Effect of wheat production location and Addition of Guar Gum on Bread Quality

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Dedication

To my family and friends

with gratitude and love
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ABSTRACT

This study was carried out to see the effect of environment and location on the quality of wheat grain from variety Debera (season 2005/2006). Two samples of wheat (Debera) were collected from two locations (Hudieba Research Station "North Sudan" and Wad Madeni Research Station "Central Sudan"). Guar gum was used with different levels as recommended improver of Sudanese wheat flour.

Results obtained showed that the wheat location has a significant (P<0.05) impact on the physiochemical properties of wheat grain where the wheat grains from North Sudan were bigger in weight and harder compared to those grown in Central Sudan. This is mainly attributed to the favorable cultivation environment of wheat in the North compared to the Central region (longer Winter in the former).

Also, the level of wet gluten was found significantly (P<0.05) higher in the North wheat (29.3%) compared to its value in Central wheat (25.6%), and the falling number of the North wheat flour (355sec.) was close to the ideal range (250-300sec.) compared to an extremely higher level (490sec.) recorded for Central wheat flour.

Addition of guar gum as an improver at 1.0% level has significantly (P<0.05) improved the water absorption, dough development time and dough stability in wheat flour of both locations, however, the one from the North remains superior (P<0.05) compared to that of the Central region.

Surprisingly, addition of guar gum 0.5% has benefited North wheat flour as reflected in better specific volume of bread (4.45cm3) compared to its control (4.33cm3), whereas it has slightly improved the specific
volume of the Central wheat flour bread (3.98cm³) compared to its control (3.90cm³). While the addition of guar gum 1.0% has benefited Central wheat flour as reflected in better specific volume of bread (4.23cm³) compared to its control (3.90cm³), whereas it has slightly depressed the specific volume of the North wheat flour bread (4.22cm³) compared to its control (4.33cm³).

The bread from North wheat flour with 0.5% guar gum was also found superior in flavour, taste and texture compared to the bread prepared from Central wheat flour.
ملخص البحث

أجريت هذه الدراسة لمعرفة تأثير المناخ والموارد الجغرافية على جودة القمح من صنف دبيرة لموسم 2005/2006، تم الحصول على العينات من مواقع من شمال السودان (محطة أبحاث الحديبة (الدام)) ومن وسط السودان (محطة البحوث الزراعية (ود مدني)). تم استخدام صنع القوارب من نوع محسن للحصول على دقيق القمح المذكور.

أوضح سبب الدراسة أن لمواقع الزراعة للقمح تأثير معنوي (P<0.05) في الخصائص الفيزيائية والكيميائية للحبوب حيث وجد أن عينة القمح من شمال السودان أكبر وزناً وأكثر صلابة من عينة القمح من منطقة وسط السودان وذلك لطول فترة الشتاء في المنطقة الأولى.

كذلك أظهرت الدراسة إرتفاع نسبة الجلوتين الرطب معنويًا (P<0.05) في قمح المنطقة الشمالية (29.3%) مقارنة بنسبته في القمح من وسط السودان (25.6%)، بينما قارب رقم السقوط في قمح المنطقة الشمالية (355)، المدي المثالي للقمح (250-300) مقارنة برقم يعتبر عالياً عند بفح وسط السودان (490).

ظهر التحسن المعنوي في بيئة دقيق القمح من الصنفين بإضافة محسن صنع القوارب فقد تحسنت معدلة الدقيق على إمتصاص الماء معنويًا وتحسنات مدة تكوين العجين وثباتها معنويًا أيضاً بإضافة نسبة (1%) صنع قوارب مقارنة بأقل منها وأكثر نسبة، مع مراعاة تفوق دقيق قمح منطقة شمال السودان في الخصائص المذكورة معنويًا على دقيق قمح منطقية وسط السودان.

بالنسبة لخواص الجودة في الخبز المصنوع من الصنفين، فقد استفاد دقيق قمح شمال السودان من إضافة محسن صنع القوارب بنسبة (5%) فقط مقارنة بقيق قمح وسط السودان فقد ظهر ذلك في الحجم النوعي لخبز الأول (4.45سم) مقارنة بشهادة (3.3سم) والحجم النوعي لخبز الثاني (3.9سم) مقارنة بشهادة (3.3سم)، أما دقيق قمح وسط السودان فقد استفاد من إضافة محسن صنم القوارب بنسبة (1%) مقارنة بقيق شمال السودان فقد ظهر ذلك في الحجم النوعي لخبز الأول (4.2سم) مقارنة بشهادة (3.9سم) والحجم النوعي لخبز الثاني (4.2سم) مقارنة بشهادة (3.3سم).

كذلك أظهر التقييم الحسي للخبز المصنوع من النوعين من الدقيق تفوق دقيق قمح الشمال المتحترى على نسبة (0.5%) صنع قوارب في خواص النكهة والطعم والقوام مقارنة بخبز دقيق قمح المنطقة الوسطى.
CHAPTER ONE
INTRODUCTION

Cereal grains are widely used for human food and animal feed throughout the world, and they are the world’s cheapest source of food energy which provide two-thirds or more of man’s energy and protein. The Protein content of cereals is of great significance, because 24% of the total protein in the average diet is derived from this source. Of all cereal grains, wheat is produced in largest tonnage around the world.

Wheat and wheat foods are long recognized as a major staple and source of calories, carbohydrates, protein, vitamins and minerals when consumed as a major components of the diet.

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

Wheat is favored for bread baking; the function of baking is to present wheat flours in attractive palatable and digestible forms. Bread is made by baking fermented dough which has main ingredients of wheat flour, water, yeast and salt.

Wheat is considered as one of the two main food crops in Sudan. It ranks after sorghum as a staple diet especially in urban centers. Wheat in Sudan is grown under irrigation during the dry and comparatively cool winter season which extends from November to February in Gazeera, Northern region, New Halfa, White Nile and other places. Sudanese wheat
is generally of poor bread making quality, which is attributed to the low protein and gluten quantity and quality, and this has an effect on the water absorption of flour which is reflected on the reological properties of the dough. Improvement of wheat flour quality is very essential for production of good quality bread and hence most of the quality problems can be solved with the right flour treatment. Guar gum has been increasingly used as natural wheat flour improver since it is safe, cheap, and has the ability to improve dough properties and bread quality. The objective of this work include:

  a) To study variations in quality of bread wheat as affected by long cool cultivating conditions in North of Sudan and short cool environment prevailing in Central regions of the country.
  b) To try to see role of guar gum as a natural improver on quality of such wheat flours known for setback with respect to bread making.
CHAPTER TWO
LITERATURE REVIEW

2.1 Types of wheat:

Wheat (*Triticum aestivum*) is often classified as hard or strong and soft or weak. During milling, the vitreous endosperm of hard wheat tends to break between the cell, producing flour that is granular to the touch and free–flowing. On the other hand, the mealy, white endosperm of soft wheat tends to be pulverized so that few or no whole cells are left. The resulting flour is softer to the touch than flour made from hard wheat and tends to clump together like talcum.

Wheat is also classified as spring or winter wheat. Spring wheat is planted in the spring and harvested in the late summer. Winter wheat is planted in the fall so that it can develop a root system before cold weather. It grows rapidly in the spring and harvested early summer. Winter wheat can be grown only in areas where the root system can survive the winter. Spring wheat is usually harder. However winter wheat may be either hard or soft depending on the variety and the growing conditions (Griswold, 1992).

In the Sudan, wheat is the second most important cereal crop, it comes after sorghum, and it is grown under irrigation during the dry and comparatively cool winter season which extends from November to February. The potential yield is limited by day temperature above 35°C at any stage of crop development. The season with acceptable heat limits ranged between 90 and 110 days (Ishage and Ageeb, 1991).

Wheat production was confined to the Northern Sudan, along the Nile banks (17-22N). However, after 1940s due to increasing demand for wheat consumption and scarcity of land, the growing area extended Southward to
the warmer central and Eastern Sudan (Ageeb, 1994). One of the main constraints of wheat production in Sudan is heat stress, which adversely affects plant growth and grain formation (Elahmadi, 1994).

Wheat is getting more important as one of the main cereal foods in the Sudan. In addition to its use as bread, wheat entered into other industries such as biscuits, cakes, macaroni, etc. The main wheat producing states in the Sudan include the Central states (Gazeera, White Nile and Blue Nile scheme), Eastern states (New Halfa and Rahad scheme) and Northern states (public and private pump scheme along the Nile bank).

2.2 Wheat quality:

Quality of wheat and end-use quality characteristics of flours are influenced by both genotype and environmental factors, (Peterson, et al. 1992). Everson (1987) stated that, climate has considerable influence on the type and variety of wheat grown, so the quality varies widely with geographical regions. Zeleny (1971) reported that, the quality of wheat is usually judged by its suitability for particular end use.

2.2.1 Physical criteria of wheat quality assessment:

2.2.1.1 Test weight:

Test weight measures the density of grain in kg per Hectoliter. Hectoliter weight is useful for the grading of wheat. Williams et al. (1986) reported that higher correlations occur between hectoliter weight (test weight) and flour yield. This is because hectoliter weight is related to grain density, rather than weight, and the denser kernels tend to contain more endosperm (flour).

Generally immature wheat or wheat affected by drought or diseases is of low density and invariably gives low yields of flour. However, the
rounder the kernels, and the smaller the crease, the higher the test weight and flour yield.

2.2.1.2 Kernel weight:

Kernel weight, usually expressed in the terms of weight per 1000 kernels. This test depends at the same time on the compactness of structure of the grain and its chemical composition including its moisture content.

Zeleny (1971) found that the thousand kernels weight for hard red spring and hard red winter wheat ranged from 20 to 32g, whereas soft white and durum wheat ranged from 30 to 40g. Ahmed (1995) stated that the thousand kernels weight of Sudanese cultivars ranged between 28 and 44g. However, Mohamed (2000) reported that the thousand kernels weight of four Sudanese wheat cultivars Debera, Elneelan, Condor and Sasaraib ranged between 32 and 38g.

2.2.2 Chemical composition of wheat grain

2.2.2.1 Moisture content:

Moisture content is one of the most important factors affecting the quality of wheat (Anon 1987). It has direct economic importance. Generally moisture content is greatly affected by relative humidity at harvest and during storage.

