Effect of Using Faba Bean Malt as a Wheat Flour Corrector on Bread Making Quality

By

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DEDICATION

To the soul of my parents, and to the father of my son, my dearest friend and husband “Elfatih” with admiration and love.

Ferial
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ABSTRACT

Germinated Faba bean (Vicia faba) flour (malt) was used in this study to correct the falling number (Alpha amylase activity) of wheat flours from origins, namely Canadian, Argentinian and Sudanese. Faba bean malt flour was used with wheat flour at different levels (1, 2, 3 and 4%) in a formula intended for bread making. The malted wheat flours were tested for rheological characteristics against a commercial improver (Top Bake), besides testing the quality attributes of bread prepared from such flours.

Addition of faba bean malt has significantly ($P \leq 0.05$) improved the falling number of the three wheat flours from 490 to 261 in the Canadian from 406 to 294 in the Argentinian, and from 508 to 277 in the Sudanese wheat flour. The level of 4% malt in wheat flour was found to enhance the water absorption property of wheat flour, but has no significant ($P \leq 0.05$) effect on the other rheological feature of the wheat flour such as dough stability, dough development time, and degree of softening. The same 4% level of malt in wheat flour was found to enhance significantly ($P \leq 0.05$) the bread specific volume of the Canadian flour (from 3.9 to 4.1), the Argentinian flour (from 3.7 to 3.8) and the Sudanese wheat flour (from 2.5 to 2.7).
خلاص الأطروبة

تم استخدام دقيق حبوب الفول المصري المنبت في هذه الدراسة لتصحيح رقم الإسقاط لثلاث عينات من دقيق القمح من مصادر مختلفة تشمل الكندي والأرجنتيني والسوداني. تم استخدام دقيق حبوب الفول المصري المنبت مع دقيق القمح (الكندي، سوداني وأرجنتيني) بمستويات مختلفة 1، 2، 3، 4% لتصنيع عينات من الخبز.

تم أجراء اختبار الصفات البيولوجية لعجين دقيق القمح (الكندي والسوداني والأرجنتيني) المضاد إليه الفول المصري المنبت مقارنة باستخدام المحاسن التجارية (Top Bake) بالإضافة إلى أجراء بعض الاختبارات الأخرى لعينات الخبز التي تم تجهيزها من كل نوع من الدقيق على حدة.

وجد أن إضافة الفول المصري المنبت قد أدى إلى تحسين رقم الإسقاط لعينات دقيق القمح الثلاث من 490 إلى 261 في دقيق القمح الكندي، ومن 406 إلى 29 في دقيق القمح الأرجنتيني ومن 508 إلى 277 في دقيق القمح السوداني. كما وجد أن استخدام دقيق الفول المصري المنبت بنسبة 4% قد قام بتحسن خاصية امتصاص الماء في الدقيق ولم يكن له تأثير معنوي (0.05≤P) يذكر على الخواص البيولوجية الأخرى للعجين مثل ثبات وزمن تجهيز العجين ودرجة نعومة العجين ولكن ادى في النهاية لتحسين الحجم النوعي للخبز المنتج من القمح الكندي بصورة معنوية (0.05≤P) من 3.9 إلى 4.3 في القمح الكندي ومن 3.7 إلى 3.8 في القمح الأرجنتيني ومن 2.5 إلى 2.7 في القمح السوداني.
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CHAPTER ONE

Introduction

Wheat (Triticum spp.) ranks first among cultivated plants of the world and provides more nourishment to the people than any other food source and contributes substantially to the feeding of domestic animals. Although the major pressure to increase world wheat production comes from the food sector, potential industrial uses of wheat are also well known.

Wheat is considered as one of the two main food crops in Sudan. It ranks after sorghum as staple diet specially in urban centers. In addition to is utilization in bread making, wheat is used in many related industries such as biscuits, cakes, macaroni and others.

Bread making is an ancient art closely identified with the development of man and his civilization-changes in man’s bread from the simple.

Bread plays a major role as one of two principles food providing nutrients to man and is considered as a vehicle for human nutrition. The quality of bread produced is mainly influenced by the quality of wheat flour, and the main bread constituent. Improvement of flour quality is very essential for production of good quality bread.

Several improvers are now commercially available, however, some of which are very dangerous to human health, and are still in use although it is legally prohibited, and hence the need for other safer bread improvers is highly appreciated.
Many plant sources have been tried to produce safer improvers for bakery products especially in bread making. Among which, legumes are the most suitable ones due their excellent functional characteristics.

Faba bean is one of the legumes which is characterized by active enzymatic properties, particularly in the germination state, and most of the germinated cereals and legumes are used currently as wheat flour correctors.

**Objectives:**

The purpose of this investigation was to:-

- Study the effect of the germinated faba bean flour as a rich amylase source in correction of the falling number of wheat flour as a pre-requisite for improving wheat flour intended for bread making.
CHAPTER TWO

2. Literature Review

2.1 Wheat composition

There are many varieties of wheat; they may be classified as hard red winter wheats, hard red spring wheats, soft red winter wheats, white wheats and durum wheats. Winter wheats are planted in the fall and harvested in the late spring or early summer. Hard wheats are higher protein content and produce more elastic dough than soft wheats. Therefore, hard wheats are used for breads, and soft wheats are used for cakes. Durum wheats are used most for pasta products e.g. spaghetti, macaroni, etc. and for the thickening of canned soups (Vieira, 1996).

Composition of the grain makes wheat a palatable food of high energy value. So the nutritionist has a major interest in the composition of Kernel. This is especially true because wheat is eaten daily by nearly every one above infant age in most of the world.

Botanically the wheat grain consists of fibrous outer layer (Bran) starchy endosperm (flour) and embryo (germ) as reported by Bushuk, (1986). Anon (1987) reported that the wheat kernel consists of endosperm, bran and germ. The endosperm constitutes about 83% of the kernel weight and it is source of white flour and contains the greatest share of protein in the whole kernel, carbohydrates, iron as well as many complex vitamins, such as riboflavin, niacin, and thiamine. Bran constitutes about 14.5% of kernel weight and it’s included in whole wheat flour, and is also available separately from nutrients in the whole wheat. The bran contains small amount of protein, larger quantities of B-
complex vitamins, trace minerals and indigestible cellulose material, (dietary fiber).

The germ constitutes about 2.5% of kernel weight. It is the embryo or sprouting section of the seed, usually separated because of the fats which limit the keeping quality of flour. Of the nutrients in whole wheat, the germ contains minimal quantities of protein, but greater share of B-complex vitamins and trace minerals. Wheat germ can be purchased separately and included in whole wheat flour. Egan et.al. (1981), found that the wheat grain has the following average composition: endosperm 85%, bran 12.5% and germ 2.5%. The composition of wheat flour however, varies considerably according to the class of wheat, its origin and the proportion of outer parts removed by particular milling process.

2.1.1. Chemical composition of wheat grain

2.1.1.1. Moisture content

Moisture content is one of the most important factors affecting the quality of wheat, since the amount of dry matter of wheat is inversely related to the moisture content, (moisture content has direct economic importance).

Wheat generally contains about 14% moisture resulting in ambient relative humidity suitable to the growth of insects and other microorganisms whose presence will markedly reduce the grains quality (Williams, 1970; Zeleny, 1971; Kenneth and Leonard, 1973). Zeleny, (1971) reported that too dry wheat has some disadvantages. Being very dry, the grain tends to be brittle and break easily during commercial handling. Also broken kernels are of little milling values since most of
them are removed in cleaning operations. Another disadvantage is that it is sometimes more difficult to temper it properly to the moisture level required for milling. Pareds-Lopez et al., (1978) reported that the moisture content of the Mexican wheat flour is 11.2% However, Badi et al. (1978) found that the moisture content of Sudanese wheat flour harvested in 1975 ranges between 10-11%. Doxastakis et al. (2002) reported that the moisture content of wheat flour is 12.6%. Moreover, Pyler (1973) mentioned that the moisture content of wheat flour is 13.0%, while Giami et al. (2005) showed that the moisture content of wheat flour is 10.5%.

