Effect of Bran Particle Size on Wheat flour Dough and Bread Quality

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Supervisor,

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قال تعالى: { يا أيها الذين آمنوا كُلوا من طُبيَّاتٍ مَا رَزَقَنَاكُمُ وَاشْكُروُنَّ لِلَّهِ إِنَّكُنَّ مُتَّقِينَ }
سورة البقرة الآية ٢٧٢
Dedication

To my mother,

Father,

and Husband,

Who taught me wonderful things in my life

To my sons

Aiman and Amgad

With love
Acknowledgements

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<td>22</td>
<td>Photograph showing Debeira, El-Nielain and Sasaraib bread with 10% Non-Fermented and Fermented coarse wheat bran.</td>
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Abstract

Studies were carried out on the effect of adding wheat bran (Non-fermented and fermented coarse, medium and fine bran) to different varieties of wheat flour (Debeira, EL Nielain and Sasaraib) 72% extraction rate for making bread.

Proximate composition was carried out for three local Sudanese wheat cultivars (100% and 72% extraction rates) and wheat bran (Non-fermented and fermented coarse, medium and fine wheat bran), mineral content and antinutritional factors were investigated for all types of the wheat bran, where flours characteristics were carried out for the three local wheat cultivars. Rheological properties and baking quality were studied for wheat flour and wheat flour with 10%, 15% and 20% wheat bran (non-fermented and fermented, coarse, medium and fine wheat bran).

Results indicated that, fermentation of wheat bran increased the percentage of crude fibre, from 15.67 to 18.67%, 15.67 to 18.00%, 15.00 to 17.67%, protein content from 20.35 to 21.65%, 18.36 to 20.79%, 21.07 to 22.40%, and carbohydrates from 60.76 to 66.07%, 63.22 to 63.96%, and from 60.05 to 61.15% of coarse, medium and fine wheat bran, respectively.

Both antinutritional factors (tannins and phytic acid) were found to decrease significantly, (p≤0.05) in coarse, medium and fine wheat bran from 0.03 to 0.01 mg catechin/100gm, 0.07 to 0.05 mg catechin/100gm and from 0.07 to 0.06 mg catechin/100gm and from 626.1 to 572.8 mg/100gm, 740.4 to 367.1 mg/100gm and from 795.2 to 301.6 mg/100gm respectively.

Also, there was an increase in Ca content and Fe content in fermented coarse, medium and fine wheat bran.
The P content decreased in fermented coarse, medium and fine wheat bran. Analysis of variance showed significant differences (p≤0.05) among the three cultivars in their specific loaf volume. There was also significant differences (p≤0.05) among the three cultivars with non-fermented and fermented wheat bran in their bread specific volume of loaves. The bread specific volume of the three cultivars with non-fermented wheat bran having higher values. Organolyptic evaluation for bread showed that the bread with 10% non-fermented and fermented coarse wheat bran gave the best results for all characteristics tested.

In general, bread with 10% non-fermented coarse wheat bran obtained the highest values.
خلاصة الأطروحة

(لا يوجد نص يمكن قراءته بشكل طبيعي من الصورة.)
محليات الفصيلة، و عينة من خميرة الخبز الذي تم تجنيده في مختبر الأشعة. 

Chapter one
Introduction

Wheat belongs to the grass family \textit{(Gramineae) (poaceae)} and the \textit{genus Triticum}. Wheat has been cultivated and used as food for man since the dawn of civilization. Its production needs fertile, well drained soil with rain during growth periods and sunny droughts at ripening time. (Boumans, 1985).

Although many people of the world eat rice as their principal cereal, wheat is very widely grown and eaten by millions of people. Normally, it is grown on nearly 400 million acres each year in 50 different countries. (Wilson, 1948).

World production of wheat grew 25% during the last decade and about 10\% of the total production is sold on the international market. Wheat is rapidly replacing sorghum as the staple cereal in urban society in the Sudan. In 1960, wheat production was only 25.000 tons and the import of wheat flour was 76.000 tons. The consumption of wheat tripled during the period 1960 to 1970 (Badi etal.1978). Wheat demand was limited prior to the 1960s, being mostly in northern Sudan and largely met by sustained domestic production in that traditional consumption area.

Demand has, however, increased over time in urban areas to magnitudes that could no longer be satisfied by local production. More over, wheat consumption has gradually shifted to many rural areas, induced by a substantial shift in consumption habits away from the traditionally used sorghum. (Ageeb etal. 1996).
The nutritional value of wheat which is the entire product made by grinding the wheat grain, a good source of carbohydrates has been recognized for centuries and has provided a main source of food for a large portion of the human race, however because wheat has been and remains an abundant and economical food and feed its value is sometimes depreciated.

On the average, wheat flour is composed of about 74% carbohydrates, 11% protein, 1.25% lipids, 0.4% mineral matter, and varying amounts of several B Vitamins. The protein-amino acid balance of wheat and wheat products is good. (Desrosier, 1977).

Bran is one of the richest sources of dietary fiber it is the indigestible outer husk of wheat, rice, oats and other cereal grains. At one time most bran was thrown out when grains were milled. Until the 1960s when scientists published several reports which stated that bran and other types of fiber could prevent heart attacks, intestinal disorders, and cancers of the breast, colon, prostate and Uterus. They developed these reports by studying rural Africans. These studies showed that diseases were rare among these people due to the large consumption of whole grains.

Huge amounts of bran were being added to everything. Bran was being added to bread, cereals, muffins, meat loaf and even baked apples. Since this time researchers have learned more and more about the health benefits and hazards of using raw bran. They also have discovered that various types of bran have different properties and different function. Researchers have studied wheat bran and determined that it is mostly insoluble, although it absorbs large amounts of water. When it is used in moderation, fibers help to prevent constipation. But when used in excessive amounts can cause bloating
and intestinal gas. Wheat bran when used properly in a high-fiber diet can help to prevent intestinal disorders, also because it helps prevent constipation, bran may also benefit people suffering from hemorrhoids. (parent, 2002). All types of bran, as well as other high-fiber foods, play an important role in weight control by promoting a feeling of fullness without overeating.

The wheat bran, being the outside of the grain, is coarse and brown whereas the shorts and middlings are much paler in colour and are fine in texture since represent the internal layers of the skin (Bland, 1971). Wheat bran, in addition to indigestible cellulose material contains about 86% niacin, 73% pyridoxine, 50% pantothenic acid, 42% riboflavin, 33% thiamine, 19% protein. (Boumans, 1985).

Wheat bran is considered to be a valuable item in the human diet because of its high cellulose content and the presence of various minerals and vitamins. The objectives of this study were:

1- To determine the composition and quality aspects of three local wheat cultivars.
2- To determine the composition of wheat bran.
3- To study the effect of fermentation of wheat bran on the anti nutritional factors.
4- To study the effect of wheat bran particle size on the dough rheological properties.
5- To determine baking characteristics of the wheat cultivars flour and the blends with bran.
CHAPTER TWO
LITERATURE REVIEW

2.1 Importance and uses of wheat in the world

Wheat, (*Triticum spp.*), is the most widely cultivated of all cereals. Wheat crop is harvested somewhere in the world, during every month of the year. In most areas of the world, it is the principle food of man. The properties of gluten in wheat are such that it produces breadstuffs generally superior to those from any of the other cereal grains (Leonard and Martin, 1963). Wheat like other cereal grains has many natural advantages as a food. It is nutritious, concentrated, readily stored and transported and easily processed to give high-refined raw foods. It contains gluten, protein, which enables a leavened dough to rise by forming minute gas cells that hold carbon dioxide during fermentation. This property enables bakers to produce light bread (Quisenberry, 1967). Most of the wheat marked is used to manufacture flour from which breads, cakes and pastries are made. The soft white wheats are used extensively for crackers, pastries and cookies. The durum wheats are processed into semolina from which macaroni and related products are made (Wilson, 1948). Inglett (1974) reported that bread is the principle food made from wheat, Flour is also a common ingredient in gravies, sauces, and soups as a thickener. Wheat is too often passed off as merely a starchy food crop, yet it contains other valuable nutritive materials, notably protein, minerals and vitamins. In fact, the amino acids yield per acre from wheat far exceeds that of animal products for every one of the essential amino acid, Wheat contains amino acids, which is sufficient source of protein. (Quisenberry, 1967).
2.2 The importance, production and consumption of wheat in the Sudan

Wheat is the second most important cereal crop in the Sudan after sorghum. As a single crop, it occupies the largest area in irrigated schemes. Wheat consumption in the Sudan has been sharply increasing, from about 220,000 tons in 1970/71 to over 800,000 tons in 1990/91, both due to population growth and rising per capita consumption. The Sudan's wheat situation is characterized by rapid growth in consumption, continuous and variable deficit between domestic needs and local production, uncertain estimates of actual wheat demand due to quota and price controls, continuous efforts for attaining self-sufficiency through a policy-driven production strategy, and intensive research for better crop adaptation and higher productivity. Technology development and government support have notably enhanced wheat production and improved self-sufficiency since the mid-eighties.

In the Sudan, wheat is getting more important as one of the main cereal foods and varieties grown are mainly used for bread making (El-Faki et al. (1978).

2.3 Wheat kernel structure

Desrosier (1977) reported that, a wheat kernel structure is often referred to as the one-seeded fruit or botanically, the caryopsis of the common wheat plant. Kernel composition varies more widely in wheat than in any other cereal grains. The anatomical structure of mature hard red winter wheat has been extensively studied. The principal parts of the grain, or tissues, are pericarp (5-8%), aleurone layer (6.0-7.0%), endosperm (81.0 - 83.0%), embryo (1.0-1.5%), and scutellum (1.5-2.0%).
2.4 Nutritive value of wheat

The nutrients in wheat are carbohydrates (mainly starch), protein, lipids, vitamins and minerals. Wheat is regarded primarily as a source of carbohydrates because starch is the preponderating chemical constituent, whilst, its valuable contribution of protein, vitamins particularly those of the B-group and minerals is often overlooked. A meal of about 100% extraction, made in India and Pakistan, is known as atta, it is used for making chapaties, a circular, flat un leavened baked product, which is the staple foodstuff (Kent, 1981).

In 1940, the Medical Research Council (M.R.C) recommended that 85% national flour should be milled so as to contain:-

1. As much of vitamin B₁ (thiamine), riboflavin and nicotinic acid as possible.
2. As much protein as possible, particularly that derived from the outer part of the endosperm.
3. As little of the bran as possible deficiency diseases are caused by insufficiency of these nutrients in the diet, Insufficiency of thiamine leads to beriberi: of riboflavin to impaired growth dermatitis, eye defects: of niacin to pellagra, of iron to anaemia. Thiamine is concerned with the metabolism of carbohydrates: riboflavin with enzyme oxidation processes (Kent, 1981).

2.5 Wheat composition

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 everyone 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).

The wheat kernel consists of endosperm, bran and gem. The endosperm constitutes about 83% of the kernel weight and it is the source of white flour and contains the greatest share of protein in the whole kernel as well as carbohydrates, iron and B-complex vitamins. 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. The bran constituents about 14.5% of kernel weight and it is included in whole wheat flour, and is also available separately from nutrients in the whole wheat. The bran contains small amounts of protein, larger quantities of B-complex vitamins trace minerals and indigestible cellulose material (dietary fiber) (Anon, 1987). Egan et al. (1981) found that the wheat grain has the following average composition endosperm 85%, bran 12.5% and germ 2.5%.

2.5.1 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 breaks easily during commercial handling. Also, broken kernels are of little milling value since most of them are removed in cleaning operations.

Another disadvantage is that it is sometimes more difficult to temper properly to the moisture level required for milling. Pareds-Lopez et al. (1978) reported that the moisture content of the Mexican wheat flour is 11.20%. However, Badi et al. (1978) found that the moisture content of Sudanese wheat flour harvested in 1975 ranges between 10-11%.

### 2.5.2 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 the flour was found to be in the range of 1.4% to 2.0% (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%, while Pareds-Lopez et al. (1978) found that the content of Mexican wheat flour with 69% extraction rate (14% moisture) ranged between 0.31-0.62%. Pomeranz and Dikeman (1983) reported the ash content of hard red winter wheat flour was found to be in the range of 1.82-2.0%. Egan et al. (1981) reported that ash content of whole meal flour ranges between 1.2-1.8% and for 72% extraction rate about 0.45%. Badi et al. (1978)
showed that the ash content of Sudanese wheat cultivars whole meal flour ranges between 1.38-1.84%.

2.5.3 Protein content

Wheat protein is a highly heterogeneous material including albumins (soluble in water), globulins (soluble in neutral salt solution), glaidins (soluble in 70% ethanol acids), gluteins (soluble in acids, 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. Austin et al. (1965) reported that gliadins are mainly responsible for the viscosity and extensibility of dough allowing it to rise during fermentation. Glutenins confer visco-elasticity to the dough; the elastic component preventing it from becoming over-extended and from collapsing either 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.

Protein quality can be defined only in terms of its usefulness; the quality of protein needed for bread-baking differs considerably from that required for pastries or pasta product (Orth and Bushuk, 1972; Schmid, 1973 and Hoseney et al. 1969).

Strong and weak flours produce dough, which have different mixing properties, this difference is due mainly to the quality and quantity of protein
(Blackman and Payen, 1987). Haldore et al. (1982) reported that protein content of whole meal flour ranges between 10-16%. While Passmer and Eastwood in (1986) reported that the protein content of wheat was 12.2 gm/100 gm. Zeleny (1971) reported that the end uses of flour is 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%.

Pareds-Lopez et al. (1978) found that protein content of Mexican wheat flour was in the range 9-11 %. While Badi et al. (1978) stated that protein content of the Sudanese wheat cultivars range between 11-14%.

### 2.5.4 Crude fiber content

Crude fiber in the wheat was defined as insoluble and combustible organic residue, which remains after the sample has been treated under prescribed condition.

Ranhotra et al. (1990) described fiber as total dietary fiber (TDF), which is defined as indigestible components in food, which include cellulose, hemicellulose, lignins, pectins and gum.

D'appolonia and Young (1978) defined fiber as cellulose and reported that cellulose represent about 40% to 43% of wheat straw, 35% of the bran and about 0.3% of the endosperm. High grade "patent" flour has little cellulose. The crude fiber content increases with the amount of branny matter present. Fiber varies with ash but the relation is evidently not linear-naturally since ash is contained mainly in the inner and fiber ,in the outer bran layer. Egan et al.(1981) reported that the fiber percentage in whole meal flour
ranges between 1.8-2.5% and of flour 72% extraction rate range between 0.1-0.3%.

2.5.5 Fat content

The fat content of four Sudanese wheat flours (100%) extraction rate and (72%) extraction rate of different cultivars grown in seasons 1991/92 ranged between 1.91-2.35% and 0.85-1.73%, respectively (Ahmed, 1995). Mohamed (2000) reported that the fat content of four Sudanese cultivars ranges between 2.15 and 2.35%. While Abdallah (2002) reported that the fat content of two Sudanese cultivars ranges between 2.740 and 2.373%.

2.6 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 considerable influence on the type and variety of wheat grown. The quality varies widely among geographical regions (Everson, 1987). Zeleny (1971) reported that the quality wheat is usually judged by its suitability for particular end use.

2.6.1 Alpha-amylase activity

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

Perten (1964) reported that the influence of alpha-amylase activity, is of a major importance in determining bread crumb quality. Alpha amylase
decreases the viscosity of starch paste and hydrolyzes 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 that, high alpha-amylase activity on the other hand, makes thin graves and bread with small loaf volume.

Jones and Omos (1967) and Perten (1996) 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 manufacturing product alpha-amylase activity is of little importance, thus dry flour is used as thicking 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 value of Sudanese varieties was abnormally high, indicating the low alpha-amylase activity in the cultivars.

Lukow and Mcvett (1991) observed that falling number of hard red spring wheat cultivars ranges between 203 and 332 seconds. While Pareds-Lopez et al. (1978) found that falling number of some commercial wheat flour is in the range of 342-488 seconds.

Kaldy and Rubenthaler (1987) found that the falling number of soft white winter and spring wheats, ranged between 380 and 451 seconds and between 111 and 479 seconds. While Ahmed (1995) showed that the falling number values of some Sudanese wheat cultivars were found to be in the
range of 397 to 482 seconds for whole flour, but for white flour (72% extraction rate) ranged between 396 and 486 seconds.

Perten (1996) reported that falling number values below 150 seconds (high amylase activity, sprout damaged wheat) is likely to produce sticky bread-crumbs, while 200 to 300 seconds (optimal amylase activity) produces bread with good crumb, and above 300 seconds (low amylase activity, sound wheat), the bread crumb is likely to be dry and the loaf volume is reduced.

2.6.2 Gluten quantity and quality

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 and 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.

Pomeranz (1971) found that the strong dough with an extensive gluten network is suitable for bread-making. While Gaines (1990) stated that weak dough without an extensive gluten network is best for cakes so glutens are designated as strong and weak glutens, and wheat from which they come as hard and soft wheat. Huebner and Rothus (1968) found that yields of gluten from the different cultivars ranged from 9 to 11% for hard wheats, and from 6.5 to 8.0% for soft wheats.
The gluten, in turn, generally consisted of 60 to 70% gliadin and 30 to 40% glutenin, while Kulkarni et al. (1987) stated that the percentage of dry gluten content ranged from 9.4 to 15.1 %, 11.7 to 15.3% for hard red winter and hard red spring wheats, respectively. But, wet gluten ranged from 25.9 to 42% for winter wheat, and from 31.0 to 41.9% for spring wheat. Both wet and dry gluten increase with increasing protein content in the flour within a cultivar.

Perten (1995) revealed that gluten index is an important test for gluten quality. Usually, there is a positive relationship between glutenin quantity and gluten index percentage (the percentage of wet gluten remaining on the sieve after centrifugation). But, there is a negative correlation with the gliadin quantity. So, gluten index is a main test for gluten quality.

Tolman et al. (1998) reported that the ratio between elasticity and extensibility (glutenin/gliadin) plays a crucial role in the handling properties of the dough and the quality of the final products.

2.6.3 Rheological Properties

Dough rheological properties are commonly evaluated by measuring the consistency with farinograph or mixograph. Farinograph is the most widely used physical dough testing instrument in the world. It measures; plasticity, mobility, optimum mixing time, mixing tolerance, stability and weakening of the dough. It is used to estimate water absorption and mixing time of a flour to be baked. Generally, Dough derives its properties from the constituents, the most important of which are the proteins, especially gluten proteins (Quisenbery and Reitz, 1967 and Kaldy et al. 1987).

Kulkarni et al. (1987) stated that the flour protein content was of significantly high positive correlation with the dough development time and water
absorption. It has significantly negative correlation with dough breakdown. He and Hoseney (1992) found that protein content was positively correlated with farinograph mixing time, mixing tolerance and water absorption.

Tanaka and Bushuk (1973) reported that the gluten with long mixing time had components of higher molecular weight than gluten of wheat cultivars with shorter mixing time. But, Singh et al. (1990) stated that an increase in proportion of gliadin gives weaker dough gluten, where as an increase in the ratio of glutenin has an opposite effect.

MacRitchie and Lafiandra (1997): Tolman et al. (1998) and Wrigley and Bekes (1999) revealed that among the different flour constituents, glutenins play a crucial and extremely important role in determining dough rheological properties and bread quality.

Tanaka and Bushuk (1973) stated that the number of sulphydryl groups (-SH) decreased during dough mixing, but there was no change in the number of disulfide bonds (S-S). While, MacRitchie (1987) observed that oxidants increase the average molecular weight of the glutens and strengthen the dough, Conversely, reductants decrease the average molecular weight and weaken the dough.

Pagenstedt (1955) found that the water absorption in percentages, as required to form a flour water-dough of a dough consistency of 500 F.U. was 50.5% for soft wheat flour and 58.6% for strong wheat flour. While, Meredith (1967) observed that water absorption of spring wheats ranged from 59 to 65.7%. While, Kulkarni et al. (1987) found that it ranges between 59.2 and 71.6% for hard red winter, and from 54 to 66% for hard red spring wheat.
Kaldy et al. (1987) stated that water absorption of soft white winter and spring wheats ranged from 54.7 to 56.1% and 50.1 to 57.8%, respectively.

Pangenstedt (1955) reported that the dough development time, stability, mixing tolerance (dough resistance) and the softening of dough after 12 minutes dough kneading of soft and strong wheat flours was found to be 1 and 3 minutes, zero and 4 minutes, 1 and 7 minutes, 150 and 40 F.U. respectively.

Meredith (1967) observed that dough development time and dough stability of different cultivars ranged from 3 to 6 minutes, and 4 to 6 minutes, respectively. Hamada et al. (1982) showed that the dough development time, stability and mixing tolerance index of spring wheats range from 3 to 7 minutes, 3 to 28 minutes and 10 to 58 B.U. respectively.