Ahmed (1995) reported that moisture content of different Sudanese wheat cultivars varies from about 6.33 up to about 8.86%. However, Mohamed (2000) found that moisture content of four Sudanese wheat cultivars Debera, Elneelan, Condor and Sasaraib range between 7.5 and 7.95%. Elagib (2002) recorded the range of moisture content of three Sudanese wheat cultivars of Debera, Elneelan, and WadiElneel ranged between 6.23 and 7.49%.
2.2.2.2 Ash content:

Ash content has been considered an important indicator of wheat flour quality. It gives some indication of the miller’s skill and the degree of refinement in processing (Pratt, 1971). Zeleny (1971) mentioned that 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. Ahmed (1995) stated that ash content of whole and white flours of different Sudanese cultivars ranged between 1.03 to 1.24%, 0.31 to 0.47% respectively. Mohamed (2000) found that ash content of whole and white flours of four Sudanese cultivars Debera, Elneelain, Condor and Sasaraib ranged from 1.35 to 1.52 , 0.38 to 0.50%, respectively.

2.2.2.3 Minerals

The minerals content is considered an important measure of flour quality. They are concentrated in the bran. Bran contains about 60% of the total minerals in wheat kernel (Burk and Solomon 1985). The percentage of mineral matter present in flour usually gives a useful indication of the grade of the flour and the ash content is significant way to determine flour grade.

Minerals depend on available soil nutrients and generally constituting about 1,8% that distributed in different parts of the kernel . kulp et al .(1980) reported that, milling wheat into flour reduces the levels of many nutrients from their original levels in the wheat . Bassiri and Nahapetian (1977) reported that environmental conditions and genetic factors are very important, factors that influence variation in mineral element concentration in wheat flours.

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

Mohamed (2000) showed that the protein content of the whole and white flour of four Sudanese cultivars Debera, Elneelain, Condor and Sasaraib ranged between 12.59 and 14.82, 11.79 and 13.85% respectively. Elagib (2002) reported that the protein contents of Wadi Elneel and Debera were 11.17% and 10.57%, respectively of the whole wheat flour.

2.2.2.5 Oil content:

The fat limit the keeping quality of wheat flour (Anon 1987). Ahmed (1995) found that fat content of whole and white flour (72% extraction rate) of Sudanese wheat cultivars ranges between 1.91 and 2.36, 0.85 and 1.73% respectively. Mohamed (2000) reported that fat contents of the white flour of Sudanese wheat cultivars Debera, Elneelain, Condor and Sasaraib, were found to be in the range of 1.33 to 1.43%.

2.2.2.6 Fibre content:

Fibre is the indigestible carbohydrate in food which acts like a broom to sweep out the digestive tract. Adequate fibre intake has been related to a lower incidence of cancer of the colon and some types of heart diseases and to better control diabetes (Anon 1987). Ahmed (1995) reported that the fibre content of Sudanese wheat cultivars ranged between 1.75 and 2.34 for whole flour and between 0.30 and 0.48% for white flour. Mohamed (2000) showed that the fibre content of the whole and white flour of four Sudanese cultivars Debera, Elneelain, Condor and Sasaraib ranged between 1.85 and 2.25, 0.40 and 0.48, respectively.
2.2.2.7 Carbohydrates

Wheat carbohydrates consist of starch and dietary fiber. Starch is the major component of wheat grain (54-72%). Kulp (1980) concluded that starch performs two functions in bread production. It serves as structure forming component and it may supply fermentable carbohydrate, while Burk and Solomons (1985) reported that the volume of baked bread is inversely related to the water binding capacity of starch.

2.3 Flour quality:

Flour quality denotes the suitability of the flour for a certain use and has no relationship to its nutritive value. Thus a flour of good quality for bread is not necessarily of good quality for cake. The formation of dough that has a good balance between elasticity and extensibility is one of the hall marks of high quality flour and one that indicates that the gluten is of good quality (Blackman and Payne 1987).

2.3.1 Protein quantity and quality:

Protein content is not the only factor determining end – use properties. Protein quality can influence the baking properties of both hard wheat flour (Orth and Bushuk, 1972) and soft white wheat flour (Kaldy and Rubenthaler, 1987).

Strong and weak flours produce dough which has different mixing properties; this difference is due mainly to the quality and quantity of protein (Blackman and Payne, 1987).

An important factor in protein quality is the gluten characteristics of dough. Gluten is formed by the interactions of the proteins, glutenin and gliadin, which also associate with lipid and pentosans during dough formation (D’Appolonia and Kim 1976).
Kaldy *et al.* (1993) mentioned that gluten is an important factor in wheat flour quality, which gives wheat flour its baking characteristics. Thus, gluten is in reality the skeleton or frame work of wheat flour dough, and is responsible for gas retention. This property gives volume and appearance of the bread.

Pomeranz (1971) reported that strong dough with an extensive gluten network is suitable for bread making. In contrast weak dough, without an extensive gluten network, is best for cookies and cakes (Gaines, 1990).

In the last few years, domestic migration in Sudan from rural area to urban area lead to increased demand for bread, so considerable work is being carried out recently at various research stations to breed high yielding with high quality and disease resistant varieties of wheat. By using kinds of additives like ascorbic acid, supplementation by legumes, and addition of the emulsifier like guar, which all of them make a good effect on the dough properties specially the last one emulsifier act as water binding and this effect positively with gluten of weak flour, because it assistance the creation of net work of gluten and make it strong enough to prepare abettor bread.

Perten (1995) stated that gluten index is important for gluten quality. Usually, there is a positive relationship between glutenin quantity and the gluten index percentage.

### 2.3.2 Alpha – amylase activity:

Wheat alpha – amylase is recognized as an important enzyme in affecting the quality of wheat for bread making. Kaldy and Rubenthaler (1987) found that the falling number of soft white, winter and spring wheat, ranged between 380 and 450 seconds, and between 111 and 479 seconds, respectively. While, Lukow and Mcvett (1991)
observed that falling number of hard red spring wheat cultivars ranges between 302 and 332 seconds.

Ahmed (1995) showed that the falling number values of some Sudanese wheat cultivars ranged between 396 and 486 seconds. However, Mohamed (2000) found that the falling number values of four Sudanese wheat cultivars Debera, Elnelain, Condor and Sasaraib ranged between 425 and 675 seconds.

2.3.3 Sedimentation value:

Wheat sedimentation test is a combined measure of gluten quality and quantity. Mohamed (2000) showed that, the sedimentation value of Sudanese wheat cultivars Debera, Elnelian, Sasaraib, and Condor ranged between 21 and 24cm³. While Elagib (2002) found that, the sedimentation value of Sudanese wheat cultivars Debera, Elnelian and ranged between 13.67 and 19.07cm³.

2.3.4 Dough rheological properties:

Rheological properties of wheat flour dough are measured with farinograph and extensograph, which characterize the gluten portion of the protein. Farinograph measures the processing characteristics of flours (development time, stability and dough softening) besides measuring water absorption of flours for evaluating the flour quality and the processing properties of the dough (ICC.Standards 2006)

The weak flour gives dough of low elasticity and stability, while the strong flour gives elastic dough with high stability. But the additives can improve these properties. Ellis and Apling (1982) reported that, addition of guar gum improved dough stability. Rao et al. (1985) showed that, the guar gum increased the water absorption.
The extensograph measures the stretching properties of wheat flour dough for determining the flour quality and for checking flour treatment with additives like ascorbic acid, proteinase or emulsifiers. It measures factors such as extensibility and resistance to extension of the dough (ICC.Standards 2006)

The profile of the extensogram reflects the flour quality. When the extensogram is flat and long, it is a result of flour with low protein and gluten contents and a wet, flowing, inelastic dough, the dough structure is too weak to retain carbon dioxide, and when the curve has a large area, high energy, well-balanced ratio of resistance to extension and extensibility, this curve results from strong wheat flour with optimum dough properties, the dough is extensible and elastic and the baking products are light with good volume (ICC.Standards 2006)

Uthayakumaran et al. (1999) reported that the increase in protein content is associated with an increase in mixing time, mixograph peak resistance, and resistance to extension, extensibility and loaf volume. Ellis and Apling (1982) mentioned that, the guar gum can improve the energy of weak dough and increase the resistance to extention .

2.4 Bread making:

The main factor, which places wheat in the front position among the world crops, is its bread-making quality. So, wheat food products are an essential part of balanced diet, because they provide good nutritional value for their caloric values. Wheat is used for several purposes, but the traditional staple food is bread, which is produced in many forms by different processes. Flour suitable for bred-making in one country may not be acceptable in others (Anon, 1987).
Finney (1978) established that the loaf volume was an indicator of baking quality, varying linearly with protein content. While Eliasson and Larson (1993) found that the differences in performance were due to gluten quantity. Basically, strong flours must be used for making good bread. If weak flour is used, loaves of small volume are produced with poor-crumb structure. So, hard wheat is preferred more than soft wheat, which increase bread yield.

Danno and Hoseney (1982) showed that the stronger-type wheat cultivars with medium-long mixing requirements; usually have better crumb grains and loaf volumes than weaker-type wheat cultivars with relatively short mixing time. Normally, good quality flour for bread baking should have high water-absorption, medium-long mixing requirement, satisfactory mixing tolerance, dough-handling properties and good loaf volume.

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, produces a coarse and heavy crumb texture and small compact volume.

Elagib (2002) stated that the quality of baked bread may be influenced by a number of variables. But protein quality, especially, gluten proteins appears to be the constituent uniquely important in the production of the expended dough matrix in baked goods. While, 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. Everson (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.

Badi et al. (1987) 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.

The bread making process is divided into three main stages: mixing, fermentation and baking. Changes in the rheological properties of the dough in each of these stages are the consequences of changes in dough structure at both the molecular and microscopic levels Faubian and Hoseney (1990).

Mixing transforms the combination of a powder – the flour – and a liquid – the water – into a cohesive visco – elastic dough. This dough is capable of retaining the carbon dioxide produced by the yeast during fermentation and the carbon dioxide, water and ethanol evaporating during oven rise. Gas retention is an essential property of dough for bread making. The transformation into a cohesive dough can be followed by observing change in the resistance to mixing or in the microscopic structure of the dough. For proper dough development, both mixing energy and mixing power must be above a critical level, for processing with short fermentation times, high level of both are required.

The objective of fermentation is to bring the dough to an optimum condition for baking. During fermentation the carbon dioxide produced by the yeast is collected in the gas cells which have been formed during mixing, and their volume increases. This expansion requires an excess pressure in
the cells, estimated to be small compared to atmospheric pressure. A major part is thought to be due to the surface tension in the gas–dough interface. The result of the expansion of the gas cells is a deformation of the dough phase, but there is little evidence that this contributes significantly to dough development.