2.1.1.2. 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 flour was found to be in range of 1.4% to 2.00% (Zeleny, 1971). Pratt, (1971) showed that ash content has been considered an important indicator of flour quality, although the ash content of flour is not related to the final performance, but it gives some indication of the miller’s skill and the degree of refinement in processing. D’appolonia and young, (1978) found that ash content of wheat flour (whole meal) is 1.85%.

Pomeranz and Dikeman, (1983) reported the ash content of hard red winter wheat flour was found to be in the range of 1.82-2.00%. Badi et al., (1978) showed that ash content of Sudanese wheat cultivars whole meal flour ranges between 1.38-1.84%. Doxastakies et al. (2002) reported the ash content of wheat flour as 0.61%. Pyler (1973) gave 1.7%
ash for the soft red winter wheat, which is the same with the white one. Giami et al., (2005) found that the ash content of wheat flour is 0.7%. Mohammed (2000) calculated the ash content of flour Sudanese wheat flours; Elneilain, Sasaraib, Condor and Debera ranging between 1.35 and 1.52%.

### 2.1.1.3. Protein content

Wheat protein is a highly heterogeneous material including albumins (Soluble in water), globulins (soluble in neutral salt solution), gliadins (soluble in 70% ethanol, acid), glutenins (soluble in acid, bases, hydrogen and hydrophilic bonding solvents). Albumins and globulins are cytoplasmic proteins with enzymatic activities, foaming and emulsifying properties. They account for 15.20% of total protein.

Gliadins known for their medium molecular weight (25000-100000) and their high extensibility, and glutenins known for their high molecular weight (1000000-3000000), and their high elasticity. Both of them are associated together with lipids and other minor components (minerals, carbohydrate) to form a unique vescoelastic protein complex referred to as gluten (Feillet, 1980).

Austin et al (1965) reported that gliadins are mainly responsible for the viscosity and extensibility of dough allowing it to rise during fermentation or baking. George, (1973) found that the protein content of wheat is highly influenced by the environmental conditions, grain yield and available nitrogen as well as the variety genotype. However, Blackman and Payne (1987) reported that wheat is an important source of protein for people of developing countries. Because of the nutritional
value of wheat grain protein wheat is considered superior compared to other cereals.

The percentage of wheat protein may be considered as a criterion for establishing the economic value of grain and will give an indication of uses for which it will be useful (William’s, 1970). Protein quality can be defined only in terms of its usefulness; the quality of protein needed for bread-making differs considerably from that required for pastries or pasta product (Hoseney, et.al 1969; Orth and Bushuk, 1972; Schmidt, 1973). Strong and weak flours produce dough which has different mixing properties; this difference is due mainly to the quality and quantity of protein. (Blakman and Payen, 1987).

Haldore et. al., (1982) reported that protein content of whole meal flour ranges between 10-16% while Passmere and East wood (1986) reported that the protein content of wheat was 12.2 gm/100gm. However, Pareds-Lopez et. al (1978) found that protein content of Mexican wheat flour was in the range of 9-11%, while Badi et al., (1978) stated that protein content of the Sudanese wheat cultivars ranged between 11-14%.

Zeleny, (1971) reported that the end uses of flour related to its protein content; so macaroni product needs protein content 13% or more, for bread protein content ranges between (12-14%) , for biscuits ranges between (8.5-10.5%) and for cake ranges between (9.0-9.5%). Mohammed (2000) calculated the protein content of four Sudanese cultivars (Sasaraib, condor, Eleneilain and Deberia) ranges between 12.29-14.82%, while Giami et. al. (2005) found that the protein content of wheat flour is 11.3% and Doxastakis et. al. (2002) showed that the protein content of wheat flour is 11.7%.
2.2. Wheat quality

Wheat is grown over a wider area in the world than any other major crop. It’s wide temperature tolerance and ability to be grown in both winter and spring under many soil types and rainfall patterns have endowed this crop with a wide range of adaptability. Because climate has a considerable influence on the type and variety of wheat grown, Zeleny, (1971) reported that the quality of wheat is usually Judged by its suitability for particular end use.

2.2.1. Gluten content

Gluten is considered to be an important factor in wheat flour quality which is formed by interaction of two proteins, glutenin and gliadin in association with lipids and pentosans during dough formation (Meredith, 1964; Hoseney et. al, 1969; Kaldy et. al, 1993). Meredith, (1964) reported that the vital wheat gluten is the most common cereal protein which gives wheat flour its baking characteristics. The gluten has specific properties of forming an elastic mass when hydrated. This elasticity and thermosetting ability of gluten give the characteristics of volume, texture and appearance of bread. Sarkki, (1980) and Pomeranz, (1971) found that strong dough with an extensive gluten net-work is suitable for bread making, while Gaines, (1990) found that a weak dough without an extensive gluten net work is best for cakes.

Gluten is considered to be an important factor in wheat flour quality which gives wheat flour its baking characteristics. Thus, gluten is in reality the skeleton or the frame of wheat –flour dough which is
responsible for gas retention. This property gives volume, texture and appearance of the bread (Meradith, 1964).

Williams, (1970) reported that the elastic or rheological properties of gluten vary with different wheat varieties in some it resists stretching whilst remaining elastic in others. Consequently glutens are designated as strong and weak glutens and wheat from which they came as strong and weak wheat. The importance of wheat gluten was reported by Sarkki (1980). According to Sarkki (1980). Gluten improves the viscoelastic properties of dough and permits the formation of gas cells in bread which ensures configuration volume, and texture in bread. Also the adhesive and film forming characteristics of hydrated wheat gluten are largely responsible for it’s use in technical fields. Adhesive modified gluten can be used in paper coating and the foaming properties of glidin may be utilized in foam drying and as a whipping agent. Solubilized gluten is also good emulsifying agent in pharmaceutical pastes.

2.2.2. Alpha-amylase activity

Wheat alpha-amylase is recognized as an important enzyme in affecting the quality of wheat for bread-making. The enzyme affects dough properties such as gasing power and consistency that may result in excessive lignification and dextrinization producing bread with wet sticky crumb (Marchylo et.al, 1976).

Perteni, (1964) reported that the influence of Alpha-amylase activity is of major importance in determining bread crumb quality. Alpha-amylase decrease the viscosity of starch paste and hydrolyses the starch to glucose, maltose and low molecular weight polysaccharides; so
alpha-amylase provides fermentable sugar for yeast fermentation to produce bread with softer crumb and greater volume.

Greenaway, (1969) found the high alpha-amylase activity, on the other hand makes thin graves and bread with small loaf volume. Jone and Omos, (1967) stated that the baker can rectify insufficient alpha-amylase activity in flour by adding a little malt flour. Malt extract or fungal alpha amylase in dough making. Blackman and Payne, (1987) found that for some manufactured product alpha-amylase activity is of little importance, thus dry flour is used as thickness agent (e.g. soups in which enzyme activity was destroyed by heat).

A comparison of Sudanese wheat with European and American wheat alpha-amylase activity was carried out by Badi et.al, (1978). They observed that the falling number values of Sudanese varieties were abnormally high, indicating the low alph-amylase activity in the cultivars. Lukow and Mcvett (1991) observed that falling number of hard red spring wheat cultivars ranges between 203-332 second, while Pareds-Lopez et. al., (1987) found that falling number of some commercial wheat flour is in the range of 342-488 second.

