بسم الله الرحمن الرحيم

UTILIZATION OF SORGHUM MALT AS BREAD FLOUR CORRECTOR

By

Asma Awad Mohamed Abbas

B.Sc. (Honours) in Agriculture science
Faculty of Agriculture
University of Gezira
Sudan
2000

Supervisor
Dr. Babiker Elwasila Mohamed

A dissertation Submitted to University of Khartoum in
Partial Fulfillment for the Requirement of the Degree of Master of
Science in Food science and Technology

Department of Food Science and Technology
Faculty of Agriculture
University of Khartoum

May 2007

DETICATION

To my father AWAD
To my mother FATIMA
To my husband ABUBAKER
To my SISTERS and BROTHERS
To my daughters LINA and LUJYN

ASMA

ACKNOWLEDGEMENTS

First and last unlimited thanks and praise Merciful to "ALLAH" who supplied me with his blessings of health to complete this study.

I wish to express my deepest thanks and appreciation to my supervisor Dr. Babiker Elwasila Mohamed, for his subtle supervision, guidance, encouragement, valuable advice and unlimited help during this study.

Thanks and gratefulness are extended to all members of the Department of Food Science and Technology, Department of Soil and Environment (Faculty of Agriculture, University of Khartoum) and Food Research Center for their highly appreciated help and for giving me full access to their laboratories.

I would like to thank Ustaz Amir Mahgoub for his assistance in this study and also to many others who helped me to complete this study.

I am deeply indebted to my family, mother, father and my husband for their prayers, moral support and continuous encouragement; brothers and sisters for their help and my daughters for their great patience during the period of this study. Deep sense of gratitude and sincere feelings to them.

Finally God bless all those who helped me during this study.

List of contents

List of Tables

List of figures

List of plates

ABSTRACT

The present study was conducted to investigate the effect of adding different levels of germinated sorghum (sorghum malt) to the Canadian wheat flour on alpha-amylase activity and hence bread making.

Proximate composition of sorghum before and after germination was determined. The falling number after germination was determined under optimum conditions of temperature (30ºc) and time (72 hour). Four levels (0.04, 0.06, 0.08 and 0.1g) of sorghum malt of the two cultivars were each added to the Canadian wheat flour. The specific volume and sensory evaluation of bread made by the Canadian wheat flour only and the Canadian wheat flour treated with each of the levels investigated was determined.

The effect of germination on chemical components of the two sorghum cultivars (faterita and tabat) was determined. The moisture content was observed to increase in both cultivars, however the increase was insignificant. A significant ($P<0.01$) increase in reducing sugars, total sugars and carbohydrate was seen in both cultivars. Ash and fat contents in both cultivars were significantly decreased ($P< 0.01$) and the protein was insignificantly decreased. Fiber content decreased significantly ($P<0.01$) in faterita cultivar, but insignificantly in tabat cultivar.

The falling number was decreased from 1220 (tabat) and 663 (faterita) to 62 in both cultivars indicating increased alpha-amylase activity. The four levels, for both cultivars, gave falling numbers ranging from 351sec to 257sec compared to 386sec of the Canadian

flour (control), indicating increased alpha-amylase activity, hence the presence of the proper amount of the enzyme following all treatments.

The specific volume of bread showed insignificant difference in the bread made, however a significant difference ($P<0.01$) was observed in the bread made by addition of 0.01g faterita malt.

Sensory evaluation showed that there was no significant difference in the bread made by treatment of Canadian wheat flour with different levels of tabat and faterita malts in color, odor, taste, texture and overall acceptability, with exception of 0.04g of tabat malt which gave significant difference ($P<0.05$) in odor, taste and overall acceptability. Although the treatment of 0.04g sorghum malt did not significantly affect bread specific volume, it provides a good color, taste, odor and texture (tabat) and a good taste and texture (faterita).

خلاصة الأطروحة

أجريت هذه الدراسة لاختبار تأثير إضافة نسب مختلفة من زريعة الذرة المعـدة (طابـت وفتريتة) إلى دقيق القمح الكندي على نشاط إنزيم الالفا اميليز و من ثم على جودة الخبز المنتج.

أجري التحليل التقريبي للذرة قبل و بعد التذريع. أختبر تأثير التذريع فى ظـروف مثالـى (30 درجة مئوية لمدة 72 ساعة) على رقم السقوط للدلالة على نشاط إنزيم الألفا أميليز. أضيفت أربعة نسب مختلفة من زريعة طابت وفتريتة (0.04، 0.06، 0.08 و0.1 جرام) إلى دقيق القمـح الكنـدي للحصول على المدى الأمثل لنشاط الألفا أميليز فى صناعة الخبز. أختبر الحجم النوعى و التقييم الحسي لعينات الخبز المصنَع من دقيق القمح الكندي (عينة شاهد) و دقيق القمح مضافا إليه النسب المذكورة آنفا

أظهرت نتائج التحليل التقريبى لعينات الذرة (طابت وفتريتة) قبل وبعد التذريع عن وجود زيادة غير معنوية فى محتوى الرطوبة وزيادة معنويـة فـى محتـوى الـسكريات المختزلـة، الكليـة والكاربوهيدرايت، و إلى وجود نقصان معنوى فى محتوى الرماد والدهون ونقصان غير معنـوى فـى محتوى البروتين للعينتين ، أما فى محتوى الألياف فنجد نقصان غير معنوى فى العينة طابت ونقـصان معنوى فى العينة فتريتة.

وجد أن هنالك نقصان فى رقم السقوط بعد التذريع من 1220 ثانية للعينة طابت و 663 ثانيـة للعينة فتريتة إلى 62 ثانية للعينتين مما يشير إلى زيادة فى نشاط إنزيم الالفا أميليز.

اعطت نتائج إضافة الأربعة نسب المختلفة من زريعة طابت وفتريتة رقم السقوط يقع فـى المدى بين 351 إلى 257 ثانية مقارنة بالعينة الشاهد التى حصلت على رقم سقوط 386 ثانية.

إختبار الحجم النوعى لعينات الخبز المصنَع أظهر أنه لا يوجد إختلاف معنوى بين العينات فى طابت ووجود إختلاف معنوى بين العينة 0.01 وبقية العينات فى الفتريتة.

إختبار التقييم الحسى أظهر أنه لايوجد فرق معنوى بين العينات فى اللون، الطعـم، الرائحـة، القوام والقبول العام للعينتين طابت و فتريتة، ماعدا النسبة 0.04 (طابت) التى أظهرت وجود إختلاف معنوى فى الطعم و الرائحة و القبول العام. مع أن العينة 0.04 لم تحرز إختلاف معنوى عـن العينـة الشاهد فى الحجم النوعى ولكنها أضافت لون، طعم، رائحة و قوام جيديين فى العينة طابت و طعم وقوام جيدين فى العينة فتريتة.

CHAPTER ONE

INTRODUCTION

Bread, the staple food in many countries, is called "stuff of life", because it has a good nutritional value, beside protein it contains plenty of, carbohydrates (starch) and is a good source of dietary fiber, calcium and some of B-vitamins (Abulhassan, 2005).

Bread baking is one of the most common food processing techniques throughout the world. Although the bread products of different countries vary in their finished form, the basic component of all bread is wheat flour to which, water salt and yeast are added. The principle ingredients for bread making are wheat flour, water, yeast, salt and various additives (Sultan, 1976).

Improvement of flour quality is very essential for production of good quality bread. Most problems can be solved with the right flour treatment. In many cases it is possible to compensate for a low gluten or protein or some enzymes like alpha-amylase. Weak dough can be balanced as required by using the right additive (Bashir, 2006).

To change the wheat flour, to delicious and good tasty bread, we require some additions of other ingredients to the flour and special process. A baker learns early in the baking process that it is difficult to make fine bread unless he gains a fair degree of insight into the chemical, physical, biological and mechanical aspect of the baking craft (Abulhassan, 2005).

The cereal grains contain the host of enzymes necessary for living organism. Wheat flour naturally contains alpha and beta-amylases, which hydrolyze glycosidic linkages in carbohydrates. The amylase hydrolyzed sugars, which are then used by yeast during the baking process. The enzyme content of flours for bread making is of great importance and must be controlled.

The proper amount of amylases must be present in flour to achieve the right amount of yeast fuel and thus resulting suitable carbon dioxide generation. The amount of alpha-amylase is controlled by adding malted wheat or malted barley or malted sorghum flour to the regular flour to increase its diastatic power to certain level. The baker can rectify insufficient alpha-amylase activity in flour by adding a little malt flour, malt extract, or fungal amylase in dough making (Jones *et al.*, 1967, Perten, 1996).

The objectives of this research were to study:

1. The effect of germination on the chemical composition of sorghum grain.
2. The effect of adding different levels of malted sorghum flour to the Canadian flour, on alpha-amylase activity.
3. The effect of treatment of Canadian wheat flour with malted sorghum on bread quality.
4. Effect of correction of falling number of Canadian wheat flour on its baking characteristics.

CHAPTER TWO

LITERATURE REVIEW

Wheat is considered one of the main food crops in Sudan. It ranks after sorghum as a staple diet especially in urban centers. In addition to its use for bread, wheat entered into other uses and encouraged the growth and development of many industries such as biscuits, cakes, macaroni and other cereal products (Mohamed, 1992).

2.1 Chemical composition of wheat

Proximate analysis provides a good initial impression of the relative value and utility impression of an agricultural commodity, and allows a basis of comparison between different species, plant parts and cultivation conditions (FAO, 1992).

2.1.1 Moisture content

Moisture content is one of the most important factors affecting the quality of wheat (Anon, 1987).

Pareds-lopez *et al*. (1978) reported that the moisture content of mexican wheat flour is 11.2% however Badi *et al*. (1976) found that the moisture content of Sudanese wheat flour harvested in 1975 range between 10 and 11%. Elagib (2002) found that the moisture content of three Sudanese wheat cultivars namely Debaira, Elneelain and Wadi Elneel range between 6.23 and 7.49%.

2.1.2 Ash content

Ash content has been considered an important indicator of flour quality. It gives some indication of the miller's skill and degree of refinement in processing (Pratt, 1971).

The ash content of wheat flour was found in the range of 0.2-0.5% (Zeleny, 1971). Egan *et al*. (1981) reported that the ash content of wheat flour ranged between 0.2 and 0.8% depending on extraction rate. Elagib (2002) showed that the ash content of whole flours of three Sudanese cultivars ranged from 1.0 to 1.45%.

