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Production of bread from Sorghum [*Sorghum Bicolor (L.)* Moench] and Maize (Za Mayes) flours mixture with addition of gum Arabic

إنتاج الخبز من خليط دقيق الذرة (الذرة الرفيعة) ودقيق الذرة الشامية مع إضافة الصمغ العربي

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الآيـة

قال تعالى:

فَكُلُوا مِمَّا رَزَقَكُمُ اللَّهُ حَلَالًا طَيِّبًا وَاشْكُرُوا نِعْمَتَ اللَّهِ إِنْ كُنْتُمْ إِيَّاهُ تَعْبُدُونَ

سورة النحل 114

DEDICATION

TO OUR:

Dear Parents

Beloved Friends

To everyone who taught us a letter

&

To everyone who supported us during study

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ABSTRACT

This study aimed to investigate the effect of different formulation of maize (M) and sorghum (Tabat -T) with addition of Gum Arabic on the quality of bread production. Bread was formulated using different percentage of sorghum and maize. Sample A (M:T 75:25), sample B (M:T 25: 75) , sample C (M:T 50: 50) and sample N (100% wheat) as control. The chemical composition of sorghum, maize, wheat (W) and the final products was determined. The results of chemical composition of T,M and W showed That there was no significant difference in the lipid content between samples T and M, but there was a significant difference between sample W and samples T and M. The highest protein content was for the sample W followed by the samples (T - M), respectively. And there were no significant differences in the carbohydrate content between samples (T - M), and there was significant difference between samples (T - M) and sample W. samples T and M has higher energy values than sample W. The results of chemical composition of samples A,B,C and N showed the samples A,B and C has higher fat contents than sample N. Sample N contained higher amounts of protein than the samples A,B and C. High amounts in carbohydrates values was found in the samples A, B and C and the lower found in sample N. Samples A,B and C has higher energy values than sample N. The evaluate organoleptics characteristic of the products showed the best color, flavor,taste,texture, and the overall Acceptance found in sample A, sample and sample B respectively.

نبذة مختصرة

هدفت هذه الدراسة إلى معرفة تأثير التركيبات المختلفة للذرة (M) والذرة الرفيعة (Tabat -T)مع إضافة الصمغ العربي على جودة إنتاج الخبز. تم تصنيع الخبز باستخدام نسب مختلفة من الذرة الرفيعة والذرة. العينة (M: T 75:25) A والعينة (M: T 25:75) B والعينة C (M: T 50:50)والعينة100) N ٪ قمح) كعينة تحكم. تم تحديد التركيب الكيميائي للذرة الرفيعة والذرة والقمح (W)والمنتجات النهائية. أظهرت نتائج التركيب الكيميائي للعينات T و M و W عدم وجود فرق معنوي في محتوى الدهون بين العينات T و M ، ولكن كان هناك فرق معنوي بين العينة W والعينة T و .M عينة W تليها العينات (T - M) ، على التوالي. ولا توجد فروق ذات دلالة إحصائية في محتوى الكربوهيدرات بين العينات (T - M) ، وكان هناك فرق معنوي بين العينات (T - M) والعينة W والعينة T و M لها قيم طاقة أعلى من العينة .W أظهر تكوين العينات A و B و C و N أن العينات A و B و C تحتوي على محتوى دهني أعلى من العينة .N احتوت العينة N على كميات بروتين أعلى من العينات A و B و .C تم العثور على كميات عالية في قيم الكربوهيدرات في العينات A و B و C والأقل الموجودة في العينة .N تحتوي العينات A و B و C على قيم طاقة أعلى من العينة .N أظهرت الخصائص الحسية التقييمية للمنتجات أفضل لون ونكهة ومذاق وملمس وإجمالي وجد القبول في العينة أ والعينة ب على التوالي.

CHAPTER ONE

INTRODUCTION

Cereal-based foods play an important role as a source of dietary energy and nutrients in human nutrition. The use of microorganisms by humans has a long tradition. Besides beer and wine production, bread making is one of the oldest arts known to man. For example, Egypt, Greece and Italy were early places of discovery of leavened breads (Kulp and Lorenz, 2003).

Sorghum is a crop that is widely grown all over the world for food and feed, it is the one of the main staples for the world poorest and most insecure people, it is a key staple in many parts of the developing world, especially in the drier and more marginal areas of the semi tropics. Celiac disease continues to be a major health problem in many countries; as a result various efforts are being made to solve this problem through the introduction of methods for increased utilization of suitable but less popular foodstuffs. Recently there has been increased interest in sorghum as gluten free cereal to substitute the gluten rich cereals in diet of people suffering from Celiac disease (Elkhalifa et al., 2004).

Improvers are mixtures of foods including additives intended to facilitate or simplify the production of baked foods to compensate for changes in processing properties due to fluctuations in raw materials and to influence the quality of baked foods. They are used specifically to improve production methods and the quality of bakery products (Wassermann, 2000).

Bread is a staple foodstuff made and eaten in most countries around the world (Owens, 2001). Bread is the most popular yeast leaved product made from wheat flour. The bread making process is one of the oldest applications of biotechnology. The term bread defines a great variety of baking products, which vary in formulation, ingredients, and processing conditions (Shetty *et al.*, 2006).

Bread products have evolved to take many forms, each based on quite different and very distinctive characteristics. In some countries the nature of bread making has retained its traditional form while in others it has changed dramatically. Of all the cereals wheat is almost unique in this respect (Owens, 2001).