2.3. Faba bean seed
2.3.1. Faba bean composition

Faba bean (Vicia Faba L.) is a member of the family leguminaceae. It also referred to as broad bean, horse bean, and field bean, windsore bean, tick bean (small types), Bakela (Ethiopia), Boby Kurmouvjge (Russia), Faveiva (Portugal), Fulmasri (Sudan), Feve (France) and called Yeshil Bakla in Turkey (Muehibauer and Tullu,
1997). It is considered as one of the most important pulse crops in the world after dry beans, dry peas and chick peas (Hawtin and Stewart, 1979).

The origin of faba bean is debatable (Duc, 1997). The crop occupied nearly $3.2 \times 10^6 \text{ ha}$ worldwide (FAO, 1992). The area grown in Sudan was 7450 ha in 1965 and was increased to 30000 ha in 1994/1995 (Salih et al., 1995). Faba bean, like other food grain legumes, is characterized by relatively high contents of protein and carbohydrates, it also contains a significant amount of crude fibre, lipids, minerals and vitamins (EL Tinay, 1993; Alonso et al., 2000).

2.3.1.1. Chemical composition of faba bean seed

2.3.1.1.1. Moisture content

Moisture content of faba bean ranges from 6-6.7% as reported by EL Tinay et al., (1989). EL Skeikh et al., (1999) reported a range of 6.34-7.12%. EL Sayed (1994) found that the moisture content of faba bean seeds ranging from 4.3-8.1%. Ali et al., (1982) reported a range of 8.3-7%. Fifteen genotypes of faba been grown at Shambat gave a range of 4.6-6.7% moisture content (EL Tinay, 1993).

2.3.1.1.2. Ash and protein content

Faba bean contains about 2.2-3.4% ash as reported by EL Tinay et al., (1989). Whereas, Ali et al., (1982) reported an range of 2.7-3.0%.

Protein content of faba bean ranges from 28.8% to 30.1% as reported by EL Tinay et al. (1989). E Skeikh et al. (1999) and EL Syed et
al. (1994) obtained 31.8-39% and 28.0-37.8% ranges of crude protein in faba bean, respectively.

2.3.2 Effect of malt flour on the rheological properties of wheat fermented dough

The influence of the malt flour addition on the fermented dough behavior depends on the flour composition and was found more significant in flours with a lower ash content. Amylograph characteristics of flour-water suspensions were affected in the same extent by the malt addition. (HR Ušková and KUČ Erovà, 2003).

The supplementing of wheat flour with enzyme preparations containing amylases, proteinases and lipoxygenase has been widely adopted in mills and bakeries while the three enzymes are present in sound wheat they normally occur in levels insufficient to produce optimal technological effects. In milling, these enzyme are retained in law levels and the flour is fortified with controlled amounts of enzyme (Reed, 1975).

Since wheat flour contains an adequate amount of native β-amylase, the supplementation of flour amylase aims at an increase in α-amylase activity. Originally, matled barley flour was used to this aim, then it was replaced by malted wheat flour and recently by fungal α-amylase.

Malt flours are relatively rich sources of maltose, minerals, soluble proteins, amylolytic and proteolytic enzymes, and flours substances, which promote vigorous yeast activity, accelerate dough conditioning and contribute a distinctive flavour and aroma to the baked product (Finney, 1985). The principal functional benefits of the malt addition
include an increased gas production in the dough, an improved crust colour (Formation a better crumb moisture retention) and an enhanced flavour development.

Malt α-amylases acting on damaged starch granules rectify the deficiency of fermentable sugar which is necessary for optimal yeast growth and gas production (Potus et al. 1994).

2.4. Rheological characteristics of wheat fermented dough

When wheat flour is mixed with water, with the required amount of energy, a dough is formed. The behavior of the resulting dough when submitted to mechanical energy input is determined by dough rheological properties (Blocksma, 1990).

Wheat flour dough’s simultaneously exhibit characteristics of viscous liquid and of an elastic solid and hence, are classified as viscoelastic materials. Dough mechanical proportion depends on a large variety of factors including flour cultivar, mixing time, rest period, etc. (Bagley et al. 1998).

Compose et al. (1997) tested the rheological behavior of wheat dough and indicated the importance of mixing energy for forming a developed dough.

Sadowska et al. (2003) found that at the comparable level of supplementation, the rheological properties of dough were found to be either very good, for up to 12.5% addition of 2-day germinated soypea flour. Lupin and soya flour, at 5 and 10% substitution levels of wheat flour, increased the stability and the tolerance index of the dough, this was reported by Doxastakis et al. (2002).
2.5. **Composite flours**

Cereals are an important source of energy and protein in the human diet. Although carbohydrates are their main dietary contribution, they also provide proteins and smaller amounts of lipids, fiber and vitamins (Walizewski *et al*., 2000).

It is commonly known that the main nutritional drawback to cereals, particularly corn, is their low protein content and the limited biological quality of their proteins (Ortega *et al*., 1986), when compared with proteins found in animals. Nevertheless the protein quality found in a given cereal can be improved by combining it with the high quality sources of protein (Martinez-flaers *et al*., 2005).

Faba bean can provide a very good supplement to weaning foods of high nutritive value (Ali *et al*., 1982). The high lysine content of grain legumes is very important nutritional attribute and probably more important than total protein content because it makes food grain legumes, a significant supplementary protein to cereal grain based diet, which are known to be deficient in lysine. (Berssani, 1989).

Composite flour technology initially confined to the process of mixing wheat flour with cereal and legume flours for making bread and biscuits, however, the term can also be used in regard to mixing of non-wheat flours; roots and tubers, legumes or other row materials (Dendy, 1992).

2.6 **Wheat flour improvers**

2.6.1. **Ascorbic acid**
It was reported that L-Ascorbic acid (AsA) plays an important role in the rheological properties of bread dough as an improver. Addition of AsA and iron, as heavy metal ions, affected the rheological properties, especially hardness of flour-water dough prepared under aerobic conditions. Addition of both AsA and iron increased the hardness of regular flour-water dough as compared with control dough; using oxygen-saturated water further increased the dough hardness. (Miller et al, 1999) They reported that dough mixed with AsA under nitrogen gas showed significantly decreased dough hardness when compared with dough mixed with AsA under air. The improved effect of AsA on dough hardness may be due to oxygen radicals generated during AsA oxidation. Miller et al, (1999) reported that oxidation increased the strength of the dough. Addition of ascorbic acid or azodicarbonamide (ADA) to dough increased both elastic modulus G (prime) and viscous modulus G (double prime), while addition of cysteine decreased both values. Hydrogen peroxide, from either calcium peroxide or glucose oxidase, increased G(prime) and G(double prime) and decreased tan delta G(double prime)/G(prime) values. In addition to strengthening the dough, hydrogen peroxide dried the dough, but ADA did not. The absorption of doughs containing 20 GU of glucose oxidase (source of hydrogen peroxide) could be increased by approximately 5% without altering the rheological properties. Presumably, the mobility of water in the gel formed by oxidative gelation decreased, thereby causing a drying of the dough.

Aamodta et al. (2003) study the effects of, ascorbic acid on dough rheology and bearth bread properties were studied by size-exclusion fast
protein liquid chromatography, Kieffer dough and gluten extensibility, and small-scale baking of hearth loaves. Ascorbic acid brought out the potential in the wheat flour known as protein quality, Ascorbic acid strengthened the doughs and improved hearth bread characteristics.