2.6.4 Baking test

The main factor, which places wheat in the front position among the world crops is its bread-making quality, so, wheat food products form 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 traditional staple is bread, which is produced in many forms by different processes and flour suitable for bread-making in one country may be unacceptable in another for baking quality.

Finney (1943) established that loaf volume was an indicator of baking quality, varying linearly with protein content, while MacRitchie (1987) found that the differences in performance are due to gluten content. Although many types of bread are made commercially, they can only be produced from a limited range of flours.
Kaldy et al. (1987) reported that the main criteria for good-bread quality, are high bread volume and a fine uniform crumb texture that is tender and moist. Generally, flour with high protein content or strong gluten or both produce a coarse and heavy crumb texture and small compact volume. Hamada et al. (1982) stated that the loaf volume depends on the bread-baking procedure used too, as the AACC straight dough method gives optimum loaf volume with medium strength flour.

Menkorska et al. (1987) showed that bread-making quality; largely depends on the quality and quantity of wheat flour proteins. While, Blackman and Payne (1987) reported that the protein content of wheat used for bread-making may vary from 11 to 15%. But, Perten (1995) stated that quality factors such as loaf volume and water absorption are related to gluten quality and quantity. Higher gluten quantity values generally give greater bread volume. Badi et al. (1978) reported that Sudanese wheat cultivars give dough with relatively low elasticity and low fermentation. While, Ahmed (1995) showed that the bread specific volume of Sudanese wheat cultivars ranged between 3.25 and 3.95 cm$^3$/g.

2.7 Definition of wheat bran

Bran is a mill fraction composed of a number of distinct tissues surrounding the starchy endosperm. The tissues are arranged in successive layers and provide physical and chemical protection to the endosperm and germ embryo. This architecture hinders individual layers from being identified after reduction to flour, but the arrangement aids specific milling practices, such as the preprocessing method (Harrigan and Bussmawn, 1999).

Schooneveld Bergmans et al. (1999) reported that, wheat bran consists primarily of structural polymers, such as cellulose, arabinoxylans and lignin,
which give strength to the outer layers of the wheat kernel and protect it against external influences.

In the 1980s, wheat bran received considerable interest as a source of dietary fiber for human consumption. An important physiological effect of wheat is its faecal bulking capacity, which is ascribed to its low degradability in the digestive tract and its high water holding capacity. Wood (1997) reported that bran is the thin outer layer of the wheat kernel process used in breakfast cereals, whole-wheat breads and others. Ranum (2000) found that bran is mainly cellulose with very little gluten, so there is not much it can be used for other than as a source of fiber. It does contain a higher vitamin and mineral content, so flour made with a higher extraction rate tends to be more nutritious. However, Bran also contains higher levels of phytic acid, which makes the minerals less available to the body, particularly when used in a non-fermented bread such as chapatti.

2.7.1 Nutritive value of wheat bran

Wheat bran, a byproduct of flour milling, is composed of the pericarp and the outermost tissues of the seed, including the aleurone layer. It constitutes almost 10% of the total weight of wheat milled for flour. On a moisture-free basis, bran contains about 17% protein and 70% carbohydrates, about 80% of which is cellulose and hemicellulose. Most of the bran protein and other nutrients are contained in the aleurone cells (Saunders et al. 1972).

Wilson (1948) reported that wheat bran, which is a byproduct of the milling industry, is richer in protein than the wheat grain, although it does contain a higher percentage of fiber. Also he found that wheat bran contains about
15.8% protein, 54.3% carbohydrates, 5.0% fat, 9.5% fiber and nutritive ratio about 24.4.

Rendleman (1982) found that analytical data provided by AACC indicated 10.4% moisture, 8.91% crude fiber, 14.3% protein, 5.22% fat, 3.2% lignin, 3.0% pectin, 17.4% starch, 7.04% sugar (as invert sugar) 22.1% pentosan, 3.36% phytic acid, 0.12% Ca (author's analysis showed 0.087% ), 0.43% 10 Mg, 0.00545% Zn, 0.0122% Fe, 0.00156% Cu, 1.38% K, 0.1% Na and 1.04% P. Ranum (2000) reported that bran, which can be either coarse or fine, coarse bran, along with some organic cleanings, is sold mainly as animal feed, while fine bran has more applications in human foods. Fine brans were characterized by a higher content of particles of less than 1 mm, while coarse brans had a higher content of particles greater than 2 mm.

There was no significant difference in the chemical composition of the brans, but fine brans showed, on average, a Significant (P≤0.05) content of crude protein. The digestibility of the chemical components did not vary widely except for crude fiber and crude protein (CP), which were on average, significantly higher in coarse than fine bran. Results suggest that the classification of wheat bran into coarse and fine brans is difficult to justify from their chemical composition and that their nutritive value seem to be related to the digestibility of its fibrous or protein fractions and less than other nutritive components (Bias et al. 2000).

Saunders (1978) mentioned that wheat bran is important source of dietary fiber, it is rich in insoluble fiber but also contains soluble fiber. Schwary and Kunerth (1988) reported that the levels of cellulose and non-cellulose-
polysaccharide were similar in the inner and outer pericarp. The lignin content of the two at higher level.

Oakenfull and Topping (1987) reported that wheat bran is all outer structure of the wheat kernel including the cells of aleurone layer. The amount of endosperm extracted with bran depends on the milling. The outer pericarp contains 30% cellulose, 12% lignin and rich in β-glucans. David and Bender (1997) reported that wheat bran has a lower water-soluble fiber content 2.9% and much higher cellulose 6.8%. Asp (1981) reported that the crude fiber of out layer represented 16.8 or 13.6%.

2.8 Definition of dietary fiber

Ron (1989) defined dietary fiber as polysaccharide components of plants, which pass unchanged through the human intestinal tract. Other materials not polysaccharides may pass unchanged through human tract include lignin, keratin, mucilages, waxes modified starches and cellulososes and polydextrose. Gordon (1999) defined it as dietary fiber consists of the remnants of edible plant cell, polysaccharides, lignin, and associated substances resistant to (hydrolysis) digestion by the alimentary enzymes of humans. Trowell and coworkers (1976) defined dietary fiber as the remnants of plant cell wall components include all digestion-resistant polysaccharides (mostly plant storage saccharides) such as gums modified cellulososes, oligosaccharides and pectins.

Proaky and Asp (1985) and James and Sandra (1987) reported no single accepted definition of dietary fiber, but there is a general consensus. It is that portion of plant material consumed in the diet resistant to breakdown by human enzymes secreted into the gastrointestinal tract. Therefore, dietary
fiber is several materials from different sources, may differ in their chemical and physical structures and in their physiological metabolic and nutritional effects. Nutritionists divided dietary fiber into two group categories, soluble fiber and insoluble fiber, few of the dietary fiber are actually physically fibrous in nature.

Paul (1988) reported the contribution of lignin to dietary fiber which led to the recommendation that the term non-starch polysaccharides should be used instead of dietary fiber. According to HWC (1985) dietary fiber has been identified as non-starch polysaccharides and lignin. Haber (2002) reported that dietary fibers are a heterogeneous group of food components. They are characterized by resistance to digestion and absorption in the human small intestine as well as complete or partial fermentation in large intestine, this definition not only encompasses traditional dietary fiber components, such as, non starch polysaccharides (cellulose, hemicelluloses) and lignin, but also oligosaccharides, resistant starches and associated plant substances.

### 2.8.1 Sources of dietary fiber

Barbara (1989) reported that un-refined cereal grains have been shown to be the best single food source of dietary. Mongeau and Brassard (1989) names 49 sources of dietary fiber classified in categories according to their total dietary fiber content. Cereal products and legumes contain were more than 4.3% crude fiber. The bran flakes contains fiber in the range of 12.3 -13.1% but oat bran fiber content is in the range of 15.5-15.8%. Sosulski and Wu (1988) reported that high fiber diets based on whole grain cereal, legumes, fruits and vegetables are being prescribed in the treatment and management of calories. Mongeau and Brassard (1989) reported the dietary fiber content of
foods is greatly influenced by moisture content. Whole grains and legumes should certainly be part of the various sources of dietary fiber in a balanced diet. Anderson (1984) reported that some foods as grain cereals, vegetables and some fruits to contain a good amount of fiber polysaccharides. Axtell (1982) reported that wheat bran is an important source of dietary fiber and rich in insoluble fiber but also contain water-soluble fiber. Anderson (1984) reported that wheat bran contain adequate amount of insoluble fiber. Nyman et al. (1984) reported that dietary fiber of wheat flour range from 2.8-12.1% of which the soluble fiber content was about 1.3% independent of the degree extraction. Consumers, have used oat bran, Barley corn and rice bran, pea, lentil, chickpea, soybean, fruit, vegetable fiber and gums as sources of dietary fiber Anon (1989). Nyman et al. (1984) reported that sorghum contain 7.5-9.0% total dietary fiber and soluble fraction 0.5% in all flour, Corn varied from 3.9-9.3% dietary fiber and the soluble fraction is 0.5. Clacco and D'appolonia (1982) reported that the amount of soluble fiber was higher in wheat than in other cereals.

2.8.2 Uses of dietary fiber in foods

Prosky et al. (1985) reported that the specific products to which fiber may be added in substantial amount are breads hot and cold cereal extracted snakes. Fiber may be added to fiber drinks, pasta and processed meats. Prosky and Asp (1985) and Passmor and Eastwood (1986) reported that soluble dietary fiber (SDF) in the form of gums incorporated in small amounts in breakfast cereal snack foods.
2.8.3 Dietary role of wheat bran.

Stanyon and Costello (1990) used wheat bran to enhance the nutritional quality of baked products such as cakes, yeast bread and muffins. The addition of wheat bran affects the physical and sensory properties of the baked products. Kies and Fox (1977) and Vaboung and Krichevsky (1980) reported that generally, water-soluble fiber improves glucose tolerance and lowers plasma lipids, but such an effect has not been observed with wheat bran because most of its dietary fiber is insoluble.

The Dietary Guidelines for Americans (1987) advocates increased consumption of fiber in the diet because of beneficial effects such as the reduced absorption of harmful substances associated with colon cancer, increased water content of the stool with a decreased transit time and intracoion pressure. The fecal water content as well as fecal wet and dry weight increases with the addition of bran to the diet (Cuminges et al. 1976 and Kay and Truswell, 1977).

Gray (1995) found that wheat bran is most effective treatment for constipation and hemorrhoids. Moreover, any increase in dietary fiber intake should be accompanied by an increase in water intake.

Jenkins et al. (1978) reported that the insoluble fibers are largely responsible for increasing the bulk of feces. McRovie et al. (2000) reported that consumption of wheat bran in excess of levels in a typical western diet significantly increased stool output.

Anderson (1984) found that the insoluble fiber, or roughage, promotes growth of bacteria in the intestine causing soft bulky stool. Efficient working of the intestines prevents many diseases of the gut. Trowell (1978) and Anderson et
al. (1979) reported that addition of fiber in the diet improved the control of blood glucose in the case of diabetic patients. James (1985) reported that the high carbohydrate-high fiber diet (HCF) lowers blood sugar and insulin needs. The diet also lowers the blood fats that are a danger to the arteries, and help in weight loss, for the insulin-dependent diabetics, it smoothes out the blood sugar by slowing down its absorption.

Roth and Mehlman (1978) and Vahouny and Kritchevsky (1980) made the hypothesis that dietary fiber (DF) is protective against diabetes, heart disease, obesity and colon cancer. Trowell (1986) reported that dietary fibers are beneficial to both diabetic and heart patients because DF lowers both blood sugar and serum cholesterol.

Ferguson and Harris (1999) reported that human intervention and animal studies have shown that supplementing with wheat bran can protect against the development of a range of cancer especially those of the colon and breast. Wheat bran is a rich source of dietary fiber (plant cell walls) that has structures and compositions, which may protect against cancer. Other nutrients and phytochemicals are present in wheat bran, some of which may also protect against cancer. These including phytic acid and various phenolic components such as phenolic acids lignin and flavonoids.

Malkki (2001) reported that the physiological effects of dietary fiber are usually compared with the intakes or contents of total dietary fiber. Many health-related effects such as cholesterol reduction attenuation of blood glucose and insulin, and prolonged satiety, are due to the physical properties of a fiber. Mani et al. (1987) reported that the effect of wheat bran supplement decreases sugar concentration in fasting and postprandial. Liu et al. (1989)
reported that wheat bran decreased blood glucose and increased Zn absorption. Ca, Cu and Mg balances were not affected.

Ray et al. (1983) reported that addition of fiber decreased excretion of glucose in the urine and decreased plasma glucose concentration. Addition of fiber also delayed gastric emptying of liquids and solids.

Harold et al. (1985) found that wheat bran diet reduced peak blood glucose concentration and peak insulin infusion rate in comparison with baseline and cellulose diets. Rinfel et al. (1990) found that addition of diet wheat bran decreased the levels of blood glucose. Fiber supplement studies with guar gum, wheat bran and apple fiber reported to lower glucose and cholesterol and glucosuria. This diet reduces insulin requirements, lowers serum cholesterol and triglycerides values (Anderson et al. 1987).

Vaaler et al. (1986) reported that patients with diabetes mellitus treated with different dietary fiber: guar gum and wheat bran showed a decrease in postprandial blood glucose levels.

Aaron et al. (1988) suggested that soluble fiber supplements may offer some improvement in carbohydrate metabolism, lowers total cholesterol and low-density lipoprotein (LDL). Himsworth (1935) showed that in normal healthy subjects the ingestion of diet high in carbohydrate improves glucose tolerance. Anderson et al. (1976) and Anderson (1980) showed that diabetic subjects fed a diet high in carbohydrate and fiber reduced blood glucose levels and diminished insulin requirement. Jenkins et al. (1980) reported that addition of purified viscous fiber to metabolic diet resulted in reduced urinary losses of glucose and ketone bodies.
American (1979): Canadian (1981) and British Diabetes Associations (1982) recommend use of fiber in treatment of diabetes because of the increased reduction in postprandial blood glucose. American Diabetes Association (1979) recommended reducing the intake of fat and increasing that of complex carbohydrate to 50% of the total calories with the ingestion of foods high in fiber as desirable. Aretaeus (1985) advised people with the symptoms of diabetes to eat a diet consisting of milk, cereals and fiber.

American Diabetes Association (1979) recommended that individuals with diabetes mellitus should increase the amount of dietary fiber in their diets in order to reduce the excretion of blood glucose and insulin following meals.

2.9 Fermentation

Dirar (1993) reported that fermentation is a method of preservation, may destroy undesirable factors in the raw product, the fermented food may have an enhanced nutritional value and digestibility. Also, he reported that fermented foods may have a better flavour than the raw products, fermentation may be used to salvage, some products that could not otherwise be used for food. Fermentation may Improve the appearance of some foods, fermentation reduces cooking time improves the texture of the food and helps solubilize some food components. The author also mentioned that the techniques of fermentation are simple and well-understood, the process involves little waste and products are well-established and acceptable.

Most fermentation is based on cereals-yeast and bacteria (mainly lactic bacteria) which are not the only organisms that carry out the fermentation. Fermentation time is short, a matter of hours, not weeks or
months. The foods have a high dietary fiber content (and are therefore good for the functioning of the gut).

**2.10 Wheat bran in bread making**

Dubois (1978) discussed that wheat bran is the traditional source of dietary fiber added to baked goods. Mongeau and Brassard (1986) reported that the prehydration of any fiber source (bran) and conditioning before blending and bread making increased water absorption, loaf volume and bread quality. Young (1978) observed that the incorporation of 5% wheat bran or maize bran into hard wheat flour reduced slightly loaf volume and specific volume of bread. Various effects of cereal brans on flours water absorption have been cited (Pomeranz, 1977; Shogren *et al.*, 1981 and Moder *et al.*, 1984).

The effect of cereal brans on functional properties of wheat flour was reported to vary with the particle size of the bran (Finney, 1979 and Finney *et al.*, 1985). Wheat bran is more detrimental to loaf volume of bread and found to increase dough water absorption (Birch and Finney, 1980; Shogren *et al.*, 1981; Rogers and Hoseney, 1982; Moder *et al.*, 1984; Lai and Hoseney, 1989). Dubois (1988) reported that the wheat and maize brans reduced dough development time to peak and increase mixogram area in proportion to the level of bran. Jeltema *et al.* (1983) reported that hemicelluloses increase dough water absorption. Mongeau and Brassard (1986) reported that addition of wheat and maize bran progressively reduced all bread quality characteristics.
Jeltema et al. (1983) reported that addition of bran to the wheat flour decreases cookies spread and causes poor top grain. Solsulki and Wu (1988) reported that addition of bran to flour added little colour over the control bread crust, whereas corn bran tend to give lighter more yellow bread crust. Brain et al. (1989) reported that the gritty texture and degradation of dough properties are often associated with the use of bran material in baked foods.

Katina et al. (2001) reported that in baking, however, addition of wheat bran results in bread with inferior quality, low volume, poor crumb structure, poor shefl-life and a bitter flavour. Pre-fermentation of wheat bran with yeast or with yeast and lactic acid bacteria improved the loaf volume, crumb structure and shelf-life of bread supplemented with bran. The positive effect of fermentation of bran on bread quality was evident in the changes of protein network structure of the breads. Pre-fermentation of the bran with yeast and lactic acid bacteria had the greatest effect on the structure of starch. The starch granules were more swollen and gelatinized in the breads made with pre-fermented bran. Also, Katina et al. (2001) reported that the bread also had added flavor and good homogenous crumb structure and the elasticity of the crumb was excellent.

2.11 Principles of baking

The function of baking is to present cereal flours in an attractive palatable and digestible form. Bread is made by baking a dough, which has for its main ingredients wheat flour, yeast and salt. Other Ingredients, which may be added include flours of other cereals, fat, malt flour, soya flour, yeast foods, emulsifiers, milk and milk products, fruit, gluten. (Kent, 1982).

2.12 Bread in human life

Leavened bread from wheat flour has been eaten in the Mediterranean Basin for at least 3,000 years since it is in particular a pleasing food with numerous advantages over other staple foods. The habit of eating bread has spread
Nutritionally, the product is superior, particularly in protein and vitamin content, to other staple foods such as rice and potatoes...etc. As with other staple foods, bread is rarely eaten alone but rather in sandwich form. It acts as a vehicle for protein and vitamin-rich materials such as meat and cheese. (Dendy et al. 1973)

2.12.1 Bread technology

Bread-making industry is not a modern discipline, but the improvements of its techniques cause slowly-lately, the changes in human food habit. Through the increased consumption of bread is derived in part, form the convenience and whole someness of bread and a result of the improvements in the transport infrastructure as well. (Dendy, 1992).

Also, the migration phenomena from country to the urban sites has imposed the spread out of the habit of eating bread consequently, in most developing countries many flour mills are built to process wheat and thus sustaining the bread eating habit.

Edwards (1970) reported that the earlier produced breads, which differ in quality from the light airy ones we enjoy, is mainly the result of the increased technical knowledge in bread-making acquired nowadays.

2.12.2 Types of bread

There are many kinds of bread peculiar to different countries because they have different characteristics in materials, methods of making and taste.
2.12.2.1 Whole meal bread
A short fermentation system is generally used for whole meal bread. For example, the dough might be allowed to ferment for 1 hour before knocking back, with 30 min to scaling and molding, at an appropriate yeast level and temperature (Kent, 1982).

2.12.2.2 Conventional bread
In this type of bread: flour, water, yeast and salt are considered the principal ingredients of bread, while other minor ingredients may be added intentionally depending on the type of bread in question. The optional ingredients used most frequently are sugar, milk and shortening, all of which improve the quality of white pan bread. In addition, small amount of dough conditioners are often used by bakers (Grjwoid, 1962).

2.12.2.3 Flat bread
This is any type of crisp bread product manufactured from wheat flour by a continuous extrusion cooking process. In this process, the flour of about 16% moisture content is heated and sheared to form a fluid melt at 130-160°C in which starch forms the continuous phase. After extrusion, it forms a continuous strip of expanded foam "specific volume 7.10 ml/g" (Kent and Evers, 1994).

2.12.2.4 Malt bread
There are several proprietary products available, which only require water and yeast to be added to produce acceptable malt bread. The recipes given should make a stiff dough, which during fermentation will soften. Then should feel quite sticky but this is usual. All malt bread requires slow baking, preferably in a falling temperature. The heavier malted types require an even
lower temperature. The slow baking necessary with this type of bread, demands a long baking time (Hanneman, 1980).