When the fermentation process is finished the dough is baked in an oven. During the first stage of baking, the dough expands further, mainly as a result of evaporation of water, carbon dioxide, and ethanol from the dough phase. Gelatinization of starch markedly increases the viscosity at temperature above 60°C, this causes a marked increase in the tensile stress in the dough membranes. During baking they rupture, and the foam is transformed into sponge. A possible explanation of the rupture is that the increase of the tensile stress in the membranes results in a value that exceeds the tensile strength of the liquid dough phase.

Bread is made of the four essential ingredients, flour, water, yeast, and salt, to which others may be added depending on the type of bread desired Badi (1978). The optional ingredients used most frequently are sugar, milk, and shortening, all of which improve the quality of bread, in addition, small amount of dough conditioners are often used by bakers.

Flour is the major ingredient in bread formula. Wheat flour, and more specifically the protein of wheat flour, is unique in its ability to form dough that retains gas. This is a fundamental property required for the production of all leavened dough based products.
American hard red winter and red spring wheat and Australian prime hard wheat with 12.5% protein content at least and 62.65% water absorption is suitable for bread making (NCFM, 2003).

In the dough, water comes next in importance to the flour. It is responsible for the formation of the gluten which gives the dough its rheological characteristics. The amount of water used for making a sac of flour into dough varies and depends on the type of flour used and the type of bread being produced. In a dough the starch took up 46% of the water, gluten 31%, and pentosans 23% (Hoseney 1986).

The baker’s yeast (*Saccharomyces cervisia*) is the best microorganism adapted for leavening of baker’s product (Cauvian and Chamberlain 1988). It needs sugar for producing carbon dioxide and alcohol. If no sugar is available in the dough – no fermentation occurs inspite of an excess of yeast.

Salt is added to every bread formula as a flavoring agent, and control the rate of fermentation. Its retarding effect on yeast activity can be demonstrated by using an excessive amount of salt. Roach (1989) observed increasing mixing time with the addition of sodium chloride, this mean salt also strengthen the gluten.

Bread improvers encompass a large group of dough additives that serve to alter the handling properties of dough or the sensory properties of bread or both. Its designs are constantly changing to meet the rapid advance in food ingredient technology and demand for higher quality bakery products.

There are many types of commercial bread improvers manufactured for a variety of applications, whether it is for pan bread, pizza bases, or fermented dough. Each bread improver type is specifically tailored to enable
the desired characteristic of dough or bread type to be achieved. The usage of bread improver can vary widely, often reflecting the level quality or type of the improving ingredients that it contains.

Bread improvers provided better gas retention, resulting in lower yeast requirements, shorter proof time and larger finished product volume. It also improved tolerance to variations in the quality of flour and other ingredients, and gave drier dough that can be mechanically processed more easily and have greater resistance to abuse.

2.4.1 Bread quality:

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.

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 a greater bread volume. Basically, strong flours must be used for making good bread. If weak flour is used, loaves of small volume are produced. Cawley (1994) studied the effect of different concentration rates of guar gum on dough and bread and reported marked differences between bread containing guar and corresponding control. Ellis and Appling (1982) mentioned that guar gum increase the specific volume of bread.

Mohamed (2000) showed that the bread specific volume of Sudanese wheat cultivars Condor, Sasaraib, Debera and Elneelian ranged between 4.05 and 3.66cm$^3$/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 dextrin's from the starch and the loss of gluten structure (Mathewson, 2000).

Kaldy and Rubenthaler (1987) reported that a 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 crumb texture.

Mettler and Seibel(1993) reported that improvement in the yield of bread and texture was affected by guar gum .Cawley (1994) reported that guar retarding staling of bread and improved shelf life.

2.4.1.3 Aroma:

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

Cauvian and Chamberlain (1988) mentioned that, yeast consumes sugars and produces carbon dioxide and alcohol, the former reaction is responsible for raising the dough, while alcohol is partly responsible for the aroma of the baked product.

2.4.1.4 Color:

Golden brown color of the crust is one of the most obvious trait of a baked product. This color results from polymerization reactions known as Millard browning and Caramelization. Millard browning occurs when amine groups on amino acids combine with carbonyl groups of reducing sugar.
molecules. It is temperature and pH dependent, with higher pH increasing the reaction rate. The reaction continuous, and colored pigments, known as melanoidins are eventually formed. Caramelization involves only the sugar in the system, and although it is fostered by condition of higher temperature and lower moisture than Millard browning, it likely contributes to the appearance as well.

Mathewson (2000) reported that, amylases and proteases can contribute to Millard reaction which requires a reducing sugar and amino group, by making these compounds available.

2.5 Guar Gum

Guar gum, also called guaran is extracted from the seed of the leguminous shrub *Cyamopsis tetragonoloba*, it is a complex carbohydrate this carbohydrate is a long chain linear molecule with a molecular weight of approximately 1 million. The long polymer chains attract and weakly capture water; as well as physically tangle with one another in solution thus producing viscosity when mixed with water (Whistler and Itymowitz, 1979)

Guar beans are grown primarily in Pakistan and India and in Sudan, the guar plant was tried at Gazeera Research Station as early as 1930 (Wistler 1984). The beans are harvested and dried following the growing season. The beans are shelled from the pods, the germ and hull removed. The resulting splits are wet-milled into powder, then powder is graded by granulation and quality. Products are re-blended according to specification, bagged and marked which is used in food and industrial products (Whistler and Itymowitz, 1979).
Guar gum is an economical thickener and stabilizer. It hydrates fairly rapidly in cold water to give highly viscous pseudoplastic solutions. High concentrations (~ 1%) are very thixotropic but lower concentrations (~ 0.3%) are far less so. Guar gum is more soluble than a better emulsifier as it has more galactose branch points. Guar gum shows high shear viscosity but is strongly shear-thinning. Being non-ionic, it is not affected by ionic strength or pH but will degrade at pH extremes at temperature (for example, pH 3 at 50°C). It shows viscosity synergy with xanthan gum. With casein, it becomes slightly thixotropic forming a biphasic system containing casein micelles. Stien (1992)

2.5.1 Important uses of guar gum

Guar gum has a variety of applications after converting the endosperm into a powder form. These include food grades and industrial grades.

2.5.1.1 Food grades

Thomas and Chopra (1980) indicated that the guar gum is used in a variety of food products, providing economical thickening as well as the favorable labeling connotation of a "natural" ingredient. Stien (1992) stated that guar gum is used as stabilizer in ice cream, Sherbets, and related products. This prime function is to bind free H₂O and prevent ice crystal growth, affects in undesirable grainy texture. It also improves mouth feel and chewiness, slows melt down and provides heat-shock resistance. Guar gum is used in cold-pack cheese, sour dressing, dips and other dairy products analogs where its hydration characteristics and stability in acidic system are important. It is used in various sauces, soups, syrups and toppings. Significant amounts of guar gum are used in canned and
intermediate moisture pet food because of its high viscosity and heat stability.

In bakery products such as breads and cakes, guar gum is used to improve mixing and recipe tolerance, to improve product shelf life through moisture retention (Stien 1992).

### 2.5.1.2 Industrial grades

Guar gum is used as explosive thickening nitrate solution and acts as water barrier. In addition to used in the process called hydraulic fracturing in oil and gas, also it is used as flocculant and floatation in mining and it is used as thickener for dyes and printing pasted, while it is used as adhesive in film forming and in sizing of paper processing, also used as a binding agent for sizing cotton wraps and jute, whereas it used for water retention in mortar, plaster and cements in building tools, finally it is used as a thickener in cream, lotion and shampoos in Cosmetics. (Whistler and Itymowitz, 1979)

### 2.5.2 Chemical Composition of Guar Gum:

#### 2.5.2.1 Moisture Content:

Whistler and Itymowitz (1979) stated that the commercial acceptable seeds should have moisture content of 10%. They have also reported that seeds of 14% or higher moistening content are usually rejected because of fermentation, even to the point of causing combustion during storage.

Whistler (1984) found out that the moisture content of guar gum ranged from 8% to 12%. Quality control department of Guar Processing Company Singa (1999) stated that the maximum moisture content of its guar gum was 12%.

#### 2.5.2.2 Protein content:

Stein (1992) stated that the crude protein of commercial guar gum ranged between 3% to 5%. Thomas et al. (1980) found that the crude protein
of guar hay was 25.3%, but other varieties showed higher protein 42%. Whistler (1984) stated that the protein of guar gum ranged from 5% to 6%. Quality control department of guar Processing Company Singa (1999) stated that the protein content of its guar gum maximized 5%.

2.5.2.3 Ash content:

Whistle (1984) reported that the ash content of guar gum varied between 0.5% to 1%. Quality control department of Guar Processing Company Singa (1999) stated that the maximum ash content of guar gum is 1.5%

2.5.2.4 Oil content:-

Rao and Sharpalakar (1985) found that oil content of guar gum varied from 2.4% to 3.3%. Ganal (1998) found that the oil content of guar gum varied from 1.4% to 1.68%. Elsiddig and Khalid (1999) reported that the fat content of guar gum ranged between 1.47% to 2.18%.

2.5.2.5 Crude fibre :-

Ganal (1998) found that the crude fibre of guar gum ranged from 8.48% to 9.37%. Elsiddig and Khalid (1999) found that the crude fibre of guar gum varied from 7.47% to 8.95%.

2.5.2.6 Carbohydrate content:-

Thomas et al. (1980) reported that the carbohydrate content of guar gum was 30%. Yadava et al. (1985) reported that the carbohydrate content of guar gum ranged between 40% to 70%.
CHAPTER THREE
MATERIALS AND METHODS

3.1 Materials:

Sudanese wheat cultivar (Debera) was obtained from Seen Flour Mills (from Northen and Gazeera state). Guar gum was obtained from Weeta Flour Mills. Yeast was obtained from Seen Flour Mills.

3.2 Methods

3.2.1 Preparation of wheat flour

The samples were cleaned and the physical characters such as, 1000 kernel weight, hectoliter weight were determined, then wheat grains were milled in Seen Flour Mill to white flour (74% extraction rate), and kept for chemical analysis and bread making.

3.2.2 Preparation of guar/wheat flour blends

The guar was blended with flour at three different levels: (0.5%, 1% and 1.5%)

3.2.3 Analytical procedures

3.2.3.1 Chemical composition:

Moisture, ash, crude protein, crude fibre and fat contents were determined for wheat flour, guar and guar-flour blends according to the AOAC (2000) method.