2.6.2. Lipoxygenase

The biochemistry of the enzyme lipoxygenase and its effect on wheat flour dough are reviewed by many workers (Faubion et al., 1981). Lipoxygenase has a number of effects on wheat flour dough. It is quite effective as a bleaching agent, increases the mixing tolerance, and improves dough rheology. The bleaching action is thought to be the coupled oxidation of pigments and unsaturated fatty acids by atmospheric oxygen. The mechanism by which lipoxygenase increases mixing tolerance is not clear. Because lipoxygenase has no effect on defatted flour, lipids are clearly involved. Lipid extracted from lipoxygenase-treated dough has been reported to decrease mixing tolerance when added back to flour. The improving effect of lipoxygenase on dough rheology has been explained as an oxidation of sulfhydryl groups by the lipid peroxides formed by the action of lipoxygenase on lipid. However, recently reported work has shown that the inhibitor nordihydroguaretic acid greatly inhibited peroxide formation but only marginally impaired rheological effects. Thus, the effect of peroxides is questionable (Faubion et al., 1981).

Hoseney et al. (1980) reported that, soy flour lipoxygenase increased mixing tolerance and improved rheological properties of wheat flour dough. Lipoxygenase overcame the effects that potassium iodate
had on mixing tolerance. Lipoxygenase had no effect when those compounds were added to defatted flour, showing that free lipids are required for lipoxygenase action. They reported that adding linoleic acid to defatted flour restored the effect of lipoxygenase., moreover, oxygen was not required for lipoxygenase to increase mixing tolerance or to overcome the deleterious effects of fast-acting oxidants or activated double-bond compounds, but it was required for lipoxygenase to improve the rheological properties of dough. Hoseney et al. (1980) concluded that lipoxygenase affects mixing tolerance by creating a free radical on certain lipids that competes for activated double-bond compounds indigenous in flour or created by fast-acting oxidants. Lipoxygenase interferes with radioactive fumaric acid's binding with the gluten proteins during dough mixing.

2.7 Baking quality of wheat flour

The main factor which places wheat in the front position among the world crops its bread making quality. So, wheat food products are an essential part of balanced diet because they provide good nutritional value for their caloric cost (Anon, 1987).

Wheat is used for several purposes but the traditions staple food is bread which is produced in many forms by different processes and flour suitable for bread-making in one country may be unacceptable in other. For baking quality, Finny (1943) established that loaf volumes was an indicator of baking quality, varying linearly with protein content. While Macritchie (1978) found that the differences in performance was due to gluten content.
Although many types of bread are made commercially, they can only be produced from limited range of flours. Basically, strong flour must be used which is developed by an extensive viscoelastic matrix dunning dough formation to retain the gas produced by fermentation. The dough expands and after baking a large well-aerated loaf is formed (Blackman and Payen, 1987).

If weak flour is used, loaves of small volume are produced with poor crumb structure. Also, hard wheat is preferred more than soft wheat because of its high water absorption properties which increase bread yields and resistance to stalling. The protein content of wheat used for bread-making may vary from 11% to 15% (Blackman and Payen, 1987).

The general principle for bread making was described by Williams (1970). The general methods of making bread is to prepare a dough of flour, yeast, salt and water, the yeast acts on the sugars present in the dough, either in the form of added glucose or sucrose or those produced by natural enzyme action on the flour producing carbon dioxide gas which distends the dough causing its rise. At the same time by the initial mixing operation and during the period of fermentation, the gluten of the dough is developed and mellowed. When the dough is considered to be in the right condition (ripe) at the end of the fermentation period the dough is divided into pieces of the correct weight, moulded to the shape required and allowed to recover and ferment further in the pieces. This part of this process is known as the proof. The pieces are then passed into oven for baking.

Badi et al., (1978) reported that Sudanese wheat cultivars give dough with relatively low elasticity.
3.1. Materials

Wheat flour from wheat grain of Sudanese, Argentinian and Canadian origins were kept in polyethylene bags at room temperature for further use.

Faba bean cultivar (Silaim), calcium sulphate, tartaric acid, ascorbic acid and commercial bread flour improver (Tob bake) were all obtained from the local market. All chemicals and reagents used were of technical grade brought from University of Khartoum.

3.2. Methods

3.2.1. Faba bean malt Preparation

The sample of Faba beans was divided into two parts, the first part was subjected to germination treatment, following traditional method. Faba bean grains were soaked for eight hours in clean water; then the soaking grains were transferred from soaked water and well distributed between two layers, after three days, the outer layer of the grain (bran) was separated manually. The germinated seeds were sun-dried and ground to flour using a mill falling number A B, Stockholm – Sweden, type 120, V 380, Kw 0.75, No. 444, 3- phase 50. Germinated and non-germinated faba bean flours were kept in polyethylene bags at kept at law temperature 4% for further use.
3.2.2. Proximate analysis of wheat flour and faba bean malt

3.2.2.1. Determination of moisture content

Moisture content of the flour of the three wheat cultivars and faba bean malt flour was determined according to the method described by the AOAC (1984). Two grams of well-mixed sample were weighed accurately in clean preheated moisture dish of known weight by using sensitive balance, and the uncovered sample and dish were kept in an oven provided with a fan at 105°C and let to stay overnight. The dish was then covered and transferred to a desiccators and weighed after reaching the room temperature. The dish was heated in the oven for another two hours and was re-weighed. The loss of weight in flour was calculated as percent of sample weight and expressed as moisture content.

\[
\text{Moisture content (\%) = } \frac{(w_1 - w_2)}{\text{Sample weight}} \times 100
\]

Where:

\[ W_1 = \text{weight of sample + dish before oven dry} \]
\[ W_2 = \text{weight of sample + dish after oven dry.} \]

3.2.2.2. Determination of ash content

Total ash content of the flour of the three wheat cultivars and faba bean malted was determined according to the AOAC method (1990) using the muffle furnace (Model Tipoformo ZA No. 18203 Gel Ran 1001). An amount of 2 grams was weighed into a clean pre-dried and weighed porcelain crucible and placed in a temperature-controlled furnace at 550—600°C for complete ashing (until white grey color).
crucible with its ash was transferred directly to a desiccator, cooled at room temperature, weighed and calculated as percent of original weight of sample. The total ash content percentage was calculated by the following formula:

\[
\text{Ash content (\%) = \left( \frac{w_1 - w_2}{w_2} \right) \times 100}
\]

\[\text{Sample wt.}\]

\[W1 = \text{weight of crucible with ash}\]

\[W2 = \text{weight of empty crucible}\]

### 3.2.2.3. Determination of crude protein

The total nitrogen of the flour of the three cultivars and faba bean malted was determined according to micro-Kjeldahl digestion and distillation method, described by the AOAC method (1990). The sample was accurately weighted (0.2g) and transferred to a Kjeldahl digestion flask. Copper sulphate-sodium sulphate catalyst and 3.5mls concentrated sulphric acid were added, and then the flask was placed into a kjeldahl digestion unit and digested until a colorless digest was obtained. The flask was then left to cool at room temperature, and the contents were then placed into the distillation apparatus. Twenty mls of 40% NaOH were added, the ammonia evolved was received in 10 mls of 2% boric acid solution. The trapped ammonia was titrated against HCl (0.1N) in presence of 2-3 drops of indicator (Bromo Cresol green and methyl red) until a brown reddish color was observed. Crude protein was calculated as follows;
Protein content (%) =
\[ \frac{(A mL - B mL) \times N \times 14.0 \times 100 \times 6.25}{0.2 \times 1000} \]

Where:
- A = volume of HCl sample
- B = volume of HCl blank.
- N = Normality of HCl
- 14.0 = each ml of HCl is equivalent to 14 mg nitrogen
- 1000 = to convert from mg to g.
- 6.25 = Protein conversion factor.