2.1.3 Protein content

Wheat is an important source of protein for people of developing countries (Blackman and Payne, 1987).

Haldor *et al*. (1982) reported that the protein content of whole wheat is between 10 and 16%. Ahmed (1995) reported that the protein content of four Sudanese wheat cultivars ranged between 8.21 and 12.26%. Mohamed (2000) showed that the protein content of the whole and white flour of four Sudanese cultivars Debaira, Elneelain, Condor and Sasarib ranged from 12.59 to 14.82%.

2.1.4 Fat content

Lipids in the grain are present mainly in the germ and bran fractions, with little in the endosperm (Southgate, 1993). The fats limit the keeping quality of wheat flour (Anon, 1987).

Ahmed (1995) found that the fat content of whole and white flour (72% extraction rate) of Sudanese wheat cultivars ranges between 1.91 and 2.36%. Mohamed (2000) reported that the fat content of four Sudanese wheat cultivars range between 2.15to 2.35%.

2.1.5 Fiber content

Fiber is the indigestible carbohydrate in food which acts like a broom to sweep out the digestive tract. Selvendran (1984) claimed that the highest concentration of fiber is found in the outer bran layers of the grain.

Ahmed (1995) reported that the crude fiber content of four Sudanese wheat cultivars ranges between 1.75 and 2.34%. Egan, *et al*. (1981) found that the fiber percentage in whole wheat flour ranges between 1.8 and 2.5% and in white flour (72% extraction rate) ranges between 0.1 and 0.3%.

2.1.6 Carbohydrates

The three major groups of carbohydrates are sugars, starches and cellulose. In general, carbohydrates constitute about 75% of the solid content of cereal (Hulse *et al*., 1980).

2.2 Chemical composition of sorghum

Sorghum is the most important cereal crop in Sudan and ranks third among cereals for human consumption (Elkhalifa, 1993). Sorghum grain composition is more variable than that of corn, because of the more variable conditions of sorghum production (Rooney, 1973).

2.2.1 Moisture content

Yousif and Magboul (1972) who analyzed fifteen sorghum cultivars grown in Sudan reported that the moisture content ranges between 5.7 and 10%. According to Mohamed (2000), the moisture content of three sorghum cultivars was ranging between 6.0 and 6.7%. Ahmed (1993) found that the moisture content of four sorghum varieties ranged between 7.09 and 9.16%. Abdelnour (2001) found that the moisture content of faterita and dabar were 9.60% and 8.75% respectively.

2.2.2 Ash content

Norris and Rooney (1970) studied the chemical composition of sorghum grain parents and hybrids and found that the ash content ranged from 0.7 to 1.5%. Ash content of sorghum grown in Sudan ranged between 1.7 and 1.72% (El Tinay *et al*. 1979). Eggam *et al.* (1983) found that the ash content of faterita, tetron and dabar varied between 1.7 and 2.1%. Yousif and Magboul (1972) determined the ash contents of different cultivar of sorghum grown in different part of Sudan were in the range of 1.2 to 2.6%. Mohamed (2000) reported the ash content of three sorghum cultivars, namely, dabar, fakimustahi and tetron as 1.74%, 1.41% and 1.41% respectively. Abdelnour (2001) found that the ash content of faterita and dabar were 1.80% and 1.55% respectively.

2.2.3 Protein content

Norris and Rooney (1970) studied the chemical composition of sorghum grain of parent and hybrids and found that the protein content ranges from 11.3 to 14%. El Tinay *et al*. (1979) reported that the protein content of sorghum grown in Sudan range between 9.75 and 11.6%. Eggam *et al.* (1983) who analyzed Tetron, Dabar and Faterita found that the protein content ranged between 10.9 and 13.4%. El Sharif (1993) analyzed dabar cultivar and found protein content was 10.8%. Elsayed (1999) analyzed tabat, mugud and faterita and found protein contents of 6.64, 9.11 and 12.71% respectively. Abdelrahman (2000) reported that the protein content of three sorghum cultivars safra, faterita and ahmer ranged between 10.1 and 13.6%. Abdelnour (2001) reported that the protein content of faterita and dabar were 13.13 and 12.95% respectively.

2.2.4 Fat content

The lipids of sorghum are important nutritionally and also influence the flavor and storage characteristic of sorghum (Wall and Blessin, 1969). The germ is the main contributor to the lipid fraction (FAO, 1995).

Rooney and Clark (1968) found lipids content for sorghum grain in the range of 3-4%. Sorghum grown in Sudan contains 2.5-3.5% fat content (El Tinay *et al*., 1979). Eggam *et al*., (1983) analyzed tetron, dabar and faterita grain and they found that the fat content varied between 4.0 and 5.0%. El Sharif (1993) analyzed dabar cultivar of sorghum and found fat content of 3.4%. Kattab *et al.* (1972) reported that the fat content of three sorghum cultivars faterita, safra and ahmer ranged from 2.7 to 3.0%. Ahmed (1993) found that the fat content of faterita and dabar were 3.36 and 4.12% respectively, while Abdelnour (2001) found that the fat content of faterita and dabar were 3.50 and 3.75% respectively.

2.2.5 Fiber content

The term of dietary fiber is used to describe a variety of indigestible plant materials (FAO 1995).

Sorghum grown in Sudan contains 1.2-1.95% crude fiber (El Tinay *et al*., 1979). Eggam *et al.* (1988) analyzed tetron, dabar and faterita grain and found crude fiber content ranged between 2.0-2.1%. El Sharif (1993) analyzed Dabar cultivar and found the crude fiber content was 0.9%. Ahmed (1993) found that the faterita contain 1.5% and dabar contain 1.7% fiber content. Whereas Elsayed (1999) reported that the fiber content of tabat and faterita was 2.33% and

2.46% respectively. Abdelnour (2001) analyzed faterita and dabar and found that their fiber contents were 1.25% and 1.7% respectively.

2.2.6 Carbohydrate content

The carbohydrate of sorghum is composed of starch, soluble sugar, pentose and cellulose. Starch is the most abundant component of it and is the major storage form of carbohydrates in sorghum.

Carbohydrates content of fifteen sorghum varieties ranged from 72.4 to 78.7% (Yousif and Magboul, 1972). Carbohydrate content of dabar, fakimustahi and tetron were 75.20%, 71.22% and 75.13% respectively (Mohamed, 2000). Analysis of four sorghum cultivar showed a range of 74.18 to 78.04% (Ahmed, 1993). The carbohydrate content of faterita and dabar were 70.47% and 71.20% respectively shown by Abdelnour (2001).

2.3 Changes in chemical composition of sorghum grain during germination

Wu and Wall (1980) reported that there was little difference in the protein content during the first three days of germination of sorghum grain. Close and Naves (1959) found a slight decrease in total nitrogen during germination of sorghum. Chavan *et al.* (1981) reported that the reducing sugars content increased from 0.4-12mg/g in low tannin cultivars and from 3.7-8.2 mg/g in high tannin cultivars grain after 120 hours of germination. The crude fiber content of sorghum malt was slightly lower than of sorghum grain (Aucamp *et al.*, 1961). Malleshi and Desikachar (1986) reported that malting raises fiber content.

In the first three days of germination, there was a little difference in the ash content and fat content of sorghum grain (Wu and Wall, 1980) however Perisse *et al.* (1959) have reported slightly lower values of ash and calcium for sorghum malt compared to the grain. Abdlrahman (2004) reported that malting treatment has been found to decrease the fat content in sorghum and millet, while malting increase ash content of cereal. The lipids content of sorghum malt has been reported to be lower than that of sorghum grain (Perisse *et al*., 1959; Acucamp *et al*., 1961; Bureng, 1979). Budair (1977) claimed that the malts of faterita sorghum are superior to the malt from other sorghum types. Elshewaya (2003) analyzed tabat and faterita malt for their proximate composition and found that the moisture content was 3.72 and 4.17%, ash content was 1.24 and 1.68%, crude fiber content was 2.52 and 2.85%, fat content was 2.75 and 1.73%, crude protein content was 10.50 and 15.46% and carbohydrates content were 79.27 and 74.09% respectively.

2.4 Bread making

Bread baking is one of the most common food processing techniques throughout the world although the bread products of different countries vary in their finished form. Bread known as a staple food in many countries, it is called "stuff of life" because it has good nutritional value (Abulhassan, 2005). The basic component of all bread is wheat flour to which water, salt and yeast are added. Other ingredients are some times added such as sugar, fats and flavoring components of wheat flour and their relative abundance are 82% starch, 12% protein and 3% fiber.

The finished product is therefore a result of dough processing, enzymatic action and cooking on a complex net work of starch, protein, fiber and fats.

The total protein of the flour was directly correlated with the baking quality .Also the baking quality was highly correlated with the percentage of total protein soluble in isopropyl alcohol (Edward, 1966).

Blackman and Payne (1987) reported that the protein content of wheat used for bread making may vary from 11-15%. Kaldy *et al*., (1987) reported that the main criteria for good quality are high bread volume and a fine uniform crumb texture that is tender and moist. Good quality flour for bread making should have high water absorption, medium to medium-long mixing requirement, satisfactory mixing tolerance, dough handling properties and good loaf volume, (Bashir, 2006)

Before the mixed dough can yield alight, aerated loaf of bread, it must be fermented for a proper length of time during which the yeast cells uniformly dispersed throughout the dough mass by mixing, act upon the available sugars. Flour basis, that must be present in dough, either as result of amylotic action on starch or as an added ingredient, if proper aeration of the dough is to be achieved (Pyler, 1973).

The effects of yeast, salt, malt and sugar during proofing were found to be analogous to their effects during fermentation; yeast increase gas production and gas retention. The addition of malt to formula affects neither the rate of production nor the rate of retention (Mark, 1968).

The principle ingredients for bread making are wheat flour, water, yeast, salt and various additives. There are many operations carried out for making bread. Each of these operations may, more or less, comprise dough mixing, fermentation, punching, scaling and rounding the dough, intermediate or final proofing and baking (Sultan, 1976).

The gluten proteins found in wheat flour make it uniquely suited to use in bread making during the kneading process, which causes the formation of coherent dough, gluten proteins form a viscoelastic net work capable of retaining the carbon dioxide produced during fermentation. Starch, the major component of wheat flour, does not play a major role in dough formation but does play an important role in the development of bread crumb during baking (Hille, 2004).

