet flour. The moisture content decreased with increasing levels of DLSF and DMF.
Table (8): Proximate composition (%) of biscuit prepared from biscuit wheat flour containing different levels of debittered lupin seed flour and decorticated millet flour.

<table>
<thead>
<tr>
<th>Biscuits</th>
<th>Moisture</th>
<th>Ash</th>
<th>Protein</th>
<th>Fat</th>
<th>Crude fiber</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>9.6±0.07(^b)</td>
<td>0.90±0.06(^c)</td>
<td>7.58±0.07(^d)</td>
<td>18.1±0.1(^d)</td>
<td>0.29±0.07(^c)</td>
</tr>
<tr>
<td>B</td>
<td>7.1±0.1(^c)</td>
<td>0.95±0.06(^bc)</td>
<td>11.69±0.07(^c)</td>
<td>20.6±0.1(^c)</td>
<td>0.38±0.05(^b)</td>
</tr>
<tr>
<td>C</td>
<td>6.9±0.07(^d)</td>
<td>1.2±0.1(^a)</td>
<td>17.87±0.1(^b)</td>
<td>21.2±0.2(^b)</td>
<td>0.42±0.1(^b)</td>
</tr>
<tr>
<td>D</td>
<td>11.5±0.00(^a)</td>
<td>1.05±0.05(^b)</td>
<td>21.88±0.01(^a)</td>
<td>22.5±0.1(^a)</td>
<td>1.35±0.07(^a)</td>
</tr>
</tbody>
</table>

- Values are means (± standard deviation)
- Mean values having different superscript letters in the same column are significantly different at (P≤0.05).

Where:

A : Control biscuit sample  
B : 75% biscuit wheat flour + 12.5% decorticated millet flour + 12.5% debittered lupin seed flour.  
C : 50% biscuit wheat flour + 25% decorticated millet flour + 25% debittered lupin seed flour.  
D : 50% decorticated millet flour + 50% debittered lupin seed flour.
flours except sample with 50% DLSF + 50% DMF (D) which contains higher moisture content 11.5% followed by (A) 9.6%, (B) 7.1% and (C) had least moisture content which was 6.9%. Generally the statistical analysis showed significant difference (P ≤ 0.05) among biscuits made from control and composite flours in terms of moisture content. It is observed that the decreasing moisture content with the increase of DLSF and DMF percent could be attributed to the low moisture content of DLSF and DMF flours. These results are in agreement with data which reported by Mohamed (2007) found that, the moisture content decreases when substituting wheat with teff flours, while Siddiq (1999) reported that the moisture content of bread wheat flour was increased by incorporation of DLSF in whole wheat flour. While high moisture content in D could be attributed to the higher fiber content in the blends.

The ash content of A is 0.90% but the other samples gave 0.95, 1.2 and 1.05 for B, C and D respectively. The statistical analysis showed no significant differences (P ≥ 0.05) between A and B also no significant difference (P ≥ 0.05) between B and D in their ash content. It is observed that there was slight increases in the ash content with increasing supplementation with DMF and DLSF. These results are similar to that obtained by Akubor (2004b) who observed increase in ash content when soy bean flour was added to maize flour for biscuit production. However Dhingra and Jood (2001) reported the ash content remained almost the same in various supplementations of barley with full fat soybean flour and barley with defatted soybean for bread production. Siddiq (1999) also observed decrease in ash content (from 1.25 to 1.17%) in breads supplemented with DLSF flour for 100% wheat flour to 25% DLSF. Singh and Goyal (2006) found that the biscuit made from 50% processed pearl millet flour had 1.8% and 1.1% ash content for sweet and salt biscuit respectively.
Increasing level of DLSF and DMF flours resulted in significant increase ($P \leq 0.05$) in protein content. Values obtained were found to be 11.69, 17.87 and 21.88% for B, C and D respectively, compared with A which had 7.58%. These results are similar to those reported by Dhingra and Jood (2001) who observed that the breads containing barley with full fat soy and barley with defatted soy flours manifested intermediate protein contents. Also these results are in agreement with Siddiq (1999) who observed a steady increase in protein content with increasing supplementation of lupin flour in whole wheat flour for bread production from 7.76 to 13.5% at 0.0% to 25% lupin flour.