3.2.3.1.1 Moisture content:

Two grams of well – mixed samples were weighed accurately in clean preheated moisture dish of known weight by using sensitive balance. The uncovered sample and dish were kept in an oven provided with a fan at 105°C and let to stay over night. The dish was then covered and transferred to a desicicator and weighed after reaching room temperature. The dish was
heated in the oven for another two hours and was re-weighed (this was repeated until constant weight was obtained). The loss of weight was calculated as percent of sample weight and expressed as moisture content:

\[
\text{Moisture content \%} = \frac{Wt_1 - Wt_2}{\text{Sample weight}} \times 100
\]

Where:

\( Wt_1 \) = Weight of sample + dish before oven dry.

\( Wt_2 \) = Weight of sample + dish after oven dry.

3.2.3.1.2 Determination of ash:

A crucible was weighed empty, and then accurately two grams of sample were put in it. The contents were ignited in a Muffle – Furnace at 550°C for 3 hours or more until white grey or reddish ash was obtained. The crucible was removed from furnace and placed in a desicator to cool then was weighed. The process was repeated until constant weight was obtained.

Ash content was calculated using the following equation:

\[
\text{Ash content \%} = \frac{Wt_1 - Wt_2}{\text{Sample weight}} \times 100
\]

Where:

\( Wt_1 \) = Weight of crucible with ashed sample.

\( Wt_2 \) = Weight of empty crucible.

3.2.3.1.3 Determination of minerals:

Extraction was carried out according to the AOAC (1975) method. To the ash obtained, about 5 ml of 5N HCl was added, and the mixture was brought to boiling for 10 minutes to dissolve the minerals in HCl. The mixture was then filtered in a conical flask and the completed to volume with distilled water. The following minerals were then determined;
**Calcium and magnesium**

Ca and Mg were determined according to Chapman and Pratt (1961). Calcium was determined by taking 2 ml of the extract in a 50 ml flask. 20 ml of distilled water added to the extract, 4 drops of 4N NaOH were added with small amount of meruxide indicator (0.5 g of ammonium purpurate was mixed with 100 g of powdered potassium sulphate) giving a pink colour. The extract was filtered against 0.01N EDTA (Ethyl diamine tetra acetic acid) until violet colour indicating the end point.

Calcium and magnesium were determined together by taking 2 ml of the extract in a 50 ml flask, 20 ml of distilled water, 10 drops of buffer (6.75 g of NH₄Cl in 57 ml concentrated ammonia diluted to 100 ml with distilled water) and 3-4 drops or Erochrome black T(E.B.T) indicator (0.1g Erochrome +0.9 g hydroxylamine hydrochloride were dissolved in 20 ml of about 95% ethanol) were added to the extract giving a purple colour. The mixture was titrated against 0.01N EDTA (2 g/L) until a blue colour indicating the end point.

The magnesium content was determined by subtracting the calcium content from calcium plus magnesium content as follows:

\[
\text{Mineral (\%) = } \frac{\text{reading titrate} \times \text{normality of EDTA} \times 1000 \times \text{diluted factor} \times \text{M. wt.} \times 100}{\text{Weight of sample} \times 1000 \times 1000 \times 2 \times \text{valency}}
\]

**Sodium and potassium**

Na and K were determined according to the AOAC (1984) method using EEL flamephotometer.

**Procedure**

Standard solution of NaCl was prepared by dissolving 2.54 g of NaCl powder in one litre of distilled water. 10 ml of solution were taken in a 1000 ml distilled water, giving 10 ppm concentration.
A standard solution of KCl was prepared by dissolving 2.54 g of KCl powder in one litre distilled water, then 10 ml of solution were taken and diluted with 1000 ml distilled water to give 10 ppm concentration. The flamephotometer was adjusted to zero using distilled water and to 100 transmission using the prepared standard solution (NaCl and KCl), then the samples were calculated as follows:

\[
\text{Mineral } \% = \frac{F.R \times D.F \times 100}{Wt. \text{ of sample } \times 10^6}
\]

Where:

- \( F.R \) = Flame reading
- \( D.F \) = Dilution factor

**Phosphorous**

Phosphorous determination was carried out according to Chapman and Pratt (1961) using CE 202 Ultraviolet Spectrophotometer. A standard curve was prepared from which the quality of phosphorous of sample was calculated.

**Reagents**

Ammonium molybdate ammonium vanadate in nitric acid was prepared by dissolving 10 gm of \((NH_4)_7Mo_7O_{24} .4H_2O\) ml distilled water. And 0.5gm. of boiling water. Then the ammonium vanadate solution was added to the ammonium molybdate solution and cooled to room temperature. 70 ml of conc. \(HNO_3\) was added to the solution and was diluted to one litre with distilled water.
Preparation of the standard curve

Phosphorous standard was prepared by dissolving 0.2195 gm of KHPO₄ in distilled water and made up to one litre volume then 50 ppm concentration of phosphorous was obtained.

Procedure

Aliquots of working standard were transferred to 50 volumetric flask, then 10 ml of molybdo-vandate reagent were added, diluted to volume with distilled water, mixed thoroughly and allowed to stand for 10 minutes. Then optical density was measured at wave length 430 nm on spectrophotometer. The phosphorous content was then calculated as follows:

\[
\text{Phosphorus} \% = \frac{\text{Reading curve} \times \text{ash dilution} \times 100}{10^6 \times \text{oven dry wt. of sample}}
\]

3.2.3.1.4 Determination of crude protein:

A 0.2 gram of samples, plus 0.4 gram catalyst mixture (potassium sulfate + cupric sulfate 10:1 by wt), and 3.5 ml of concentrated nitrogen free sulfuric acid, were mixed together in small Kjeldahl flask (100 ml). The mixture was digested for two hours, then cooled, diluted, and placed in the distillation apparatus. Fifteen ml of 40% NaOH solution were added and mixture was heated and distilled until 50 ml were collected in a 100 ml conical flask. The ammonia evolved was received in ten ml of 2% boric acid solution plus 3-4 drops of universal indicators (methyl red and bromo cresol green). The trapped ammonia was titrated against (0.02N) HCl. The percentage (g/100) of protein was calculated by using an empirical factor (5.7) to convert nitrogen into protein as follows:
Nitrogen content % = \( \frac{TV \times N \times 14.00 \times 100}{1000 \times \text{wt. of sample}} \)

Protein content % = (nitrogen content %) \times 5.7

Where:
TV = Actual volume of HCl used for titration (ml HCl – ml blank).
N = Normality of HCl.
14.00 = each ml of HCl is equivalent to 14 mg nitrogen.
1000 = to convert from mg to gm.
5.7 = Constant factor for wheat flours and wheat products.

**3.2.3.1.5 Determination of fat:**

A dry empty extraction flask was weighed. Two grams sample was weighed and placed in an empty thimble plugged with a piece of cotton wool. The thimble was placed in soxhlet extractor. Extraction was carried out for 7 hours with petroleum spirit (60-80°C). The apparatus was carefully dismantled and the solvent was evaporated to dryness in an air – oven. The flask with extracted ether was cooled and weighed.

The total fat content was calculated as follows:

Fat content % = \( \frac{Wt_1 - Wt_2}{\text{Sample weight}} \times 100 \)

Where:
Wt_1 = Weight of flask + extracted fat.
Wt_2 = Weight of empty flask.

**3.2.3.1.6 Determination of crude fibre:**

Two grams of an air dried fat – free sample, were transferred to a dry 600 ml beaker. The sample was digested with 200 ml of 1.25% (0.26N) \( \text{H}_2\text{SO}_4 \) for
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 1.25% (0.23N) NaOH for 30 minutes, and treated similarly as above. After the last washing the residue was transferred to ashing dish, and dried in an oven at 105°C over night then cooled and weighed. The dried residue was ignited in a muffle furnace at 550°C to constant weight, and allowed to cool, then – weighed.

The fibre percentage was calculated as follows:

\[ \text{Crude fibre \%} = \frac{Wt_1 - Wt_2}{\text{Sample weight}} \times 100 \]

Where:

- \( Wt_1 \) = Weight of sample and crucible.
- \( Wt_2 \) = Weight of crucible with ashed sample

3.2.3.1.7 Carbohydrates

The carbohydrate contents were calculated according to Pearson (1976) by difference. The sum of moisture, ash, crude protein, crude fiber and oil contents were subtracted out of 100 to obtain carbohydrate content.

3.2.3.2 Quality attributes of wheat flour:

3.2.3.2.1 Gluten quantity and quality:

Gluten quantity and quality, were carried on wheat flours and guar flours-blends according to standard ICC method of (1968 revised 1996) by using Glutomatic instrument (Type 2200).

Ten grams of the sample was mixed into dough with 5 ml distilled water in a test chamber with bottom sieve. The dough was then washed with
2% solution of sodium chloride. The gluten ball obtained was centrifuged by centrifuge (Type 2015) and quickly weighed.

The percentage of wet gluten remaining on the sieve after centrifugation is defined as the gluten index. The total wet gluten was dried in a heater (Glutork 2020) to give the dry gluten. The weight of gluten was multiplied by ten to give the percentage of wet or dry gluten.

3.2.3.2.2 Falling number:

Alpha – amylase activity was carried on wheat flours and guar-flour blends according to (Perten (1996) - manual falling number (1400)). Appropriate flour sample weight, was weighed and transferred into falling number tube and 25±0.2 ml distilled water were added, the stopper was fitted into the top of the viscometer, and shacked 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, and then the viscometer stirrer was stopped in up position, released and sinked 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 1995) and (AACC 1992), corresponding to 7g at 14% moisture, no change is made in the quantity of the water used (25 ml).

Calculations:

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

Where:

\( m \) = Actual moisture percentage of the flour sample.
(R. W.) = The required flour sample weight used for determination.

3.2.3.2.3 Sedimentation values:

Sedimentation value was carried on wheat flours with and without guar according to the AACC (2000) method. A 3.2 gram of sieved flour sample were placed in 100 ml glass stoppered graduated cylinder, simultaneously timing started when 50 ml containing bromophenol blue was added, then flour and water were thoroughly mixed by moving stoppered cylinder horizontally length wise, alternately right and left, through space of 7 In 12 times in each direction in 5 sec, then flour was completely swept into suspension during mixing.

At the end of first 2 min period, the contents were mixed for 30 sec, in this manner the cylinder was completely inverted then righted up, as if it were pivoted at centre, this action was performed smoothly 18 times in the 30 sec. then was let to stand 1.5 min. After that 25 ml of isopropyl alcohol lactic acid (reagent 4) were added, mixed immediately by inverting cylinder four times as the latest step then was let to stand 1.75 min., mixed again for 15 sec, then the cylinder was immediately placed in up right position and let to stand for 5 min. The factor to obtain sedimentation value was brought from table on 14% moisture basis, (AACC, 2000).