The general methods of making bread is to prepare a dough of flour, yeast, salt and water, the yeast act on the sugars present in the dough, either in the form of added glucose or sucrose or those produced by natural enzymatic action on the flour, producing carbon dioxide gas which distends the dough causing it to rise. At the same time by the initial mixing operation and during the period of fermentation the gluten of the dough is developed and mellowed (Williams, 1970).

2.4.1 Bread quality

Bread quality is usually judged by: loaf volume, crumb texture, aroma and color.

2.4.1.1 Loaf volume

Cauvain and Chamberlain (1988) stated that, loaf volume increase is attributed to improved gas retention and to extending the period of dough expansion during the baking stage.

Mohamed (2000) showed that the bread specific volume of Sudanese wheat cultivars Condor, Sasarib, Debaira and Elneelian ranged between 3.66 and 4.05 cm^3/g. However Elagib (2002) found that the bread specific volume of Sudanese wheat cultivars debaira, Wadielneel and Elneelian ranged between 2.95 and 3.47 cm^3/g.

2.4.1.2 Crumb texture

The texture may be too soft, some times "gummy", this retention of moisture in the crumb results from the production of too many dextrins from the starch and the loss of gulten structure (Mathewson, 2000).

Kaldy and Rubenthaler (1987) reported that the fine uniform crumb texture that is tender and moist is one of the main criteria for good bread quality. Generally, flour with high protein content or strong gluten or both, produces a coarse and heavy texture.

2.4.1.3 Aroma

Aroma is an important factor governing food acceptability. The aroma of bread results from the interaction of reducing sugars and amino component, accompanied by the formation of aldehydes. Also aroma is affected by the products of alcoholic and in some cases, lactic acid fermentation (Kent, 1983; Lyla, 2002).

2.4.1.4 Color

One of the most important sensory quality attributes of food is color, because no matter how nutritionus flavorful or well textured a food may be, it is unlikely to be eaten unless it has the right color (Ashkenazi *et al*., 1991).

Mathewson (2000) reported that, amylases and protease can contribute to Millard reaction which requires a reducing sugar and amino group.

2.5 Enzymes in wheat

The enzymes are biocatalysts elaborated by living cells. All enzymes have proven to be proteins and respond to modifications in the environment, such as moisture, pH, salts, coagulants and temperature.

Enzymes are classified according to the substrate on which they act. In cereal enzymology, major attention has been devoted to the amylases and proteases. Less attention has been given to the lipases, phosphatases, phosphylases, oxidases, dehydrogenases and decarboxylases (John, 1965).

Because arabinoxylans have important functional properties in bread making, enzymes capable of hydrolyzing these polysaccharides are of great insert. The level of hemicellulase activity in wheat flour is usually far too low to deliver an optimum effect in bread making. (Hille, 2004).

Use of protease in sponge dough reduces mixing requirement at the dough stage. Protease treated dough are more extendible and can be sheeted more thinly and molded with greater ease a fact which is particularly beneficial in the case of "bulky" dough (Pomeranze, 1966). In general, several effects can be expected as a result of specific enzymatic modification of the flour components (Mathewson, 2000).

2.5.1 Amylases activity

Amylase activity is one of the factors influencing baking quality, (Novo 1974). Use of amylases in the baking industry is of long standing, its original purpose was to generate fermentable sugars by amylases hydrolysic of starch to improve volume and general bread characteristics. (Kuracina *et al*., 1987).

2.5.1.1 Beta-amylase activity

Beta-amylase is available abundantly in most sound, un-germinated cereals. It is responsible for releases of maltose unit from the non reducing side of the glucosidic chain by breaking of alpha 1-4 bond (Johnson, 1965). Beta-amylase can produce some maltose to aid fermentation with out the presence of alpha-amylase, but the amount produced is relatively small (Mathewson, 2000).

2.5.1.2 Alpha-amylase activity

Wheat alph-amylase is recognized as an important enzyme in affecting the quality of wheat for bread making (Stear, 1990). The influence of alpha-amylase activity is of 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 sugar for yeast fermentation to produce bread with softer crumb and greater volume (Perten, 1964). Alpha-amylases in contrast to beta, is present in ungerminated cereal in only trace amount. Dextrin production in bread depends on source and amount of alpha-amylase employed (Johnson, 1965). Supplementation of alpha-amylase is therefore necessary, to provide benefits such as improved gas retention and increase loaf volume (Lindah, 1992). 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 (Jones *et al.,* 1967 and Perten 1996). Greenaway (1969) found that the high alpha-amylase activity makes thin graves and bread with small loaf volume.

Perten (1996) mentioned that falling number values below 150 second (high alpha amylase activity) in sprout damaged wheat it's likely to produce sticky bread, while 200-300 second (optimal amylase activity) and above 300 second (low amylase activity) in sound wheat.

Kadly *et al.* (1987) found that the falling number of white winter and spring wheat, ranged between 380-450 second, while Lukow, et al (1991) observed that falling number of hard red spring wheat cultivars ranges between 302-332 second. Ahmed (1995) showed that the falling number values of some Sudanese wheat cultivars ranged between 396-486 second. However Mohamed (2000) found that the falling number values of four Sudanese wheat cultivars Debaira, Elneelain, Condor and Sasarib ranged between 425-675 second.

2.6 Germination

Malting is process where the grains are allowed to germinate under controlled conditions of temperature and moisture (Adsule 1984).

It was thought that germination was necessary to increase enzyme activity of grains and to induce the physicochemical changes in the caryopses known as modification. (Fleming *et al.*, 1964).

Malting up grades the quality and taste of cereals by making considerable biochemical change (e.g.) releases amylase enzymes that break starches down in to digestible forms including sugar (Malleshi and Desilachar, 1986).

The malting process that generates fermentable mono and disaccharides from starch is dependent upon the activity of alpha and beta amylases and maltose which develop during germination (Novellie, 1960, 1962). Sorghum grain contains only traces of alpha and beta amylases (Keen, 1944).

For optimum development of diastatic power in sorghum high temperature (25-30°C) and high moisture contents are needed during germination. The diastatic power increased rapidly on the first 2-4 days of germination, there after the rate of development slowed down.

The optimum condition of malting requires high moisture and temperature of 25-30ºC where maximum amylases activity occurs at six to seven days (Novellie 1962).

The high alpha-amylase activity was obtained after 72 hour at 30°C. Optimizing the wheat flour falling number required 0.07 g tabat malt and 0.06 faterita malt (Mustafa and Elshewaya, 2004).

CHAPTER THREE
MATERIALS AND METHODS

3.1 Materials

3.1.1 Samples

Two Sorghum cultivars (Tabat and Faterita), and commercial Canadian wheat flour were purchased from the local market.

3.1.2 Chemicals

Chemicals used in this study were of analytical grade obtained from University of Khartoum.

3.2 Methods

3.2.1 Preparation of samples

Sorghum was cleaned and freed from foreign materials, dirt and stones. One part was milled and passed through 0.3mm sieve, and then kept at 4°C for subsequent chemical analysis. The remaining part was used for germination.

3.2.2 Proximate analysis

Proximate analysis was carried out to determine the various components of the grain and malt. Moisture, ash, crude fat and crude fiber contents were determined according to AOAC (1999). Crude protein content was determined by macro kjeldal technique described by Parten (1975).Carbohydrates content were calculated by difference.

3.2.3 Sugars determination

Reducing and total sugars were determined by the method of Lane and Eynon (1932) as described by Person (1976) with some modifications.

3.2.3.1 Reducing sugars

Fifteen grams flour sample were taken in a 250 ml volumetric flask and the sample was mixed with 100 ml distilled water in a water bath set at 70ºC and left for 30 minutes for extraction. The extract was cooled to room temperature (25°C±2) and the volume was completed to 250 ml by distilled water. The solution was clarified by 2 ml of lead and calcium salts and 3 ml potassium oxalate and then filtered. A 10 ml of fehling solution (fehling A and B) were pipette in a conical flask .The burette was filled with the sugar solution prepared, 15 ml was run into fehling solution and mixed well. The liquid was boiled on asbestos-covered gauze and further quantities of the sugar solution (1 ml at a discharged) were added, 3-5 drops of aqueous methylene blue solution (1%) were then added. The boiling liquid was continuing titrating until the indicator is completely colored. At end point all the blue colors were discharged and the liquid was orange-red.

The same procedure was used with malt sample except that 5 g of malt sample were used instead of 15 g of grain sample.

The percent of reducing sugars were calculated as:

$$\text{Reducing sugars\%} = \frac{\text{mg sugar/100 ml of solution x dilution factor}}{\text{1000 x weight of sample}}$$

3.2.3.2 Total sugars

Six milliliters of concentrated HCL were added to 50 ml sugar solution and kept in a water bath set at 70°C in for 5 minutes. The solution was completed to 100 ml, cooled and 3 drops of phenolphthalein indicator were added, neutralized with sodium hydroxide (NaOH) and titrated as described in section 3.2.3.1. Total sugars were then calculated as mg, from the Lane and Eynon Tables described by Person (1976).

3.2.4 Germination

The germination of sorghum grains was carried out according to the method of Bhise *et al*. (1988) with some modifications. The seeds were soaked in distilled water for 24 hour, and then in 0.2% formaldehyde (1:2 w/v) for 40 minutes to prevent mould growth during germination. The soaked solution was drained and the seeds were washed several times and further soaked in distilled water for 20 minutes to remove the remaining formaldehyde. The wet seeds were then spread on a wet germination paper and sprayed with distilled water and germinated in an incubator at 30°C for 72 hours.

3.2.5 Determination of alpha amylase activity

Alpha amylase activity was determined according to the AOAC (1984) method using falling number (F.N) system.

Different levels of malt (0.04, 0.06, 0.08, 0.1g) were added to seven grams (or appropriate weight sample calculated to 14% H_2O bases = 7.0 (100-14)/(100-M), where M= actual % H_2O wheat flour was weighed into dry falling number tube. Distilled water (25ml) was added and the tube was closed with rubber stopper and shaked well until a homogenous suspension was formed. The tube was placed in a water bath and locked into position. The sample was stirred with viscometer stirrer for 60 seconds. The stirrer was then stopped in upper position and left to drop by its own weight. The time in seconds (the stirrer dropping time) for the stirrer to fall through the homogenous paste was recorded as the falling number.