2.12.2.5 Wheat germ bread

This is made from white flour with the addition of not less than 10% of processed germ, which has been heat-treated to destroy glutathione, a component, which has an adverse effect on bread quality. A fermentation process to in activate glutathione, as an alternative to heat treatment, was described in Australia in 1940 (Kent, 1982).

2.12.2.6 Gluten bread: high-protein bread

These breads are made by supplementing flour with a protein source, such as wheat gluten, whey extract, casein, yeast, soya flour, Procea and slimcea are proprietary breads in which the additional protein is provided by wheat gluten. In the U.K. high-protein bread, and protein bread must contain not less than 22% protein, while gluten bread must contain not less than 16% protein (Kent, 1982).

2.12.2.7 Granary bread

This is a proprietary bread made from a mixture of wheat and rye which has been allowed to sprout, Klin dried and rolled. To this barley, malt is added (Kent, 1982).

2.12.2.8 Dietary bread (high fiber bread)

This bread has both higher fiber content and fewer calories per unit than normal bread. The high fiber content is achieved by addition of various supplements, such as cracked or kibbled wheat, wheat bran hulls of field peas, or powdered cellulose. A type of cellulose used in U.S.A called Solka-
Floc, is delignified alpha-cellulose obtained from wood, Usage levels are 5-10%. Its use in bread is not currently permitted in the U.K (Kent, 1982).

2.12.2.9 High starch bread

Flour milled from local crop is used with imported wheat supply to save some of the foreign currency. This arrangement is particularly appropriate for developing countries, which do not grow wheat. Satisfactory bread can be made from such composite flour, a blend of wheat flour with flour of either cereals such as maize, sorghum, millet or rice or with flour from root crops such as cassava (Kent and Evers, 1994).

Possible levels of substitution as percentage by weight of the composite flour, are 15-20% for sorghum flour and millet flour, 20-25% for maize is possible by the use of bread improvers or by modifying the bread making process. A more economical blend, producing acceptable bread, is 50%, 10% and 40% of wheat, rice and cassava flours, respectively (Bean and Nishita, 1985). Bread of acceptable quality is being made in Senegal and Sudan from a blend of 70% imported wheat flour of 72% extraction rate and 30% of flour milled locally from white sorghum of 72-75%) extraction rate and also can be made at even higher rate of substitution. The use of hardened fat or margarine (2% on flour weight basis) and emulsifiers, such as lecithin or stearates are recommended to achieve good bread quality (Kent and Evers, 1994).

2.12.2.10 Bread fortified with micronutrients

A major contribution to nutrition in the US was made by the bread enrichment programme. During the 1930s' public health authorities were greatly concerned by the alarming incidence of nutritional deficiency diseases such
as pellagra and beriberi; iron-deficiency anaemia was widespread, as was riboflavin-deficiency, first recognized in 1938 (Sebrell, 1966).

The Food and Nutrition Board of the National Academy of Sciences (NAS/NRC) suggested in 1974 that cereal-grain products should be fortified with six vitamins and flour minerals in view of the many changes in consumption patterns, food technology and marketing and the new information concerning the nutritional status of the US population. The Board's proposal was a timely upgrading of the enrichment programme of cereal-grain product. Furthermore, Because about 26% of daily caloric intake comes from cereal-grain products, these products can improve the nutritional level of population groups that need improvement most.

Currently, many cereal-grain products are fortified only with thiamine, niacin, riboflavin and iron with calcium as optional nutrient. The new recommendation also included vitamin A, pyridoxine (B₆), folic acid, calcium, magnesium and zinc.

Bread was fortified with the full vitamin, mineral supplement, its stability during baking and storage was excellent. No off flavour was noticed by trained taste panelists in bread stored for five days at room temperature or for four weeks at freezer temperature (Emodi and Scialpi, 1980).

The feasibility of fortifying flour, bread, rice and corns products with suggested nutrients was reported earlier. Other nutrients have been proposed as candidates for the bread enrichment programme. For instance, it has been suggested that with vitamin E, vitamin B₆ and lysine (Rubin, 1966).
Chapter Three

Materials and Methods

3.1 Materials:

Three local wheat Cultivars, Debeira, ElNiEilain and Sasaraib were obtained from Agricultural Research Corporation (A R C) (Harvest season 2002/2003). Wheat bran was obtained from Sayga flour Mills (Khartoum) other food materials: yeast, salt, sugar, shortening and ascorbic acid were purchased from the local market (Khartoum). All chemicals and reagents were liberally donated by Food Research Center (F R C) laboratories.

3.2 Methods

3.2.1 preparation of food materials.

3.2.1.1 wheat flour:

Cleaning of wheat grains was done by aspiration sieving and manual separation of impurities by hand. For obtaining uniform seeds, 2.8 micron sieve was used for removing small grains. A sample of each cultivar was ground in falling number A.B. mill to whole wheat flour (100% extraction rate). Also another sample of each cultivar was tempered to 13.5% moisture for 24 hours; then milled in Barbender Quadrumat junior mill (Regulation-No (1) to white flour, the flour was adjusted to 72% extraction rate by adding the right amount of ground and sieved bran of the same wheat. Each sample was well mixed and placed in air-tight plastic container, then stored under appropriate conditions (Deep freezer); until used. (plate 1)

3.2.1.2 Wheat bran:

Wheat bran was sieved and separated to pass through a special plan sifter (sieves 355, 500 and 710 micron). The throughs were classified as fine bran
Plate 1. Debeira, El-Nielain and Sasaraib Grains
over 355 micron sieve (Tyler standard screen scale, opening in inches. 0138 meshes to the inch 42 U.S.A. series equivalent 45 OH1044060 U.S.A) and over 500 micron sieve (Tyler standard screen scale testing sieve opening in inch .0195 meshes to the inch 32 U.S.A series Equivalent 35 OH1044060 U.S.A) were classified as medium bran and the overs of the sieve No. 710 (Tyler standard screen scale opening in inches.027 meshes to the inch 24 U.S.A series Equivalent 25 OH1044060 U.S.A) were classified as coarse bran, each of wheat bran mixed well and stored in air- tight plastic container at a Deep freezer until used. (plate 2).

3.2.1.3 Fermented wheat bran:

The wheat bran ( coarse, medium and fine wheat bran) ,each of them was mixed with 2 % dry yeast and 30 ppm Ascorbic Acid, then covered with water and well mixed. After that they were Placed in an incubator at 30°C for 4 hours ( incubator RO -8 memmerr made in western Germany ) and bran was spread on a wide tray then placed in an oven ( oven Heraeus Type T5050 Fabrik –Nr 8204271 ) at 70°C until dry. Each of the sample packed in polyethylene bags and stored at a deep freezer until used.( plate 3).

3.2.1.4 Blends of wheat flour and wheat bran.

The wheat brans ( fermented and non fermented wheat bran ( coarse, medium and fine) were added to wheat flour ( Debeira wheat flour, El Nielain wheat flour and sasaraib wheat flour) as follows percentage 10% , 15% and 20% .
Plate 2. Non – Fermented Wheat Bran

NON- FERMENTED COARSE WHEAT BRAN

NON- FERMENTED MEDIUM WHEAT BRAN

NON- FERMENTED FINE WHEAT BRAN
Plate 3. Fermented wheat bran

FERMENTED COARSE WHEAT BRAN

FERMENTED MEDIUM WHEAT BRAN

FERMENTED FINE WHEAT BRAN
3.3 Preparation of Bread samples

The various wheat / wheat bran flour blends and the control (0.0% wheat bran) were fermented and baked according to the procedure described by Badi et al. (1978) The modified formula used is as follows:

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat flour</td>
<td>100%</td>
<td>90%</td>
<td>85%</td>
<td>80%</td>
</tr>
<tr>
<td>Wheat bran</td>
<td>0</td>
<td>10%</td>
<td>15%</td>
<td>20%</td>
</tr>
<tr>
<td>Water</td>
<td>F.W.A+3%</td>
<td>F.W.A+6%</td>
<td>F.W.A+6%</td>
<td>F.W.A+6%</td>
</tr>
<tr>
<td>Sugar</td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>Salt</td>
<td>1%</td>
<td>1%</td>
<td>1%</td>
<td>1%</td>
</tr>
<tr>
<td>Yeast</td>
<td>1%</td>
<td>1%</td>
<td>1%</td>
<td>1%</td>
</tr>
<tr>
<td>Shortening</td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>Improver</td>
<td>80 ppm</td>
<td>80 ppm</td>
<td>80 ppm</td>
<td>80 ppm</td>
</tr>
<tr>
<td>Ascorbic acid</td>
<td>80 ppm</td>
<td>80 ppm</td>
<td>80 ppm</td>
<td>80 ppm</td>
</tr>
</tbody>
</table>

Where:

F.W.A = Farinograph Water Absorption

The tap-water was used according to farinograph water absorption plus 3% and 6% water were added to wheat flour and wheat flour with bran respectively. All ingredients were then weighed and mixed to form a dough in Mono-universal laboratory dough mixer for 5 minuets at medium speed, the dough was allowed to rest 10 minutes at room temperature (30°C) and then it was scaled to three portions of 120 g each. The three dough portions were made into round balls and allowed to rest for another 15 minutes then molded and put into a pan and placed in the fermentation cabinet for final Proof between 50-60 minutes. Baking was done in Simon Rotary Test Oven at
220°C with saturation of steam. Baking time was 10-15 minutes, after one hour the loaves were weighed in grams, and the volumes were measured in ml using the Millet seed displacement method (Volumeter) the specific bread volume (volume per unit weight) was expressed in ml/gm. Different types of breads were prepared using wheat flour blends with Non fermented wheat bran and with fermented wheat bran with different particle size and different percentages, also whole wheat bread prepared as control sample. The loaves sliced with an electric knife and slices were kept closed in polyethylene bags at room temperature for sensory evaluation in the same day.

3.4 Analytical methods

3.4.1 Proximate Composition

3.4.1.1 Moisture content

The moisture content was determined according to the method of AACC (1983) using Buhler Rapid Moisture tester (type ML I-1000). Ten grams of sample was placed on pan, when the oven temperature reached 130°C. After 10 minutes, the reading of moisture percentage was directly obtained from scale reading.

3.4.1.2 Ash content

The ash content of the sample was measured according to the A.O.A.C method (1990) using muffle furnace (model Tipoformo ZA No. 18203 Gef Ran 1001), 2 gms of sample was weighed into porcelain crucible and placed in a temperature controlled furnace at 600 °C for complete ashing, the crucible with ash was transferred directly to a dessicator, cooled, weighed and calculated as percent of original weight of sample.

Ash content ( % ) = \( \frac{(wt_1-wt_2)}{\text{Sample weight}} \times 100 \)
3.4.1.3 Protein content

The protein content of the samples was determined by the micro kjedahl technique according to the A.O.A.C method (1984). 0.2g of sample was weighed accurately into micro -kjeldahl flask, 0.4 g catalyst mixture and 3.5ml of concentrated sulphuric acid were added, the sample and content were heated on an electric heater for 2 hr and cooled, then the contents were placed into the distillation apparatus. Twenty ml 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 (0.02 N) using universal indicator (methyl red + bromo cresol green), the total nitrogen and protein were calculated using the following formula.

\[ N\% = \frac{\text{Volume of HCL} \times N \times 14 \times 100}{\text{Weight of sample} \times 1000} \]

\[ P\% = N\% \times 6.25 \]

Where,

- \( N\% \) = crude nitrogen
- \( P\% \) = crude protein
- \( N \) = normality of HCL
- 14 = equivalent weight of nitrogen.

3.4.1.4 Fat content

Total fat was determined according to the A.O.A.C method (1984). 2g sample was extracted with petroleum ether BP 60 -80 °C for 8 hr. in soxhlet apparatus. The fat content was calculated according to the following equation.
Fat % = \( \frac{w_2 - w_1}{\text{wt of sample}} \times 100 \)

where:

\( W_1 = \) weight of empty flask

\( W_2 = \) weight of flask with oil

3.4.1.5 Crude fiber :-

The Crude fiber content was Carried out by the method of AOAC (1984). 2.7 to 3.0 g of the dried and defatted sample, were transferred to a 600 ml beaker with a few anti-bumping granules. The sample was digested with 200 ml of 0.255 N sulphuric acid for exactly 30 minutes, and the beaker was periodically swirled. The Contents were removed and filtered through buchner funnel, and washed with boiling water. The digestion was repeated using 200 ml of 0.313 N sodium hydroxide for 30 minutes, and treated similarly as above. After that the fiber was washed with 1 % hydrochloric acid to neutralize the sodium hydroxide and then rinsed with distilled water. After the last washing the residue was transferred to ashing dish, and dried in an oven at 103 °C for one hour then cooled and weighed. The dried residue was ignited in muffle furnace at 500°C over night, cooled and reweigh. The crude fibre was calculated using the following equation:

\[ \text{CF} \% = \frac{W_1 - W_2}{WS} \times 100 \]

Where:

\( \text{CF} \% \) = crude fibre

\( WS = \) weight of sample

\( W_1 = \) weight of curucible with sample.

\( W_2 = \) weight of curucible with ashed sample.
3.4.1.6 Carbohydrate content

The total carbohydrates were calculated by difference according to Pearson (1976) using formula; total CHO = 100-( moisture % + fat % + protein%+ ash%).

3.4.1.7 Determination of Mineral content

3.4.1.7.1 Determination of Calcium and Iron (Ca and Fe)

According to Pearson (1970) mineral contents were determined by the Atomic Absorption spectrum (A.A.S) model GBC 932 plus, which consist of:-

1- Hollow cathode lamp as source of electromagnetic ray.
2- Monochromator
3- Nebulizer
4- Spray chamber
5- Burner

This apparatus was connected with a compressor for air and an Acetylene cylinder. A software program controls the whole analysis process.

Preparation of sample:

One gram of sample put into a weighed porcelain crucible, the crucible were placed in a muffle furnace at 550°C for six hours each crucible was cooled in the dessicator and weighed.

The ash obtained was treated with 10 ml concentrated hydrochloric acid, added to it 1 ml of nitric acid, then put on sand path or heater to dissolve, cooled and transferred to 100 ml-Volumetric flask filled to mark with distilled water, then well shaked. After prepare the sample, which is desired to determine an element concentration on it, the hollow cathode lamp was selected according to which element concentration is searched, because
each element has specific hollow cathode lamp. The acetylene cylinder was
opened and compressor was adjusted the ratio of inlet, was 2:8 units for
acetylene and air. The software is provided with parameters such as
element, which is searched, wavelength and number of sample with labels.
the burner is ignited to create a satiable flame of Air-Acetylene. Through this
flame ray of electromagnetic from hollow Cathode lamp passed. The sample
is provided to instrument through sample capillary tube when the sample
reach the flame is changed to gaseous state and then free atoms. These free
atoms absorb apart of the electromagnetic ray.

**Preparation of standard Curve(Ca,Fe)**

From standard solution concentration, various dilutions were prepared.

**Calculation:**

Metal content (ppm) = Dilution factor x reading from (A. A. S).

\[
\text{Dilution factor} = \frac{\text{volume of stock solution} \times \text{Vol. of solution taken for reading}}{\text{sample weight} \times \text{Volume taken for sample}}
\]

**3.4.1.7.2 Determination of phosphorus :**

Phosphorus was Determined by the spectrophotometer CECIL CE 1021 1000
Series according to person (1970).

**Preparation of the sample**

One gram of sample was weighed, 25 ml of HCL + 10 ml of HNO₃ were
added, covered, Heated gently, Evaporated to 5 ml, cooled, 5 ml of HCLO₄
were added, taken to fuming, cooled, 25 ml of deionized water were added,
boiled, filtered into 250 ml volumetric flask, 10 ml into 100 ml volumetric flask
was pipetted, 20 ml of reagent added, fitted to mark, shaked well. read at 460
nm after 1 hour.
Reagents

1- Vanomolybdate solution, Dissolve 35 gm of ammonium molybdate in 350 ml of distilled water, dilute to 500 ml.

2- Volumetric flask, dissolve 1.12 gm of ammonium Vanadate in a mixture of 240 ml of HCLO₄ acid, and 260 ml of distilled water, add 1 to 2, mix well.

Standard solution.

Weighed 0.3835 gm of dried potassium Hydrogen phosphate into 1 liter distilled water, this solution contains 0.2 mg P/ml (phosphorus).

3.5 Anti-nutritional factor

3.5.1 Tannin content

The rapid visual technique ( price and Butler 1978 ) was used to quickly distinguish between zero, low, intermediate and high tannin sample by development of shades of yellow, green and blue color.

Quantitative estimation of tannins was carried out using modified vanillin -HCL in methanol and 1 % vanillin / methanol, the reagent was prepared daily by mixing equal volume of 1 % vanillin / methanol fresh and 8% conc. HCL/ methanol, it was discarded if a trace of color appeared.

D(+) catechin was used to prepare the standard curve. this was done by adding 100 mg of D + catechin to 50 ml of 1 % HCL / methanol, from this stock solution, various dilutions were prepared, 5ml of vanillin / HCL reagent (0.5%)

Were added to 1 ml of each dilution. The absorbance was read using spectrophotometer (Jenway 6305 U V / Vis. Spectrophotometer) . At 500 nm after 20 min. at 30°C from addition of reagent, the absorbance was plotted against catehin concentration.

A 0.2 gm of the sample was put in a test tube then 10 ml of 1% conc. HCL in methanol were added. The test tube was capped and continuously shaken for 20 minutes in a mechanical shaker ( gerhardt schuttelmaschine RO10 Type RO10, Gerhardt Bonn App Nr208569 ) and then centrifuged at 2500 rpm for 5 minutes (Bench centrifuge BTL made in England). One ml of the
supernatant after centrifugation was pipetted into each of the tubes and then proceeding as was described in standard above. For zero setting, before absorbance was read, 1 ml blank solution was mixed with 5 ml 4% conc-HCL and 5ml vanillin reagent in a test tube and incubated for 20 minutes at 30°C (blank) (incubator RO -8 memmerr made in Germany). Absorbance at 500 nm was read on spectrophotometer (Jenway 6305 UV/Vis. Spectrophotometer), and concentration of condensed tannin was determined from the standard curve.

Tannin concentration was expressed as catechin equivalent (CE) as follows:-

\[ \text{C.E} \% = \frac{C \times 10 \times 100}{200} \]

where:

- \( C \) = concentration corresponding to the optical density
- 10 = volume of extract (ml)
- 200 = sample weight (mg)

### 3.5.2 Phytic Acid content

Phytic acid was determined by the method of wheeler and ferrel (1971), phytic acid was extracted in low acid media, then precipitated as ferric phytate by addition of Fe CL₃ which was converted to Fe (OH)₃ by addition of NaoH. The ferric hydroxide was dissolved as Fe(N0₃)₃ through addition of HNO₃. Fe(N0₃)₃ was measured optically. The phytate phosphorus was calculated assuming a 4:6 iron: phosphorus ratio. Two gm of milled dried sample were weighed in 125 ml conical flask. 50 ml of 3 % tri-chloro acitic acid (T.C.A) were added to the flask, then put in a mechanical shaker for 3 hours (shaker gerhardt schuttel maschine RO10 type Ro10 Gerhardt Bonn APP. Nr 208569) The suspension was centrifuged for 5 minutes (Bench centrifuge BTL and B & T made in England).
Ten ml aliquot of the supernatant were transferred to 40 ml tube, 4 ml of FeCl₃ solution were added by pipette (FeCl₃ solution containing 2 mg Fe⁺³ ions / ml T.C.A). The tube was heated in a boiling water bath for 45 minutes, then cooled and centrifuged for 10-15 minutes.

The clear supernatant was decanted, the precipitate was washed twice by dispersing well in 25ml 3% T.C.A. heated for 10-15 minutes in a boiling water bath, then centrifuged.

The washing was repeated once more using water, the washed precipitate was dispersed in water and 3 ml of 1.5 N NaOH was added with mixing, water was added till 30 ml volume, then the tube was headed in a boiling water bath for 30 minutes and hot filtered using whatman No 2, the precipitate was washed with hot H₂O, the washing was decanted. The precipitate was dissolved from the paper with 40 ml hot 3.2 N HNO₃ into 100 ml volumetric flask, The paper was washed with H₂O, the washing was collected in the same flask then completed to volume. 0.5 ml aliquot was taken from the above solution and transferred into 10 ml volumetric flask, then 2 ml 1.5 N KSCN was added and completed to volume by H₂O, then immediately read in a spectrophotometer (Jenway 6305 U V / Vis. Spectrophotometer) within 1 minute at 480 nm.
Calculations

A standard curve of different Fe(NO$_3$)$_3$ concentrations was plotted to calculate, the Fe$^{+3}$ concentration, the phytate phosphorus was calculated from the Fe$^{+3}$ Concentration assuming 4:6 iron:phosphorus.