The fat content of wheat flour biscuit (A) was 18.1%, which increased significantly ($P \leq 0.05$) on blending with decorticated millet flour and debittered lupin seed flour and found to be 20.6, 21.2 and 22.5% for B, C and D respectively. The increasing fat content with increasing flour blends was due to higher fat content of lupin and millet flours. These results are in agreement with that mentioned by Dhingra and Jood (2001) who observed increasing fat content with increasing supplementation of full fat soybean with barley flour for bread production, also similar to studied by Siddiq (1999) who observed that the fat content of bread containing DLSF had higher fat than that of 100% wheat flour (control). Singh and Goyal (2006) determined that, the fat content of biscuit made from 50% refined wheat flour + 50% processed pearl millet flour and found to be 32.4% and 36.1% for sweet and salty biscuits respectively.

The fiber content was significantly increased ($P \leq 0.05$) with increasing level of replacement of DLSF and DMF. The fiber content of wheat flour biscuit (A) was found to be 0.29%, this value increased to 0.38, 0.42 and 1.35% for B, C and D respectively. No significant difference ($P \geq 0.05$) was observed between B and C, also increase of
fiber content with increase of DMF and DLSF percent. This was due to the higher fiber content of DLSF and DMF than BWF. The results are contrary to that finding of Siddiq (1999) who reported the level of crude fiber in the wheat bread was not affected by inclusion of lupin flour. Singh and Goyal (2006) found that the fiber content was 0.5% and 0.7% for sweet biscuit and salty biscuit made from 50% refined wheat flour plus 50% processed millet flour respectively.

4.3.2 *In vitro* protein digestibility of biscuits

The *in vitro* protein digestibility of biscuits samples is given in Table (9). Wheat biscuit (A) had 63.68% IVPD, which changed significantly (P ≤ 0.05) on inclusion of DMF and DLSF and was found to be 69.54, 76.40 and 74.74% for B, C and D respectively. The increasing of IVPD with the increase of DMF and DLSF blends may be due to the lack of nutrients enzyme inhibitors in the lupin flour (Mathews, 1989) the results are similar to that studied by Rayas – Duarte et al (1996) who observed that the lupin containing spaghetti showed higher *in vitro* protein digestibility than did other composite samples. Siddiq (1999) also showed that the incorporation of higher levels of debittered lupin seed flour in bread production significantly (P ≤ 0.05) improved the IVPD of the composite flour bread compared to the control.

4.3.3 Mineral content of biscuit

The mineral content of wheat flour biscuit containing different levels of debittered lupin seed flour and decorticated millet flour are presented in Table (10). Wheat biscuit had 5.5 mg/100g Ca, incorporation of DLSF and DMF resulted in an increase of Ca values to 8, 9.8 and 11.15 mg/100g for (B, C and D respectively). The statistical analysis showed significant difference (P ≤ 0.05) between biscuits made from
Table (9): *In vitro* protein digestibility (%) of biscuit prepared from biscuit wheat flour containing different levels of debittered lupin seed flour and decorticated millet flour.

<table>
<thead>
<tr>
<th>Biscuits</th>
<th>Protein (%)</th>
<th>IVPD (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>7.58(±0.07)\textsuperscript{d}</td>
<td>63.68 (±0.006)\textsuperscript{d}</td>
</tr>
<tr>
<td>B</td>
<td>11.69 (±0.07)\textsuperscript{c}</td>
<td>69.54 (±0.01)\textsuperscript{c}</td>
</tr>
<tr>
<td>C</td>
<td>17.87 (±0.1)\textsuperscript{b}</td>
<td>76.40(±0.01)\textsuperscript{a}</td>
</tr>
<tr>
<td>D</td>
<td>21.88 (±0.01)\textsuperscript{a}</td>
<td>74.74(±0.006)\textsuperscript{b}</td>
</tr>
</tbody>
</table>

- Values are means (± standard deviation)
- Mean values having different superscript letters in the same column are significantly different ( \( p \leq 0.05 \)).

Where:

A : Control biscuit sample
B : 75% biscuit wheat flour + 12.5% decorticated millet flour + 12.5% debittered lupin seed flour.
C : 50% biscuit wheat flour + 25% decorticated millet flour + 25% debittered lupin seed flour.
D : 50% decorticated millet flour + 50% debittered lupin seed flour.
control and composite flour in their Ca content. The results are similar to that reported by Abdelatief (2007) who found increase in Ca content with increasing levels of decorticated pigeon pea flour for biscuit production. Dhingra and Jood (2001) also observed increase in Ca content with increasing levels of supplementing bread with barley plus full fat soybean flour. Magnesium content was increased with increasing levels of DLSF and DMF and was found to be 25 mg/100g for wheat biscuit (A) increase to 29, 31.3 and 37 mg/100g for B, C and D respectively. Generally analysis of variance showed significant difference ($P \leq 0.05$) among the biscuit samples. Abdelatief (2007) showed increased level of decorticated pigeon pea flour (DPPF) in wheat flour increasing its Mg content from 44.75 mg/100g to 338.29 mg/100g at 0.0% to 25% blends.