3.2.6 Bread making

Bread samples were made as follows:

The various wheat/sorghum malt flour blends and the control (wheat flour) were fermented and baked according to the procedure described by Badi *et al*. (1978) with some modifications. The formula used was as follows:

Wheat Flour containing different levels (0.04, 0.06, 0.08, 0.1) of malt	250 g
Dry active yeast	2.5 g
Salt	1.5 g
Sugar	3.0 g
Water	170 ml

Dry ingredients mentioned were weighed and mixed in a mono-universal laboratory dough mixer. Water was added and mixed for 3 minutes at medium speed. The dough was allowed to rest for 10 minutes at room temperature (38±2°C).Then scaled to three portions of 120g each. The three dough portions were roughly rounded into round balls and allowed to rest for another 10 minutes, then molded, placed in pans and transferred in the fermentation cabinet for (45 minutes). Finally, the fermented dough samples were baked into bread in Simon Rotary baking Test Oven at 250°C for 20 minutes. The loaves were left to cool, sliced with an electric knife and some slices were kept at room temperature (38±2°C) for sensory evaluation.

3.2.6.1 Physical analysis

3.2.6.1.1 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 were run until the container is full. The volume of seeds displaced by the loaf was considered as the loaf volume.

3.2.6.1.2 Bread weight

The loaf weight of bread was taken in gram by sensitive balance.

3.2.6.1.3 Bread specific volume

The specific volume of the loaf was calculated according to the AACC method (2000) by dividing volume (cc) by weight (gm).

3.2.6.2 Sensory evaluation

The organoleptic quality of bread samples was assessed according to the ranking method described by Ihekoronye and Ngoddy (1985). Assessors (12) were asked to rank bread samples according to sensory attributes for color, odor, taste, texture and overall acceptability.

3.2.7 Statistical analysis

Triplicates of each sample were statistically analyzed, using the complete randomized design. The analysis of variance was performed to examine the significant effect in all parameters measured. Duncan multiple range test was used to separate the means (Duncan, 1955).

CHAPTER FOUR
RESULS AND DISCUSSION

4.1 Proximate Chemical Composition

The proximate chemical composition of Sorghum grain flour and sorghum malt flour is shown in table (1).

4.1.1 Moisture content

The moisture content of Sorghum grains was found to be 10.3% and 9.85% for tabat and faterita cultivars respectively. No significant difference ($P > 0.05$) in moisture content was observed between the two cultivars investigated. Faterita moisture content lies within the range of 5.7-10% reported by Yousif and Magboul (1972) for fifteen varieties of sorghum grown in Sudan, however tabat gave higher. The values obtained were higher compared to the value of 2.4% for Dabar (El Sharif, 1993); the range of (7.09-9.16%) of four sorghum varieties (Ahmed, 1993); the range (6.0-6.7%) for three sorghum varieties (Mohamed, 2000) and values 9.60% for faterita and 8.75% for dabar (Abdnour, 2001).

The moisture content of Sorghum malt was found to be 10.7% for tabat and 10.1% for faterita. Elshewaya (2003) reported lower moisture content values for tabat malt (3.72%) and faterita malt (4.17%). The results of the present study indicated that germination increases the moisture content, however the increase was not significant.

Table 1: Proximate composition of sorghum grains and sorghum malt.

Type of flour	Moisture content (%)	Ash content (%)	Protein content (%)	Fat content (%)	Fiber content (%)	Carbo-hydrates (%)
Tabat grain	10.3^{a}	1.6^{a}	10.4^{b}	4.6^{a}	0.9^{b}	72.2^{b}
Tabat malt	10.7^{a}	0.7^{b}	10^{b}	1.2^{c}	0.8^{b}	76.6^{a}
Faterit grain	9.85^{a}	1.7^{a}	12.3^{a}	5.3^{a}	1.6^{a}	69.3^{c}
Faterita malt	10.1^{a}	0.8^{b}	11.7^{a}	3.5^{b}	0.9^{b}	73^{b}

Means with the same superscript letters in each column are insignificantly different.

4.1.2 Ash content

The ash content of sorghum was found to be 1.6% for tabat cultivar and 1.7% for faterita cultivar. These values were higher than the range of 0.7-1.5% reported by Norris and Rooney (1970) for sorghum grown in Sudan. Faterita ash content lies within the range 1.7-2.1% reported by Eggam (1983) for faterita, tetron and dabar, however tabat ash content is lower than this range. Both tabat and faterita cultivars ash content obtained in the present investigation lies within the range 1.2-2.6% reported by Yousif and Magboul (1972) who determined the ash content of different cultivars of sorghum grown in different part of Sudan. Abdelnour (2001) reported 1.55% ash content for dabar and 1.80% for faterita.

The ash content of tabat and faterita malt flour were 0.7%, 0.8% respectively. These values were lower than the values of 1.24% (tabat malt) and 1.64% (faterita malt) reported by Elshewaya (2003). Germination decreased ash content of both cultivars investigated. Wu and Wall (1980) reported that there was a little difference in the ash content of sorghum grain in the first three days of germination. Slightly lower values of ash content for sorghum malt compared to sorghum grain were reported by Perisse *et al*. (1959).

4.1.3 Protein content

The protein content of the two sorghum cultivars of tabat and faterita were 10.4% and 12.3% respectively. Tabat protein content lies within the range of 9.75-11.6% reported by El Tinay (1979) for sorghum grown in Sudan; however faterita protein content is higher than this range. Tabat protein content is lower than the range 10.9-13.4% reported by Eggam *et al*. (1983) for tetron, dabar and faterita, while faterita protein content lies within the range. The protein content of both tabat and faterita lies within the range 10.1-13.6% reported by Abderhman (2000) for protein content of three sorghum cultivars safra, faterita and ahmer. Abdelnour (2001) reported 13.13% for faterita and 12.95% for dabar which were higher than the values obtained in this study. Elsayed (1999) reported 6.64%for tabat and 12.71% for fateria.

The protein contents of tabat and faterita malt flour were found to be 10% and 11.7% respectively. Elshewaya (2003) found protein content of 10.5% for tabat malt and 15.46% for faterita malt which were higher than the values obtained in this study. From the results of this study it was noticed that germination decreases the protein content of grains, however the difference is not significant. Variation in sorghum grain and malt protein contents may be attributed to the little difference in the protein content during the first three days of germination of sorghum grain (Wu and Wall, 1980).

4.1.4 Fat content

Fat contents obtained in the present investigation were 4.6% for tabat and 5.3% for faterita. These values were higher than the value of 3.4% reported by El sharif (1993) for dabar cultivar. Tabat fat content lies within the range 4.0-5.0% reported by Eggam (1983) who analyzed teteron, dabar and faterita, however faterita fat content is higher than this range. Abdlenour (2001) reported values of 3.50% for faterita and 3.75% for dabar which were lower than the values obtained in the present investigation. Once again lower values were reported by Ahmed (1993) and these were 3.36% for faterita and 4.12% for dabar fat contents.

Fat content of tabat and faterita malt flour were 1.2% and 3.5% respectively. Elshewaya (2003) reported higher value for tabat malt (2.75%) and lower value for faterita malt (1.73%). The fat content of sorghum malt was observed to decrease significantly (P< 0.01) compared to sorghum grain. Malting decreased fat content in sorghum and millet (Abdlrahman, 2004). The decrease in fat content may be also attributed to difference in fat content during germination of sorghum grain (Wu and Wall, 1980).

4.1.5 Fiber content

The fiber contents of tabat and faterita flours were found to be 0.9% and 1.6% respectively. Faterita fiber content lies within the range 1.2-1.95% reported by El Tinay *et al*. (1979) for sorghum grown in Sudan, however tabat fiber content is lower. Crude fiber content for both tabat and faterita cultivars were lower than the range 2.0-2.1 reported by Eggam *et al*. (1983) for analyzed tetron, dabar and fatrerita, and the values of 2.33% (tabat) and of 2.46% (faterita) reported by Elsayed (1999). A similar value for tabat fiber content was reported by El sharif (1993) for dabar variety. Ahmed (1993) reported 1.5% for faterita and 1.7% for dabar while Abdelnour (2001) reported 1.25% for faterita and 1.7% for dabar.

The fiber content of tabat and faterita malt flours were 0.8% and 0.9% respectively. These values were lower than the values of 2.52% (tabat malt) and 2.85% (faterita malt) reported by Elshewaya (2003). In the present investigation the crude fiber content of sorghum grain observed to be higher than sorghum malt, however the variation is not significant in tabat cultivar and significant (P< 0.01) in faterita cultivar. Aucamp *et al*. (1961) observed that the crude fiber content of sorghum malt was slightly lower than that of sorghum grain.

4.1.6 Carbohydrate content

Carbohydrate contents were found to be 72.2% for tabat and 69.3% for faterita. The carbohydrates content of both tabat and faterita cultivars were lower than the values ranging from 72.4 to 78.7% reported by Yousif and Magboul (1972) studies fifteen sorghum varieties. The values obtained in this investigation were lower than the range 74.18-78.04% reported by Ahmed (1993) for four sorghum varieties. Abdelnour (2001) reported carbohydrate content of 70.47% for faterita and 71.20% for dabar.

Carbohydrate content of tabat malt was 76.6% and faterita malt was 73.0%. These results were lower than the value of 79.27% tabat malt and 74.09% faterita malt reported by Elshewaya (2003). The carbohydrate content of sorghum malt was observed to increase significantly ($P< 0.01$) compared to the sorghum grain. This variation may be attributed to the fact that the content of other parameter such as ash content, protein content, fat content and fiber content were decreased. The starch content of sorghum malt was reported to be slightly higher than the sorghum grain (Perisse *et al*., 1959).

4.1.7 Sugars content

Results of reducing and total sugars were presented in table 2. Tabat grain gave 1.6% reducing sugars and 2.6% total sugars and faterita grain gave 1.4% reducing sugars and 2.8% total sugars. Asimilar value for tabat total sugar was reported by Elsharif (1993) for dabar variety. Elshewaya (2003) reported lower values of reducing

Table 2: **Reducing and total sugars of sorghum grains and sorghum malt**.