3.2.3.3 Rheological properties

3.2.3.3.1 Farinograph characteristics

The rheological properties of the dough prepared from wheat flour and guar-flour blends were measured using the brabender farinograph E according to the ICC (2000) method.

The titration curve:
For determining the correct water absorption of the flour, a titration curve was recorded.

After the parameters were edited in the parameters window and the automatically zero-point setting was done, the flour was added into the mixer (weight of sample according to the moisture content of it), then the flour was mixed for 1 min, the water from the burette was added into the mixer until the dough consistency reached 500 farinograph-units (Fu) (if the consistency is higher than 500 Fu more water must be added and vice-versa. The instrument was then switched off and a real amount of water needed for the test flour was shown in the evaluation.

**The standard curve**

After measuring, mixer was cleaned and the farinograph was prepared; the flour was added into the mixer and the correct amount of water was added. The instrument was run for 20 min, and then shut off. The following characteristics of farinograph were determined:

Fig. (1) shows the curve of a farinogram with the evaluation points of water absorption as the amount of water added to the flour with 14% moisture content to produce a maximum consistency of 500 F.U., development time as the time (in min.) between the addition of water and the torque curve before weakening begins, dough stability as the time between the first and the second intersecting point of the upper trace of the torque with the line of consistency, and the degree of softening as the difference between the line of consistency and the medium line of the torque curve 12 min. after development time.
3.2.3.3.2 Extensograph characteristics

Extensograph experiments were carried out on wheat flour samples and gluten-flour blends according to the ICC standard method (2000) using Brabender Extensograph Instrument®.

Dough was prepared from flour (according to the moisture of sample), 2% of sodium chloride and quantity of water (less 2% than farinograph absorption curve) was mixed in Brabender Farinograph for 5 min. A test piece (150 g) was rounded into a ball, shaped into a cylinder and placed in the cabinet for three periods; 45, 90 and 135 min. After each period, the dough piece was placed on the balance system; a hook was moved downward, engaged the middle of the dough piece and extends it till it breaks. The dough of first test was removed from holder, re-shaped as before and placed in the rest cabinet for the second period then stretched again. A third test was made on the same dough as above.
The following characteristics of the extensogram were determined:

Fig. (2) Shows the curve of an extensogram with the evaluation points.

dough energy which is the area under the curve in cm$^2$. (The value describes the work applied for stretching the dough and is a measure for the flour quality), resistance to extension which is the height of the extensogram at a constant deformation of the dough, this value was determined at the point where the test has run 50 cm from the beginning of stretching, dough extensibility which is the total length of the curve in cm until the point of rupture, and the ratio which is the quotient of resistance and extensibility.

\[
\text{Ratio} = \frac{\text{Resistance to extension (BU)}}{\text{Extensibility (cm)}}
\]

Fig. (2): Extensogram and evaluation point according to Brabender ICC
3.2.3.3 Baking test

3.2.3.3.3.1 Preparation of bread samples

Wheat flour containing guar gum was used for making bread according to Badi et al. (1978). A 250 g flour, water (according to farinograph water absorption), salt (1%), yeast (2%), sugar (2%) and oil (2%) were weighed and mixed to form a dough in mono-universal laboratory dough mixer for 5 min. at medium speed. The dough was allowed to rest for 10 min. at room temperature, then three pieces of 120 g dough were weighed, made into round ball and allowed to rest for another 15 min., then moulded, put into pan and placed in the fermentation cabinet for final proof for 1 hr. Baking was done in an oven at 220°C with saturation of steam for 10-15 min. After the loaves were cooled, they were weighed then the volumes measured in ml using the millet seed displacement method (volumeter) and their specific volumes (v/w) were calculated.

The loaves were sliced with an electrical knife, and then each loaf with its slice was photographed.

3.2.3.3.3.2 Physical characteristics of bread

3.2.3.3.3.3 Bread weight

The weight of the loaf bread was taken in g.

3.2.3.3.3.4 Bread volume

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

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

3.2.4 **Sensory evaluation of bread:**

The loaves were sliced with an electric knife and prepared for sensory evaluation at the same day, by the ranking test according to the procedure described by Ihekoronye and Ngoddy (1985). Ten semi-trained assessors were provided coded samples and asked to evaluate the general appearance, flavour, taste, texture and overall quality (Appendix 1) of bread slices. Sum of ranks were then statistically (P<0.05) interpreted according to the same ranking test described earlier.

3.2.5 **Statistical analysis:**

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

4.1 Chemical composition

The chemical composition of the wheat cultivar (Debera) from the Northern State and Gazeera (season 2005/06) and guar gum is shown in Tables 1 to 5.

4.1.1 Proximate composition of wheat and wheat flour

4.1.1.1 Moisture content

The moisture content of whole wheat flour (100% extraction) of Debera from the North was 8.8%, which is higher than that of Debera from Gazeera (6.2%). The results obtained here were similar to values obtained by Ahmed (1995) who reported that the moisture content of Sudanese wheat cultivars ranged between 6.3 and 8.6%, however, the moisture content of tempered wheat flour (74% extraction) of Debera from the North was 13.3% and for Debera from Gazeera was 12.3%.

Statistical analysis of the results showed significant different (P≤0.05), this may be attributed to the differentiation in the temperature of the two locations, that is the weather in Gazeera is warmer than in the North.

4.1.1.2 Ash content

The ash content of the whole wheat Debera flours is shown in Table 1, whereas Table 2 shows the ash content of white wheat Debera flour of cultivars. Ash content of whole wheat flour of Debera from the North was 1.4% and that of Debera from Gazeera was 1.63%, whereas the ash content white wheat flour of Debera from the North and Debera from Gazeera was 0.54% and 0.55%, respectively.
Table (1): proximate composition of the wheat flours (100% extr.) of Debera cultivar (harvested season 2005/06) grown at two locations

<table>
<thead>
<tr>
<th>Debera locations</th>
<th>Moisture (%)</th>
<th>Protein (%) [Nx5.7]</th>
<th>Ash (%)</th>
<th>Fat (%)</th>
<th>Fibre (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>North State</td>
<td>8.8±0.10b</td>
<td>13.4±0.06a</td>
<td>1.64±0.01a</td>
<td>1.73±0.02a</td>
<td>1.74±0.01a</td>
</tr>
<tr>
<td>Gazeera area</td>
<td>6.2±0.06a</td>
<td>12.6±0.06b</td>
<td>1.40±0.01b</td>
<td>1.05±0.01b</td>
<td>1.83±0.01b</td>
</tr>
</tbody>
</table>

Values having different superscript letter in the same column differ significantly (P≤0.05).

Table (2): proximate composition of white flour (74% extr.) of Debera cultivar (harvested season 2005/06) grown at two locations

<table>
<thead>
<tr>
<th>Debera locations</th>
<th>Moisture (%)</th>
<th>Protein (%) [Nx5.7]</th>
<th>Ash (%)</th>
<th>Fat (%)</th>
<th>Fibre (%)</th>
<th>CHO (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>North State</td>
<td>13.3±0.10b</td>
<td>11.8±0.06a</td>
<td>0.54±0.01a</td>
<td>1.07±0.02a</td>
<td>1.08±0.01a</td>
<td>71.54±0.01b</td>
</tr>
<tr>
<td>Gazeera area</td>
<td>12.3±0.06a</td>
<td>10.1±0.06b</td>
<td>0.55±0.01a</td>
<td>1.04±0.01b</td>
<td>1.07±0.01b</td>
<td>74.94±0.01a</td>
</tr>
</tbody>
</table>

Values having different superscript letter in the same column differ significantly (P≤0.05).
These results were similar to data reported by Zeleny (1971) who found that the ash content of the whole wheat flour and white wheat flour ranged between 1.4 to 2.0% and 0.20 to 0.50%, respectively.

Statistical analysis of the results showed significant difference (P≤0.05) between flours 100% extraction rate and wheat flours 74% extraction rate.

### 4.1.1.3 Protein content

The protein content of whole wheat flour (100% extraction) of Debera cultivar from the North was 13.4% which is higher than the protein content of Debera cultivar from Gazeera (12.6%). The protein content of the white wheat flour (74% extraction) of Debera cultivar from the North and from Gazeera was 11.8% and 10.1%, respectively. These values are comparable with the data reported by Elagib (2002) who found that the protein content of white wheat flour of different Sudanese cultivars ranged between 9.3 and 11.1%. The values also lie within the range obtained by Mohamed (2000) who reported that the protein content of whole flours of different Sudanese cultivars ranged between 12.3% to 15.3. This variation in protein content between the two location, may be due to the variation in growing condition such as amount of nitrogen and drying temperature in Gazeera State, which can partly denature grain protein and cause loss in protein.

Analysis of variance showed significant differences (P≤0.05) among the whole and white flours of Debera cultivars from the North and from Gazeera.

### 4.1.1.4 Fat content

The fat content of the whole wheat flour and white wheat flour of Debera from the North was 1.73% and 1.07%, respectively, which was
higher than the fat content of Debera from Gazeera (1.50 and 1.04%, respectively).

These values were similar to those reported by Ahmed (1995) that the fat content of white flour of Sudanese cultivars ranged between 0.85 and 1.73%, however, they were lower than those obtained by Ahmed (1995) and Mohamed (2002) who reported higher fat content of whole flour of Sudanese wheat (1.91 and 2.35%).

Statistical analysis of results showed significant (P≤0.05) among the whole and white flour cultivars in their fat content.

4.1.1.5 Fibre content

Fibre values of the whole wheat flour were shown in Table 1, whereas Table 2 shows the fibre values of white wheat flour of the two locations. The fibre content of the whole wheat flour and white wheat flour of Debera cultivar from the North was 1.74 and 1.08%, respectively, whereas the fibre content of Debera from Gazeera was 1.83 and 1.07% to the whole wheat flour and white wheat flour, respectively.

Analysis of variance showed insignificant differences (P>0.05) among the whole and white wheat flour of the Debera cultivar in their fibre contents.

4.1.1.6 Carbohydrate

The carbohydrate values are shown in Table 2. The carbohydrates content of Debera grown in the North was 71.84%, while carbohydrates content of Debera grown in Gazeera was 74.94%. The results obtained were similar to value of Mohamed (2000) who reported that carbohydrates content of four Sudanese wheat cultivars ranged between 72.2 and 80.1%.
4.1.1.7 Minerals content

Table (3) shows the macro elements content of Debera cultivar from the North and Debera cultivar from Gazeera. It is clear that the extraction of 74% has affecte positively in minerals content, in addition to the difference between the content of Debera cultivar from North and Deberia cultivar from Gazeera, which the first gave a highly results.