<table>
<thead>
<tr>
<th>ml standard</th>
<th>Conc. ppm Fe</th>
<th>A</th>
<th>Conc./A=K</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5</td>
<td>3</td>
<td>0.44</td>
<td>6.818</td>
</tr>
<tr>
<td>2.5</td>
<td>5</td>
<td>0.92</td>
<td>5.435</td>
</tr>
<tr>
<td>3.5</td>
<td>7</td>
<td>1.06</td>
<td>6.604</td>
</tr>
<tr>
<td>4.5</td>
<td>8</td>
<td>1.45</td>
<td>5.517</td>
</tr>
</tbody>
</table>

Mean k = 6.0935

Phytic acid = $\frac{6 \times A \times \text{mean } k \times 20 \times 10 \times 50 \times 100}{4 \times 1000 \times 2}$  mg p/100g sample

A = optical density

3.6 Dough Characteristics

3.6.1 Gluten content

Gluten content of whole and white flour was determined according to the ICC method (1982) by Glutomatic instrument (Type 2200). Ten grams: ± 0.01 of the sample were mixed with 5 ml distilled water for 20 seconds in a test chamber with bottom sieve. The dough was first washed with 2 % NaCl for 15 minutes and then with distilled water which was automatically controlled. The gluten ball obtained was centrifuged for a minute by centrifuge (Type 2015 Gluten Index) and then weighed to give wet gluten. It was then dried in a heater (Glutork 2020 -Glutimer) to give the dry gluten.
Calculation :-

The percentage of wet gluten remaining on the sieve is defined as the gluten index and is calculated in the following way: -

\[
\text{Gluten Index} = \frac{\text{gluten remained on sieve (g)} \times 100}{\text{Total gluten (g)}}
\]

The wet gluten content expressed as a percentage of the mass of the original sample is calculated in the following way: -

\[
\text{Wet gluten} = \frac{\text{tot. gluten (g)} \times 100}{10 \text{ (g)}} = \text{tot gluten} \times 10
\]

The dry gluten content in percent is calculated in the following way: -

\[
\text{Dry gluten} = \text{weight of dry gluten} \times 100
\]

3.6.2 Falling number (seconds)

Alpha -amylase activity in whole or white flour, was determined according to Perten (1996) manual falling number ( 1800- Specialists in systems for quality control of grain and flour -Perten Instruments ).

Appropriate flour sample weight, was weighed and introduced into cleaned and dried falling number tube. Then 25 ± 0.2 ml distilled water were added, the stopper was fitted into the top of the viscometer, and shaked well ( 20 -30 times or more if necessary) , until a homogenous suspension was formed. The viscometer tube was placed in the boiling water-bath, and locked into position.

The test automatically starts. The sample was stirred for 60 seconds, the viscometer stirrer was stopped in an up position, released and sanked under its own weight through the uniform gelatinized suspension. The time in seconds for the stirrer to fall through the suspension was recorded as the falling number (seconds) the required flour sample weight ( R. W ) , is obtained from the correction tables of sample weight to 14 % moisture basis.
(ICC 107/1, 1995) and AACC 56-81B, (1992), corresponding to 7g at 14% moisture. No change is made in the quantity of the water used (25 ml).

**Calculations:**

\[
(\text{R.W.}) \ g = 7 \times \frac{(100 - 14)}{(100 - m)}
\]

where:

\(m\) = Actual moisture percentage of the flour sample

\(\text{R.W.}\) = The required flour sample weight used for determination

**3.6.3 Farinograph of Dough**

The rheological properties of the doughs prepared from wheat flour (control) and the blends were estimated using the Brabender farinograph method (Brabender OHG, Kulturte, 51-55, D-47055, Duisburg, Germany) according to the method of AACC (1986).

**3.6.3.1 The titration curve:**

Brabender farinograph was operated as described in AACC method (1986). 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 cleaned mixer. The farinograph was switched on 63 rpm for one minute, then the distilled water was added from a especial burette (at deviation from the 500 units consistency, the correct water absorption can be calculated from the deviation, 20 units deviation correspond to 0.5% water, if the consistency, is higher than 500 F. U. more water is needed and vice-versa).
When the consistency is constant, the instrument was switched off and the water drawn from the burette indicates water absorption of the flour in percentage.

3.6.3.2 The standard curve

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

The significant readings taken from a Farinogaph was shown in figure (1)

3.7 Evaluation of Bread quality

The different types of bread were cooled at room temperature (38±2°C) for an hour after baking and quality measures were made on triplicate loaves as follows:

3.7.1 Bread volume

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

3.7.2 Bread weight:

The loaf weight of bread was taken in gm.

3.7.3 Bread specific volume

The specific volume of the loaf was calculated according to the AACC method (1986) by dividing volume (CC) by weight (gm),
Dough Development time (min)
Dough Stability (min)
Degree of softening (F.U.)

Arrival Time (min.)
Departure Time (min.)

Fig. 1. Farinograph readings
3.7.4 Organoleptic evaluation

The bread samples were assessed organoleptically by the ranking test according to procedure described by Ihekovonye and Ngoddy (1985) with a slight modification. Fifteen panelists were served coded bread samples in dishes and asked to examine the samples and rank them for color, taste, crumb texture, crumb grain and preference.

The ranking test depends on the range of 10-9 as excellent, >9-7 is very good, >7-5 is good, >5-3 is fair and >3-1 is poor.

3.8.1 Method of statistical analysis

Analysis of variance was carried out according to the SAS (1997) system using 5% level of significance.
CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Chemical composition of wheat flours

The chemical composition of the three local wheat cultivars flour (100% and 72% extraction rates) (season 2002/2003) is shown in Tables (1) and (2).

4.1.1 Moisture content

The moisture content of the whole-wheat flour (100% extraction rate) of the Sasaraib, EI-Nielain and Debeira are found to be 7.60, 7.90 and 7.08%, respectively. These results were in agreement with values obtained by Ahmed (1995), who found that the moisture values of Sudanese wheat cultivars ranged from 6.33 to 8.86%. These values were lower than the range of 10-11 % and 11.2% reported by Badi et al. (1976) and Pereds-Lopez (1978). However, moisture content of Sasaraib and EI-Neilain agreed with that reported by Mohamed (2000) (7.65 and 7.90%). Statistical analysis of the results showed significant differences (P ≤0.05) among the three cultivars in their moisture content.

4.1.2 Ash content

Ash content of the whole-wheat flour is presented in Table (1), while Table (2) shows ash content of white wheat flour of the three cultivars.

Ash content of whole and white flours ranged from 1.44 to 1.66% and 0.43 to 0.62%, respectively. The highest value was observed in cultivar Debeira, whereas, the lowest value was observed in cultivars EI-Neilain and Sasaraib. These results are comparable with the data reported by Zeleny (1971) who reported values of ash content of the whole-wheat flour in the range of 1.4 to 2.0%. Badi et al. (1976), Badi et al. (1978) and Mohamed
Table (1): Proximate composition of the three local wheat cultivars
(harvest season 2002/03 (72% extraction rate))

<table>
<thead>
<tr>
<th>Cultivars</th>
<th>Moisture (%)</th>
<th>Protein (%) [Nx6.25]</th>
<th>Oil (%)</th>
<th>Ash (%)</th>
<th>Crude fibre (%)</th>
<th>Carbohydrates (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sasaraib</td>
<td>7.600±0.10</td>
<td>13.997±0.40</td>
<td>2.060±0.02</td>
<td>1.440±0.04</td>
<td>5.427±0.13</td>
<td>74.903±0.3</td>
</tr>
<tr>
<td>El-Nielain</td>
<td>7.900±0.00</td>
<td>13.110±0.22</td>
<td>1.797±0.01</td>
<td>1.637±0.01</td>
<td>7.630±0.07</td>
<td>75.557±0.3</td>
</tr>
<tr>
<td>Debeira</td>
<td>7.083±0.08</td>
<td>14.967±0.14</td>
<td>1.947±0.03</td>
<td>1.663±0.01</td>
<td>8.290±0.05</td>
<td>74.340±0.1</td>
</tr>
</tbody>
</table>
### Table (2): Proximate composition of the three local wheat cultivars

(harvest season 2002/03 (100% extraction rate)

<table>
<thead>
<tr>
<th>Cultivars</th>
<th>Moisture (%)</th>
<th>Protein (% [Nx6.25])</th>
<th>Oil (%)</th>
<th>Ash (%)</th>
<th>Crude fibre (%)</th>
<th>Carbohydrate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sasaraib</td>
<td>13.567±0.06</td>
<td>12.673±0.02</td>
<td>1.170±0.03</td>
<td>0.527±0.02</td>
<td>3.060±0.06</td>
<td>72.0±0.06</td>
</tr>
<tr>
<td>El-Nielain</td>
<td>13.567±0.06</td>
<td>10.443±0.02</td>
<td>0.923±0.01</td>
<td>0.427±0.01</td>
<td>2.640±0.00</td>
<td>74.6±0.04</td>
</tr>
<tr>
<td>Debeira</td>
<td>13.733±0.06</td>
<td>13.077±0.05</td>
<td>0.867±0.02</td>
<td>0.623±0.01</td>
<td>5.100±0.04</td>
<td>71.7±0.06</td>
</tr>
</tbody>
</table>
(2000) reported that the ash content of Sudanese wheat cultivars ranges between 1.38-1.84%, 1.2-1.8% and 1.35-1.52%, for whole wheat flours. Egan et al. (1981) found that ash content of whole wheat flours ranged between 1.2 and 1.8% and for white flour (72% extraction rate) about 0.45%.

The ash content of Sasaraib was lower than that reported by Abdallah (2002) who reported ash content as 1.5%. Ahmed (1995) reported that ash content of whole and white flour (72% extraction rate) of different Sudanese cultivars ranged between 1.03 and 1.24%, 0.31 and 0.47% respectively. Analysis of variance showed significant differences (P≤0.05) among flours (100% extraction rate) and wheat flours (72% extraction rate) in their ash content of the three cultivars.

4.1.3 Protein content

Protein content of the whole flours is illustrated in Table (1), while Table (2), shows the protein content of white flour, of the three cultivars grown in season 2002/2003. Protein content of the whole-wheat flour, was found to be in the range of 13.11 to 14.97%. The highest value was observed in cultivar Debeira, whereas cultivar EI-Nielain gave the lowest value. Protein contents of white flours ranged from 10.44 to 13.08%. Cultivar Debeira gave the highest value, whereas EI-Nielain gave the lowest value. Statistical analysis of the results, has shown significant differences (P≤0.05) among the three cultivars in their protein values of the whole and white flours. These results were in good agreement with the values reported by Ahmed (1995) and Mohamed (2000) who reported that protein content of whole flour of different Sudanese cultivars ranged between 12.38 and 15.32% and 12.59 to 14.82% and protein content of white flour ranged from 11.79 to 13.85%. While
Quisenberry and Reitz (1967) reported that protein contents of wheat flours (100, 80 and 72% extraction rates) are 13.3, 12.0 and 11.8%, respectively. Moreover, protein content of Sasaraib gave higher value than the protein content reported by Abdallah (2002)( 12.1) . This may be due to the season in which wheat cultivars were grown.

4.1.4 Crude fibre content

Fibre values of the whole flour of the three cultivars were shown in Table (1), whereas Table (2) shows fibre content of white flour. Fibre contents of the whole and white flours ranged from 1.967 to 2.033%, 1.65 to 1.85%, respectively.

These results are comparable with those reported by Zeleny (1971) and Saundres (1983) who found that the crude fiber values ranged from 2.0 to 2.7% and 1.60 to 2.45%, respectively. Egan *et al*, (1981): Ahmed (1995) and Mohamed (2000) found that the crude fiber content for whole flour were in the range of 1.8 to 2.5%, 1.75 to 2.34 and 1.85 to 2.25%, respectively.

Statistical analysis of results, showed no significant differences among the whole and white flours of the three cultivars in their fiber content, (Pr≤0.05)

4.1.5 Fat content

Fat values of the whole-wheat flour are presented in Table (1), whereas fat values of white wheat flour of the three cultivars are shown in Table (2). Fat contents of the whole and white flours were found to be in the range of 1.80 to 2.06% and 0.87 to 1.17%, respectively. The highest value was observed in cultivar Sasaraib, whereas Debeira and El-Nielain cultivars gave the lowest value.
These results were in good agreement with the values reported by Elagib (2002) who reported that fat content of El-Nelain and Debeira cultivars was 1.8 and 2.0%, respectively. These results are comparable with those reported by Quisenberry and Reitz (1967) who reported that oil content of wheat flours (100, 80 and 72% extraction rates) are 2.0, 1.3 and 1.2%, respectively.

Moreover, these values agreed with the result reported by Ahmed (1995) who reported that fat content of Sudanese wheat cultivars ranges between 1.91 and 2.36% for whole-wheat flour, and between 0.85 and 1.73% for white flour (72% extraction rate). Mohamed (2000) stated that fat content of Sudanese wheat cultivars ranges between 2.15 and 2.35% for whole wheat flour, and between 1.33 to 1.43% for white flour (72% extraction rate). Analysis of variance showed significant differences (P≤0.05) among the three cultivars in their fat content of the whole and white flours.

4.1.6 Carbohydrates

The results of carbohydrates content of the whole wheat flour and white wheat flour of the three cultivars are shown in Tables (1) and (2). Carbohydrates content of the whole and white flours were found to be in the range of 74.34 to 75.56 and 71.70 to 74.64%, respectively. The highest value was observed in cultivar El-Nielain, whereas Debeira cultivar gave the lowest value.

These results were in good agreement with the values reported by Elagib (2002): Mohamed (2000) and Abdallah (2002), Who reported that the carbohydrates of El-Neilain and Debeira cultivars were 80.6 and 77.65%, and
for four Sudanese wheat cultivars ranged between 72.20 and 80.1 \%, and for two wheat cultivars 73.865\% and 73.854\%, respectively.

4.2 Falling number

The falling number of whole and white flours of the three cultivars are shown in Tables (3) and (4). Alpha-amylase activity of the whole and white flours was found to be in the range of 394 to 471 seconds and 516 to 639 seconds respectively. The highest value was observed in cultivar Debeira (low alpha-amylase activity), while the lowest value was observed in EI- Nielain cultivar (high alpha-amylase activity).

Analysis of variance showed no significant differences ($P \leq 0.05$) between Sasaraib and EI-Nielain (100\% extraction rate) and there was a significant difference between Debeira and the other cultivars (100\% extraction rate). But the three cultivars showed significant differences ($P \leq 0.05$) in falling number of wheat flours (72\% extraction rate).

These results were relatively in good agreement with the data reported by Badi et al. (1978) who found that the falling number values of Sudanese wheat cultivars were abnormally high in the cultivars compared with European and American wheats.

Mohamed (2000) stated that falling number values of Sudanese wheat cultivars ranges between 432 to 655 seconds for whole wheat flour, and between 425 to 675 seconds for white flour respectively.

Ahmed (1995) showed that falling number values of some Sudanese wheat cultivars were found to be in the range of 397 to 482 seconds for whole flour, 396 to 486 seconds for white flour (72\% extraction rate).

Lukow and McVett (1991) observed that the falling number of hard red spring wheat cultivars ranges between 203 and 332 seconds. Kaldy and Rubenthaler (1987) found that the falling number of soft white winter and spring wheats ranged between 380 and 451 seconds, 111 and 479 seconds, respectively.
<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Falling number (sec.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sasaraib</td>
<td>395.000±10.15</td>
</tr>
<tr>
<td>El-Nielain</td>
<td>394.000±4.58</td>
</tr>
<tr>
<td>Debeira</td>
<td>470.667±11.37</td>
</tr>
</tbody>
</table>

100% extraction rate  

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Falling number (sec.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sasaraib</td>
<td>569.333±22.90</td>
</tr>
<tr>
<td>El-Nielain</td>
<td>516.667±8.62</td>
</tr>
<tr>
<td>Debeira</td>
<td>639.333±1.53</td>
</tr>
</tbody>
</table>

72% extraction rate  

*
From these results it could be observed that the values of falling number of the three cultivars, were relatively high (low alpha – amylase activity), and the falling number of white flour is higher than the falling number of the whole flour and this may be due to the rate of extraction (percentage of bran in flour).

4.3 Gluten quantity and quality

Wet and dry gluten values of the whole wheat flour are presented in Table (5), whereas Table (6) shows the wet and dry gluten values of the white flour. Wet gluten contents of the whole and white flour were found to be in the range of 22.28 to 29.57 and 26.25 to 29.81, respectively. Sasaraib cultivar gave the highest value, whereas the lowest value was observed in El-Nielain cultivar. Dry gluten values of the whole and white flour ranged from 7.366 to 9.6041 and 9.422 to 10.12 respectively. The highest value was observed in Sasaraib, whereas El-Nileain cultivar gave the lowest value. These results are comparable with those obtained by Huebner and Rothfus (1968) who found that dry gluten yields from different cultivars ranged from 9 to 11 % for hard wheats and 6.5 to 8.0% for soft wheats. Kulkarni et al. (1987) reported that the percentage of dry gluten ranged from 9.4 to 15.1% and 11.7 to 15.3% for hard red winter and hard red spring wheat, respectively. Wet gluten ranged from 25.9 to 42.0% for winter wheat, and from 31.0 to 41.9 for spring wheat. Mohamed (2000) found that wet gluten contents of the whole and white flours Sudanese cultivars (season 1997/98) in the range of 26.2 to 31.9% and 32.6 to 38.77%, respectively, and the dry gluten values of the whole and white flours ranged from 8.2 to 9.9% and 10.1 to 11.9%, respectively.
Table 5. Gluten quantity and quality(%) of the three local wheat cultivars* (harvest season 2002/03) (100% extraction rate)

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Wet gluten</th>
<th>Dry gluten</th>
<th>Gluten index (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sasaraib</td>
<td>29.571±0.41</td>
<td>9.604±0.16</td>
<td>50.273±2.64</td>
</tr>
<tr>
<td>El-Nielain</td>
<td>22.275±0.43</td>
<td>7.366±0.04</td>
<td>23.869±0.75</td>
</tr>
<tr>
<td>Debeira</td>
<td>28.478±0.51</td>
<td>9.455±0.18</td>
<td>54.661±1.22</td>
</tr>
</tbody>
</table>

100% extraction rate

Table 6. Gluten quantity and quality(%) of the three local wheat cultivars* (harvest season 2002/03) (72% extraction rate)

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Wet gluten</th>
<th>Dry gluten</th>
<th>Gluten index (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sasaraib</td>
<td>29.807±0.17</td>
<td>9.952±0.05</td>
<td>71.805±1.95</td>
</tr>
<tr>
<td>El-Nielain</td>
<td>26.252±0.76</td>
<td>9.422±0.21</td>
<td>63.048±1.31</td>
</tr>
<tr>
<td>Debeira</td>
<td>28.760±0.59</td>
<td>10.119±0.28</td>
<td>92.207±1.91</td>
</tr>
</tbody>
</table>

72% extraction rate
Analysis of variance showed significant differences (P≤0.05) among the three cultivars in their wet gluten contents, but there were no significant differences between Sasaraib and Debeira (P≤0.05) in their dry gluten content.

EI-Nielain cultivar showed significant differences (P≤0.05) in the dry gluten. Gluten index percentages of the whole and white wheat flours of the three cultivars are presented in Tables (5) and (6), respectively. Gluten index values of the whole and white flours of the three cultivars ranged from 23.87 to 54.66, 63.05 to 92.21, respectively. Cultivar Debeira gave the highest value, whereas the lowest value was observed in EI- Nielain cultivar.

Statistical analysis of results has shown significant differences (P≤0.05) among the three cultivars in their gluten index values. These results were in good agreement with the values reported by Mohamed (2000) who reported that gluten index values of the whole and white flours of the four cultivars (season 1997/98) ranged from 69.31 to 82.96% and 69.96 to 82.21 %, respectively.

From these results, it can be observed that gluten index value (gluten quality) is unaffected by the rate of extraction.

4.4 Chemical composition of non-fermented and fermented wheat bran

The chemical composition of non-fermented and fermented wheat bran is shown in Tables (7) and (8).

4.4.1 Moisture content

The moisture content of non-fermented coarse, medium and fine wheat bran was 9.78, 9.70 and 9.77%, respectively.