Type of flour	**Tabat grain**	**Tabat malt**	**Faterita grain**	**Faterita malt**
Reducing sugars %	1.6 [c]	6.4 [b]	1.4 [c]	10.7 [a]
Total sugars %	2.6 [b]	12.4 [a]	2.8 [b]	12.3 [a]

Means with the same superscript letters in each row are insignificantly differente sugars 0.63% for tabat and higher value of 1.67% for faterita and lower values of total sugars 1.34%, 2.24% for tabat and faterita respectively. Reducing sugars of tabat and faterita malts were 6.4% and 10.7% respectively, while total sugars were 12.4% and 12.3% respectively. Elshewaya (2003) reported lower values of reducing sugars 0.83% (tabat malt) and 1.77% (faterita malt).Once again lower values of total sugars of 2.61% (tabat malt) and of 5.02% (faterita malt) were reported by Elshewaya (2003). The results in this study showed that sugars (reducing and total) were significantly ($P<0.01$) increased after germination. Chavan *et al*. (1981) reported reducing sugars content increased from 0.4 to 12mg/g in low tannin cultivars and from 3.7 to 8.2 mg/g in high tannin grain after 120 hours of germination.

4.2. Effect of germination on tabat and faterita flours alpha-amylase activity:

The effect of germination at 30°C for 72 hour on alpha-amylase activity was studied. Alpha-amylase activity was determined using falling number system. The results were shown in table 3.

The alpha-amylase activity of both cultivars was increased after germination as the falling number were observed to decrease from 1220 second to 62 second for tabat and from 662 second to 62 second for faterita. Alpha-amylase activities after germination for both cultivars (tabat and faterita) were significantly increased ($P<0.01$). Sorghum (tabat and faterita) germinated for 72 hour at 30°C resulted in increased alpha-amylase activity (Mustafa and Elshewaya, 2004). Palmer and Agu (1997) found that germination temperature of 30°C had raised the level of alpha-amylase produced compared to20°C.Lasekan (1996) stated that the increase in germination time

Table 3: Effect of germination on tabat and faterita flours alpha-amylase activity

Type of flour	Falling number second
Tabat grain	1220[a]
Tabat malt	62[c]
Faterita grain	663[b]
Faterita malt	62[c]

Means with the same superscript letters in column are insignificantly different was found to produce more alpha-amylase. The optimum condition of malting requires high moisture and temperature of 25-30°C where maximum alpha-amylase activity occurs in 6-7 days (Novellia, 1962).

4.3 Treatment of regular wheat flour with different levels of sorghum malt.

Optimizing the wheat flour falling number (alpha-amylase activity) required addition of 0.07 g tabat malt and 0.06 g faterita malt to wheat flour (Mustafa and Elshewaya, 2004). Based on the levels recommended by Mustafa and Elshewaya, (2004), an attempt in the present investigation was carried out to study the effect of adding different levels of sorghum (tabat and faterita) malts on alpha-amylase activity. Levels of 0.04 g, 0.06 g, 0.08 g and 0.1 g for both tabat and faterita malts were added to the Canadian (commercial) wheat flour, to see their effect on alpha-amylase activity and hence bread quality.

The results of addition of different levels of tabat and faterita malt to the Canadian (commercial) wheat flour were shown in Table 4 and (Figs 1 and 2).

The results indicated that addition of the various levels of tabat malt resulted in an increased alpha-amylase activity compared to the control. The addition of the four levels of tabat malt to the Canadian (commercial) wheat flour decrease the falling number from 386 sec (control) to 351 for 0.04 g, 338 for 0.06 g, 325 for 0.08 g and 302 for 0.1 g. The increase in alpha-amylase activity was observed to be significantly different ($P<0.05$) between control and other levels. Addition of the four levels resulted in an optimum range of alpha-amylase activity that lies within the range required for bread making.

Table 4: Alpha-amylase activity of wheat flour as affected by addition of different levels of sorghum malt.

Level of malt (g/7g wheat)	F.N (sec) RFF	F.N (sec) RFT
0.00 (control)	386[a]	386[a]
0.04	308[b]	351[b]
0.06	286[b]	338[b]
0.08	265[b]	325[b]
0.1	257[b]	302[b]

Means with the same superscript letters in each column are insignificantly different

RFF = Regular flour treated with faterita malt

RFT = Regular flour treated with tabat malt

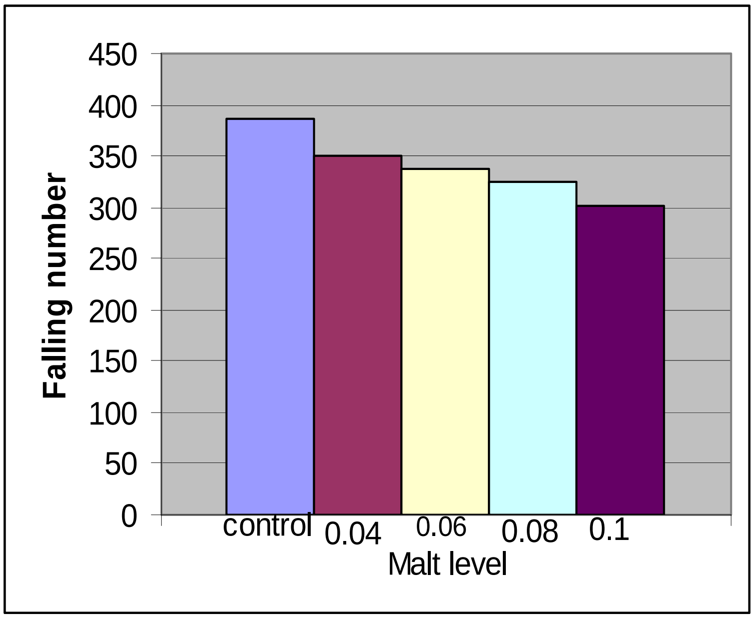


Fig (1): Effect of addition of different levels of tabat malt flour on alpha-amylase activity of Canadian wheat flour

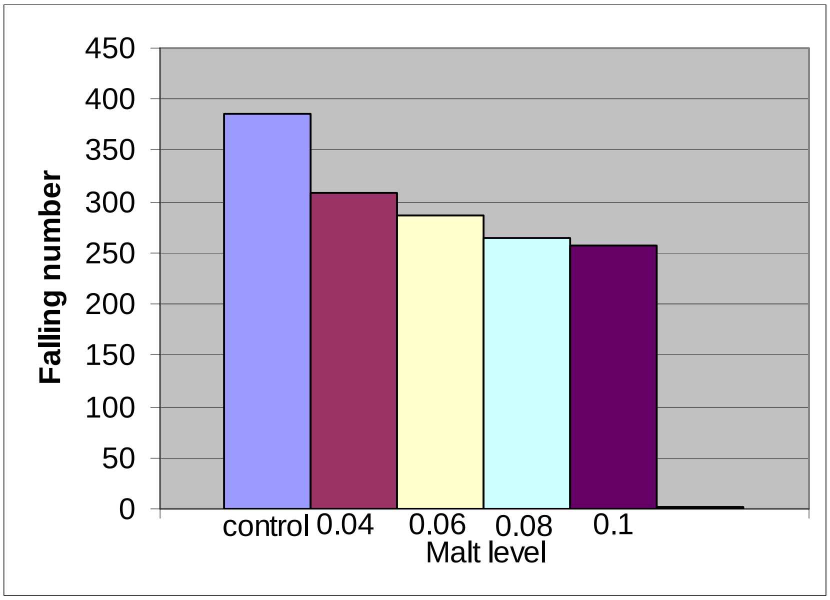


Fig (2): effect of addition of different levels of faterita malt flour on alpha-amylase activity of Canadian wheat flour.

The results indicated that the addition of the various levels of faterita malt to Canadian (commercial) wheat flour decreased the falling number from 386 sec (control) to 308 sec for 0.04 g, 286sec for 0.06 g, 265 sec for 0.08 g and 257 g for 0.1 g. This result indicated that the addition of various levels of faterita malt resulted in an increased alpha-amylase activity compared to the control. The increase in alpha-amylase activity was observed to be significantly different ($P<0.01$) between control and other levels. Once again addition of the four levels resulted in an optimum range of alpha-amylase activity required for bread making.

Perten (1996) claimed that falling number values below 150 seconds indicated high alpha-amylase activity in sprout damaged wheat, while 200-300 seconds indicated optimal alpha-amylase activity and above 300 seconds indicated low alpha-amylase activity in sound wheat. Pareals-Lopez *et al*. (1987) found that the falling number of some commercial wheat flours is in the range of 342 to 488sec.

4.4.1 Effect of addition of different levels of tabat malt flour on bread specific volume.

Addition of different levels (0.04, 0.06, 0.08 and 0.1 g) of tabat malt flour to the Canadian (commercial) wheat flour on specific volume of bread was studied. The results were shown in Table 5 and Fig. 3. The specific volumes of bread obtained were 4.89, 4.71, 4.86 and 4.55cm^3/g respectively as compared to 5.13cm^3/g for the control. No significant difference was observed between and within control and all levels. However addition of 0.04g tabat malt to the Canadian wheat flour gave the highest bread specific volume which was 4.89cm^3/g compared to other levels. Early findings showed that addition of 0.07g tabat malt to wheat flour gave bread with 4.12 cm^3/g specific volume (Elshewaya, 2003).

4.4.2 Effect of addition of different levels of faterita malt flour on bread specific volume.

Addition of different levels (0.04, 0.06, 0.08 and 0.1 g) of faterita malt flour to the Canadian (commercial) wheat flour on specific volume of bread was studied. The results were shown in Table 6 and Fig 4. The specific volumes of bread obtained were 5.10, 4.96, 4.99, and 4.61cm^3/g respectively as compared to 5.17cm^3/g for the control. There was no significant difference between and within control and all levels with exception of 0.01g level which showed significant difference ($P<0.01$). However addition of 0.04g faterita malt to commercial wheat flour gave the highest bread specific volume which was 5.10cm^3/g compared to other levels.

Early findings showed that addition of 0.06g faterita malt to wheat flour gave bread with 4.306 cm^3/g specific volume (Elshewaya, 2003).

Table 5: Effect of addition of different levels of tabat malt flour on bread specific volume.

Level of malt (g/7g wheat)	Loaf volume (cm^3)	Loaf weight (g)	Specific volume(cm^3/g)
control	537	104.6	5.13^{a}
0.04	512	104.6	4.89^{a}
0.06	507	107.6	4.71^{a}
0.08	525	108.0	4.86^{a}
0.1	493	108.5	4.55^{a}

Means with the same superscript letters in the specific volume column are insignificantly different.