3.2.3 Determination of gluten

Gluten was determined according to the ICC method (1982). Ten grams of flour were mixed with 4.8 ml distilled water for 20 second in a test chamber bottom sieve. The dough was first washed with 2% NaCl for 15 minutes and then with distilled water. Gluten ball obtained was centrifuged for 1 minute and then weighed to give the wet gluten. It was then dried in an electric heater to give the dry gluten.

Wet and dry gluten were calculated as follows:

Wet gluten (%) = \( \frac{\text{wt. of wet gluten}}{\text{Wt. of sample}} \times 100 \)

Dry gluten (%) = \( \frac{\text{wt. of dry gluten}}{\text{Wt. of sample}} \times 100 \)

Gluten index = \( \frac{\text{Total wet gluten} - \text{Pass gluten}}{\text{Total Wet gluten}} \times 100 \)
3.2.4. Determination of alpha-amylase activity

Alpha-amylase activity was determined according to the AOAC method (1984) using the falling number system (F.N). A 6.6 g of sample were weighed into the falling number tube, 25 ml distilled water was added and the tube was closed with rubber, and shaken well until a homogenous solution was formed. The tube was then placed in the water bath of the falling number apparatus. The sample was stirred with stirrer for 60 seconds and the stirrer was automatically stopped. The time in seconds for the stirrer to fall through the homogenous solution was recorded as the falling number.

3.2.5. Rheological properties of dough

The rheological properties of the dough prepared from pure wheat flour and flours containing improver, faba bean malt, and commercial improvers (Top Bake and ascorbic acid) were determined using the Brabender Farinograph methods of the AOAC (1983).

3.2.5.1. Farinograph characteristics
3.2.5.1.1. The titration curve

The titration curve was used for the assessment of the water absorption of each flour sample. A sample of 300 g flour was weighed and transferred into clean Farinograph mixer. The Farinograph was switched on at 63 rpm for one min, and then the distilled water was added from special burette. When the consistency was constant, the instrument was switched off and the water drawn from the burette was taken as water absorption of the flour.
3.2.5.1.2. The standard curve

A sample of 300g was weighed and then introduced into the mixture; Faninograph waswitched on, and the water quantity, determined earlier by the titration curve, was fed at once, the instrument was operated for further 12 min, and then switched-off.

The readings taken from the Farinograph were:

- The quantity of water to be added to the flour during bread production was taken from water absorption reading.
- The difference between zero and the point at which the top of the curve first intersect the 500 F.U. Line was taken as arrival time
- The difference between zero to the point where the top of the curve leaves the 500 F.U. line was taken as departure time.
- The difference between the time where curve first intercept (arrival time) and leaves (the departure time) the 500 F.U. consistency line was taken as dough stability.
- The difference between the dough strength between the moment dough weakening begins and after 12 minutes dough kneading in F.U. was taken as the softening of the dough.
3.2.6. Bread making

The bread produced from Sudanese, Argentinian, and Canadaian wheat flours treated with ascorbic acids. Top Bake (commercial improver) and faba bean malt with calcium tartarate and calcium sulphate, separately, was made according to Badi et al., (1978). The main formula is composed of wheat flour (250 g), dry yeast (2.5 g), salt (1.5 g), sugar (3 g), oil (5g), and water (150 ml).

All ingredients were mixed to make dough in dough mixture for 5 minutes. The dough was allowed to stand for 15 minutes at room temp (37°C). The dough was then cut into small pieces and left to stand for another 15 minutes (i.e. 30 minutes for the first fermentation). The dough was then placed on small trays and transferred into an incubator for 45 minutes at 38.2°C (second fermentation) the trays were then put in the Simon Rotatory Test Oven at 220-250°C for 20 minutes.

3.2.7 Baking test

3.2.7.1. Bread volume

Volume of bread from all treated samples was determined according to the method described by Badi et al., (1978). By using volumeter apparatus which was designed as grain replacement system. Where bread was put in a container of known volume. The apparatus was adjusted by small millet seeds. The volume was measured from the replaced volume of the seeds.
3.2.7.2. Bread weight

Bread weight of all treated samples was determined in grams using a sensitive balance.

3.2.7.3. Bread specific volume

The bread specific volume of all treated samples was measured according to the method described by the AOAC (1984) by dividing the volume of the bread by its weight.

3.2.7.4. Sensory evaluations of loaf bread

Loaf bread samples were assessed organoleptically by the ranking test according to the procedure described by Ihekoronye and Ngoddy (1985). Ten semi-trained assessors were provided coded samples and asked to evaluate the general appearance, flavor, taste, texture and overall quality (Appendix 1) of bread slices.

Sum of ranks were then statistically (P ≤ 0.05) interpreted according to the same ranking test described earlier.

3.2.8. Statistical analysis

Data generated, except for sensory evaluations, was analyzed using Statistical Package for Social Sciences (SPSS). Means (SD) were tested using one factor analysis of variance (ANOVA), and then separated using Duncan’s Multiple Range Test (DMRT) according to Mead and Gurnow (1983).

CHAPTER Four
Results and Discussion
4.1. The chemical composition of commercial wheat cultivars and faba bean malt

The chemical composition of Canadian, Argentinian and Sudanese wheat grain of 78% extraction rate and faba bean malt flour are shown in Table 4.1. The results are expressed on dry matter basis per 100g material.

4.1.1. Moisture content

The moisture content of the three wheat cultivars were 12.2% for Canadian, 13.0 for Argentinian and 11.20 for Sudanese Dibera cultivar. There were significant (P≤0.05) differences among the three cultivars.

These result were comparable with those obtained by Zeleny (1971) and Badi et al. (1978) who reported values of moisture content 8-14% and 10-11%, respectively.

The moisture content of faba bean malt seed flour was 8.03%. This value is similar to that obtained by Ali et al. (1982) who reported a range of 8.3-8.7% for moisture content of faba bean malt and less than the 6.0-6.7% range obtained by El tiny et al (1989).

4.1.2 Ash Content

The ash content of the three commercial wheat flour cultivars as shown in Table 4.1 were 0.31% for Canadian, 0.25% for Argentinian and 0.42% for Sudanese.

There was significant (P≤0.05) differences among the three wheat cultivars. Egan et al. (1981), reported 0.45% ash content of wheat flour (72% extraction rate) which is similar with these values. The ash content of faba bean malt was 3.4% as shown in Table 4.1. This result is similar
to that obtained by Elsheikh et al., (1999) who reported that the ash content of wheat flour in the range of 3.03-3.64%.

4.1.3 Protein Content

The protein content of the three commercial wheat flour cultivars as shown in Table 4.1 were 15.20% for Canadian, 13.79% for Argentinian and 11.14% for the Sudanese cultivar.

There were significant (P≤0.05) differences among the three cultivars in their protein level. These results are comparable with the range of 10 – 16 % protein in wheat reported by Haldore et al. (1981). Pareds-Lopez et al. (1978) found protein content of wheat flour in the range of 9-11% which is lower than values reported in this study.

This variation in protein of the three wheat cultivars may be attributed to the variations in environmental conditions. The Canadian wheat showed higher protein content than both the Argentinian and Sudanese wheats.

The protein content of faba bean malt as shown in Table 4.1 is 28.0%. This result is similar to those reported by Elsayed (1994) who reported protein content of wheat flour in the range 28.0 % to 37.8%. The value obtained lies in the range obtained by Chaven et al. (1989) who reported 20-41% protein content for faba bean malt.