These results were in agreement with value obtained by Sid Ahmed (2003) who found that the moisture content of wheat bran was 9.53% and the similar value of moisture was reported by Miller (1979).
Table 7. Chemical composition of non-fermented wheat bran

<table>
<thead>
<tr>
<th>Wheat bran</th>
<th>Moisture (%)</th>
<th>Protein (%) [Nx6.25]</th>
<th>Fat (%)</th>
<th>Ash (%)</th>
<th>Crude fibre (%)</th>
<th>Carbohydrate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse</td>
<td>9.783±0.14</td>
<td>20.353±0.23</td>
<td>3.280±0.04</td>
<td>5.823±0.03</td>
<td>15.667±1.15</td>
<td>60.760±0</td>
</tr>
<tr>
<td>Medium</td>
<td>9.700±0.10</td>
<td>18.363±0.04</td>
<td>3.260±0.01</td>
<td>5.460±0.10</td>
<td>15.667±1.53</td>
<td>63.217±0</td>
</tr>
<tr>
<td>Fine</td>
<td>9.767±0.15</td>
<td>21.067±0.25</td>
<td>4.263±0.02</td>
<td>4.853±0.04</td>
<td>15.000±1.00</td>
<td>60.050±0</td>
</tr>
</tbody>
</table>
Table 8. Chemical composition of fermented wheat bran

<table>
<thead>
<tr>
<th>Wheat bran</th>
<th>Moisture (%)</th>
<th>Protein (% [Nx6.25])</th>
<th>Fat (%)</th>
<th>Ash (%)</th>
<th>Crude fibre (%)</th>
<th>Carbohydrate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse</td>
<td>5.067±0.06</td>
<td>21.650±0.28</td>
<td>1.727±0.02</td>
<td>5.487±0.02</td>
<td>18.667±0.58</td>
<td>66.070±0</td>
</tr>
<tr>
<td>Medium</td>
<td>6.800±0.10</td>
<td>20.787±0.08</td>
<td>2.777±0.01</td>
<td>5.680±0.02</td>
<td>18.000±1.00</td>
<td>63.957±0</td>
</tr>
<tr>
<td>Fine</td>
<td>7.700±0.10</td>
<td>22.400±0.10</td>
<td>3.767±0.04</td>
<td>4.983±0.08</td>
<td>17.667±1.53</td>
<td>61.150±0</td>
</tr>
</tbody>
</table>
The moisture content of non-fermented wheat bran is higher than 7.9% reported by Thompson and Weber (1979), but lower than 12.8% reported by Springsteen et al. (1977). Statistical analysis of the results showed non-significant differences (P≤0.05) among the three non-fermented wheat bran in their moisture content. The moisture content of fermented coarse, medium and fine wheat bran was 5.07, 6.80 and 7.70%, respectively. The moisture content of fermented fine wheat bran was almost similar to that reported by El-AWad (2003) 7.8% but lower than 10.4% reported by Rendleman (1982). The moisture content of fermented coarse and medium wheat bran is less than 8.9, 7.8 and 14.3% reported by Idris (1998); Ranhotra (1994) and Ranhotra (1993), respectively. Statistical analysis of the results showed significant differences (P≤0.05) among the three-fermented wheat bran in their moisture content.

4.4.2 Ash content

The ash content of non-fermented coarse, medium and fine wheat bran was 5.82, 5.46 and 4.85%, respectively. These results were in agreement with the values reported by Ellis (1981), El-AWad (2003) and Sid Ahmed (2003) who found that the ash content of wheat bran was 5.8, 5.4 and 5.1, respectively.

A value of 5.8% ash in wheat bran was reported earlier by Thompson and Weber 1979 and Mongeau and Brassard, 1986. Statistical analysis of the results showed significant differences (P≤0.05) among the three non-fermented wheat brans in their ash content.
The ash content of fermented coarse, medium and fine wheat bran was 5.49, 5.68 and 4.98%, respectively.

The ash content of fermented wheat bran is higher than 4.0% reported by Idris (1998) but less than 6.9, 6.5, 7.4, 10.3, 6.7 and 7.0% reported by Ranhotra (1994); Fellars et al, (1966); Posner (1991); Mallasy (1998); Springsteen et al, (1977) and Thompson and Weber (1979), respectively. Statistical analysis of the results showed significant differences ($P \leq 0.05$) among the three fermented wheat bran in their ash content.

### 4.4.3 Protein content

The protein content of non-fermented coarse, medium and fine wheat bran was 20.35, 18.36 and 21.07% respectively.

The protein content of non-fermented wheat bran is almost similar to that reported by El-AWad (2003) and Ellis (1981) 19.9 and 18.0%, respectively. It was higher than 17.8% for protein content of wheat bran reported by Thompson and Weber (1979).

Statistical analysis of the results showed significant differences ($P \leq 0.05$) among the three non-fermented wheat brans in their protein content. The protein content of fermented coarse, medium and fine wheat bran was 21.65, 20.79 and 22.40%, respectively.

These results were higher than 14.90, 14.3 and 12.5% reported by Ranhotra et al.(1994); Rendleman (1982) and Springsteen et al, (1977), respectively.

Mongeau and Brassard (1986) reported that wheat bran is richer in protein than other cereal brans. Statistical analysis of the results showed significant differences ($P \leq 0.05$) among the three fermented wheat brans in their protein content.
4.4.4 Crude fiber content

The crude fiber content of non-fermented coarse, medium and fine wheat bran was 15.67, 15.67 and 15.00%, respectively. El-AWad (2003) and Sid Ahmed (2003) reported that the crude fiber content of wheat bran was 9.6% and 13.33%, respectively. Crude fiber content of wheat bran 13.7% reported earlier by Sosulski and Wu (1988).

Statistical analysis of the results showed no significant differences (P≤0.05) among the three non-fermented wheat brans in their crude fiber content.

The crude fiber content of fermented coarse, medium and fine wheat bran was 18.67, 18.00 and 17.67%, respectively. These results were higher than 8.9%, 13.6% reported by Rendleman (1982) and Ellis (1981) respectively. Statistical analysis of the results showed no significant differences (P≤0.05) among the three fermented wheat brans in their crude fiber content. Mallasy (1998) and Idris (1998) reported that the crude fiber content of wheat bran was 10.4% and 7.5%, respectively.

4.4.5 Fat content

The fat content of non-fermented coarse, medium and fine wheat bran was 3.28, 3.26 and 4.26%, respectively.

These results were in good agreement with the results obtained by Thompson and Weber (1979) and Rendleman (1982) who found that the fat content of wheat bran was in the range of 3.5 to 5.2%.

These results are less than 7.2 and 5.6% reported by Mallasy (1998) and El-Wad (2003), respectively.
Statistical analysis of the results showed non-significant differences (P≤0.05) between non-fermented coarse wheat bran and non-fermented medium wheat bran but there is significant difference (P≤0.05) between these wheat brans and non-fermented fine wheat bran in their fat content.

The fat content of fermented coarse, medium and fine wheat bran was 1.73, 2.78 and 3.77%, respectively.

These results were in agreement with value obtained by Ranhotra (1994): Idris (1998) and Sid Ahmed (2003), who reported that the fat content of wheat bran was 2.7, 3.9 and 1.4%, respectively. Ranhotra (1990) reported wheat bran to contain a greater amount of fat. Statistical analysis of the results showed significant differences (P≤0.05) among the three fermented wheat brans in their fat content.

### 4.4.6 Total carbohydrates

The total carbohydrates content of non-fermented coarse, medium and fine wheat bran were 60.76, 63.22 and 60.05%, respectively. The non-fermented medium wheat bran carbohydrates were significantly (P≤0.05) higher that both non-fermented coarse wheat bran and non-fermented fine wheat bran.

The total carbohydrates content of fermented coarse, medium and fine wheat bran was 66.07, 63.96 and 61.15%, respectively. The fermented coarse wheat bran carbohydrates were significantly (P≤0.05) higher than both fermented medium wheat bran and fermented fine wheat bran.

Sosulski and Wu (1988) reported that the total carbohydrates of wheat bran were 56.9%. Also Idris (1998) reported that the total carbohydrates of deffated wheat bran were 17.1%.
4.5 Antinutritional factors in wheat bran

Tables (9) and (10) show the antinutritional factors of non-fermented and fermented wheat bran.

4.5.1 Tannin content

The tannin content of non-fermented coarse, medium and fine wheat bran was 0.03167, 0.06500 and 0.07333 mg catechin/100 gm material, respectively.

The non-fermented fine wheat bran was significantly (P ≤ 0.05) higher in tannin content than both non-fermented medium wheat bran and non-fermented coarse wheat bran.

The tannin content of fermented coarse, medium and fine wheat bran was 0.00833, 0.05000 and 0.06500 mg catechin/100 gm material, respectively (Table 10). The fermented fine wheat bran was significantly (P ≤ 0.05) higher than both fermented medium wheat bran and fermented coarse wheat bran. Babiker et al. (1993) reported that tannin content of some cultivars of faba bean plants was in the range of 0.012 - 0.067%. EI Mubarak et al. (1988) reported that the tannin content of the cultivar BF2/2 of faba bean, which was grown at Shambat and New Halfa was in the range of 0.02-0.9% and 0.03-0.05%, respectively. Al Zidany (1994) reported that tannin content of broad bean was in the range of 0.024 - 0.038%. A value of 1.1-6.9% tannin in the testa of sorghum was reported by Mwasru (1988).

Sid Ahmed (2003) reported that the tannin content of wheat, Maize and sorghum brans was 1.86, 1.13 and 2.66 catechin/100 gm material, respectively.
### Anti-nutritional factors in non-fermented wheat bran  
**Table 9.**

<table>
<thead>
<tr>
<th>Wheat bran</th>
<th>Tannin ((mg)catechin/100 gm material)</th>
<th>Phytic acid (mg/100 gm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse</td>
<td>0.032±0.01</td>
<td>626.107±7.92</td>
</tr>
<tr>
<td>Medium</td>
<td>0.065±0.00</td>
<td>740.360±0.00</td>
</tr>
<tr>
<td>Fine</td>
<td>0.073±0.00</td>
<td>795.202±7.92</td>
</tr>
</tbody>
</table>

### Anti-nutritional factors in fermented wheat bran  
**Table 10.**

<table>
<thead>
<tr>
<th>Wheat bran</th>
<th>Tannin ((mg)catechin/100 gm material)</th>
<th>Phytic acid (mg/100 gm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse</td>
<td>0.008±0.00</td>
<td>572.789±5.28</td>
</tr>
<tr>
<td>Medium</td>
<td>0.050±0.00</td>
<td>367.133±2.64</td>
</tr>
<tr>
<td>Fine</td>
<td>0.065±0.00</td>
<td>301.628±4.57</td>
</tr>
</tbody>
</table>
From the results, it is clear that the values of tannin content of wheat bran decreased in fermented wheat bran and this may be due to yeast fermentation.

4.5.2 Phytic acid content

Phytic acid content of non-fermented coarse, medium and fine wheat bran was 626.1, 740.4 and 795.2 mg/100 gm respectively.

Phytic acid of non-fermented fine wheat bran was significantly (P≤0.05) higher than in non-fermented medium wheat bran and non fermented coarse wheat bran. Mustafa et al. (2002) reported that phytic acid of non-fermented wheat bran was 755.26 mg/100 g.

A value of 222 mg phytic acid in 100 gm wheat bran was reported by Elhag (1993). Sid Ahmed (2003) reported that the phytic acid content of wheat bran was 19.69 mg/100 gm.

Phytic acid content of fermented coarse, medium and fine wheat bran was 572.8, 367.1 and 301.6 mg/100 gm, respectively.

Phytic acid of fermented coarse wheat bran was significantly (P≤0.05) higher than in fermented medium wheat bran and fermented fine wheat bran.

Mustafa et al. (2002) reported that phytic acid of fermented wheat bran was 17.67 mg/100 g. Dohery and Faubious (1982) reported wheat bran contains more phytic acid than sorghum and maize brans. The results showed that yeast fermentation of wheat bran reduced the phytic acid content.

4.6 Mineral matter content of wheat bran

Tables (11) and (12) show the mineral matter content of non-fermented and fermented wheat bran.
### Table 11. Mineral matter content of non-fermented wheat bran

<table>
<thead>
<tr>
<th>Sample</th>
<th>Content (%)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ca</td>
<td>Fe</td>
<td>P</td>
</tr>
<tr>
<td>Coarse</td>
<td>0.01964</td>
<td>0.02064</td>
<td>0.0025</td>
</tr>
<tr>
<td>medium</td>
<td>0.02082</td>
<td>0.03114</td>
<td>0.0036</td>
</tr>
<tr>
<td>fine</td>
<td>0.02182</td>
<td>0.02284</td>
<td>0.0032</td>
</tr>
</tbody>
</table>

### Table 12. Mineral matter content of fermented wheat bran

<table>
<thead>
<tr>
<th>Sample</th>
<th>Content (%)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ca</td>
<td>Fe</td>
<td>P</td>
</tr>
<tr>
<td>Coarse</td>
<td>0.02019</td>
<td>0.02315</td>
<td>0.00260</td>
</tr>
<tr>
<td>medium</td>
<td>0.02704</td>
<td>0.02664</td>
<td>0.00180</td>
</tr>
<tr>
<td>fine</td>
<td>0.06641</td>
<td>0.03283</td>
<td>0.00150</td>
</tr>
</tbody>
</table>
Calcium content of non-fermented coarse, medium and fine wheat bran was found to be 0.01964, 0.02082 and 0.02182%, respectively. The non-fermented fine wheat bran Ca content was slightly higher than both non-fermented medium wheat bran and non-fermented coarse wheat bran. Calcium content of fermented coarse, medium and fine wheat bran was found to be 0.0219, 0.02704 and 0.06641%, respectively. The fermented fine wheat bran Ca content was the highest compared to fermented medium wheat bran and fermented coarse wheat bran.

Rendleman (1982) found that wheat bran contains about 0.12% calcium and he also reported that wheat bran contains 0.087% calcium. A value of 360 mg/100 gm was reported by Pomeranz and Gain (1983) in red wheat flour, whereas a value of 46.6 mg/100 gm in whole wheat flour meal was reported by Tangkongchitr and Seib (1982). Sid Ahmed (2003) found that Ca content of wheat bran bread was 371.5 mg/100 gm.

Iron content of non-fermented coarse, medium and fine wheat bran was found to be 0.02064, 0.03114 and 0.02284%, respectively.

The non-fermented medium wheat bran Fe content was the highest compared to non-fermented fine wheat bran and non-fermented coarse wheat bran. Iron content of fermented coarse, medium and fine wheat bran was found to be 0.02315, 0.02664 and 0.03283%, respectively.

The fermented fine wheat bran Fe content was the highest compared to fermented medium wheat bran and fermented coarse wheat bran. A value of 5.8 mg/100 gm Fe content in whole wheat flour meal was reported by Tangkongchitr and Seib (1982). Simwemba and Hoseney (1984) reported the
binding of Fe by phytate depending on the concentration of Fe and pH. Sid Ahmed (2003) found that Fe content of wheat bran bread was 8.65 mg/100 gm while Rendleman (1982) found that wheat bran contains 0.0122% iron.

Phosphorous content of non-fermented coarse, medium and fine wheat bran was found to be 0.0025, 0.0036 and 0.0032%, respectively.

The non-fermented medium wheat bran P content was the highest compared to non fermented fine wheat bran and non-fermented coarse wheat bran. The P content of fermented coarse, medium and fine wheat bran was found to be 0.0026, 0.0018 and 0.0015%, respectively.

The fermented coarse wheat bran P content was the highest compared to fermented medium wheat bran and fermented fine wheat bran. Frolich and Asp (1984) found that the phosphorous P content of bread dough containing bran was 0.20 mg / 1g sample.

A value of 1013 mg/100g wheat bran crude P was reported by internet report (2004). Rendleman (1982) found that the wheat bran contains about

4.7 Rheological properties

4.7.1 Rheological properties of the flours of the three cultivars

Dough rheological properties of the flours of the three cultivars were shown in Tables (13) to (18), Farinograms of the three cultivars were shown in figures (2) to (58).

Water-absorption values of the flours ranged from 56.0 to 58.2%. The highest value was observed in cultivar Sasaraib, whereas Debeira gave the lowest value. Dough development time, ranged from 1.4 to 5.8 minutes. The highest value was observed in cultivar Sasaraib, whereas Debeira gave the lowest value.
<table>
<thead>
<tr>
<th>Flour blends</th>
<th>Farinograph reading</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Water absorption (%)</td>
</tr>
<tr>
<td>Control S.W.F</td>
<td>58.2</td>
</tr>
<tr>
<td>90% S.W.F. 10% N.F.C.W.B</td>
<td>59.8</td>
</tr>
<tr>
<td>85% S.W.F. 15% N.F.C.W.B</td>
<td>62.5</td>
</tr>
<tr>
<td>80% S.W.F. 20% N.F.C.W.B</td>
<td>64.4</td>
</tr>
<tr>
<td>90% S.W.F. 10% N.F.M.W.B</td>
<td>61.7</td>
</tr>
<tr>
<td>85% S.W.F. 15% N.F.M.W.B</td>
<td>64.3</td>
</tr>
<tr>
<td>80% S.W.F. 20% N.F.M.W.B</td>
<td>66.6</td>
</tr>
<tr>
<td>90% S.W.F. 10% N.F.F.W.B</td>
<td>64.5</td>
</tr>
<tr>
<td>85% S.W.F. 15% N.F.F.W.B</td>
<td>66.5</td>
</tr>
<tr>
<td>80% S.W.F. 20% N.F.F.W.B</td>
<td>69.8</td>
</tr>
</tbody>
</table>

Where:
- S.W.F. : Sasaraib wheat flour
- N.F.C.W.B. : Non-fermented coarse wheat bran
- N.F.M.W.B. : Non-fermented medium wheat bran
- N.F.F.W.B. : Non-fermented fine wheat bran
Table 14. Effect of Fermented wheat bran on dough rheological properties of Sasaraib wheat flour

<table>
<thead>
<tr>
<th>Flour blends</th>
<th>Water absorption (%)</th>
<th>Dough development time (min.)</th>
<th>Dough stability (min.)</th>
<th>Degree of softening (F.U.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control S.W.F.</td>
<td>58.2</td>
<td>5.8</td>
<td>6.7</td>
<td>78</td>
</tr>
<tr>
<td>90% S.W.F. 10% F.C.W.B</td>
<td>60.8</td>
<td>6.7</td>
<td>5.4</td>
<td>45</td>
</tr>
<tr>
<td>85% S.W.F. 15% F.C.W.B</td>
<td>62.8</td>
<td>7.7</td>
<td>6.2</td>
<td>25</td>
</tr>
<tr>
<td>80% S.W.F. 20% F.C.W.B</td>
<td>65.5</td>
<td>8.7</td>
<td>13.0</td>
<td>493</td>
</tr>
<tr>
<td>90% S.W.F. 10% F.M.W.B</td>
<td>63.9</td>
<td>6.0</td>
<td>4.9</td>
<td>107</td>
</tr>
<tr>
<td>85% S.W.F. 15% F.M.W.B</td>
<td>66.3</td>
<td>7.0</td>
<td>3.9</td>
<td>94</td>
</tr>
<tr>
<td>80% S.W.F. 20% F.M.W.B</td>
<td>66.8</td>
<td>9.5</td>
<td>6.9</td>
<td>475</td>
</tr>
<tr>
<td>90% S.W.F. 10% F.F.W.B</td>
<td>63.0</td>
<td>5.0</td>
<td>4.6</td>
<td>124</td>
</tr>
<tr>
<td>85% S.W.F. 15% F.F.W.B</td>
<td>66.1</td>
<td>5.3</td>
<td>3.5</td>
<td>117</td>
</tr>
<tr>
<td>80% S.W.F. 20% F.F.W.B</td>
<td>68.4</td>
<td>6.5</td>
<td>3.3</td>
<td>104</td>
</tr>
</tbody>
</table>

Where:
S.W.F. : Sasaraib wheat flour
F.C.W.B. : Fermented coarse wheat bran
F.M.W.B. : Fermented medium wheat bran
F.F.W.B. : Fermented fine wheat bran
Table 15. Effect of Non-fermented wheat bran on dough rheological properties of El – Nielain wheat flour.