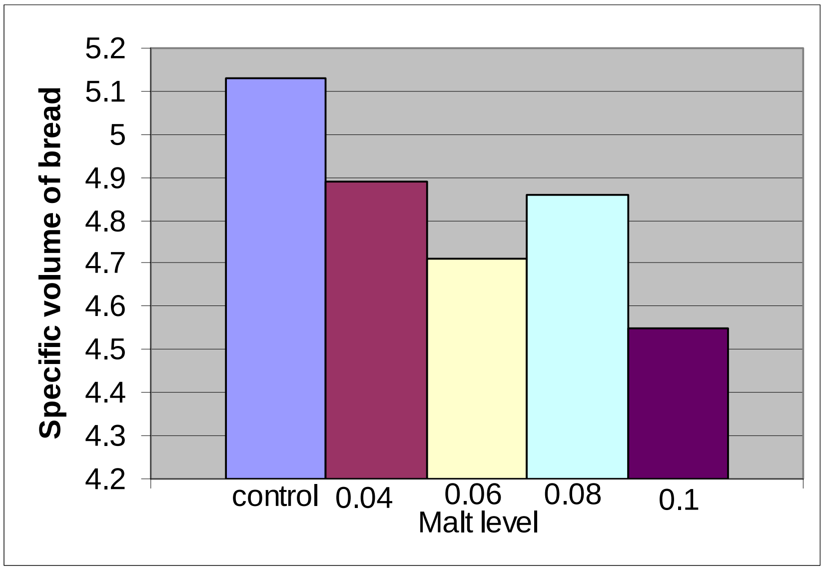


Fig. (3): Effect of addition of different levels of tabat malt flour on bread specific volume.

Table6: Effect of addition of different levels of faterita malt flour on bread specific volume.

Level (g/g wheat)	Loaf volume (cm^3)	Loaf weight (g)	Specific volume (cm^3/g)
control	547	105.8	5.17 [a]
0.04	542	106.2	5.10 [a]
0.06	532	107.2	4.96[a]
0.08	537	107.5	4.99 [a]
0.1	503	109.3	4.61[b]

Means with the same superscript letters in the specific volume column are insignificantly different

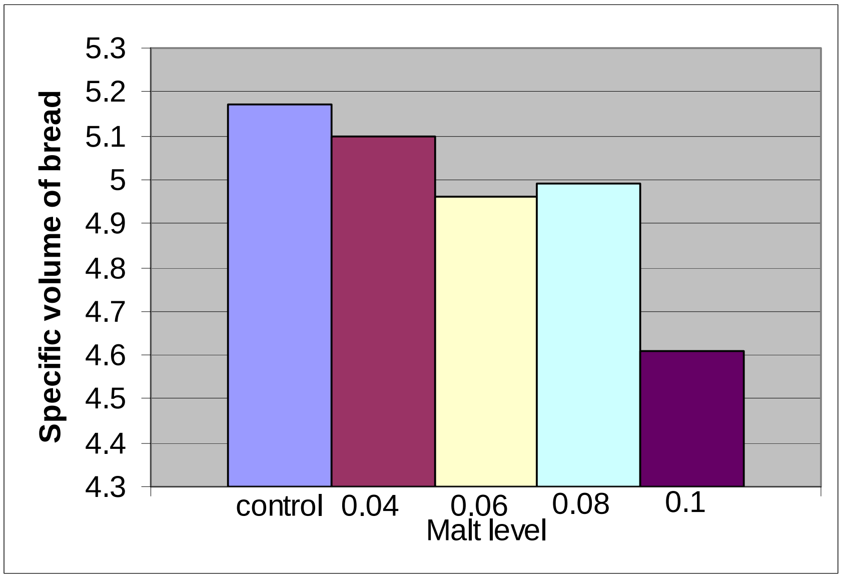


Fig (4): effect of addition of different levels of faterita malt flour on bread specific volume

Its worth mentioning that the bread specific volume of some Sudanese wheat cultivars namely condor, sasarib, debaira and elneelian ranged between 3.66 and 4.05cm^3/g (Mohamed, 2000), while Elagib (2002) reported bread specific volume ranged from 2.95 to 3.47cm^3 for some Sudanese wheat cultivars Debira, Wadielneel and Elneelian.

3.4 Sensory evaluation

Twelve judges are evaluated bread containing different levels of sorghum malt (tabat and faterita).

Table 7 shows the results of the sensory evaluation of bread baked by addition of different four levels (0.04, 0.06, 0.08 and 0.1 g) of tabat malt flour. The bread made by either the Canidian (control) flour or the flour treated with different levels of tabat malt was not significantly different. However the bread made by addition of 0.04g tabat malt was significantly different ($P<0.05$) in odor, taste and overall acceptability. From the results in table 7 it was concluded that the addition of 0.04 g tabat malt to the regular wheat flour evaluated the best in color, taste, odor, texture and overall acceptability.

Table 8 shows the results of the organoliptic qulatiy of bread baked by addition of the four levels of faterita malt flour. The bread made by either control flour or the flour treated with different levels of faterita malt was not significantly different in color, taste, odor, texture and over all acceptability. From the results in table 8 it was concluded that the addition of 0.04 g faterita malt to the regular wheat flour evaluated the best in taste, texture and over all acceptability.

Table7: Organoleptic quality of bread containing different levels of tabat malt

Level of malt in bread	Sum of ranks				
	color	taste	odor	texture	Over all acceptability
Control	29[a]	44[a]	41[a]	42[a]	47[a]
0.04 g	25[a]	31[a]	21[b]	24[b]	20[b]
0.06 g	40[a]	33[a]	31[a]	34[a]	30[a]
0.08 g	43[a]	32[a]	40[a]	38[a]	37[a]
0.1 g	44[a]	39[a]	43[a]	40[a]	41[a]

Means with the same superscript letters in each column are insignificantly different

Table(8): organoliptic quality of bread containing different levels of faterita malt.

sample	Sum of ranks				
	color	taste	odor	texture	Over all acceptability
Control	28[a]	34[a]	32[a]	35[a]	28[a]
0.04g	32[a]	27[a]	36[a]	30[a]	26[a]
0.06g	35[a]	35[a]	34[a]	39[a]	34[a]
0.08g	42[a]	43[a]	33[a]	41[a]	42[a]
0.1g	40[a]	41[a]	42[a]	37[a]	44[a]

Means with the same superscript letters in each column are insignificantly different

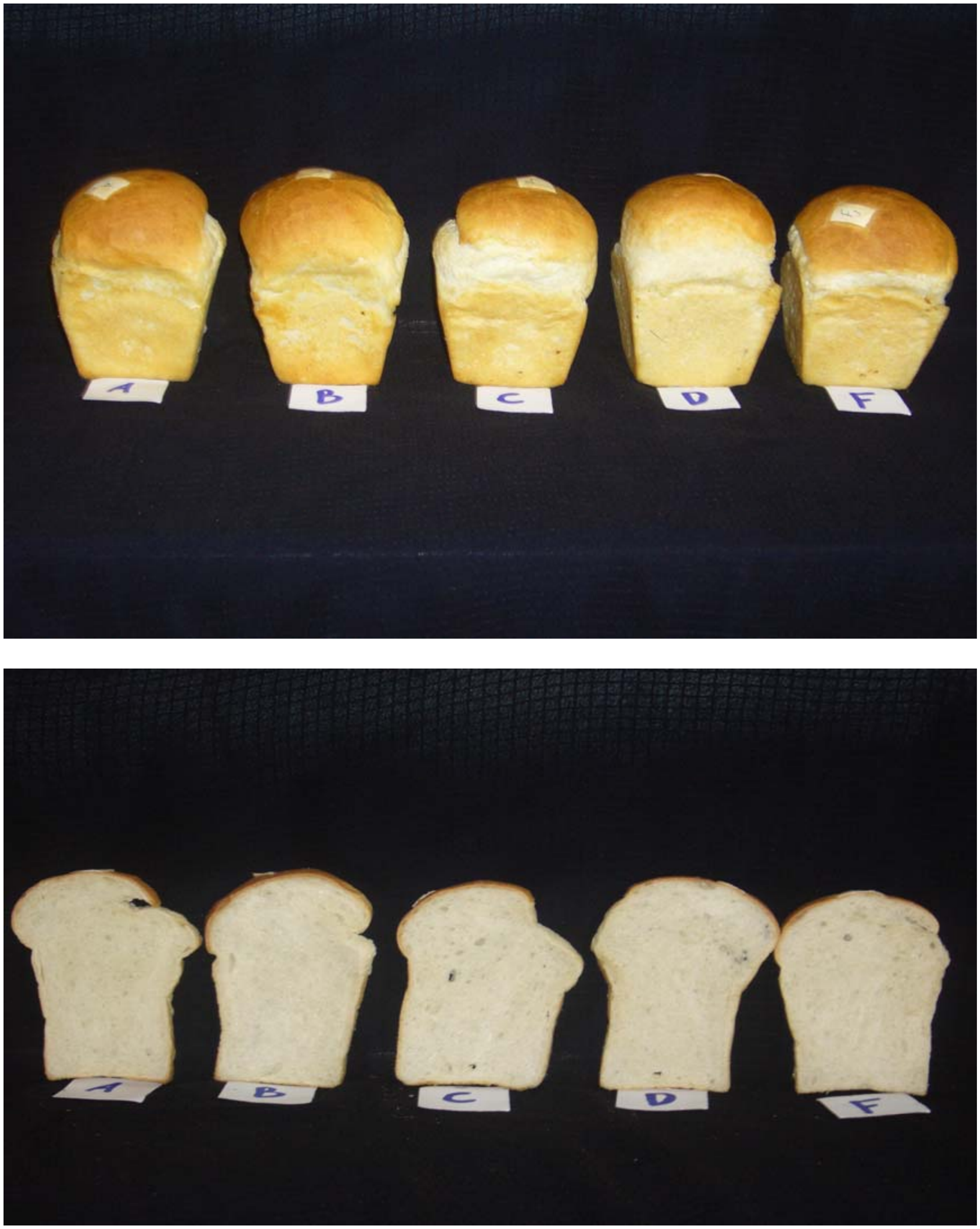
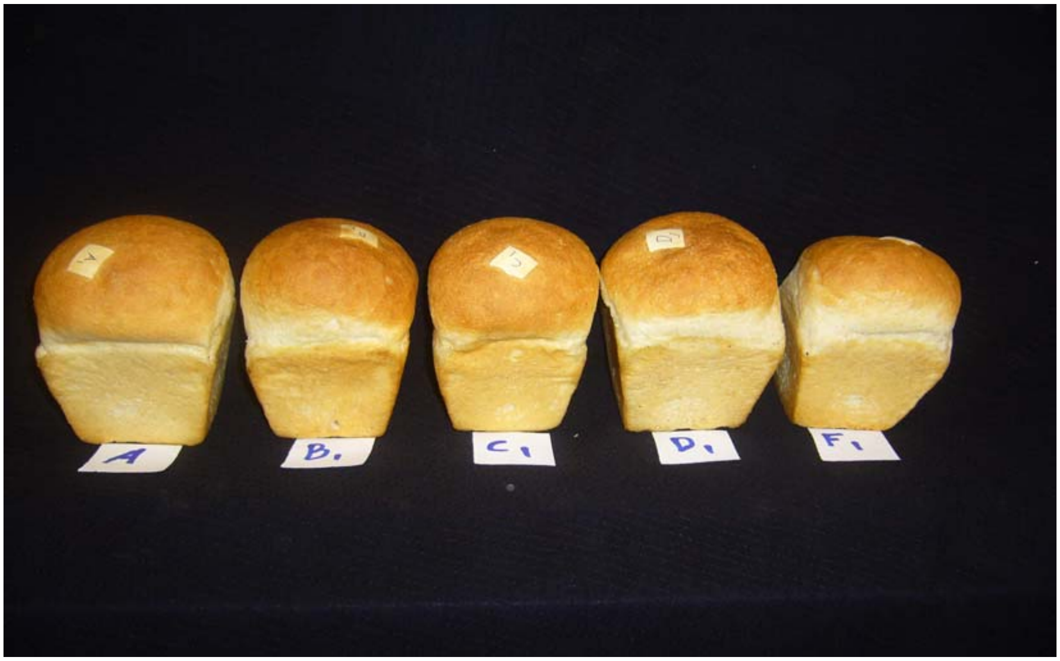