Table 4.1 Chemical feature of wheat flours and faba bean malt*.
<table>
<thead>
<tr>
<th>Sample source</th>
<th>Protein (%)</th>
<th>Ash (%)</th>
<th>Moisture (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canadian wheat</td>
<td>15.20\textsuperscript{a}</td>
<td>0.31\textsuperscript{b}</td>
<td>12.2\textsuperscript{b}</td>
</tr>
<tr>
<td>Argentinian wheat</td>
<td>13.79\textsuperscript{b}</td>
<td>0.25\textsuperscript{c}</td>
<td>13.0\textsuperscript{a}</td>
</tr>
<tr>
<td>Sudanese wheat</td>
<td>11.14\textsuperscript{c}</td>
<td>0.42\textsuperscript{a}</td>
<td>11.20\textsuperscript{c}</td>
</tr>
<tr>
<td>Faba bean malt</td>
<td>28.0</td>
<td>3.4</td>
<td>11.20</td>
</tr>
</tbody>
</table>

* Any two mean values in wheat samples having different superscript letter in each column differ significantly (P≤0.05).
4.2. Gluten quality:

The results of gluten values of Canadian, Argentinian and Sudanese wheat flour are shown in Table 4.2. The Canadian wheat flour recorded significantly (P≤0.05) higher level of wet gluten(36.2), followed by the Argentinian (28.3), while the Sudanese wheat flour recorded the minimum level (22.7). Similarly the three types of wheat flours followed the same trend with both, dry gluten and gluten index.

The wet gluten content of the whole flour of Sudanese cultivars was found in the range of 26.2 to 31.9% as reported by Mohammed (2000). Ahmed (2004) found the wet gluten content of the flour of Sudanese cultivars to be in the range of 26.25 to 29.81% Kulkarni et al. (1987) reported that the percentage of dry gluten range from 9.4 to 15.1% for hard red winter wheat. Ahmed (2005) reported values from 10.12 to 9.5% for dry gluten of Sudanese wheat cultivars.
Table 4.2 Gluten values* of wheat flours.

<table>
<thead>
<tr>
<th>Wheat type</th>
<th>Wet gluten</th>
<th>Dry gluten</th>
<th>Gluten index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canadian</td>
<td>36.20\textsuperscript{a}</td>
<td>12.0\textsuperscript{a}</td>
<td>74.2\textsuperscript{a}</td>
</tr>
<tr>
<td>Argentinian</td>
<td>28.3\textsuperscript{b}</td>
<td>8.7\textsuperscript{b}</td>
<td>73.0\textsuperscript{b}</td>
</tr>
<tr>
<td>Sudanese</td>
<td>22.7\textsuperscript{c}</td>
<td>7.5\textsuperscript{b}</td>
<td>54.0\textsuperscript{c}</td>
</tr>
</tbody>
</table>

* Any two mean values having different superscript letters in each column differ significantly (P≤0.05).
4.3. Alpha amylase activity

A dummy test was performed using the Argentinian wheat flour to compare between non germinated and germinated faba bean flour as flour corrector. Both non germinated and germinated faba bean flour were used as flour corrector at 1 to 4% levels with the Argentinian wheat flour. A 4% level of both non germinated and germinated faba bean flour in wheat flour resulted in reduction of falling number of the latter from 406 to 365 and 293, respectively. Such result lead to dropping non germinated faba bean flour and using germinated flour for further work.

The results of falling number of different wheat flours (Canadian, Argentinian and Sudanese) and wheat flour containing different levels of faba bean malt flour are shown in Table 4.3. The initial falling number of the Argentinian wheat flour was 406 sec, followed by the Canadian wheat flour (490 sec), whereas the highest value was recorded with the Sudanese wheat flour (508 sec- low alpha amylase activity). Addition of 1 to 4% of faba bean malt four to Canadian, Argentinian, and Sudanese wheat flour has significantly (P≤0.05) improved the falling number of these flours. Falling number of Canadian wheat flour has improved from 490 to 261 by using 4% faba bean malt. Argentinian wheat flour has improved from 406 to 294 by using 4% faba bean malt. While the Sudanese wheat flour has improved from 508 to 277 by using 4% faba bean malt. Addition of faba bean malt (Alpha amylase) significantly (P≤0.05) enhance the alpha amylase activity of wheat flour and strongly reflected in development in rheological characteristic of wheat flour. Generally, falling number of most wheat flour were reported to be in the range of 342 -488 sec. (Pards- lopez et al., 1978). Table 4.3 The effect of faba bean malt on the falling number of wheat flour*

<table>
<thead>
<tr>
<th>Level of malt in wheat flour (%)</th>
<th>Wheat flour source</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Canadian</td>
<td>Argentinian</td>
</tr>
<tr>
<td>0</td>
<td>490.667±0.058a</td>
<td>406.000±1.73a</td>
</tr>
<tr>
<td>1</td>
<td>416.000±6.56b</td>
<td>398.000±3.46a</td>
</tr>
<tr>
<td>2</td>
<td>384.333±5.86c</td>
<td>374.667±5.51b</td>
</tr>
<tr>
<td>3</td>
<td>321.333±7.51d</td>
<td>344.000±6.93c</td>
</tr>
<tr>
<td>4</td>
<td>261.333±3.51e</td>
<td>294.333±5.13d</td>
</tr>
</tbody>
</table>

*Table 4.3 The effect of faba bean malt on the falling number of wheat flour.
* Any two mean values having different superscript letters in each column differ significantly (P ≤ 0.05)

4.4. Rheological Characteristics of wheat flours:

The rheological properties of the flours from Canadian, Argentinian and Sudanese wheat with different treatments (ascorbic acid control, Top Bake and faba bean malt with calcium sulphate and calcium tartarate) are shown in Tables 4.4 and 4.5.

4.4.1. Farinograph characteristics

The farinogram readings of wheat flour dough with different treatments are shown in Table 4.4 (Appendix 1. to 9.). The water absorption (corrected for 500 Fu) of Sudanese wheat flour treated with
ascorbic acid (control) and germinated faba bean was significantly (P≤0.05) higher than the flour treated with Top Bake (commercial improver). The water absorption corrected to 14.0 % was in the same pattern compared to the correction for 500fu. The Development time (min.) of Sudanese wheat flour treated with ascorbic acid (control) was significantly (P≤0.05) higher than that treated with Top Bake (commercial improver) and germinated faba bean. The Stability (min.) of Sudanese wheat flour treated with ascorbic acid and Top Bake (commercial improver) was significantly (P≤0.05) higher versus germinated faba bean. The degree of softening (10 min. after begin) of Sudanese wheat flour was significantly (P≤0.05) better for Top Bake (commercial improver) followed by ascorbic acid and then germinated faba bean. The degree of softening (1cc/12 min. after max) of Sudanese wheat flour was significantly (P≤0.05) better for germinated faba bean followed by Top Bake (commercial improver) and ascorbic acid. The Farinograph quality number was significantly (P≤0.05) better for Top Bake compared with ascorbic acid and germinated faba bean.