Iron contents were increased with increasing levels of decorticated millet flour and debittered lupin seed flour there was significant difference ($P \leq 0.05$) among biscuit samples in term of Fe value. And was found to be 1.63, 1.95, 2.1 and 2.9 mg/100g for (A), B, C and D respectively. A gave the lowest value but D gave the highest value. The results in agreement with that studied by Abdelatief (2007) who reported that the iron content increase when wheat flour supplemented with DPPF for biscuit production. However the breads containing barley plus full fat soy flour decreased iron content as observed by Dhingra and Jood (2001).

Potassium content of wheat biscuit (A) gave highest value which was 125 mg / 100g while other blends showed no significant difference ($p \geq 0.05$) but gave similar values of potassium content 100 mg/100g. The statistical analysis of sodium showed that no significant ($p \geq 0.05$) difference in wheat biscuit A, and B which contain the same value of Na 200 mg/100g, while significant difference between C and D was found to be 175 mg/ 100g and 150 mg/100g respectively.
Table (10): Mineral content (mg/100g) of biscuit prepared from biscuit wheat flour containing different levels of debittered lupin seed flour and decorticated millet flour.

<table>
<thead>
<tr>
<th>Flour sample</th>
<th>Ca</th>
<th>Mg</th>
<th>Na</th>
<th>K</th>
<th>P</th>
<th>Fe</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>5.5±0.005d</td>
<td>25±0.06d</td>
<td>150±0.001c</td>
<td>125±0.001a</td>
<td>460±0.006d</td>
<td>1.63±0.05d</td>
</tr>
<tr>
<td>B</td>
<td>8.00±0.06c</td>
<td>29±0.00c</td>
<td>175±0.001b</td>
<td>100±0.001b</td>
<td>470±0.006c</td>
<td>1.95±0.006c</td>
</tr>
<tr>
<td>C</td>
<td>9.8±0.006b</td>
<td>31.3±0.006b</td>
<td>200±0.001a</td>
<td>100±0.00a</td>
<td>490±0.006b</td>
<td>2.1±0.006b</td>
</tr>
<tr>
<td>D</td>
<td>11.15±0.006b</td>
<td>37±0.006a</td>
<td>200±0.006a</td>
<td>100±0.006a</td>
<td>520±0.006a</td>
<td>2.9±0.006a</td>
</tr>
</tbody>
</table>

- Values are means (± standard deviation)
- Mean values having different superscript letters in the same column are significantly different at \((P \leq 0.05)\).

Where:

A : Control biscuit sample
B : 75% biscuit wheat flour + 12.5% decorticated millet flour + 12.5% debittered lupin seed flour.
C : 50% biscuit wheat flour + 25% decorticated millet flour + 25% debittered lupin seed flour.
D : 50% decorticated millet flour + 50% debittered lupin seed flour.
Wheat biscuit had 460 mg/100g phosphorus increasing to 470, 490 and 520 for B, C and D respectively. There was significant difference (p ≤ 0.05) among biscuit samples in phosphorus content.

4.4 Physical characteristics of wheat biscuits supplemented with lupin and millet flour.

4.4.1 Biscuit thickness and diameter of biscuit pieces

The thickness and diameter of biscuit prepared from BWF with DLSF and DMF are illustrated in table (11). The (A) gave 31.56 cm, B, C and D gave 32.50, 31.69 and 30.94 cm diameter respectively. It is observed that increase in diameter appears on addition of DMF and DLSF to BWF. Generally the analysis of variance showed significant difference (p ≤ 0.05) among biscuits sample in term of diameter. The low diameter value of biscuit made from 100% wheat flour compared to composite blends may due be to high gluten content present in wheat flour (Mariotti et al, 2001, 2002; Morens et al, 2003) than composite flour blends which an elastic network (Chris, 1987) capable of holding the gluten strands such that during baking, there is contraction in the product structure. The blends lupin flour doesn't contain gluten (Sironi et al, 2005), also millet flour doesn't contain gluten and forms dough of poor elasticity (Singh and Goyal, 2005) thus lead to effect a similar contraction, hence the large diameter values. The thickness of biscuit was also affected by replacement and was observed to increase from 5.27 cm (A)control to 5.92 and 5.46 cm by B and C, respectively), whereas it was reduce to 5.23 cm by D. The results are in agreement with Abdelatief (2007) who found that, the thickness and width of biscuit increase gradually with the incorporation of decorticated pigeon pea flour.
Table (11): Spread ratio of biscuit prepared from biscuit wheat flour containing different level of debittered lupin seed flour and decorticated millet flour.