This result is with a good agreement with Elghali (2000) who reported that the different locations of wheat cultivar has an affect on elements of sample.

4.1.2 Proximate composition of guar gum

4.1.2.1 Moisture content

The moisture content of guar gum as shown in Table (4) was 6.5%. This value is lower than the one reported by Whistler et al. (1979) who gave moisture content of guar gum between 8 to 12% . This lower value may be due to variation in varieties.

4.1.2.2 Ash content

Table (4) shows the ash content of guar gum as 0.50%. This result is similar to those obtained by Whistle et al. (1979) who reported that the ash content of guar gum ranged between 0.5 to 1.0%.

4.1.2.3 Protein content

The protein content of guar gum as shown in Table (4) was 3.5%. The value obtained is within the range obtained by Stein, Hall and Co. (1992) who stated that the crude protein of guar gum ranged between 3 to 5%.

4.1.2.4 Fat content

Fat content in guar gum was 0.5%, this result is lower than what was reported by Elahmadi (1994), who gave fat content of guar gum as 1.4-1.6%. This lower value may be due to variation in varieties.
Table (3): Mineral matter of Debera cultivar grown at two locations and Guar Gum (mg/100gm)

<table>
<thead>
<tr>
<th>Samples</th>
<th>Mineral matter (mg/100gm)</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ext. rate</td>
<td>P</td>
<td>K</td>
<td>Na</td>
<td>Ca</td>
<td>Mg</td>
</tr>
<tr>
<td>Debera from North</td>
<td>100%</td>
<td>0.38</td>
<td>4.8</td>
<td>9.8</td>
<td>6.6</td>
<td>0.30</td>
</tr>
<tr>
<td></td>
<td>74%</td>
<td>0.39</td>
<td>5.1</td>
<td>10.3</td>
<td>6.8</td>
<td>0.31</td>
</tr>
<tr>
<td>Debera from Gazeera</td>
<td>100%</td>
<td>0.29</td>
<td>4.0</td>
<td>9.1</td>
<td>5.0</td>
<td>0.26</td>
</tr>
<tr>
<td></td>
<td>74%</td>
<td>0.31</td>
<td>4.5</td>
<td>9.6</td>
<td>5.3</td>
<td>0.29</td>
</tr>
<tr>
<td>Guar Gum</td>
<td>100%</td>
<td>1.65</td>
<td>2.1</td>
<td>5.0</td>
<td>0.45</td>
<td>0.75</td>
</tr>
</tbody>
</table>

Table (4): Chemical composition of guar gum used in bread making

<table>
<thead>
<tr>
<th>Moisture (%)</th>
<th>Protein (%) [Nx6.25]</th>
<th>Ash (%)</th>
<th>Fat (%)</th>
<th>Fibre (%)</th>
<th>CHO (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.50</td>
<td>3.50</td>
<td>0.50</td>
<td>0.50</td>
<td>1.45</td>
<td>87.55</td>
</tr>
</tbody>
</table>
4.1.2.5 Fibre content

As illustrated in Table 4, fibre content of guar gum was 1.45%. This result is lower than the result reported by Elsidig and Khalid (1999) who gave fibre content of guar gum in the range of 7.4 to 8.9%. This variation may be attributed to differentiation in varieties.

4.1.2.6 Carbohydrate content

The carbohydrate content of guar gum presented in Table (4) was 87.5%. This value is higher than the results reported by Yadava et al. (1985) who found that the carbohydrate content of guar gum ranged between 40 to 70%.

4.1.2.7 Minerals content

Table 3 shows the macro elements of guar gum. Guar gum has high content of potassium, this value obtained agreed with Murwan (1999).

4.2 Physical criteria of wheat quality assessment

4.2.1 Kernel weight

Weight per thousand kernels of wheat cultivars is shown in Table 5. Analysis of variance showed significant differences (P ≤ 0.05) among the cultivars in their kernel weight.

Thousand kernels weight of Debera cultivar from the North and Debera cultivar from Gazeera was 34.8 and 31.2 g, respectively.

This result is confirmed by data reported by Ahmed (1995) who found that the weight of 1000 kernels of different Sudanese cultivars ranged between 28 and 44 g.

4.2.2 Test weight

Table 5 shows that the hectoliter weight of Debera cultivar from the North and Debera cultivar from Gazeera was 83.0 and 78.0 kg/hectoliter, respectively. This result agreed with Mustafa (1993) who stated that the
hectoliter weight of red spring cultivars ranged between 74.5 and 90.7 kg/hectoliter.

Statistical analysis of the results showed significant differences (P≤0.05) among cultivars in their hectoliter weight.

4.3 Quality parameters of wheat flour and blends

The quality parameters (gluten quality and quantity, falling number and sedimentation) of wheat flour and blends were shown in Table 6.

4.3.1 Wet gluten

There is significant decrease in the wet gluten content between the cultivars in both locations with the increase in the level of guar gum powder in the blends.

The wet gluten content of Debera cultivar flour from the North (control) is 29.3%. This result is in agreement with Mohamed (2000) who found that the wet gluten of Sudanese cultivars ranged between 26.2 to 31.9%, whereas the gluten content of Debera cultivar flour from Gazeera (control) is 25.6%. The value obtained is lower than the result of Debera cultivar from the North and also disagreed with Ahmed (2004) who stated that the wet gluten content of Sudanese cultivars to be in the range of 26.2 to 29.8%.

This confusion in wet gluten may be attributed to the warm whether in Gazeera State, which affect the moisture content of the grain, and this plays a vital factor in lowering the quality and quantity of the flour.

Addition of guar gum powder in wheat flour caused a significant decrease (P≤0.05) in wet gluten. Result gave 28.4, 26.6 and 24.0% for Debera cultivar from North at 0.5, 1 and 1.5% of guar gum powder, respectively and 24.9, 23.4 and 20.2 % for Debera cultivar from Gazeira at0.5, 1 and 1.5% of guar gum, respectively.
Table (5):  Hectolitre and thousand kernels weight of Debera grown at two locations (season 2005/06)

<table>
<thead>
<tr>
<th>Debera locations</th>
<th>Hectolitre weight (kg/hectolitre)</th>
<th>1000-kernels weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>North State</td>
<td>83.0±0.79&lt;sup&gt;a&lt;/sup&gt;</td>
<td>34.79±0.58&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Gazeera area</td>
<td>78.0±0.26&lt;sup&gt;b&lt;/sup&gt;</td>
<td>31.20±0.30&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Values having different superscript letter in the same column differ significantly (P≤0.05).
4.3.2 Dry gluten

Dry gluten content of control for Debera cultivar flour from North is 9.7%, while the dry gluten content of control for Debera cultivar from Gazeera is 8.5%.

Addition of guar gum powder was affected negatively in the dry gluten content significantly (P ≤ 0.05).

This result showed 9.5, 8.6 and 8.0% for Debera cultivar from North at 0.5, 1 and 1.5% of guar gum powder, respectively and 8.3, 7.8 and 6.7% for Debera cultivar from Gazeera at 0.5, 1.0 and 1.5% guar gum, respectively.

A significant decrease in the dry gluten content was observed with decreasing the percent of wet gluten content.

4.3.3 Gluten index

The control of Debera cultivar flour from North showed 73.2 gluten index, whereas the result 70.2 gluten index refer to Debera cultivar from Gazeera. This value agreed with Perten (1995) who stated that the optimum range of gluten index for bread making is between 60 and 90.

Addition of guar gum powder in wheat flour caused a significant increase (P ≤ 0.05) in gluten index. Result gave 78.2, 80.7 and 84.7 for Debera cultivar from North at 0.5, 1.0 and 1.5% guar gum, respectively, and 73.2, 76.3 and 80.1 for Debera cultivar from Gazeera at 0.5, 1.0 and 1.5% guar gum, respectively.

Guar gum affected positively in the gluten index due to it is ability to make a network of gluten more strong.
Table (6): Gluten quantity and quality, falling number and sedimentation value of wheat flour containing different levels of guar gum

<table>
<thead>
<tr>
<th>Debera locations</th>
<th>Guar levels</th>
<th>Gluten quantity and quality</th>
<th>Falling number (sec)</th>
<th>Sedimentation value (cm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Wet gluten (%)</td>
<td>Dry gluten (%)</td>
<td>Gluten index (%)</td>
</tr>
<tr>
<td>North State</td>
<td>Control 0.0%</td>
<td>29.3±0.00^a</td>
<td>9.7±0.00^a</td>
<td>73.2±0.00^e</td>
</tr>
<tr>
<td></td>
<td>0.5%</td>
<td>28.4±0.21^b</td>
<td>9.5±0.07^b</td>
<td>78.2±0.21^c</td>
</tr>
<tr>
<td></td>
<td>1.0%</td>
<td>26.6±0.14^c</td>
<td>8.6±0.07^c</td>
<td>80.7±0.42^b</td>
</tr>
<tr>
<td></td>
<td>1.5%</td>
<td>24.0±0.14^f</td>
<td>8.0±0.70^g</td>
<td>84.7±0.35^a</td>
</tr>
<tr>
<td>Gazeera area</td>
<td>Control 0.0%</td>
<td>25.6±0.21^d</td>
<td>8.5±0.00^d</td>
<td>70.2±0.00^f</td>
</tr>
<tr>
<td></td>
<td>0.5%</td>
<td>24.9±0.35^e</td>
<td>8.3±0.14^d</td>
<td>73.2±0.14^e</td>
</tr>
<tr>
<td></td>
<td>1.0%</td>
<td>23.4±0.35^g</td>
<td>7.8±0.14^e</td>
<td>76.3±0.42^d</td>
</tr>
<tr>
<td></td>
<td>1.5%</td>
<td>20.2±0.42^h</td>
<td>6.7±0.14^f</td>
<td>80.1±0.57^b</td>
</tr>
</tbody>
</table>

Values having different superscript letter in the same column differ significantly (P≤0.05).
4.3.4 Sedimentation test

Table 6 shows significant differences (P≤0.05) among the blends in their sedimentation value.

The Debera flour from North showed 19.0 ml sedimentation value, while the Debera flour from Gazeera gave 17.7 ml as sedimentation value. This result was agreed with Elagib (2002) who found that sedimentation values for Sudanese cultivars ranged from 13.6 to 19.07 ml. Addition of guar gum at 0.5, 1.0 and 1.5% to Debera cultivar flour from North and Debera cultivar flour from Gazeera gave a result as 18.7, 19.8, 21.0, 18.3, 19.7 and 20.0 ml, respectively.