The water absorption (corrected for 500 Fu) of Argentinian wheat flour treated with ascorbic acid (control) was significantly (P≤0.05) higher than that treated with Top Bake (commercial improver); however, the one treated with germinated faba bean was similar to both treatments. The Water absorption corrected to 14.0 % was significantly (P≤0.05) higher for wheat flour treated with ascorbic acid (control) followed by germinated faba bean and Top Bake (commercial improver). The development time (min.) and the Farinograph quality number of
the Argentinian wheat flour treated with ascorbic acid (control) was significantly (P ≤ 0.05) high followed by Top Bake (commercial improver) and germinated faba bean. The stability (min.) of the Argentinian wheat flour treated with Top Bake (commercial improver) was significantly (P ≤ 0.05) high, followed by ascorbic acid and germinated faba bean. The degree of softening (10 min. after beginning) of the Argentinian wheat flour treated with germinated faba bean was significantly (P ≤ 0.05) higher than that treated with ascorbic acid and Top Bake (commercial improver). The degree of softening (1cc/12 min. after max) of the Argentinian wheat flour treated with Top Bake (commercial improver) was significantly (P ≤ 0.05) high, followed by germinated faba bean and ascorbic acid. The water absorption (corrected for 500 Fu) of Canadian wheat flour treated with germinated faba bean was significantly (P ≤ 0.05) higher than that treated with Top Bake (commercial improver), yet it was similar (P ≥ 0.05) to that treated with ascorbic acid (control). The water absorption corrected to 14.0 % was significantly (P ≤ 0.05) higher for Canadian wheat flour treated with Top Bake (commercial improver), or ascorbic acid compared to germinated faba bean and was similar to that treated with Top Bake. The development time (min.) and degree of softening (1cc/12 min. after max) of the Canadian wheat flour treated with ascorbic acid (control) was significantly (P ≤ 0.05) higher followed by Top Bake (commercial improver) and germinated faba bean. The stability of dough (min.) and Farinograph quality number of the Canadian wheat flour treated with Top Bake (commercial improver) were significantly (P ≤ 0.05) high, followed by
ascorbic acid and germinated faba bean. The degree of softening (10 min. after beginning) of the Canadian wheat flour was significantly (P≤0.05) higher for germinated faba bean followed by ascorbic acid and Top Bak (commercial improver). The positive effect of germinated faba bean flour treatment in the three wheat cultivars can easily be seen in both water absorption (corrected for 500) and degree of softening (1 cc/12min after max).

Table 4.5 shows differences among farinogram readings for wheat flours. The water absorption (corrected for 500 F.U) of Sudanese, Argentinian and Canadian wheat flour treated with ascorbic acid was not significant (P≤0.05) different from Sudanese flour treated with Top Bake (commercial improver) and germinated faba bean as well as with Canadian flour treated with germinated faba bean. On the other hand, the Argentinian and Canadian wheat flours treated with Top Bake (commercial improver), and Argentinian wheat flour treated with germinated faba bean showed the lowest water absorption (corrected for 500). The water absorption corrected to 14.0 % was significantly (P≤0.05) higher for Sudanese wheat flour treated with ascorbic acid and germinated faba bean, when compared with Canadian wheat flour treated with ascorbic acid and Top Bake (commercial improver), and Argentinean wheat flour treated with Top Bake (commercial improver), and germinated faba bean. Significantly (P≥0.05) low values were recorded for Canadian wheat flour treated with germinated faba bean. The development time (min.) of Sudanese wheat flours subjected to different treatments was significantly (P≤0.05) lower compared with
other wheat flours treated with ascorbic acid, Top Bake (commercial improver) and germinated faba bean. The stability (min.) of the Argentinian wheat flour treated with ascorbic acid and Top Bake (commercial improver) and Canadian wheat flour treated with germinated faba bean was significantly (P≤0.05) high, followed by Canadian wheat flour treated with ascorbic acid and germinated faba bean and Argentinian wheat flour treated with germinated faba bean. The degree of softening (10 min. after begin (F.U) of Sudanese wheat flour treated with ascorbic acid and Top Bake (commercial improver) was significantly (P≤0.05) higher than that recorded for Sudanese, Argentinian wheat flours and Canadian treated with germinated faba bean. The lowest values were shown by Argentinian wheat flour treated with ascorbic acid and Top Bake (commercial improver) and Canadian treated with ascorbic acid and Top Bake (commercial improver). The degree of softening (1cc/12 min. after max) of Canadian wheat flour treated with ascorbic acid, germinated faba bean and Top Bake (commercial improver) and the Argentinian wheat flour treated with Top Bake (commercial improver) and germinated faba bean were similar. It was obvious that the lowest values were shown by Sudanese wheat flour treated with ascorbic acid / germinated faba bean. The farinograph quality number was significantly (P≤0.05) higher for Argentinian wheat flour treated with ascorbic acid and germinated faba bean and Canadian treated with Top Bake (commercial improver), followed by Canadian wheat flour treated with ascorbic acid and germinated faba bean. The Sudanese wheat flour with different treatments obtained the lowest values.
4.5 Baking Test

The baking characteristics of the flours of the three commercial wheat cultivars treated with ascorbic acid, germinated faba bean and Top Bake (commercial improver) are given in Table 4.6 (Plates 4.1-4.6).

Table 4.6 shows the bread volume, bread weight and bread specific volume of bread prepared from Canadian, Argentinian and Sudanese wheat flour treated with ascorbic acid, germinated faba bean flour and Top Bake (commercial improver).
The bread volume of these flours shows significant (P≤0.05) differences among them. The volume of Canadian bread treated with ascorbic acid, germinated faba bean and Top Bake (commercial improvers), were 425.0, 479.7 and 511.7 respectively. The Argentinian wheat bread volume treated with ascorbic acid, germinated faba bean and Top Bake (commercial improver) shows no significant (P≤0.05) differences among the them, where the volume of Argentinian bread treated with ascorbic acid, germinated faba bean and Top Bake (commercial improver), were 428.7, 430.0 and 476.7 respectively. The Sudanese wheat bread sample treated with ascorbic acid was the lowest in volume compared with bread sample treated with germinated faba bean/Top Bake (commercial improver), where such volumes were 273. 3,306.7 and 393.3 respectively for Sudanese wheat flour treated with ascorbic acid, germinated faba bean and commercial improver of Top Bake.

The treatment with ascorbic acid shows differences among Canadian, Argentinian and Sudanese wheat bread, where the Canadian wheat bread volume was the highest and Sudanese wheat bread volume was the lowest. Addition of germinated faba bean revealed differences in
bread volumes of Canadian, Argentinian and Sudanese wheat bread, where the Canadian bread was the highest and the Sudanese bread was the lowest. Addition of Top Bake (commercial improver) to wheat flours gave different volumes where the Canadian bread was the highest, and the Sudanese was the lowest. Generally Canadian wheat flour treated with, germinated faba bean and Top Bake (commercial improver) resulted in better bread volume compared to the Argentinian and Sudanese wheat flours.

The bread weights are shown in Table 4.6. Addition of germinated faba bean flour to Canadian, Argentinian and Sudanese wheat flours gave better bread weight compared to addition of ascorbic acid and Top Bake (commercial improver).

The specific volume of bread samples from Canadian, Argentinian and Sudanese wheat flour treated with ascorbic acid, germinated faba bean and Top Bake (commercial improver) are shown in Table 4.6. Addition of ascorbic acid, germinated faba bean and Top Bake (commercial improver) to Canadian wheat flour show significant (P≤0.05) differences among breads treated with ascorbic acid and that treated with germinated faba bean/ Top Bake (commercial improver ), where the specific volume were 3.9, 4.3, and 4.8 respectively. Addition of ascorbic acid, germinated faba bean and Top Bake (commercial improver) to Argentinian wheat flour resulted in significant (P≤0.05) differences among the bread treated with Top Bake (commercial improver) and that treated with ascorbic acid/ germinated faba bean, where specific volume were 3.7, 3.8 and 4.5, respectively.
In case of addition of ascorbic acid, germinated faba bean and Top Bake (commercial improver) to Sudanese wheat flour, significant (P≤0.05) differences of observe in Sudanese wheat bread, where the specific volumes recorded were 2.5, 2.7, and 3.1, respectively.

It can be figured out that the main factors that affect specific volume in bread making is the wheat protein rather than falling number. Finny, (1943) reported that the bread volume was an indictor of baking quality of flour, varying linearly with protein content and quality. Macithchie (1978) found that the differences in performance of dough in baking test were due to gluten content and quality.

Hestangen and Frolish (1983) and lukour (1990) reported value of bread volume 355- 376 for Canadian wheat flour bread. Bread specific volume increased positively with brad volume.
Table 4.6 Physical characteristics of bread prepared from Canadian, Argentinian and Sudanese wheat flours.