<table>
<thead>
<tr>
<th>Biscuits</th>
<th>Thickness(cm)</th>
<th>Diameter(cm)</th>
<th>Spread ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>5.27(± 0.3)(^c)</td>
<td>31.56(± 0.05)(^c)</td>
<td>5.99(± 0.04)(^a)</td>
</tr>
<tr>
<td>B</td>
<td>5.92(± 0.1)(^a)</td>
<td>32.50(± 0.2)(^a)</td>
<td>5.49(± 0.4)(^d)</td>
</tr>
<tr>
<td>C</td>
<td>5.46(± 0.9)(^b)</td>
<td>31.69(± 0.4)(^b)</td>
<td>5.80(± 0.03)(^c)</td>
</tr>
<tr>
<td>D</td>
<td>5.23(± 0.12)(^d)</td>
<td>30.94(± 0.6)(^d)</td>
<td>5.92(± 0.7)(^b)</td>
</tr>
</tbody>
</table>

- Values are means (± standard deviation)
- Mean values having different superscript letters in the same column are significantly different ( p≤ 0.05).

Where:

A : Control biscuit sample
B : 75% biscuit wheat flour + 12.5% decorticated millet flour + 12.5%debittered lupin seed flour.
C : 50% biscuit wheat flour + 25% decorticated millet flour + 25%debittered lupin seed flour.
D : 50% decorticated millet flour + 50%debittered lupin seed flour.
4.4.2 Biscuit spread ratio

The spread ratio of biscuits prepared from BWF, DMF and DLSF mixtures are shown in Table (11). There was significant deference \((p \leq 0.05)\) between biscuits made from BWF containing different levels of DMF and DLSF in terms of spread ratio. The spread ratio of A (100% wheat flour) was 5.99 decreased to 5.49, 5.80 in (B, and C, respectively) and increased again to 5.92 in (D). These results are contrary to the finding of Abdelatief (2007) who reported increase in biscuit spread ratio with substitution by decorticated pigeon pea flour, also Lorenz et al (1980) who found cookie spread ratio increased with increasing amounts of millet flour. Badi et al (1976) reported decrease in cookies spread ratio with increased levels of millet flour. The reduction in spread ratio could be attributed to the water holding capacity of lupin flour, which absorbs more moisture resulting of reduction in spread ratio.

4.5 Sensory evaluation of biscuits

The sensory characteristics of biscuits are shown in Table (12). Significant difference \((p \leq 0.05)\) was observed between biscuits made from biscuit wheat flour with debittered lupin seed flour and decorticated millet flour, with respect to color, aroma, texture, taste, mouth feel and over all acceptance.

The color preference score ranged between 8 – 6.37. The highest value was given by A which was 8 but B gave 7.4, while the lowest value was given by D (6.37).

The aroma preference ranged between 6.83 and 5.76. Appearance score for A was 6.83 which decreased significantly upon increasing the blending levels at (75% BWF + 12.5% DMF + 12.5% DLSF), (50% BWF + 25% DMF +25% DLSF) and (50% DMF +50% DLSF) and was found to be (6.37, 6.7 and 5.76 respectively).
Table (12): Sensory evaluation of biscuit prepared from biscuit wheat flour containing different levels of debittered lupin seed flour and decorticated millet flour.

<table>
<thead>
<tr>
<th>Biscuit</th>
<th>Color</th>
<th>Aroma</th>
<th>Taste</th>
<th>Texture</th>
<th>Mouth feel</th>
<th>Overall acceptance</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>8 ±0.2a</td>
<td>6.83±0.01a</td>
<td>7.27±0.06a</td>
<td>7.33±0.03b</td>
<td>7.33±0.05a</td>
<td>7.75±0.15a</td>
</tr>
<tr>
<td>B</td>
<td>7.4±0.10c</td>
<td>6.37±0.15c</td>
<td>6.8±0.12b</td>
<td>7.23±0.01c</td>
<td>6.97±0.01b</td>
<td>7.51±0.006b</td>
</tr>
<tr>
<td>C</td>
<td>7.43±0.1b</td>
<td>6.7±0.06b</td>
<td>5.43±0.01c</td>
<td>7.73±0.5a</td>
<td>6.53±0.4c</td>
<td>7.01±0.01c</td>
</tr>
<tr>
<td>D</td>
<td>6.37±0.1d</td>
<td>5.76±0.02d</td>
<td>4.11±0.01d</td>
<td>6.33±0.3d</td>
<td>5.9±0.00d</td>
<td>5.05±0.01d</td>
</tr>
</tbody>
</table>

- Values are means (± standard deviation)
- Mean values having different superscript letters in the same column are significantly different (p ≤ 0.05).