Plate (1): Bread containing different levels of faterita malt

A: control
B: level 0.04g
C: level 0.06g
D: level 0.08g
F: level 0.1g



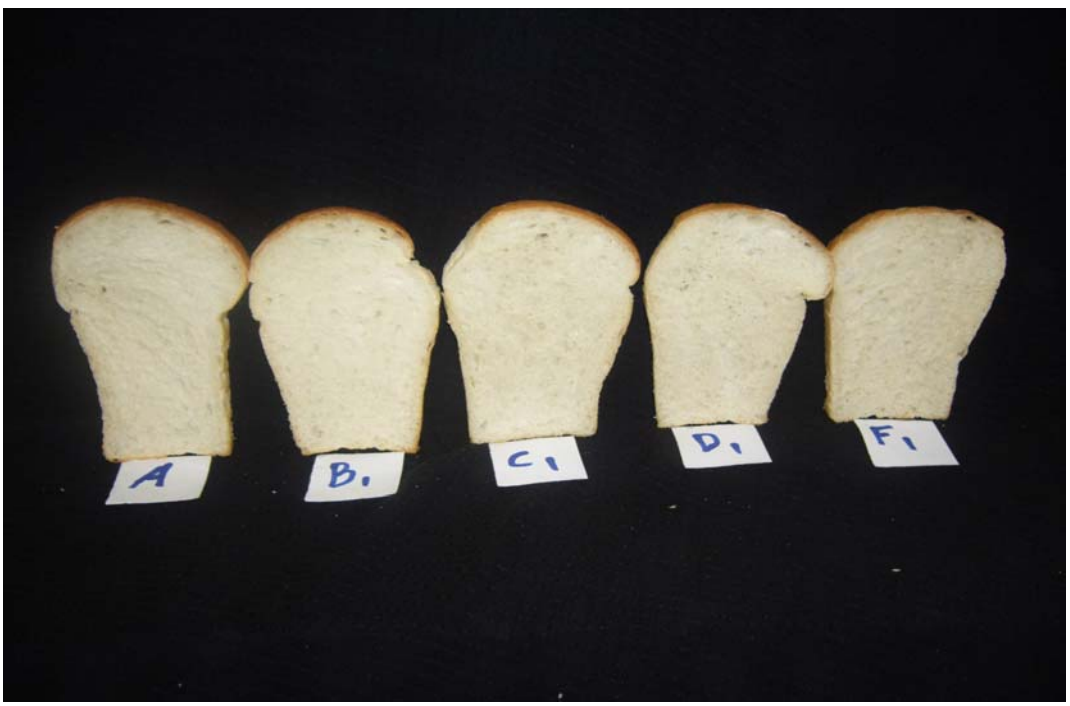


Plate (2): Bread baked by addition of different levels of tabat malt

A: control
B1: level 0.04g
C1: level 0.06g
D1: level 0.08g
F1: level0.1g

4.6 Conclusions and Recommendations

4.6.1 Concolutions

From the findings of the present investigation, it can be concluded that:

1- The chemical components of sorghum grains (tabat and faterita) after germination revealed the followings:-

- The moisture content was observed to increase in both cultivars; however the increase was in significant.
- A significant ($P<0.01$) increase in carbohydrate, reducing sugars and total sugars was seen in both cultivars.
- Ash and fat contents in both cultivars were significantly ($P<0.01$) decreased.
- The protein was not significantly decreased in both cultivars.
- Fiber content decreased significantly ($P<0.01$) in faterita cultivar but not significantly in tabat cultivar.
- Tabat reducing sugars after germination is poor, because that tabat is not suitable for germination

2- Treatment of the Canadian commercial wheat flour with various levels of germinated sorghum (tabat and faterita) cultivars resulted in a significant ($P<0.05$) increase in alpha-amylase activity.

3- Specific volume of bread made by addition of different levels of both tabat and faterita malt were not significantly different from that made from the Canadian flour (control). However addition of 0.1g faterita malt to the Canidian (commercial) wheat flour showed significant difference ($P<0.01$) in bread specific volume.

4- There was adverse effect in bread specific volume when sorghum malt was added.

5- Sensory evaluation showed that there was no significant difference in the bread made by treatment of regular flour with different levels of tabat and faterita malt, with exception of 0.04g level of tabat malt which gave significant difference ($P<0.05$) in the bread made. Although the treatment of the regular flour by 0.04g sorghum malt did not significantly affect bread specific volume, it provides a good color, taste, odor and texture in tabat cultivar, and a good taste and texture in faterita cultivar.

4.6.2 Recommendations

1. Although the addition of sorghum malt at all levels to the Canadian wheat flour did not significantly affect the specific volume of bread, it is recommend to blend the Canidian wheat flour with germinated sorghum to enhance taste, odor and texture.
2. Tabat malt is not recommended to correct the Canidian wheat flour.
3. Generally sorghum malt is recommended for correction of Canidian wheat flour only if required depending on the falling number of wheat i.e when the falling number of wheat is below the optimum range required for bread making.

REFERENCES

AACC (2000). Approved Method of Analysis of American Association of Cereal Chemists, 10th Edition, St. Paul, MN., USA.

Abderahman, I.E. (2000). Microbiological and Biochemical changes during fermentation of sorghum. M.Sc. thesis. Faculty of Agriculture, University of Kartoum, Sudan.

Abdelnour, K.M. (2001). The effect of decortications on wet milling and starch quality of sorghum and millet grains. M.Sc. Thesis. Faculty of Agriculture, University of Khartoum. Sudan.

Abdelrahman, M.S. (2004). Effect of malt pre treatment and fermentation on Anti-Nutrional Factors and mineral bioavilability of pearl millet. PH.D thesis University of Khartoum, Sudan.

Abulhassan, H.M.A. (2005). Effect of baker's yeast storage on it's viability, Activity and bread making. M.Sc thesis of Agriculture, University of Khartoum, Sudan.

Adsule, K.N.; Lawand, K.M. and Kadam, S.S. (1984). Malted sorghum: A potential source for low cost weaning food. Nutrition and processing quality of sorghum.

Ahmed, E.S. (1995). Proximate composition and flour quality of wheat cultivars grown in Sudan. M.Sc. Thesis University of Khartoum. Sudan.

Ahmed, S.B. (1995). Tannins content, amylase activity and cyanide content of germinated sorghum grain. M.Sc. thesis, faculty of Agriculture, University of Khartoum, Sudan.

Ahmed, E.E. (1993). A comparative study of wet milling properties of some sorghum varieties. M.Sc. Thesis, Faculty of Agriculture, University of Khartoum.

Anon (1987). Wheat facts. In: Official publications of the National Association of wheat growers, 10: 7.

AOAC (1970). Association of Official Analytical Chemists, Official Methods of Analysis, Washington, D.C, 12th Edn.

AOAC (1984). Association of Official Analytical Chemists, Official Methods of Analysis , 14^{th} Edition, Washington. D. C.

AOAC (1990). Association of Official Analytical Chemists, Official Method of Analysis, Washington. D.C.

Ashkenazi, P.; Yarnitzky, C. and Cais, M. (1991). Anal. Chem. pp. 248-289.

Aucamp, M.C.; Grief, T.J.; Novellie, L.; Papendick, B.; Schwartz, M.H. and Steer, G.A. (1961). Kaffricorn malting and brewing studies, vш, Nutritive value of some kaffricon production. J. Science Food Agric. 12: 440-456 .

Badi, S.M.; Hoseney, R.C. and Casady, A.J. (1976). Pearl millet characterization by SEM, amino acid analysis, lipid composition and prolamin solubility. J. of Cereal Chem. 53-478 .

Badi, S.M.; El Faki, H.A. and Perten, H. (1978). Evalution of Sudanese wheat varieties . J. of Food Science and Technology, 10: 5-11.

Bashir, M.A. (2006). Characterization and improvement of flour of three Sudanese wheat cultivars for bread making. M.Sc. Thesis University of Khartoum, Sudan.

Bhise, V.J.; Chavan, J. K. and Kadam, S.S. (1988). Effect of malting on proximate composition and in vitro protein and starch digestibility of grain sorghum. J. of Food Science Technol. 25: (6) 327.

Blackman, J.A. and Payne, P.I. (1987). In: wheat breeding it's scientific bases. Lupton, F.G.H. (ed). Chapman and Hall London pp. 455-465.