<table>
<thead>
<tr>
<th>Flour blends</th>
<th>Farinograph reading</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Water absorption (%)</td>
<td>Dough</td>
<td>Dough</td>
<td>Degree of</td>
</tr>
<tr>
<td></td>
<td></td>
<td>development</td>
<td>stability</td>
<td>softening</td>
</tr>
<tr>
<td></td>
<td></td>
<td>time (min.)</td>
<td>(min.)</td>
<td>(F.U.)</td>
</tr>
<tr>
<td>Control E.W.F.</td>
<td>56.9</td>
<td>2.9</td>
<td>3.0</td>
<td>117</td>
</tr>
<tr>
<td>90% E.W.F. 10% N.F.C.W.B</td>
<td>59.5</td>
<td>3.2</td>
<td>3.3</td>
<td>92</td>
</tr>
<tr>
<td>85% E.W.F. 15% N.F.C.W.B</td>
<td>61.0</td>
<td>4.3</td>
<td>3.9</td>
<td>75</td>
</tr>
<tr>
<td>80% E.W.F. 20% N.F.C.W.B</td>
<td>61.7</td>
<td>5.4</td>
<td>4.9</td>
<td>54</td>
</tr>
<tr>
<td>90% E.W.F. 10% N.F.M.W.B</td>
<td>60.8</td>
<td>3.8</td>
<td>3.6</td>
<td>117</td>
</tr>
<tr>
<td>85% E.W.F. 15% N.F.M.W.B</td>
<td>62.5</td>
<td>4.2</td>
<td>2.9</td>
<td>106</td>
</tr>
<tr>
<td>80% E.W.F. 20% N.F.M.W.B</td>
<td>63.9</td>
<td>5.3</td>
<td>3.3</td>
<td>80</td>
</tr>
<tr>
<td>90% E.W.F. 10% N.F.F.W.B</td>
<td>60.5</td>
<td>3.5</td>
<td>3.2</td>
<td>116</td>
</tr>
<tr>
<td>85% E.W.F. 15% N.F.F.W.B</td>
<td>62.8</td>
<td>3.7</td>
<td>3.1</td>
<td>117</td>
</tr>
<tr>
<td>80% E.W.F. 20% N.F.F. W.B</td>
<td>64.3</td>
<td>5.0</td>
<td>2.9</td>
<td>94</td>
</tr>
</tbody>
</table>

Where:

E.W.F. : El-Nielain wheat flour
N.F.C.W.B. : Non-fermented coarse wheat bran
N.F.M.W.B. : Non-fermented medium wheat bran
N.F.F.W.B. : Non-fermented fine wheat bran
Table 16. Effect of fermented wheat bran on dough rheological properties of El – Nielain wheat flour

<table>
<thead>
<tr>
<th>Flour blends</th>
<th>Farinograph reading</th>
<th>Water absorption (%)</th>
<th>Dough development time (min.)</th>
<th>Dough stability (min.)</th>
<th>Degree of softening (F.U.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control E.W.F.</td>
<td></td>
<td>56.9</td>
<td>2.9</td>
<td>3.0</td>
<td>117</td>
</tr>
<tr>
<td>90% E.W.F. 10% F.C.W.B</td>
<td></td>
<td>58.1</td>
<td>3.7</td>
<td>4.8</td>
<td>32</td>
</tr>
<tr>
<td>85% E.W.F. 15% F.C.W.B</td>
<td></td>
<td>60.1</td>
<td>19.4</td>
<td>15.7</td>
<td>504</td>
</tr>
<tr>
<td>80% E.W.F. 20% F.C.W.B</td>
<td></td>
<td>60.4</td>
<td>20.0</td>
<td>13.0</td>
<td>516</td>
</tr>
<tr>
<td>90% E.W.F. 10% F.M.W.B</td>
<td></td>
<td>60.6</td>
<td>4.5</td>
<td>3.5</td>
<td>81</td>
</tr>
<tr>
<td>85% E.W.F. 15% F.M.W.B</td>
<td></td>
<td>61.3</td>
<td>6.0</td>
<td>9.2</td>
<td>28</td>
</tr>
<tr>
<td>80% E.W.F. 20% F.M.W.B</td>
<td></td>
<td>63.7</td>
<td>11.7</td>
<td>17.0</td>
<td>468</td>
</tr>
<tr>
<td>90% E.W.F. 10% F.F.W.B</td>
<td></td>
<td>60.3</td>
<td>3.8</td>
<td>3.2</td>
<td>94</td>
</tr>
<tr>
<td>85% E.W.F. 15% F.F.W.B</td>
<td></td>
<td>62.4</td>
<td>4.2</td>
<td>3.4</td>
<td>82</td>
</tr>
<tr>
<td>80% E.W.F. 20% F.F.W.B</td>
<td></td>
<td>65.3</td>
<td>5.4</td>
<td>3.0</td>
<td>47</td>
</tr>
</tbody>
</table>

Where:

E.W.F. : El-Nielain wheat flour
F.C.W.B. : Fermented coarse wheat bran
F.M.W.B. : Fermented medium wheat bran
F.F.W.B. : Fermented fine wheat bran
Table 17. Effect of Non-fermented wheat bran on dough rheological properties of Debeira wheat flour

<table>
<thead>
<tr>
<th>Flour blends</th>
<th>Farinograph reading</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Water absorption</td>
<td>Dough development time</td>
<td>Dough stability</td>
<td>Degree of softening</td>
</tr>
<tr>
<td></td>
<td>(%) (min.)</td>
<td>(min.)</td>
<td>(min.)</td>
<td>(F.U.)</td>
</tr>
<tr>
<td>Control D.W.F.</td>
<td>56.0</td>
<td>1.4</td>
<td>7.9</td>
<td>54</td>
</tr>
<tr>
<td>90% D.W.F. 10% N.F.C.W.B</td>
<td>58.5</td>
<td>4.7</td>
<td>7.3</td>
<td>75</td>
</tr>
<tr>
<td>85% D.W.F. 15% N.F.C.W.B</td>
<td>60.2</td>
<td>5.2</td>
<td>7.0</td>
<td>82</td>
</tr>
<tr>
<td>80% D.W.F. 20% N.F.C.W.B</td>
<td>64.5</td>
<td>6.7</td>
<td>7.2</td>
<td>74</td>
</tr>
<tr>
<td>90% D.W.F. 10% N.F.M.W.B</td>
<td>59.7</td>
<td>4.3</td>
<td>6.0</td>
<td>87</td>
</tr>
<tr>
<td>85% D.W.F. 15% N.F.M.W.B</td>
<td>62.1</td>
<td>5.4</td>
<td>6.2</td>
<td>102</td>
</tr>
<tr>
<td>80% D.W.F. 20% N.F.M.W.B</td>
<td>64.4</td>
<td>9.4</td>
<td>12.3</td>
<td>525</td>
</tr>
<tr>
<td>90% D.W.F. 10% N.F.F.W.B</td>
<td>59.2</td>
<td>3.2</td>
<td>5.2</td>
<td>102</td>
</tr>
<tr>
<td>85% D.W.F. 15% N.F.F.W.B</td>
<td>61.4</td>
<td>4.5</td>
<td>5.2</td>
<td>106</td>
</tr>
<tr>
<td>80% D.W.F. 20% N.F.F.W.B</td>
<td>63.5</td>
<td>4.9</td>
<td>5.2</td>
<td>100</td>
</tr>
</tbody>
</table>

Where:
D.W.F. : Debeira wheat flour
N.F.C.W.B. : Non-fermented coarse wheat bran
N.F.M.W.B. : Non-fermented medium wheat bran
N.F.F.W.B. : Non-fermented fine wheat bran
<table>
<thead>
<tr>
<th>Flour blends</th>
<th>Farinograph reading</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Water absorption (%)</td>
</tr>
<tr>
<td>Control D.W.F.</td>
<td>56.0</td>
</tr>
<tr>
<td>90% D.W.F. 10% F.C.W.B</td>
<td>58.7</td>
</tr>
<tr>
<td>85% D.W.F. 15% F.C.W.B</td>
<td>60.6</td>
</tr>
<tr>
<td>80% D.W.F. 20% F.C.W.B</td>
<td>63.0</td>
</tr>
<tr>
<td>90% D.W.F. 10% F.M.W.B</td>
<td>61.6</td>
</tr>
<tr>
<td>85% D.W.F. 15% F.M.W.B</td>
<td>65.1</td>
</tr>
<tr>
<td>80% D.W.F. 20% F.M.W.B</td>
<td>66.2</td>
</tr>
<tr>
<td>90% D.W.F. 10% F.F.W.B</td>
<td>60.4</td>
</tr>
<tr>
<td>85% D.W.F. 15% F.F.W.B</td>
<td>62.6</td>
</tr>
<tr>
<td>80% D.W.F. 20% F.F.W.B</td>
<td>65.0</td>
</tr>
</tbody>
</table>

Where:
D.W.F. : Debeira wheat flour
F.C.W.B. : Fermented coarse wheat bran
F.M.W.B. : Fermented medium wheat bran
F.F.W.B. : Fermented fine wheat bran
Fig. 2 Farinogram of dough prepared from Debeira wheat flour

Fig. 3 Farinogram of dough prepared from El – Nielain wheat flour
Fig. 4 Farinogram of dough prepared from Sasaraib wheat flour

Fig. 5 Farinogram of dough prepared from Debeira flour with 10% Non-Fermented coarse wheat bran.
Fig. 6 Farinogram of dough prepared from Debeira flour with 15% Non-Fermented coarse wheat bran.

Fig. 7 Farinogram of dough prepared from Debeira flour with 20% Non-Fermented coarse wheat bran.
Fig. 8 Farinogram of dough prepared from Debeira flour with 10% Non-Fermented medium wheat bran.

Fig. 9 Farinogram of dough prepared from Debeira flour with 15% Non-Fermented medium wheat bran.
Fig. 10 Farinogram of dough prepared from Debeira flour with 20 % Non-Fermented medium wheat bran.

Fig. 11 Farinogram of dough prepared from Debeira flour with 10 % Non-Fermented fine wheat bran.
Fig. 12 Farinogram of dough prepared from Debeira flour with 15% Non-Fermented fine wheat bran.

Fig. 13 Farinogram of dough prepared from Debeira flour with 20% Non-Fermented fine wheat bran.
Fig. 14. Farinogram of dough prepared from El-Nielain flour with 10% Non-Fermented coarse wheat bran.

Fig. 15. Farinogram of dough prepared from El-Nielain flour with 15% Non-Fermented coarse wheat bran.
Fig. 16 Farinogram of dough prepared from El-Nielain flour with 20% Non-Fermented coarse wheat bran.

Fig. 17 Farinogram of dough prepared from El-Nielain flour with 10% Non-Fermented medium wheat bran.
Fig. 18 Farinogram of dough prepared from El-Nielain flour with 15% Non-Fermented medium wheat bran.

Fig. 19 Farinogram of dough prepared from El-Nielain flour with 20% Non-Fermented medium wheat bran.
Fig. 20 Farinogram of dough prepared from El-Nielain flour with 10% Non-Fermented Fine wheat bran.

Fig. 21 Farinogram of dough prepared from El-Nielain flour with 15% Non-Fermented Fine wheat bran.
Fig. 22 Farinogram of dough prepared from El-Nielain flour with 20% Non-Fermented Fine wheat bran.

Fig. 23 Farinogram of dough prepared from Sasaraib flour with 10% Non-Fermented Coarse wheat bran.
Fig. 24 Farinogram of dough prepared from Sasaraib flour with 15% Non-Fermented Coarse wheat bran.

Fig. 25 Farinogram of dough prepared from Sasaraib flour with 20% Non-Fermented Coarse wheat bran.
Fig. 26  Farinogram of dough prepared from Sasaraib flour with 10% Non- Fermented medium wheat bran.

Fig. 27  Farinogram of dough prepared from Sasaraib flour with 15% Non- Fermented medium wheat bran.
Fig. 28 Farinogram of dough prepared from Sasaraib flour with 20% Non-Fermented medium wheat bran.

Fig. 29 Farinogram of dough prepared from Sasaraib flour with 10% Non-Fermented Fine wheat bran.
Fig. 30 Farinogram of dough prepared from Sasaraib flour with 15% Non-fermented Fine wheat bran.

Fig. 31 Farinogram of dough prepared from Sasaraib flour with 20% Non-fermented Fine wheat bran.
Fig. 32 Farinogram of dough prepared from Debeira flour with 10% Fermented coarse wheat bran

Fig. 33 Farinogram of dough prepared from Debeira flour with 15% Fermented coarse wheat bran
Fig. 34 Farinogram of dough prepared from Debeira flour with 20% Fermented coarse wheat bran.

Fig. 35 Farinogram of dough prepared from Debeira flour with 10% Fermented medium wheat bran.
Fig. 36 Farinogram of dough prepared from Debeira flour with 15% Fermented medium wheat bran.

Fig. 37 Farinogram of dough prepared from Debeira flour with 20% Fermented medium wheat bran.
Fig. 38 Farinogram of dough prepared from Debeira flour with 10% Fermented Fine wheat bran

Fig. 39 Farinogram of dough prepared from Debeira flour with 15% Fermented Fine wheat bran
Fig. 40 Farinogram of dough prepared from Debeira flour with 20% Fermented Fine wheat bran

Fig. 41 Farinogram of dough prepared from El-Nielan flour with 10% Fermented coarse wheat bran
Fig. 42 Farinogram of dough prepared from El – Nielain flour with 15% Fermented coarse wheat bran

Fig. 43 Farinogram of dough prepared from El – Nielain flour with 20% Fermented coarse wheat bran
Fig. 44 Farinogram of dough prepared from El – Nielain flour with 10% Fermented medium wheat bran

Fig. 45 Farinogram of dough prepared from El – Nielain flour with 15% Fermented medium wheat bran
Fig. 46 Farinogram of dough prepared from El - Nielain flour with 20% Fermented medium wheat bran

Fig. 47 Farinogram of dough prepared from El - Nielain flour with 10% Fermented Fine wheat bran
Fig. 48 Farinogram of dough prepared from El – Nielain flour with 15 % Fermented Fine wheat bran

Fig. 49 Farinogram of dough prepared from El – Nielain flour with 20 % Fermented Fine wheat bran
Fig. 50: Farinogram of dough prepared from Sasaraib flour with 10% Fermented coarse wheat bran

Fig. 51: Farinogram of dough prepared from Sasaraib flour with 15% Fermented coarse wheat bran
Fig. 52: Farinogram of dough prepared from Sasaraib flour with 20% Fermented coarse wheat bran

Fig. 53: Farinogram of dough prepared from Sasaraib flour with 10% Fermented medium wheat bran
Fig. 54: Farinogram of dough prepared from Sasaraib flour with 15% Fermented medium wheat bran

Fig. 55: Farinogram of dough prepared from Sasaraib flour with 20% Fermented medium wheat bran
Fig. 56: Farinogram of dough prepared from Sasaraib flour with 10% Fermented Fine wheat bran.

Fig. 57: Farinogram of dough prepared from Sasaraib flour with 15% Fermented Fine wheat bran.
Fig. 58: Farinogram of dough prepared from Sasaraib flour with 20% Fermented Fine wheat bran
Dough stability of the flours ranged from 3.0 to 7.9 minutes. Debeira gave the highest value, whereas the lowest value was observed in cultivar EI-Nielain.

Degree of softening for the flours of the three cultivars were found to be in the range of 54 to 117 F.U. The highest value was observed in EI-Nielain, whereas Debeira gave the lowest value.

These results were relatively in good agreement with those reported by Pagenstedt (1955) who found that water-absorption in percentages were 50.5% for soft flour and 58.6% for strong flour. Mohamed (2000) reported that water-absorption values of the flours of four Sudanese cultivars ranged from 57.5 to 61.0%.

Meredith (1967) observed that the water absorption values of different cultivars were found to be in the range of 60.6 to 63.5%. While Hamade et al. (1982) reported that it ranged from 59.0 to 65.7% for spring wheats. Kaldy et al. (1987) reported that it ranged from 54.7 to 56.1% for white winter wheat, and from 50.1 to 57.8% for white spring wheat. Pagenstedt (1955) reported that the dough development time, dough stability and softening of dough after 12 minutes of soft and strong flours was found to be 1.0 and 3.0 minutes, zero and 4.0 minutes, 150 and 40 F.U. respectively. While Meredith (1967) found that dough development time and dough stability were 3.0 to 6.0 minutes, and 4.0 to 6.0 minutes, respectively. Hamada (1982) showed dough development time and stability of spring wheats to range from 3 to 7 minutes and from 3 to 28 minutes, respectively. While Mohamed (2000) found that development time, dough stability and degree of softening were 3.0 to 5.0 minutes 1.0 to 3.5 minutes and 40 to 70 F. U. respectively.
4.7.2 Rheological properties of dough prepared from wheat flour containing wheat bran

Rheological properties of wheat flour with non-fermented or fermented wheat bran blends were shown in Tables (13) to (18) and figures (2) to (58). Water absorption values of the three cultivars with 10, 15 and 20% non-fermented coarse wheat bran ranged from 58.5 to 59.8%, 60.2 to 62.5% and 61.7 to 64.5%, respectively. The highest value was observed in Debeira with 20% non-fermented coarse wheat bran, whereas Debeira with 10% non-fermented coarse wheat bran gave the lowest value. Water absorption values of the three cultivars with 10, 15 and 20% non-fermented medium wheat bran ranged from 59.7 to 61.7%, 62.1 to 64.3% and 63.9 to 66.6%, respectively. The highest value was observed in Sasaraib with 20% non-fermented medium wheat bran, whereas the lowest value was observed in Debeira with 10% non-fermented medium wheat bran. Water absorption values of the three cultivars with 10, 15 and 20% non-fermented fine wheat bran ranged from 59.2 to 64.5%, 61.4 to 66.5% and 63.5 to 69.8% respectively. The highest value was observed in Sasaraib with 20% non-fermented fine wheat bran, whereas the lowest value was observed in Debeira with 10% non-fermented fine wheat bran. These results were relatively in good agreement with those reported by Hamada et al. (1982) who reported that water absorption ranged from 59 to 65.7% for spring wheats bran.
Water absorption values of the three cultivars with 10, 15 and 20% fermented coarse wheat bran from 58.1 to 60.8%, 60.1 to 62.8% and 60.4 to 65.5% respectively.

The highest value was observed in Sasaraib with 20% fermented coarse wheat bran, whereas EI-Nielain with 10% fermented coarse wheat bran gave the lowest value. Water absorption values of the three cultivars with 10, 15 and 20% fermented medium wheat bran ranged from 60.6 to 63.9%, 61.3 to 66.3% and 63.7 to 66.8%, respectively. Sasaraib with 20% fermented medium wheat bran gave the highest value whereas the lowest value was observed in EI-Nielain with 10% fermented medium wheat bran.

Water absorption values of the three cultivars with 10, 15 and 20% fermented fine wheat bran ranged from 60.3 to 63.0%, 62.4 to 66.1% and 65.0 to 68.4%, respectively. The highest value was observed in Sasaraib with 20% fermented fine wheat bran, whereas EI-Nielain with 10% fermented fine wheat bran gave the lowest value.

A value of 65.6% dough water absorption of wheat flour/bran composite flour was reported by Matsuo (1978). Young (1978) reported that bran increases farinograph water-absorption. Anaka and Tipples (1979) reported that high water-absorption gives more stability curve, long development time and thin band.

Sid Ahmed (2003) reported that water absorption of wheat flour containing wheat bran was 70.9% and showed higher water-absorption as compared to wheat flour containing maize bran and wheat flour containing sorghum bran.
Hoseney (1982) reported that when wheat bran was added to wheat flour, water-absorption was increased. From results it could be observed that the percentage 20% from non-fermented and fermented wheat bran gave the highest water absorption, whereas the percentage 10% from non-fermented and fermented wheat bran gave the lowest values of water-absorption.

The dough development time of the three cultivars with 10, 15 and 20% non-fermented coarse wheat bran ranged from 3.2 to 5.5 min, 4.3 to 5.9 min, and 5.4 to 6.7 min respectively.

Debeira flour with 20% non-fermented coarse wheat bran gave the highest value, whereas El-Nielain with 10% non-fermented coarse wheat bran gave the lowest value. The dough development time of the three cultivars with 10, 15 and 20% non-fermented medium wheat bran ranged from 3.8 to 5.0 min, 4.2 to 5.4 min, and 5.3 to 9.4 min, respectively. The highest value was observed in Debeira with 20% non fermented medium wheat bran, whereas El-Nielain with 10% non-fermented medium wheat bran gave the lowest value.

The dough development time of the three cultivars with 10%, 15% and 20% non-fermented fine wheat bran ranged from 3.2 to 4.4 min, 3.7 to 4.8 min, and 4.9 to 5.5 min, respectively. Sasaraib with 20% non-fermented fine wheat bran gave the highest value, whereas Debeira with 10% non-fermented fine wheat bran gave the lowest value.

These results are comparable with those obtained by Young (1978) who found that the dough development time in wheat flour and wheat bran composite flour was 9.0 and 6.5 min.
The dough development time of the three cultivars with 10%, 15% and 20% fermented coarse wheat bran ranged from 3.7 to 6.7 min, 7.7 to 19.4 min and 8.7 to 20.0 min, respectively.

El-Nielain with 20% fermented coarse wheat bran gave the highest value, whereas El-Nielain with 10% fermented coarse wheat bran gave the lowest value. The dough development time of the three cultivars with 10%, 15% and 20% fermented medium wheat bran ranged from 4.3 to 6.0 min, 6.0 to 7.2 min, and 9.5 to 11.7 min, respectively.