The sedimentation test was based on the fact that gluten imbibes water and swells greatly when treated with dilute lactic acid under standard conditions. The amount of water imbibes and volume occupied by a weight of flour depends on the quality of gluten. Strong gluten swell the most and occupies the bigger volume (Williams, 1970).

4.3.5 Falling number

Falling number of the flour for Debera cultivar from North was 355 sec, whereas the Debera cultivar flour from Gazeera gave a result as 490 sec (low alpha-amylase activity).

This result is higher than the range obtained by Pederson and Eggum (1983) who reported falling number of most wheat flours between 342-488 sec. This higher falling number may be attributed to dry harvest season which consequently affect the activity of alpha-amylase.

Addition of guar gum powder at 0.5, 1.0 and 1.5 in Debera flour from North and Debera flour from Gazeera affected negatively and gave results as 380, 398, 422, 502, 535 and 556 sec, respectively and this may be due to the lowering activity of alpha-amylase enzyme more.
4.4 Rheological characteristics of Debera flour and blends

4.4.1 Farinograph characteristics

The farinograph characteristics of Debera cultivar from North and Gazeera (control) and the blends were shown in Table 7 and Appendices 1 to 12.

The water absorption of control bread flour of Debera cultivar from North was 61.2%, addition of guar gum powder in the ratios 0.5, 1.0 and 1.5% was shown to increase the water absorption of the blends to 61.9, 36.1 and 65.0, respectively, while the water absorption of control bread flour of Debera cultivar from Gazeera was 60.3%, also addition of guar gum powder in ratios 0.5, 1.0 and 1.5% was shown to increase the water absorption of the blend to 60.8, 62.2 and 64.1%, respectively.

These results are in agreement with Rao et al. (1985) who stated that addition of different gums increased the water absorption of wheat flour.

The development time of control Debera flour from North was 4.3 min, which is higher than development time of control Debera flour from Gazeera, which was 3.5 min. These results agreed with the findings of Anaka and Tipples (1979) who reported that dough development time decrease in the flour with low protein content.

Addition of guar gum powder in ratios of 0.5, 1.0 and 1.5% decreased the development time of wheat flour, results were 3.7, 2.9 and 2.4 sec for Debera flour from North, respectively and 2.5, 2.2 and 2.0 sec for Debera flour from Gazeera, respectively. These results agreed with Rao et al. (1985) who reported that addition of guar gum decreased the dough development time.
Table (7): Farinograph characteristics of Debera flour containing different levels of guar gum

<table>
<thead>
<tr>
<th>Debera locations</th>
<th>Level of guar in wheat flour (%)</th>
<th>Flour water absorption (corrected for 500 F.U)</th>
<th>Flour water absorption (corrected to 14% MC)</th>
<th>Dough development time (min)</th>
<th>Dough stability (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>North State</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.0%</td>
<td>61.2&lt;sup&gt;f&lt;/sup&gt;</td>
<td>59.2&lt;sup&gt;f&lt;/sup&gt;</td>
<td>4.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.9&lt;sup&gt;f&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>0.5%</td>
<td>61.9&lt;sup&gt;e&lt;/sup&gt;</td>
<td>59.9&lt;sup&gt;d&lt;/sup&gt;</td>
<td>3.7&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.4&lt;sup&gt;d&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>1.0%</td>
<td>63.1&lt;sup&gt;c&lt;/sup&gt;</td>
<td>60.8&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.9&lt;sup&gt;c&lt;/sup&gt;</td>
<td>5.7&lt;sup&gt;c&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>1.5%</td>
<td>65.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>62.7&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.4&lt;sup&gt;d&lt;/sup&gt;</td>
<td>4.8&lt;sup&gt;f&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td><strong>Gezeera area</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.0%</td>
<td>60.3&lt;sup&gt;h&lt;/sup&gt;</td>
<td>59.0&lt;sup&gt;f&lt;/sup&gt;</td>
<td>3.5&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.4&lt;sup&gt;d&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>0.5%</td>
<td>60.8&lt;sup&gt;g&lt;/sup&gt;</td>
<td>59.6&lt;sup&gt;e&lt;/sup&gt;</td>
<td>2.5&lt;sup&gt;d&lt;/sup&gt;</td>
<td>5.7&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>1.0%</td>
<td>62.2&lt;sup&gt;d&lt;/sup&gt;</td>
<td>61.1&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.2&lt;sup&gt;c&lt;/sup&gt;</td>
<td>6.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>1.5%</td>
<td>64.1&lt;sup&gt;b&lt;/sup&gt;</td>
<td>63.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.0&lt;sup&gt;c&lt;/sup&gt;</td>
<td>5.1&lt;sup&gt;e&lt;/sup&gt;</td>
<td></td>
</tr>
</tbody>
</table>

Mean(s) having different superscript letter(s) in each column differ significantly (P≤0.05).

min. = minutes
The dough stability time of wheat flour was increased by addition of guar gum powder at 0.5 and 1.0%, while the ratio 1.5% decreased the dough stability time of wheat flour. This negative result may be due to the increment of ration of guar gum powder, which is make the dough very viscose also affect in dough strength.

The dough stability time with 0.5, 1.0 and 1.5% guar gum were 5.4, 5.7 and 4.8 min, respectively compared with control Debera flour from North, which is 4.9 min.

In case of flour from Gazeera cultivar, dough stability was 5.7, 6.3 and 5.1 min for ratios 0.5, 1.0 and 1.5% guar gum, respectively.

4.4.2 Extensograph characteristics

The extensograph characteristics of wheat flour and blends are shown in Table 8 and Appendices 13 to 22.

Debera flour with guar gum exhibited an increase in the energy and resistance at 45, 90 and 135 min, compared to the control flour.

This effect is in agreement with study of Rao et al. (1985) who reported an increase in resistance to extension by addition of guar gum to wheat flour.

from the present results, using guar gum powder in ratios of 0.5, 1.0 and 1.5% showed higher values of energy at 45, 90 and 135 min of Debera flour from North than the values of Debera flour from Gazeera, while the ratio 1.5% of guar gum showed significant decrease (P≤0.05) in energy results compared with other ratios of guar gum.

The results also showed that as the fermentation time increased the resistance values of the flour blends and the control increased. Whereas addition of guar gum powder to wheat flour showed slight decrease in extensibility at 45,90 and 135 min compared with control wheat flour.
Table (8): Extensograph characteristics of Debera flour containing different levels of guar gum

<table>
<thead>
<tr>
<th>Debera locations</th>
<th>Levels of guar (%)</th>
<th>Energy (cm²)</th>
<th>Resistance to extension (B.U)</th>
<th>Extensibility (mm)</th>
<th>Ratio number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>45</td>
<td>90</td>
<td>135</td>
<td>45</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>Testing time (min)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>North Stae</td>
<td>0.0%</td>
<td>59ª</td>
<td>61ª</td>
<td>58ª</td>
<td>224ª</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>146ª</td>
<td>138ª</td>
</tr>
<tr>
<td></td>
<td>0.5%</td>
<td>75ª</td>
<td>81ª</td>
<td>86a</td>
<td>276ª</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>148ª</td>
<td>136ª</td>
</tr>
<tr>
<td></td>
<td>1.0%</td>
<td>73ª</td>
<td>75ª</td>
<td>85ª</td>
<td>314ª</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>134ª</td>
<td>112ª</td>
</tr>
<tr>
<td></td>
<td>1.5%</td>
<td>72c</td>
<td>79ª</td>
<td>73ª</td>
<td>342ª</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>126ª</td>
<td>122ª</td>
</tr>
<tr>
<td></td>
<td>0.0%</td>
<td>61f</td>
<td>65e</td>
<td>62ª</td>
<td>277ª</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>131ª</td>
<td>112ª</td>
</tr>
<tr>
<td></td>
<td>0.5%</td>
<td>60ª</td>
<td>70ª</td>
<td>68ª</td>
<td>286ª</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>126ª</td>
<td>120ª</td>
</tr>
<tr>
<td></td>
<td>1.0%</td>
<td>70ª</td>
<td>71ª</td>
<td>74ª</td>
<td>318ª</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>132ª</td>
<td>120ª</td>
</tr>
<tr>
<td></td>
<td>1.5%</td>
<td>63ª</td>
<td>56ª</td>
<td>64ª</td>
<td>318ª</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>121ª</td>
<td>103ª</td>
</tr>
<tr>
<td>Gezira State</td>
<td>0.0%</td>
<td>61ª</td>
<td>65ª</td>
<td>62ª</td>
<td>277ª</td>
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<td>131ª</td>
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<td></td>
<td>0.5%</td>
<td>60ª</td>
<td>70ª</td>
<td>68ª</td>
<td>286ª</td>
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<td>126ª</td>
<td>120ª</td>
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<tr>
<td></td>
<td>1.0%</td>
<td>70ª</td>
<td>71ª</td>
<td>74ª</td>
<td>318ª</td>
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<td>132ª</td>
<td>120ª</td>
</tr>
<tr>
<td></td>
<td>1.5%</td>
<td>63ª</td>
<td>56ª</td>
<td>64ª</td>
<td>318ª</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>121ª</td>
<td>103ª</td>
</tr>
</tbody>
</table>

Mean(s) having different superscript letter(s) in each column differ significantly (P≤0.05).

* Test after 45, 90 and 135 min.
* B.U = Brabender unit.
* m.m = millimeter.
This effect agreed with Rao et al. (1985) who reported a decrease in extensibility with addition of surfactant gels to wheat flour.

This negative effect may be due to the dilution of gluten content specially gliadin, which is responsible for extensibility.

4.5 Baking test

The effect of addition at ratios 0.5, 1.0 and 1.5% of guar gum powder on the baking characteristics of Debera flour from North and Debera flour from Gazeera is shown in Tables 9 and 10 and Plates 1, 2 and 3

4.5.1 Loaf bread specific volume

Table 9 shows the bread volume, bread weight and bread specific volume.

Control loaf bread volume of Debera flour from North is 465 cm, addition of guar gum gave a significant difference (P≤0.05) in bread volume. The loaf bread of 0.5% guar gum gave the highest value, even more than control it gave 480.0 sec, while the ratios 1.0 and 1.5% guar gum gave the result of 450.0 and 435.0 cc, respectively. Whereas the control loaf bread volume of Debera flour from Gazeera is 408 cc, the ratio 1.0% guar gum gave the highest value, it was 462 cc, while the ratios 0.5 and 1.5% guar gum gave the lowest values, which were 422.0 and 418.0 cc, respectively.