Where:
- A : Control biscuit sample
- B : 75% biscuit wheat flour + 12.5% decorticated millet flour + 12.5% debittered lupin seed flour.
- C : 50% biscuit wheat flour + 25% decorticated millet flour + 25% debittered lupin seed flour.
- D : 50% decorticated millet flour + 50% debittered lupin seed flour.
Plate (1) Biscuits made from BWF and different ratios of DLSF and DMF

Where:

A : Control biscuit sample
B : 75% biscuit wheat flour + 12.5% decorticated millet flour + 12.5% debittered lupin seed flour.
C : 50% biscuit wheat flour + 25% decorticated millet flour + 25% debittered lupin seed flour.
D : 50% decorticated millet flour + 50% debittered lupin seed flour.
The texture preference score varied from 7.73 to 6.33. The highest value was given by C 7.73, A , B and D, gaves (7.33, 7.23 and 6.33 respectively).

Taste score decreased on increasing the level of substitution of debittered lupin seed flour and decorticated millet flour. Biscuit containing (50% DMF + 50% DLSF) has lowest values in taste (4.11), while highest value was by A 7.27, B and C were given values (6.8 and 5.43 respectively). The decrease in taste score may be due to the bitter taste of lupin.

Mouth feel score varied from 7.33 to 5.9. The highest value was given by A control biscuit wich was 7.33 followed by B 6.97, and C 6.53 while D, had the least score of mouth feel 5.9.

Overall acceptance. The control gained the highest score of over all acceptance 7.75 while B, C and D, gained score of (7.51, 7.01 and 5.01 respectively.)
CHAPTER FIVE
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions
1. Addition of DLSF and DMF to wheat flour affected the Farinograph characteristics in various ways by increasing in water absorption and decreasing dough stability.
2. Incorporation of DLSF and DMF in wheat flour have improved the nutritional value of biscuit as they contained appreciable amount of protein, ash, fiber, fat and minerals. Also highest in-vitro protein digestibility than biscuit containing 100% wheat flour.
3. Increment of DLSF and DMF in biscuit decreased the spread ratio. Also the decrease was shown in sensory evaluation scores with increased level of addition, but 75% BWF + 12.5% DMF + 12.5% DLSF (B) had high preference observed by the panelists.

5.2 Recommendation
1. Millet and lupin flours can be a good choice for development of quality and nutritious convenience biscuit products.
2. Millet and lupin based convenience biscuit food products can perhaps be popularized through proper marketing strategies to ensure consumer acceptability.
3. Composite flour made of millet and lupin flour could be used as replacement to wheat flour biscuits for people who suffer from celiac disease.
4. Use of composite flour will reduce over dependence on imported wheat flour so as to save foreign exchange. It will also lead to diversification of food use of such crops in the confectionary industry.
5. Agronomic studies are needed to intensify plant breeding programs to produce lupin cultivars with low levels of the alkaloids.

6. It is recommended that biscuits up to 50% (25% DLSF + 25% DMF) could be baked with satisfactory performance.


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APPENDICES

Appendix (I): Sensory evaluation of biscuits sample (Hedonic scale):
Please examine the following samples of biscuits in front of you, and give values to attributes shown below.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Color</th>
<th>Aroma</th>
<th>Taste</th>
<th>Texture</th>
<th>Mouth feel</th>
<th>Overall acceptance</th>
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Excellent  8 – 9
Very good   6 – 7.9
Good        4 – 5.9
Fair        2 – 3.9
Poor        1 – 1.9
APPENDIX (II)

Farinogram of dough prepared from 100% biscuit wheat flour
APPENDIX (III)

Farinogram of dough prepared from 75% biscuit wheat flour + 12.5% decorticated millet flour + 12.5% debittered lupin seed flour
APPENDIX (IV)

Farinogram of dough prepared from 50% biscuit wheat flour + 25% decorticated millet flour + 25% debittered lupin seed flour