The highest value was observed in El-Nielain with 20% fermented medium wheat bran, whereas Debeira with 10% fermented medium wheat bran gave the lowest value. The dough development time of the three cultivars with 10%, 15% and 20% fermented fine wheat bran ranged from 3.8 to 5.0 min, 4.2 to 5.3 min and 5.4 to 6.7 min, respectively. The highest value was observed in Debeira with 20% fermented fine wheat bran, whereas El-Nielain with 10% fermented fine wheat bran gave the lowest value.

Anaka and Tipples (1979) reported that the farinograph development time was decreased with the flour of low protein content, A value of 7.3 min, development in Canadian wheat flour was reported by Lukour (1990).

Sid Ahmed (2003) reported that the dough development time of wheat bran composite flour was 11.6 min. From these results it could be observed that the percentage 20% from non-fermented and fermented wheat bran gave the highest value, whereas the percentage 10% from non-fermented and fermented wheat bran gave the lowest value of the dough development time.
The dough stability values of the three cultivars with 10, 15 and 20% non-fermented coarse wheat bran ranged from 3.3 to 7.3 min, 3.9 to 7.0 min and 4.1 to 7.2 min, respectively.

The highest value was observed in Debeira with 10% non fermented coarse wheat bran, whereas El-Nielain with 10% fermented coarse wheat bran gave the lowest value.

The dough stability values of the three cultivars with 10, 15 and 20% non-fermented medium wheat bran ranged from 3.6 to 6.0 min, 2.9 to 6.2 min and 4.0 to 12.3 min, respectively.

Debeira with 20% non-fermented medium wheat bran gave the highest value, whereas El-Nielain with 15% non-fermented medium wheat bran gave the lowest value. The dough stability values of the three cultivars with 10, 15 and 20% non-fermented fine wheat bran ranged from 3.2 to 5.2 min, 3.1 to 5.2 min, and 2.9 to 5.2 min respectively. The highest value was observed in Debeira with 10, 15 and 20% non-fermented fine wheat bran, whereas El-Nielain with 20% non fermented fine wheat bran gave the lowest value.

These results disagree with that reported by Sid Ahmed (2003) who found that the dough stability of wheat bran composite flour was 19.0 min, and it was significantly higher than maize bran composite flour and sorghum bran composite flour. The dough stability values of the three cultivars with 10, 15 and 20% fermented coarse wheat bran ranged from 4.8 to 9.8 min, 6.2 to 16.7 min, and 13.0 to 13.4 min, respectively.

Debeira with 15% fermented coarse wheat bran gave the highest dough stability value whereas, El-Nielain with 10% fermented coarse wheat bran gave the lowest value.
The dough stability values of the three cultivars with 10, 15 and 20% fermented medium wheat bran ranged from 3.5 to 6.0 min, 3.9 to 9.2 min, and 6.9 to 17.0 min, respectively.

The highest value was observed in El-Nielain with 20% fermented medium wheat bran, whereas El-Nielain with 10% fermented medium wheat bran gave the lowest value. The dough stability values of the three cultivars with 10, 15 and 20% fermented fine wheat bran ranged from 3.2 to 5.5 min, 3.4 to 4.7 min, and 3.0 to 5.0 min, respectively. Debeira with 10% fermented fine wheat bran gave the highest value, whereas El-Nielain with 20% fermented fine wheat bran gave the lowest value.

Anaka and Tipples (1979) reported that high water absorption usually gives more dough stability curve. Values of 3.4 and 13.9 cm dough stabilities in durum flour and bread wheat flour were reported by Bakhshi and Brian (1987). From these results, it is clear that Debeira flour blends gives more dough stability curve.

The degree of softening values of the three cultivars with 10, 15 and 20% non-fermented coarse wheat bran ranged from 75 to 99 F.U. 75 to 112 F.U. and 54 to 101 F.U., respectively.

The highest value was observed in Sasaraib with 15% non-fermented coarse wheat bran, whereas El-Nielain with 20% non-fermented coarse wheat bran gave the lowest value. The degree of softening values of the three cultivars with 10, 15 and 20% non-fermented medium wheat bran ranged from 87 to 126 F.U. 102 to 126 F.U. and 80 to 525 F.U. respectively.
The highest value was observed in Debeira with 20% non fermented medium wheat bran, whereas El-Nielain with 20% non fermented medium wheat bran gave the lowest value.

The degree of softening values of the three cultivars with 10, 15 and 20% non-fermented fine wheat bran ranged from 102 to 121 F.U. 106 to 131 F.U. and 94 to 137 F.U. respectively.

Sasaraib with 20% non-fermented fine wheat bran gave the highest value, whereas El-Nielain with 20% non-fermented fine wheat bran gave the lowest value. These results were in agreement with data reported by Badi et al. (1978) who reported that increasing of water absorption indicates weakening of the dough.

The degree of softening values of the three cultivars with 10, 15 and 20% fermented coarse wheat bran ranged from 32 to 45 F.U., 25 to 515 F.U. and 493 to 553 F.U., respectively.

Debeira with 20% fermented coarse wheat bran gave the highest value, whereas Sasaraib with 15% fermented coarse wheat bran gave the lowest value.

The degree of softening values of the three cultivars with 10,15 and 20% fermented medium wheat bran ranged from 81 to 107 F.U., 28 to 94 F.U., and 468 to 506 F.U., respectively.

The highest value was observed in Sasaraib with 20% non fermented medium wheat bran, whereas El-Nielain with 15% fermented medium wheat bran gave the lowest value.

The degree of softening values of the three cultivars with 10, 15 and 20% fermented fine wheat bran ranged from 94 to 124 F. U., 82 to 117 F.U., and 47 to 104 respectively.
Sasaraib with 10% fermented fine wheat bran gave the highest value whereas EI-Nielain with 20% fermented fine wheat bran gave the lowest value.

Blackman and Paymes (1987) reported that if weak flour was used breads of small volumes were produced with poor crumb structure. Anon (1989) reported that wheat germ was known to weaken gluten.

Brain et al. (1989) reported that the incompletely hydrated cellulose particles function as inclusion that weaken the dough by cutting gluten stands. Sid Ahmed (2003) reported that the degree of softening of wheat bran composite flour was 10.0 B.U. (715.9g wheat flour and 284.1g wheat bran).

Generally, the increasing substitution of wheat bran in commercial wheat flour decreased dough stability time and this finding supports the results reported by Tanaka and Bushuk (1973).

4.8 Baking test

4.8.1 Baking test of the flours of the three cultivars

Baking characteristics of the flours of the three cultivars, are shown in tables (19) to (24) and in plates (4) to (21), Specific volume (cm³/g,) values of the flours breads ranged from 3.22 to 4.112 cm³/g. Sasaraib gave the highest value, whereas EI-Nielain gave the lowest value. Analysis of variance showed significant differences (P≤0.05) among the three cultivars in their loaf specific volume.

These results were confirmed by data reported by Ahmed (1995) who showed that the bread specific volume of Sudanese wheat cultivars ranged between 3.25 and 3.95 cm³/g. Also the results were in good agreement with the results reported by Mohamed (2000) who reported that the bread specific
volume of four Sudanese wheat cultivars ranged between 3.66 and 4.05 cm$^3$/g.

### 4.8.2 Baking test of the flours containing wheat bran

Baking test of the flours with non-fermented and fermented wheat bran blends were shown in tables (19) to (24) and plates (4) to (21).

Bread specific volume (cm$^3$/g) values of the three cultivars with 10, 15 and 20% non-fermented coarse wheat bran ranged from 3.054 to 3.804 cm$^3$/g, 3.075 to 3.757 cm$^3$/g, and 2.486 to 3.359 cm$^3$/g, respectively. Sasaraib gave the highest value, whereas EI-Nielain gave the lowest value. Bread specific volume (cm$^3$/g) values of the three cultivars with 10, 15 and 20% non-fermented medium wheat bran ranged from 3.000 to 3.710 cm$^3$/g, 2.674 to 3.519 cm$^3$/g, and 2.391 to 3.213 cm$^3$/g, respectively.

The highest value was observed in Sasaraib, whereas EI-Nielain gave the lowest value. Bread specific volume (cm$^3$/g) values of the three cultivars with 10, 15 and 20% non-fermented fine wheat bran ranged from 2.847 to 3.924 cm$^3$/g, 2.641 to 3.802 cm$^3$/g, and 2.612 to 3.466 cm$^3$/g, respectively. Sasaraib gave the highest value, whereas EI-Nielain gave the lowest value. From these results, it can be concluded that the bread specific volume decreases with increasing of wheat bran percentage and cultivar Sasaraib gave the highest value of bread specific volume with all non-fermented wheat bran (all percentages), whereas EI-Nielain gave the lowest value. This finding
<table>
<thead>
<tr>
<th>Flour blends</th>
<th>Bread specific volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control S.W.F</td>
<td>3.987±0.08</td>
</tr>
<tr>
<td>90% S.W.F. 10% N.F.C.W.B</td>
<td>3.804±0.07</td>
</tr>
<tr>
<td>85% S.W.F. 15% N.F.C.W.B</td>
<td>3.757±0.09</td>
</tr>
<tr>
<td>80% S.W.F. 20% N.F.C.W.B</td>
<td>3.359±0.16</td>
</tr>
<tr>
<td>90% S.W.F. 10% N.F.M.W.B</td>
<td>3.710±0.11</td>
</tr>
<tr>
<td>85% S.W.F. 15% N.F.M.W.B</td>
<td>3.519±0.04</td>
</tr>
<tr>
<td>80% S.W.F. 20% N.F.M.W.B</td>
<td>3.213±0.14</td>
</tr>
<tr>
<td>90% S.W.F. 10% N.F.F.W.B</td>
<td>3.924±0.08</td>
</tr>
<tr>
<td>85% S.W.F. 15% N.F.F.W.B</td>
<td>3.802±0.07</td>
</tr>
<tr>
<td>80% S.W.F. 20% N.F.F.W.B</td>
<td>3.466±0.04</td>
</tr>
</tbody>
</table>

Where:

S.W.F. : Sasaraib wheat flour
N.F.C.W.B: Non-fermented coarse wheat bran
N.F.M.W.B: Non-fermented medium wheat bran
N.F.F.W.B: Non-fermented fine wheat bran
Table 20. Effect of fermented wheat bran on bread Specific volume of Sasaraib flour

<table>
<thead>
<tr>
<th>Flour blends</th>
<th>Bread specific volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control S.W.F</td>
<td>4.112±0.16</td>
</tr>
<tr>
<td>90% S.W.F. 10% F.C.W.B</td>
<td>3.580±0.06</td>
</tr>
<tr>
<td>85% S.W.F. 15% F.C.W.B</td>
<td>3.441±0.05</td>
</tr>
<tr>
<td>80% S.W.F. 20% F.C.W.B</td>
<td>3.085±0.09</td>
</tr>
<tr>
<td>90% S.W.F. 10% F.M.W.B</td>
<td>3.729±0.11</td>
</tr>
<tr>
<td>85% S.W.F. 15% F.M.W.B</td>
<td>3.165±0.12</td>
</tr>
<tr>
<td>80% S.W.F. 20% F.M.W.B</td>
<td>2.960±0.04</td>
</tr>
<tr>
<td>90% S.W.F. 10% F.F.W.B</td>
<td>3.590±0.01</td>
</tr>
<tr>
<td>85% S.W.F. 15% F.F.W.B</td>
<td>3.161±0.01</td>
</tr>
<tr>
<td>80% S.W.F. 20% F.F.W.B</td>
<td>2.829±0.10</td>
</tr>
</tbody>
</table>

Where:
S.W.F. : Sasaraib wheat flour
F.C.W.B: fermented coarse wheat bran
F.M.W.B: fermented medium wheat bran
F.F.W.B: fermented fine wheat bran
Table 21. Effect of Non fermented wheat bran on bread
Specific volume of El-Nielain flour

<table>
<thead>
<tr>
<th>Flour blends</th>
<th>Bread specific volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control E.W.F</td>
<td>3.220±0.07</td>
</tr>
<tr>
<td>90% E.W.F. 10% N.F.C.W.B</td>
<td>3.054±0.07</td>
</tr>
<tr>
<td>85% E.W.F. 15% N.F.C.W.B</td>
<td>3.075±0.02</td>
</tr>
<tr>
<td>80% E.W.F. 20% N.F.C.W.B</td>
<td>2.486±0.11</td>
</tr>
<tr>
<td>90% E.W.F. 10% N.F.M.W.B</td>
<td>3.000±0.11</td>
</tr>
<tr>
<td>85% E.W.F. 15% N.F.M.W.B</td>
<td>2.674±0.09</td>
</tr>
<tr>
<td>80% E.W.F. 20% N.F.M.W.B</td>
<td>2.391±0.06</td>
</tr>
<tr>
<td>90% E.W.F. 10% N.F.F.W.B</td>
<td>2.847±0.08</td>
</tr>
<tr>
<td>85% E.W.F. 15% N.F.F.W.B</td>
<td>2.641±0.08</td>
</tr>
<tr>
<td>80% E.W.F. 20% N.F.F.W.B</td>
<td>2.612±0.07</td>
</tr>
</tbody>
</table>

Where:
E.W.F. : El-Nielain wheat flour
N.F.C.W.B: Non-fermented coarse wheat bran
N.F.M.W.B: Non-fermented medium wheat bran
N.F.F.W.B: Non-fermented fine wheat bran
Table 22. Effect of fermented wheat bran on bread Specific volume of El-Nielain flour

<table>
<thead>
<tr>
<th>Flour blends</th>
<th>Bread specific volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control E.W.F</td>
<td>3.309±0.04</td>
</tr>
<tr>
<td>90% E.W.F. 10% F.C.W.B</td>
<td>2.987±0.02</td>
</tr>
<tr>
<td>85% E.W.F. 15% F.C.W.B</td>
<td>2.809±0.09</td>
</tr>
<tr>
<td>80% E.W.F. 20% F.C.W.B</td>
<td>2.317±0.03</td>
</tr>
<tr>
<td>90% E.W.F. 10% F.M.W.B</td>
<td>2.816±0.12</td>
</tr>
<tr>
<td>85% E.W.F. 15% F.M.W.B</td>
<td>2.508±0.04</td>
</tr>
<tr>
<td>80% E.W.F. 20% F.M.W.B</td>
<td>2.105±0.08</td>
</tr>
<tr>
<td>90% E.W.F. 10% F.F.W.B</td>
<td>2.885±0.04</td>
</tr>
<tr>
<td>85% E.W.F. 15% F.F.W.B</td>
<td>2.922±0.03</td>
</tr>
<tr>
<td>80% E.W.F. 20% F.F.W.B</td>
<td>2.503±0.07</td>
</tr>
</tbody>
</table>

Where:
E.W.F. : El-Nielian wheat flour
F.C.W.B: fermented coarse wheat bran
F.M.W.B: fermented medium wheat bran
F.F.W.B: fermented fine wheat bran
Table 23. Effect of Non fermented wheat bran on bread Specific volume of Debeira flour

<table>
<thead>
<tr>
<th>Flour blends</th>
<th>Bread specific volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control D.W.F</td>
<td>3.871±0.04</td>
</tr>
<tr>
<td>90% D.W.F. 10% N.F.C.W.B</td>
<td>3.707±0.08</td>
</tr>
<tr>
<td>85% D.W.F. 15% N.F.C.W.B</td>
<td>3.384±0.04</td>
</tr>
<tr>
<td>80% D.W.F. 20% N.F.C.W.B</td>
<td>3.315±0.02</td>
</tr>
<tr>
<td>90% D.W.F. 10% N.F.M.W.B</td>
<td>3.544±0.04</td>
</tr>
<tr>
<td>85% D.W.F. 15% N.F.M.W.B</td>
<td>3.197±0.04</td>
</tr>
<tr>
<td>80% D.W.F. 20% N.F.M.W.B</td>
<td>2.827±0.06</td>
</tr>
<tr>
<td>90% D.W.F. 10% N.F.F.W.B</td>
<td>3.403±0.04</td>
</tr>
<tr>
<td>85% D.W.F. 15% N.F.F.W.B</td>
<td>3.371±0.03</td>
</tr>
<tr>
<td>80% D.W.F. 20% N.F.F.W.B</td>
<td>3.020±0.02</td>
</tr>
</tbody>
</table>

Where:
D.W.F. : Debeira wheat flour
N.F.C.W.B: Non-fermented coarse wheat bran
N.F.M.W.B: Non-fermented medium wheat bran
N.F.F.W.B: Non-fermented fine wheat bran
Table 24. Effect of fermented wheat bran on bread Specific volume of Debeira flour

<table>
<thead>
<tr>
<th>Flour blends</th>
<th>Bread specific volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control D.W.F</td>
<td>4.064±0.07</td>
</tr>
<tr>
<td>90% D.W.F. 10% F.C.W.B</td>
<td>3.569±0.05</td>
</tr>
<tr>
<td>85% D.W.F. 15% F.C.W.B</td>
<td>3.304±0.01</td>
</tr>
<tr>
<td>80% D.W.F. 20% F.C.W.B</td>
<td>2.755±0.13</td>
</tr>
<tr>
<td>90% D.W.F. 10% F.M.W.B</td>
<td>2.755±0.13</td>
</tr>
<tr>
<td>85% D.W.F. 15% F.M.W.B</td>
<td>3.370±0.08</td>
</tr>
<tr>
<td>80% D.W.F. 20% F.M.W.B</td>
<td>3.160±0.08</td>
</tr>
<tr>
<td>90% D.W.F. 10% F.F.W.B</td>
<td>2.460±0.11</td>
</tr>
<tr>
<td>85% D.W.F. 15% F.F.W.B</td>
<td>3.193±0.18</td>
</tr>
<tr>
<td>80% D.W.F. 20% F.F.W.B</td>
<td>2.988±0.02</td>
</tr>
</tbody>
</table>

Where:
D.W.F. : Debeira wheat flour
F.C.W.B: fermented coarse wheat bran
F.M.W.B: fermented medium wheat bran
F.F.W.B: fermented fine wheat bran
Plate 4. El-Nielain bread with non fermented coarse wheat bran

Plate 5. Sasaraib bread with non fermented coarse wheat bran

Plate 6. Debeira bread with non fermented coarse wheat bran
Plate 7. Debeira bread with non fermented medium wheat bran

Plate 8. El-Nielain bread with non fermented medium wheat bran
Plate 9. Sasaraib bread with non fermented medium wheat bran
Plate 10. Debeira bread with non fermented fine wheat bran

Plate 11. El-Nielain bread with non fermented fine wheat bran
Plate 12. Sasaraib bread with non fermented fine wheat bran
Plate 13. Debeira bread with fermented coarse wheat bran

Plate 14. El-Nielain bread with fermented coarse wheat bran
Plate 15 Sasaraib bread with fermented coarse wheat bran

Plate 16. Debeira bread with fermented medium wheat bran
Plate 17. El-Nielain bread with fermented medium wheat bran

Plate 18. Sasaraib bread with fermented medium wheat bran
Plate 19. Debeira bread with fermented fine wheat bran

Plate 20. El-Nielain bread with fermented fine wheat bran
Plate 21. Sasaraib bread with fermented fine wheat bran
is supported by results reported by Mohamed (2000). Bread specific volume (cm$^3$/g) values of the three cultivars with 10, 15 and 20% fermented coarse wheat bran ranged from 2.987 to 3.580 cm$^3$/g, 2.809 to 3.441 cm$^3$/g and 2.317 to 3.085 cm$^3$/g, respectively.

Sasaraib gave the highest value, whereas El-Nielain gave the lowest value. Bread specific volume (cm$^3$/g) values of the three cultivars with 10, 15 and 20% fermented medium wheat bran ranged from 2.816 to 3.729 cm$^3$/g, 2.508 to 3.165, and 2.105 to 2.460 cm$^3$/g, respectively.

The highest value was observed in cultivar Sasaraib, Whereas cultivar El-Nielain gave the lowest value. Bread specific volume cm$^3$/g values of the three cultivars with 10, 15 and 20% fermented fine wheat bran ranged from 2.885 to 3.590, 2.922 to 3.161 and 2.503 to 2.829 cm$^3$/g, respectively. Sasaraib gave the highest value, whereas El-Nielain gave the lowest value. From these results, it can be concluded that the bread specific volume of the three cultivars with non-fermented wheat bran was high compared to the bread specific volume of the three cultivars with fermented wheat bran, This finding is supported by earlier results of lai et al. (1989) who reported that the effect of bran on loaf volume varies with the source of bran.

Michael et al. (1989) reported that maize bran composite flour gave higher bread volume than wheat bran composite flour. Also, he reported that the addition of cereal brans reduced the loaf volume. Bean (1990) reported that dough contains protein below 10% gave lower loaf volume.