<table>
<thead>
<tr>
<th>Wheat flour source</th>
<th>Bread volume</th>
<th>Bread Weight</th>
<th>Bread specific volume</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ascorbic acid</td>
<td>Germinated Faba bean</td>
<td>Top bake</td>
</tr>
<tr>
<td>Canadian</td>
<td>425.0&lt;sup&gt;c&lt;/sup&gt;</td>
<td>479.7&lt;sup&gt;a&lt;/sup&gt;</td>
<td>511.7&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Argentinian</td>
<td>428.7&lt;sup&gt;b&lt;/sup&gt;</td>
<td>430.0&lt;sup&gt;b&lt;/sup&gt;</td>
<td>476.7&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sudanese</td>
<td>273.3&lt;sup&gt;e&lt;/sup&gt;</td>
<td>306.7&lt;sup&gt;d&lt;/sup&gt;</td>
<td>393.3&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

* Any two mean values having different superscript letters in each column and row (for each parameter) differ significantly (P≤0.05)
Plate 4.1 Bread made from Sudanese (S), Argentinian (A) and Canadian (C) wheat flours treated with ascorbic acid as improver.
Plate 4.2 Bread made from, Sudanese (S) Argentinian (A) and Canadian (C) wheat flours treated with Top Bake (Commercial improver).

S: Sudanese wheat bread without Top Bake
T.B: Top Bake.
Plate 4.3 Bread made from Sudanese (S), Argentinian (A) and Canadian (C) wheat flours treated with faba bean malt flour as improver.

S: Sudanese without faba bean malt
F: Faba bean malted.
Plate 4.4 Slices of bread prepared from Sudanese (S), Argentinian (A) and Canadian (C) wheat bread containing ascorbic acid as improver.
Plate 4.5 Slices of bread prepared from Sudanese (S), Argentinian (A) and Canadian (C) wheat bread containing Top Bake as improver.

S: slices of Sudanese wheat bread without Top Bake.

T.B: Top Bake.
Plate 4.6 Slices of bread prepared from Sudanese (S), Argentinian (A) and Canadian (C) wheat bread containing faba bean malt as improver.

S: slices of Sudanese wheat bread without faba bean malt.
F: Faba bean malt.

4.6. Sensory evaluation of bread samples
Table 4.7 shows the effect of faba bean malt flour and Top Bake improvers on the organoleptic quality (general appearance, flavor, taste, texture and overall preference) of bread made from three commercial wheat flour.

The results showed no significant (P≤0.05) difference in general appearance between the bread made from Argentinian and Sudanese wheat flours treated with Top Bake and those produced from the Argentinian and Canadian wheat flour treated with faba bean malt flour.

With respect to flavor (taste and odor) and texture of bread there were no significant (P≤0.05) differences among the three breads prepared from the Canadian, Argentinian, and Sudanese wheat flours.

It was obvious that the overall quality of bread prepared from wheat flour containing faba bean malt was more or less similar to bread prepared from flours containing commercial improvers such as Top Bake. Of course bread made from Canadian wheat flour was superior since the quality of the Canadian wheat itself is known to be superior to Sudanese wheat (Makawi, 2006).

Table 4.7 Sensory evaluation* of bread prepared from different wheat flours**
<table>
<thead>
<tr>
<th>Bread source</th>
<th>Sum of ranks</th>
<th>General appearance</th>
<th>Flavor</th>
<th>Taste</th>
<th>Texture</th>
<th>Preference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentinian wheat flour with Top Bake</td>
<td>31&lt;sup&gt;b&lt;/sup&gt;</td>
<td>29&lt;sup&gt;a&lt;/sup&gt;</td>
<td>34&lt;sup&gt;a&lt;/sup&gt;</td>
<td>33&lt;sup&gt;b&lt;/sup&gt;</td>
<td>33&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Canadian wheat flour with Top Bake</td>
<td>19&lt;sup&gt;b&lt;/sup&gt;</td>
<td>28&lt;sup&gt;a&lt;/sup&gt;</td>
<td>29&lt;sup&gt;a&lt;/sup&gt;</td>
<td>25&lt;sup&gt;a&lt;/sup&gt;</td>
<td>24&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Sudanese wheat flour with Top Bake</td>
<td>44&lt;sup&gt;b&lt;/sup&gt;</td>
<td>52&lt;sup&gt;a&lt;/sup&gt;</td>
<td>48&lt;sup&gt;a&lt;/sup&gt;</td>
<td>46&lt;sup&gt;b&lt;/sup&gt;</td>
<td>45&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Argentinian wheat flour with faba bean malt</td>
<td>54&lt;sup&gt;b&lt;/sup&gt;</td>
<td>49&lt;sup&gt;a&lt;/sup&gt;</td>
<td>41&lt;sup&gt;a&lt;/sup&gt;</td>
<td>48&lt;sup&gt;b&lt;/sup&gt;</td>
<td>49&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Canadian wheat flour with faba bean malt</td>
<td>46&lt;sup&gt;b&lt;/sup&gt;</td>
<td>44&lt;sup&gt;a&lt;/sup&gt;</td>
<td>49&lt;sup&gt;a&lt;/sup&gt;</td>
<td>48&lt;sup&gt;b&lt;/sup&gt;</td>
<td>49&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Sudanese wheat flour with faba bean malt</td>
<td>58&lt;sup&gt;c&lt;/sup&gt;</td>
<td>56&lt;sup&gt;a&lt;/sup&gt;</td>
<td>52&lt;sup&gt;a&lt;/sup&gt;</td>
<td>53&lt;sup&gt;b&lt;/sup&gt;</td>
<td>55&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
</tr>
</tbody>
</table>

*Any two mean values having different superscript letters in each column differ significantly (P≤0.05) according to Ihekoronye and Ngoddy (1985).

**Wheat flours containing different flour improvers.
CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1. Conclusions:
From the results obtained in this study, the following points can be concluded:

- Addition of germinated faba bean flour (faba bean malt) has tremendously improved the falling number of wheat flour irrespective of wheat cultivar tested.
- The commercial improver (Top Bake) has the advantage of improving the protein fraction in wheat compared to faba bean malt which acts as flour corrector and hence can’t compete with Top Bake with respect to the high specific volume of bread produced by the latter, yet, faba bean malt can still be used with any type of wheat to help at the wheat flour correction stage for the falling number.

5.2. Recommendations:

- Faba bean malt flour can successfully be used for correction of high falling number of any type of wheat flour intended for bread making.
- Further work is needed to use a blend of an improver that act as flour corrector, and protein modifier at the same time
and hence there will be no need for further addition of commercial improvers at baking stage.

REFERENCES


**FAO (1994) production Year Book. FAO, Rome Italy.**


Appendix 1. Farinogram of the Sudanese wheat flour containing no improvers.
Appendix 2. Farinogram of the Argentinian wheat flour containing no improver.
Appendix 3. Farinogram of the Canadian wheat flour containing no improver.
Appendix 4. Farinogram of the Sudanese wheat flour containing commercial improver (Top Bake).
Appendix 5. Farinogram of the Argentinian wheat flour containing commercial improver (Top Bake).
Appendix 6. Farinogram of the Canadian wheat flour containing commercial improver (Top Bake).
Appendix 7. Farinogram of the Sudanese wheat flour containing faba bean malt, calcium sulphate and calcium tartarate.
Appendix 8. Farinogram of the Argentinian wheat flour containing faba bean malt, calcium sulphate and calcium tartarate.
Appendix 9. Farinogram of the Canadian wheat flour containing faba bean malt, calcium sulphate and calcium tartarate.