Budair, A.A. (1977). Chemical studies on sorghum grain and their products . M.Sc. Thesis, University of Khartoum, Sudan.

Bureng, P.L. (1979). A study on malting characteristics of sorghum grain and their preparation of fermented food (hulumur). Ph.D. thesis. National college of food technology university of Reading, UK.

Cauvain, S.P. and Chamberlain, N. (1988). The bread improving effect of fungal alpha-amylase. J. Cereal Science 8: 239-248.

Chavan, J.K.; Kadam, S.S. and Salunkhe (1981). Change in tannin free amino acids, reducing sugars and starch during seed germination of low and high tannin cultivars of sorghum. J. of Food Science 49: 638-639.

Close, J. and Naves. (1959). The amino acid composition of sorghum in the Belgian cong: Introduction to the study of fermented beverages prepared from this cereal (in French), Annls, Nutr, Aliment. 12: 41-50.

Duncan, D.B. (1955). Multiple ranges and multiple F- test. Biometrics, 11: 1-42.

Egan, H.; Kirik, R. and Sawyer (1981). Persons chemical analysis of food 8th edition Longman scientific and technical London.

Eggam, B.O.; Monowar, L.; Bachknuds, K.E.; Munch, L. and Axtell (1983). Nutrition quality of sorghum and sorghum food from Sudan. J. of Food Science, 1: 127-137.

Elagib, F.A.A. (2002). Study of the proteins and baking quality of three Sudanese wheat cultivars. Ph.D. Thesis, University of Khartoum, Sudan..

Elkhalifa, A.O. (1993). Effect of fermentation and germination on the protein fractions, tannin content and in vitro protein digestibility of low and high tannin cultivars of sorghum. M.Sc. Thesis, University of Khartoum.

El Sharif, K.H. (1993). Microbiological and biochemistry of abreh fermentation . M.Sc. Thesis, University of Khartoum, Sudan.

Elsayed, A.A. (1999). The role of sorghum malt to enhance conventional fermented of sorghum flour used for kisra preparation. M.Sc. Thesis, University of Khartoum, Sudan.

El Tinay, A.H.; Abdegadr, A.H. and El Hidai, M. (1979). Sorghum fermented kisra bread : nutritive value of kisra. J. of Science food Agric .30: 859-863.

FAO (1995). Sorghum and millet in human nutrition. FAO, Food and nutrition series No. 27. Roma, Italy. P: 55-60.

FAO (1992). Maize in human nutrition "Food and Agriculture Organization of the United Nation", Roma, Italy. No. 25.

Furia, E.T. (1972). Hand book of Food Additives. Page 39-40.

Greenaway, T.W. (1969). The sprouted wheat problem the search for a solution. J of Cereal Science Today. 14:390-395.

Haldor, H.; Norman, E.B. and Anderson, R.G. (1982). Wheat in the third world weslevleur press, Boulder Colorado,USA .

Hille, R.D.J. and Schooneveld, F.E.M. (2004). Bergmans Dsm baking enzymes Delft, Netherlands . J of Cereal Foods World. Vol. 49 No. 5.

Hulse, J. H.; Laing, E.M. and Pearson, O.E. (1980). Sorghum and millets, their composition and nutritive value. Academic press. London, U.K.

Ihekoronye, N.I. and Nogddy, P.O. (1985). Integrated food, Sci. and Tech. for Tropics. Macmillan publisher.

James, R.; Fleming and John, A.; Johnson (1964). Some recent advances in the chemistry of malting. J. of Cereal Science Today, Vol. 9, No 3.

John, A.; Johnson. (1965). Enzyme in wheat technology in retrospect . J. of Cereal Science Today. Vol. 10, No 6 .

Jones, K. and Omos, A. (1967). The techniques and chemistry of baking process. Modern Cereal Chem.. 6: 251-256.

Kaldy, M.S. and Rubenthaler, G.L. (1987). Milling baking and physical-chemical properties of select soft white winter and spring wheat. J. of Cereal Chem. 64: 302-307.

Kattab, A.H.; Karamalla, K.A. and Nour, A.A.M. (1972). Amino acid composition of some sorghum varieties . Sudan , J. of Food Sci. Tech 4: 27-29.

Keen, E. (1944). A comparative study of the development of alpha amylase in germination cereals. J. of Cereal Chem., 21: 304-314.

Kent, N.L. (1983). Technology of Cereal . Third edition publication of British Library cataloging.

Kuracina, T.A.; Lorenz, K. and Kulp (1987). Starch functionality as affect by amylases from different sources. J. of Cereal Chem. 64: 182-186.

Lasekan, O.O. (1996). Effect of germination on alpha-amylase activities and rheological properties of sorghum (sorghum bicolor) and A acha (digitaria exilis) grains. J. of Food Sci. Technol. Vol. 33. No. 4, 329-331.

Lindah, L and Eliasson, C.A. (1992). A comparison of some rheological properties of durum and wheat flour dough. J. of Cereal Chem. 69(1): 30-34.

Lukow, O.M. and Mcvett, P.B.E. (1991). Effect of cultivar and environment on quality characteristic of spring wheat. J. of Cereal Chem.. 68: 597-601.

Lyla, A.A. (2002). Pastry and bread with use baker's yeast. University of Tanta , Egypt.

Malleshi, N.G. and Desikachar, H.S.R. (1986). Nutritive value of malted millet flours, Qual,plant. Foods. Hum. Nutr. 36: 191-196.

Marek, C.J.; Bushuk, W. and Irvine, N.G. (1968). Board of grain commissioners for Canada, grain research laboratory Winnipeg, Manitoba .Canada. J. of Cereal Science Today. Vol. No (1) page 4.

Mathewson, P.R. (2002). Enzymatic activity during bread baking. cereal. food world 45:98.

Mohamed, E.A. (2000). Evaluation of four local wheat cultivars with special emphasis on protein fractions. M.Sc. Thesis, University of Khartoum.

Mohamed, A.O. (2000). The role of sorghum flour starches (Amylose/ Amylopectin) in composite bread quality. M.Sc. Thesis, Faculty of Agriculture, University of Khartoum, Sudan.

Mohamed, A.S. (1992) . Production and utilization of wheat in Sudan. M.Sc. Thesis, University of Khartoum.

Mustafa, I.A. and Elshewaya, M.A.A. (2004). Optimizing malting condition of millet and sorghum grains for bread making. Proceedings of the 12^{th} ICC Cereal and Bread Congress. Using Cereal Science and Technology for the Benefit of Consumers 23-26 May 2004, Harrogate, U.K.

Norris, J.R. and Rooney, L.W. (1970). Wet milling properties of four sorghum parents and their hybrids. J. of Cereal Chem. 57: 300.

Novellie, L. (1962). Kaffircorn malting and brewing studies. xi. Effect of malting condition on the diastatic power of kaffircorn malt. J. of Science Food Agric. 13: 115-120.

Novo enzyme in formation (1974). Enzyme in the production of baked goods, (IB number 002F-e).

Palmer, G.H. and Agu, R.C. (1997). Effect of mashing procedures on some sorghum varieties germinated at different temperature. Process biochemistry, Vol. 32. No 2, pp. 147-158.

Paredes-Lopez, O.; Rosa, A.P. and Gonzalezost Guedan, J. (1987). Physiochemical and functional properties of Mexican wheat flour for bread making. J. of Cereal Food World. 32: 602-608.

Pearson, D. (1976). The chemical analysis of foods. National college of food technology, University of Reading, Weybridge, surrey.

Perisse, J. J.; Adrian, A.R. and Leberrc, S. (1959). National balance in conversion of sorghum in to beer, preparation composition. Aliments. 13: 1-5.

Perten, H. (1964). Application of the falling number method for evaluation alpha-amylase activity. J. of Cereal Chem. 14: 122-139.

Perten, H. (1996). Manual falling number 1500, as a measure of alpha amylases activity. (ISO-standard No. 3039 (1974). ICC standard No. 10711(1995) and AACC method 50-80 IB (1992). Hudding sweeten.

Pyler, J. E. (1973). Book of baking science and technology. Vol. 11: 586-589.

Rooney, L.W. and Miller, F.R. (1981). Variation in the structure and kernel characteristics of sorghum. In: Proceedings of international symposium on sorghum grain quality ICRISAT Center Patancheru India, pp. 143-162 .

Rooner, W.L. and Clark, E.L. (1968). The chemistry and processing of sorghum grain. J. of Cereal Science today, Vol. B No. (7) .

Rooney, L.W. (1973). A review of the physical properties and structure of sorghum grains as related to utilization in "Industrial uses of cereal".

Pratt, D.B. (1971). In wheat chem. and tech. Pomeranz, Y . (ed) pp. 201-225. Am. Associ. of Cereal Chem.. stpaul Minnisota.

Selvendran, R.R. (1984). The plant cell wall as a source of dietary fiber chemistry and structure. Journal of chemical nutrition. 39: 320 – 327.

Southate, D.A.T. (1993). Cereal and cereal products. In: Human nutrition and dietetics. Garrow, J.S. and James, W.P.T. gth (ed) . Longman Singapore.

Stear, C.E. (1990). Hand book of bread making technology. Elsevier Science publishers Ltd, Essex, England.

Sultan, W.Y. (1976). Wheat and wheat products partical baking. Avi Publishing Co., West port, coon pp. 14-36.

Wall, J.S. and Blessin, C.W. (1969). Composition and structure of sorghum grains. Cereal Science Today. 14 (8): 264-276.

Williams, J. (1970). Brief notes on wheat and flour evaluation Sudan. J. of Food Sci. Techno. 2 (1): 38-42.

Wu, Y.V. and Wall, J.S. (1980). Lysine content of protein increase by germination of normal and high lysine sorghum. J. of Agric. Food Chem. 28: 455-458.

Yeshaiahu P. (1966). Protein composition and bread making potentialities of wheat flour. J. of Cereal Science Today Vol. 11. No. (5).

Yousif, Y.B. and Magboul, B.I. (1970). Nutritive value of Sudan stuffs. Part 1: sorghum valgure dura. Sudan. J. of Food Science and Technology. 4: 39-45.

Zeleny, L. (1971). In wheat chemistry and technology (Pomerona, Y . ed). 2nd edition. Am. Associ. of Cereal Chem. St. Paul Minnesota, U.S- A . pp .19-40.