Perten (1980) reported that the volume of bread decreased with a decreased sorghum extraction rate due to the reduction of protein and fiber in the flour. Table (25) and plate (22) shows the bread specific volume of
Table 25. Effect of 10% Non-fermented and fermented coarse wheat bran on bread specific volume of Sasaraib, El-Nielain and Debeira flour

<table>
<thead>
<tr>
<th>Flour blends</th>
<th>Bread specific volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>90% S.W.F 10% N.F.C.W.B</td>
<td>3.736±0.04</td>
</tr>
<tr>
<td>90% E.W.F 10% N.F.C.W.B</td>
<td>3.333±0.11</td>
</tr>
<tr>
<td>90% D.W.F 10% N.F.C.W.B</td>
<td>3.741±0.05</td>
</tr>
<tr>
<td>90% S.W.F 10%. F.C.W.B</td>
<td>3.422±0.03</td>
</tr>
<tr>
<td>90% E.W.F 10%.F.C.W.B</td>
<td>2.956±0.02</td>
</tr>
<tr>
<td>90% D.W.F 10%.F.C.W.B</td>
<td>3.020±0.01</td>
</tr>
</tbody>
</table>

Where:
S.W.F : Sasaraib wheat flour
E.W.F : El-Nielain wheat flour
D.W.F :Debeira wheat flour
N.F.C.W.B :Non- Fermented coarse wheat bran
F.C.W.B : Fermented coarse wheat bran
Plate 22. Debeira, El-Nielain and Sasaraib bread with 10% Non Fermented and Fermented coarse wheat bran

Where:
- S.W.F: Sasaraib wheat flour
- E.W.F: El-Nielain wheat flour
- D.W.F: Debeira wheat flour
- N.F.C.W.B: Non-fermented coarse wheat bran
- F.C.W.B: Fermented coarse wheat bran

Where:
- S.W.F.+10% N.F.C.W.B
- E.W.F.+10% N.F.C.W.B
- D.W.F.+10% N.F.C.W.B
- S.W.F.+10% F.C.W.B
- E.W.F.+10% F.C.W.B
- D.W.F.+10% F.C.W.B
Sasaraib, El-Nielain and Debeira with 10% Non-fermented and fermented coarse wheat bran. Bread specific volume (cm$^3$/g) values of the three cultivars with 10% non-fermented and fermented coarse wheat bran ranged from 2.956 to 3.741 cm$^3$/g.

Debeira with 10% Non-fermented coarse wheat bran gave the highest value whereas El-Nielain with 10% fermented coarse wheat bran gave the lowest value. Statistical analysis of the results showed no significant difference ($p \leq 0.05$) between Sasaraib bread with 10% Non-fermented coarse wheat bran and Debeira bread with 10% Non-fermented coarse wheat bran in their bread specific volume. Also, there is no significant differences ($p \leq 0.05$) between ElNielain bread with 10% fermented coarse wheat bran and Debeira bread with 10% fermented coarse wheat bran in their bread specific volume. Generally, Sasaraib bread and Debeira bread with 10% non-fermented and fermented coarse wheat bran are the best in their bread specific volume.

These results of bread specific volume were higher than 2.5 and 2.2 cc/g reported by Siddiq (1999) and Sid Ahmed (2003). Also, high values of bread volume 355 – 376 and 376 cc Canadian wheat flour bread were reported by Hestangen and Frolish (1983) and Lukour (1990) respectively.

4.9 Organoleptic evaluation of bread with wheat bran

Tables from (26) to (31) show the sensory evaluation of breads containing non-fermented and fermented wheat bran. The control of the three cultivars Sasaraib, El-Nielain and Debeira breads were found to be excellent in colour, odour, taste, Crumb texture, Crumb grain and preference by panelists.
Table 26: Sensory evaluation of bread from Sasaraib wheat flour and Sasaraib with non-fermented wheat bran blends

<table>
<thead>
<tr>
<th>Flour blends</th>
<th>Sum of ranks</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Colour</td>
<td>Odour</td>
<td>Taste</td>
<td>Crumb texture</td>
<td>Crumb grain</td>
<td>Preference</td>
</tr>
<tr>
<td>Control S.W.F.</td>
<td>10</td>
<td>10</td>
<td>9.5</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>90% S.W.F 10% N.F.C.W.B</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>85% S.W.F 15% N.F.C.W.B</td>
<td>6</td>
<td>8</td>
<td>8</td>
<td>5</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>80% S.W.F 20% N.F.C.W.B</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>7</td>
<td>5.5</td>
</tr>
<tr>
<td>90% S.W.F 10% N.F.M.W.B</td>
<td>7</td>
<td>5</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>85% S.W.F 15% N.F.M.W.B</td>
<td>4</td>
<td>5</td>
<td>5.5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>80% S.W.F 20% N.F.M.W.B</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>6</td>
<td>5.5</td>
</tr>
<tr>
<td>90% S.W.F 10% N.F.F.W.B</td>
<td>9</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>85% S.W.F 15% N.F.F.W.B</td>
<td>5.3</td>
<td>7</td>
<td>2</td>
<td>5.5</td>
<td>5.5</td>
<td>6.5</td>
</tr>
<tr>
<td>80% S.W.F 20% N.F.F.W.B</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

Where :
S.W.F. : Sasaraib wheat flour
N.F.C.W.B. : Non-fermented coarse wheat bran
N.F.M.W.B. : Non-fermented medium wheat bran
N.F.F.W.B. : Non-fermented fine wheat bran
<table>
<thead>
<tr>
<th>Flour blends</th>
<th>Colour</th>
<th>Odour</th>
<th>Taste</th>
<th>Crumb texture</th>
<th>Crumb grain</th>
<th>Preference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control S.W.F.</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>90% S.W.F 10% F.C.W.B</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>85% S.W.F 15% F.C.W.B</td>
<td>4</td>
<td>7</td>
<td>7</td>
<td>8</td>
<td>2</td>
<td>6.5</td>
</tr>
<tr>
<td>80% S.W.F 20% F.C.W.B</td>
<td>6</td>
<td>7</td>
<td>7</td>
<td>5</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>90% S.W.F 10% F.M.W.B</td>
<td>7</td>
<td>6</td>
<td>7</td>
<td>6.5</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>85% S.W.F 15% F.M.W.B</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>4.5</td>
<td>4.5</td>
</tr>
<tr>
<td>80% S.W.F 20% F.M.W.B</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>90% S.W.F 10% F.F.W.B</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>7</td>
<td>5.33</td>
<td>3</td>
</tr>
<tr>
<td>85% S.W.F 15% F.F.W.B</td>
<td>3.66</td>
<td>2</td>
<td>5.5</td>
<td>5</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>80% S.W.F 20% F.F.W.B</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>4.5</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Where:

S.W.F : Sasaraib wheat flour
F.C.W.B. : Fermented coarse wheat bran
F.M.W.B. : Fermented medium wheat bran
F.F.W.B. : Fermented fine wheat bran
Table 28: Sensory evaluation of bread from El-Nielain wheat flour and El-Nielain with non-fermented wheat bran blends

<table>
<thead>
<tr>
<th>Flour blends</th>
<th>Colour</th>
<th>Odour</th>
<th>Taste</th>
<th>Crumb texture</th>
<th>Crumb grain</th>
<th>Preference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control E.W.F</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>90% E.W.F 10% N.F.C.W.B</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>85% E.W.F 15% N.F.C.W.B</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>6</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>80% E.W.F 20% N.F.C.W.B</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>90% E.W.F 10% N.F.M.W.B</td>
<td>8</td>
<td>6</td>
<td>7</td>
<td>7</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>85% E.W.F 15% N.F.M.W.B</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>80% E.W.F 20% N.F.M.W.B</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>2.75</td>
<td>4</td>
</tr>
<tr>
<td>90% E.W.F 10% N.F.F.W.B</td>
<td>7</td>
<td>7</td>
<td>6</td>
<td>7</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>85% E.W.F 15% N.F.F.W.B</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>3.33</td>
<td>2.5</td>
</tr>
<tr>
<td>80% E.W.F 20% N.F.F.W.B</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1.5</td>
<td>1</td>
</tr>
</tbody>
</table>

Where:
- E.W.F : El-Nielain wheat flour
- N.F.C.W.B : Non-fermented coarse wheat bran
- N.F.M.W.B : Non-fermented medium wheat bran
- N.F.F.W.B : Non-fermented fine wheat bran
Table 29: Sensory evaluation of bread from El-Nielain wheat flour and El-Nielain with fermented wheat bran blends

<table>
<thead>
<tr>
<th>Flour blends</th>
<th>Colour</th>
<th>Odour</th>
<th>Taste</th>
<th>Crumb texture</th>
<th>Crumb grain</th>
<th>Preference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control E.W.F</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>90% E.W.F 10% F.C.W.B</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>85% E.W.F 15% F.C.W.B</td>
<td>8</td>
<td>8</td>
<td>7.5</td>
<td>7</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>80% E.W.F 20% F.C.W.B</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>4.5</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>90% E.W.F 10% F.M.W.B</td>
<td>6.5</td>
<td>7</td>
<td>4</td>
<td>6</td>
<td>6</td>
<td>6.5</td>
</tr>
<tr>
<td>85% E.W.F 15% F.M.W.B</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>4.33</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>80% E.W.F 20% F.M.W.B</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>90% E.W.F 10% F.F.W.B</td>
<td>7</td>
<td>8</td>
<td>6.66</td>
<td>8</td>
<td>6</td>
<td>6.5</td>
</tr>
<tr>
<td>85% E.W.F 15% F.F.W.B</td>
<td>4.5</td>
<td>4.5</td>
<td>4</td>
<td>5</td>
<td>3.5</td>
<td>2</td>
</tr>
<tr>
<td>80% E.W.F 20% F.F.W.B</td>
<td>1</td>
<td>1.5</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Where:

E.W.F : El-Nielain wheat flour
F.C.W.B. : Fermented coarse wheat bran
F.M.W.B. : Fermented medium wheat bran
F.F.W.B. : Fermented fine wheat bran
Table 30: Sensory evaluation of bread from Debeira wheat flour and Debeira with non-fermented wheat bran blends

<table>
<thead>
<tr>
<th>Flour blends</th>
<th>Colour</th>
<th>Odour</th>
<th>Taste</th>
<th>Crumb texture</th>
<th>Crumb grain</th>
<th>Preference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control D.W.F</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>90% D.W.F 10% N.F.C.W.B</td>
<td>9</td>
<td>10</td>
<td>10</td>
<td>9</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>85% D.W.F 15% N.F.C.W.B</td>
<td>6</td>
<td>9</td>
<td>8</td>
<td>7.5</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>80% D.W.F 20% N.F.C.W.B</td>
<td>3</td>
<td>5</td>
<td>5</td>
<td>1</td>
<td>4.5</td>
<td>4.25</td>
</tr>
<tr>
<td>90% D.W.F 10% N.F.M.W.B</td>
<td>8</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>85% D.W.F 15% N.F.M.W.B</td>
<td>5</td>
<td>6</td>
<td>5</td>
<td>3.3</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>80% D.W.F 20% N.F.M.W.B</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>4.5</td>
<td>2</td>
</tr>
<tr>
<td>90% D.W.F 10% N.F.F.W.B</td>
<td>7</td>
<td>4.5</td>
<td>7</td>
<td>7</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>85% D.W.F 15% N.F.F.W.B</td>
<td>4</td>
<td>2.6</td>
<td>4</td>
<td>5</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>80% D.W.F 20% N.F.F.W.B</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1.5</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Where:
D.W.F: Debeira wheat flour
N.F.C.W.B: Non-fermented coarse wheat bran
N.F.M.W.B: Non-fermented medium wheat bran
N.F.F.W.B: Non-fermented fine wheat bran
Table 31: Sensory evaluation of bread from Debeira wheat flour and Debeira with fermented wheat bran blends

<table>
<thead>
<tr>
<th>Flour blends</th>
<th>Sum of ranks</th>
<th></th>
<th></th>
<th>Crumb grain</th>
<th>Preference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Colour</td>
<td>Odour</td>
<td>Taste</td>
<td>Crumb texture</td>
<td></td>
</tr>
<tr>
<td>Control D.W.F</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>90% D.W.F 10% F.C.W.B</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>85% D.W.F 15% F.C.W.B</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>80% D.W.F 20% F.C.W.B</td>
<td>4</td>
<td>1</td>
<td>5.5</td>
<td>3.5</td>
<td>7</td>
</tr>
<tr>
<td>90% D.W.F 10% F.M.W.B</td>
<td>7</td>
<td>7.5</td>
<td>7.5</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>85% D.W.F 15% F.M.W.B</td>
<td>3</td>
<td>5</td>
<td>5</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>80% D.W.F 20% F.M.W.B</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>90% D.W.F 10% F.F.W.B</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>85% D.W.F 15% F.F.W.B</td>
<td>5</td>
<td>3.5</td>
<td>4</td>
<td>5</td>
<td>5.5</td>
</tr>
<tr>
<td>80% D.W.F 20% F.F.W.B</td>
<td>1.5</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Where:
- D.W.F: Debeira wheat flour
- F.C.W.B.: Fermented coarse wheat bran
- F.M.W.B.: Fermented medium wheat bran
- F.F.W.B.: Fermented fine wheat bran
Table 32: Sensory evaluation of bread from Sasaraib, El-Nielain and Debeira with non-fermented and fermented 10% coarse wheat bran

<table>
<thead>
<tr>
<th>Flour blends</th>
<th>Colour</th>
<th>Odour</th>
<th>Taste</th>
<th>Crumb texture</th>
<th>Crumb grain</th>
<th>Preference</th>
</tr>
</thead>
<tbody>
<tr>
<td>90% S.W.F. 10% N.F.C.W.B.</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>90% E.W.F. 10% N.F.C.W.B.</td>
<td>4</td>
<td>4.5</td>
<td>4</td>
<td>4.5</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>90% D.W.F. 10% N.F.C.W.B.</td>
<td>5</td>
<td>6</td>
<td>5</td>
<td>5</td>
<td>4.5</td>
<td>4</td>
</tr>
<tr>
<td>90% S.W.F. 10% F.C.W.B.</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>90% E.W.F. 10% F.C.W.B.</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>90% D.W.F. 10% F.C.W.B.</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1.5</td>
<td>1</td>
</tr>
</tbody>
</table>

Where:
S.W.F.: Sasaraib wheat flour
E.W.F.: El-Nielain wheat flour
D.W.F.: Debeira wheat flour
N.F.C.W.B.: Non-fermented coarse wheat bran
F.C.W.B.: Fermented coarse wheat bran
Sasaraib, EI-Nielain and Debeira breads with 10% non fermented coarse wheat bran were found to be excellent in colour, odour, taste, crumb texture, crumb grain and preference by panelists.

Sasaraib, EI-Nielain and Debeira breads with 15% non fermented coarse wheat bran were found to be good in colour and very good and good in odour, taste, crumb grain, crumb texture and preference, But Sasaraib bread was found to be fair in crumb texture by panelists.

Sasaraib bread with 20% non –Fermented coarse wheat bran was found to be good compared with Debeira and El-Nielain bread by panelists.

Panelists preferred Sasaraib bread with 10% ,15% and 20% Non-Fermented medium wheat bran than Debeira and El-Nielain breads.Debeiia and Sasaraib breads with 10%and 15% Non- Fermented fine wheat bran were found to be good compared with El-Nielain bread by panelists.

The three cultivars Sasaraib, El-Nielain and Debeira breads with 20% non fermented fine wheat bran were found to be poor in colour, odour, taste, crumb texture, crumb grain and preference by panelists. From these results it can be concluded that panelists preferred the bread with 10% Non-Fermented coarse wheat bran than the other. These results were in good agreement with the results reported by Prentice and Fargo (1977) who reported that the high fiber bread had the same acceptability as the whole wheat bread.

Sasaraib, El-Nielain and Debeira breads with 10% fermented coarse wheat bran were found to be excellent in colour, odour, taste, crumb grain crumb texture and preference by panelists. Sasaraib bread with 15% and 20%
Fermented coarse wheat bran was found to be good compared with Debeira and El-Nielain bread. 10% fermented medium wheat bran bread for the three cultivars Sasaraib, Debeira and El-Nielain were found to be better than the other percentages. 10% fermented fine wheat bran bread for Debeira and El-Nielain were found to be good compared to Sasaraib bread which was found to be fair by panelists. Sasaraib, El-Nielain and Debeira breads with 15% and 20% fermented fine wheat bran were found to be poor by panelists.

From these results, it can be observed that panelists preferred the bread with 10% fermented coarse wheat bran.

These results are comparable with data reported by Sosulski and Wu (1988) who reported that more yellow crust bread was attained when corn bran was added to wheat flour, but wheat bran gave red colour to the crumbs that darkened it more severely than the pigment in other brans. Generally, from these results it can be observed that the panelists preferred the bread with non-fermented coarse wheat bran (10%).

Table 32 shows the final sensory evaluation of breads containing 10% non-fermented coarse wheat bran and 10% fermented coarse wheat bran with the three cultivars Sasaraib, El-Nielain and Debeira. Sasaraib bread with 10% non-fermented coarse wheat bran was the best in colour, odour, taste, crumb texture, crumb grain and preference compared to the rest of the breads. This characteristic of the bread led it to be the best by panelists. Debeira bread with 10% non-fermented coarse wheat bran was found to be second after Sasaraib bread. Sasaraib, El-Nielain and Debeira breads with 10% fermented coarse wheat bran were found to be poor in colour, odour, taste, crumb texture, crumb grain and preference by panelists.
Table 32: Sensory evaluation of bread from Sasaraib, El-Nielain and Debeira with non-fermented and fermented 10% coarse wheat bran

<table>
<thead>
<tr>
<th>Flour blends</th>
<th>Sum of ranks</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Colour</td>
<td>Odour</td>
<td>Taste</td>
<td>Crumb texture</td>
<td>Crumb grain</td>
<td>Preference</td>
</tr>
<tr>
<td>90% S.W.F. 10% N.F.C.W.B.</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>90% E.W.F. 10% N.F.C.W.B.</td>
<td>4</td>
<td>4.5</td>
<td>4</td>
<td>4.5</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>90% D.W.F. 10% N.F.C.W.B.</td>
<td>5</td>
<td>6</td>
<td>5</td>
<td>5</td>
<td>4.5</td>
<td>4</td>
</tr>
<tr>
<td>90% S.W.F. 10% F.C.W.B.</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>90% E.W.F. 10% F.C.W.B.</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>90% D.W.F. 10% F.C.W.B.</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1.5</td>
<td>1</td>
</tr>
</tbody>
</table>

Where:
S.W.F : Sasaraib wheat flour
E.W.F. : El-Nielain wheat flour
D.W.F. : Debeira wheat flour
N.F.C.W.B. : Non-fermented coarse wheat bran
F.C.W.B : Fermented coarse wheat bran
From these results, it can be concluded that panelists preferred the bread with 10% non-fermented coarse wheat bran than the other breads.

Gur and Janette (1988) reported that the dark crumbs were related to the presence of high ash content. Michael and Brain (1989) observed a gritty texture when cereal brans were added to the formulation of baked goods. These results agree with data reported by Stanyon and Costello (1990) who reported that wheat bran affects sensory properties of baked products.

Sosulski and Wu (1988) reported that wheat bran bread has a good texture. Sid Ahmed (2003) reported that the maize bran bread was significantly (P≤0.05) better in appearance, flavour and taste compared to the wheat bran bread and wheat bread. Also he reported that the sorghum bran bread was poor in appearance, flavour, taste and has a gritty texture.
Chapter Five

Conclusions and Recommendations

5.1 Conclusions

- Fermentation of wheat bran increases the percentage of crude fibre, protein, Minerals and total carbohydrates contents.
- Fermentation decreased tannins and phytic acid in wheat bran.
- Wheat flour with 10% non–Fermented or Fermented coarse wheat bran showed the best results of dough rheological properties compared with 15% and 20% bran.
- Cultivar Sasaraib gave the best flour quality for bread–making compared with the other cultivars investigated.
- The bread with 10% non fermented coarse wheat bran was found to be highly acceptable by panelists specially Sasaraib bread.
- Ascorbic acid gave the best results for bread quality.
5.2 Recommendations

- Ascorbic acid, shortening and sugar should be added to improve the bread quality of Sudanese wheat flour.

- 10% non-fermented coarse wheat bran should be used in bread-making although fermented wheat bran can be used to decrease the antinutritional factors and increase the nutritive value.

- Further studies are needed to investigate the nutritional value of fermented wheat bran bread.

- Studies are also needed to investigate fermented wheat bran bread when used with patients suffering from certain diseases such as obesity and diabetes.
References