Specific volume of control bread of Debera flour from North was 4.33 cc/g. The highest value of specific volume gave at ratio 0.5% guar gum as 4.45 cc/g, whereas the ratios 1.0 and 1.5% gave results 4.22 and 4.12 cc/g, respectively. While the specific volume of control loaf bread of Debera flour from Gazeera was 3.90 cc/g, addition of guar gum affected positively at ratios 0.5 and 1.0% gave results as 3.98 and 4.23 cc/g, respectively. While guar gum affected negatively at ratio 1.5% and the result was 3.82 cc/g.
Table (9): Physical characteristics of bread prepared from Debera flours containing different levels of guar gum

<table>
<thead>
<tr>
<th>Debera locations</th>
<th>Level of guar in wheat flour</th>
<th>Bread volume (cm.)</th>
<th>Bread weight (gm.)</th>
<th>Bread specific volume (cm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>North State</strong></td>
<td>Control (0.0%)</td>
<td>465±5.00\text{ab}</td>
<td>107.3±0.12\text{bc}</td>
<td>4.33±0.05\text{ab}</td>
</tr>
<tr>
<td></td>
<td>0.5%</td>
<td>480±5.00\text{b}</td>
<td>107.9±0.59\text{ab}</td>
<td>4.45±0.02\text{a}</td>
</tr>
<tr>
<td></td>
<td>1.0%</td>
<td>450±18.03\text{abc}</td>
<td>106.6±2.00\text{bc}</td>
<td>4.22±0.12\text{bcd}</td>
</tr>
<tr>
<td></td>
<td>1.5%</td>
<td>435±31.22\text{bcd}</td>
<td>109.2±0.26\text{a}</td>
<td>4.12±0.10\text{cde}</td>
</tr>
<tr>
<td><strong>Gazeera area</strong></td>
<td>Control(0.0%)</td>
<td>408±17.56\text{d}</td>
<td>104.6±0.70\text{de}</td>
<td>3.90±0.17\text{e}</td>
</tr>
<tr>
<td></td>
<td>0.5%</td>
<td>422±10.41\text{cd}</td>
<td>105.8±0.78\text{cd}</td>
<td>3.98±0.11\text{e}</td>
</tr>
<tr>
<td></td>
<td>1.0%</td>
<td>462±2.89\text{ab}</td>
<td>109.1±0.53\text{a}</td>
<td>4.23±0.05\text{bc}</td>
</tr>
<tr>
<td></td>
<td>1.5%</td>
<td>418±20.21\text{d}</td>
<td>103.9±0.40\text{e}</td>
<td>3.82±0.18\text{de}</td>
</tr>
</tbody>
</table>

Values having different superscript letter in the same column differ significantly (P≤0.05).
From the present results, it is clear that the specific volume of the loaf bread was affected by the addition of improvers and by wheat quality as indicated by the amount of protein content, gluten quantity and quality and sedimentation value. These results are supported by that obtained by Elagib (2002).

4.5.2 Sensory evaluation

Table 10 shows the effect of guar gum powder on the organoleptic quality (general appearance, flavor, taste, texture and overall preference) of bread made from Debera flour North and Debera flour from Gazeera.

The Evaluation of general appearance of bread made from Debera flour from north, ranged between 23 to 38, and the ratio 0.5% guar gum gave the best result.

Whereas the general appearance of bread prepared from Debera flour from Gazera ranged between 18 to 41. The ratio 1% guar gum gave the better bread.

The flavour and taste affected as the same, and it is clear in this study addition of guar gum not bad, except in high level 1.5%.

Addition of guar gum improved the bread made from Debera flour, ratio 0.5% gave a better result for bread prepared from north cultivar and the ratio 1% gave the best evaluate for bread prepared from Gazera cultivar, compared with control flour.

This positive effect in a good agreement with (Cawly 1984). Who stated that bread with guar had a soft texture, better softness and improved shelf life.

From these results it is clear that the Panelists prefer the bread prepared from north cultivar with ratio of 0.5% guar gum. Also they preferred the bread made from Gazera cultivar with ratio of 1% guar gum.
Table (10): Organoleptic quality of bread prepared from Debera flour containing different level of guar gum

<table>
<thead>
<tr>
<th>Debera locations</th>
<th>Level of guar gum in w.f.</th>
<th>General appearance</th>
<th>Flavor</th>
<th>Taste</th>
<th>Texture</th>
<th>Preference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
<td>38&lt;sup&gt;c&lt;/sup&gt;</td>
<td>15&lt;sup&gt;a&lt;/sup&gt;</td>
<td>26&lt;sup&gt;b&lt;/sup&gt;</td>
<td>26&lt;sup&gt;b&lt;/sup&gt;</td>
<td>23&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>North State</td>
<td>0.5%</td>
<td>23&lt;sup&gt;b&lt;/sup&gt;</td>
<td>15&lt;sup&gt;a&lt;/sup&gt;</td>
<td>18&lt;sup&gt;a&lt;/sup&gt;</td>
<td>18&lt;sup&gt;a&lt;/sup&gt;</td>
<td>17&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>1.0%</td>
<td>24&lt;sup&gt;b&lt;/sup&gt;</td>
<td>23&lt;sup&gt;b&lt;/sup&gt;</td>
<td>22&lt;sup&gt;b&lt;/sup&gt;</td>
<td>27&lt;sup&gt;b&lt;/sup&gt;</td>
<td>25&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>1.5%</td>
<td>36&lt;sup&gt;c&lt;/sup&gt;</td>
<td>40&lt;sup&gt;c&lt;/sup&gt;</td>
<td>38&lt;sup&gt;c&lt;/sup&gt;</td>
<td>30&lt;sup&gt;b&lt;/sup&gt;</td>
<td>47&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Gazeera area</td>
<td>Control</td>
<td>20&lt;sup&gt;b&lt;/sup&gt;</td>
<td>27&lt;sup&gt;b&lt;/sup&gt;</td>
<td>23&lt;sup&gt;b&lt;/sup&gt;</td>
<td>35&lt;sup&gt;b&lt;/sup&gt;</td>
<td>36&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>0.5%</td>
<td>21&lt;sup&gt;b&lt;/sup&gt;</td>
<td>21&lt;sup&gt;b&lt;/sup&gt;</td>
<td>22&lt;sup&gt;b&lt;/sup&gt;</td>
<td>24&lt;sup&gt;b&lt;/sup&gt;</td>
<td>21&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>1.0%</td>
<td>18&lt;sup&gt;a&lt;/sup&gt;</td>
<td>27&lt;sup&gt;b&lt;/sup&gt;</td>
<td>24&lt;sup&gt;b&lt;/sup&gt;</td>
<td>16&lt;sup&gt;a&lt;/sup&gt;</td>
<td>15&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>1.5%</td>
<td>41&lt;sup&gt;c&lt;/sup&gt;</td>
<td>37&lt;sup&gt;c&lt;/sup&gt;</td>
<td>39&lt;sup&gt;c&lt;/sup&gt;</td>
<td>28&lt;sup&gt;b&lt;/sup&gt;</td>
<td>36&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Any two sum of ranks having different superscript letter in the same column differ significantly (P ≤ 0.05).
CHAPTER FIVE
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

- The study showed that the wheat location has a significant (P<0.05) impact on the physiochemical properties of wheat grain where the wheat grains from North Sudan were bigger in weight and harder compared to those grown in Central Sudan. This is mainly attributed to the favorable cultivation environment of wheat in the North compared to the Central region (longer Winter in the former).

- The level of wet gluten was found significantly (P<0.05) higher in the North wheat compared to its value in Central wheat.

- The falling number of the North wheat flour was close to the ideal range compared to an extremely higher level recorded for Central wheat flour.

- Addition of guar gum as an improver at (1.0%) level has significantly (P<0.05) improved the water absorption, dough development time and dough stability in wheat flour of both locations, however, the one from the North remains superior (P<0.05) compared to that of the Central region.

- The bread from North wheat flour with (0.5%) guar gum was also found superior in flavour, taste and texture compared to the bread prepared from Central wheat flour.

5.2 Recommendations

- Emphasis on wheat production in Northern areas of Sudan and increasing the cultivated area due to the suitability of the climate in this area.
• The tendency to use natural additives instead of the chemical ones so as to reduce the hazards of infection and diseases.
• Developing of scientific research and studies pertinent to Sudanese wheat varieties in order to produce quality and healthy bread.
• Provision or improved seeds of wheat to the farmers and raising their awareness to adopt the technical packages that are stipulated for wheat production in Sudan.
• Controlling of wheat imports and encouraging the domestic flour mills to process the local wheat in order to reduce the cost of production and increase the country earnings and reduce the burdens on the consumer.
• Increasing the research on guar production.
REFERENCES


Finney, K.F. (1978). Contribution of individual chemical constituents of the functional (bread making) properties of wheat. Pages 139-158 In:


Appendex (1) farinogram of control flour of Debaira from North.

Appendex (2) farinogram of 0.5% guar gum in flour of Debaira from North.
Appendex (3) farinogram of 1% guar gum in flour of Debera from North.

Appendex (4) farinogram of 1.5% guar gum in flour of Debera from North.
Appendix (5) farinogram of control flour of Debena from Gazera

Appendix (6) farinogram of guar gum 0.5% in flour of Debena from Gazera
Appendex (7) farinogram of guar gum 1% in flour of Debera from Gazera

Appendex (8) farinogram of guar gum 1.5 % in flour of Debera from Gazera
Appendix (9): Dough stability of Debela flour containing different levels of guar gum
Appendi (10): Dough development time of Debera flour containing different levels of guar gum
Appendix (11): Flour water absorption (corrected for 14% MC) of Deberra flour containing different levels of guar gum.
Appendix (12): Flour water absorption (corrected for 500 F.U) of Debera flour containing different levels of guar gum
Appendex (13) extensogram of control flour of Debera from North

Appendex (14) extensogram of 0.5% guar gum in flour of Debera from North
Appendix (15) extensograph of 1% guar gum in flour of Debera from North.

Appendix (16) extensogram of 1.5% guar gum in flour of Debera from North.
Appendex (17) extensogram of control flour of Debera from Gazeir

Appendex (18) extensogram of 0.5% guar gum in flour of Debera from Gazeera
Appendex (19 ) extensogram of 1% guar gum in flour of Debera from Gazeera

Appendex (20 ) extensogram of 1.5% guar gum in flour of Debera from Gazeera
Appendex (21) Effect of extensograph on ratio number of Debera flour containing different levels of guar gum
Appendix (22) Effect of extensograph on extensibility of Debaira flour containing different levels of guar gum
Appendix (23) Effect of extensograph on resistance to extension of Debaira flour containing different levels of guar gum
Appendix (24) Effect of extensograph on energy of Debaira flour containing different levels of guar gum

Testing time (min)