Nowadays, the use of additives has become a common practice in baking industry. The need for their use arises due to the fact that numerous benefits. However, some additives are focused on improving dough machinability (Baker, 2010).

Gum Arabic is a dried gummy exudation obtained from the stems and branches of Acacia Senegal trees. It is used in bakery and sweet roll glazing between 2-5% as film forming improver and sugar adhesives. Also, it is used in bread(38% concentration) as baking improver, glazing stabilizer, and in soft cakes between 3-5% as softener and water retention agent (The Gum Arabic Company Ltd , 2005).

In Sudan bread is relatively expensive because it is made from imported wheat that is not grown extensively in Sudan for climatic reasons. This situation has placed a huge burden on the Sudanese economy. Moreover some people are suffering from celiac disease. Thus, an alternative source of flour that can be used to produce bread will be a welcomed development. So the ultimate goal of this study was to investigate the effect of different formulation of maze and sorghum (Tabat) with addition of gum Arabic on the quality of bread.

To achieve the goal, there were some specific objectives included :

1. To determine chemical composition of sorghum and maize.
2. To formulate bread using different percentage of sorghum and maze and gum Arabic.
3. To determine chemical composition of the products.
4. To evaluate organoleptics characteristic of the products.

CHAPTER TWO

LITERATURE REVIEW

2.1 Cereal grains:

Cereals are the fruits of cultivated grasses, members of the monocotyledonous family *Gramineae*. Most of the 195,000 species of flowering plants produce edible parts which could be utilized by man; however less than 0.1% or fewer than 300 species are used for food. Approximately 17 plant species provide 90% of mankind's food supply, of which cereal grains supply far and away the greatest percentage (Cordain, 1999). Grain crops, or cereals, are by far the most important sources of plant food for the human race. On a worldwide basis, they provide almost half of the energy and protein of the diet (Vaughan and Geissler, 2010).

Eight cereal grains: wheat, maize, rice, barley, sorghum, oats, rye, and millet provide 56% of the food energy and 50% of the protein consumed on earth. Three cereals: wheat, maize and rice together comprise at least 75% of the world's grain production. It is clear that humanity has become dependent upon cereal grains for the majority of its food supply. As Mangelsdorf has pointed out, 'cereal grains literally stand between mankind and starvation'; therefore, it is essential that we fully understand the nutritional implications of cereal grain consumption upon human health and well being (Cordain, 1999). Cereals represent an important food category as they contribute a large portion of our daily calorie supply. Besides energy, cereal products are important for nutrition because of their contents of dietary fiber and a wide range of micronutrients and bioactive components including minerals, vitamins, antioxidants, and other bioactive compounds (Hamaker, 2008).

2.1.2 Historical perspective of cereals:

Widespread consumption of cereal grains began in the Middle East about 10,000 years ago, when agriculture first began. It was then that wheat was first planted and cultivated (Figoni, 2008).

Wheat became so important that at one time its export from Greece was prohibited, and bread was such a staple and important food that its weight and price were fixed in law (Cauvain and Young, 2006).

The status of the baker began to change during the years of the Roman Empire. It became a profession for men, and baking acquired a respectable and significant status as a trade. During this period the first guilds, or trade unions, of bakers began to form, reflecting the respectable nature of the trade (Cauvain and Young, 2006).

The traditional baked products with which we are all familiar have a long history of development through trial and error rather than systematic study. The origins of many baked products can be assigned to the error category. Indeed, the discovery of leavened bread has been ascribed to the error of leaving dough overnight before baking, and the discovery of laminated pastry to the apprentice who forgot to add fat to the bread dough and tried to recover the situation by folding the missing ingredient into the dough after mixing (though there can be no absolute proof of either story). More recently, systematic studies have been applied to the development of new baked products but most commonly the rule sets applied have tended to be limited and confined by the traditional definition of baked products (Cauvain and Young, 2006).

2.1.3 Importance of cereals:

Cereal products are amongst the most important staple foods of mankind. Nutrients provided by bread consumption in industrial countries meet close to 50% of the daily requirement of carbohydrates,one third of the proteins and 50–60% of vitamin B. Moreover, cereal products are also a source of minerals and trace elements (Belitz *et al.*, 2009).

2.1.4 Applicability of cereals to make bread:

Only milled grain products from wheat and rye can be used to make bread. No other cereal is capable of retaining gas to the same extent as wheat during fermentation and baking (Brennan, 2006).

Milled products from other types of cereal such as rice, barley, oat or corn will not yield proper dough when combined with liquid. These results in products with a low increase in volume, hardly any browning and which, in addition, are hard to cut, spread and chew. On the other hand, milled wheat and rye products in combination with liquid will yield visco-elastic doughs which retain the gas from the yeast fermentation (CO2) in the form of tiny bubbles. In wheat dough, the so-called gluten is responsible for that. This protein absorbs water and forms an extensible and elastic membrane which encloses the gas bubbles. In rye doughs, the gas is retained due to the high viscosity of swollen gumlike substances (pentosanes) present in the dough. However, the gas permeability of the mass surrounding the gas bubbles is higher in rye dough than in wheat dough. Therefore, ryecontaining baked goods have a lower specific volume than wheat dough products (Wassermann, 2009).

While staple food, such as corn and wheat flours are usually fortified with iron, rice grains present much hard problems and challenges. In addition, whole brown rice is barely consumed, and its commercial milling (polishing) produces considerable loss of micronutrients, up to 30% and 67% for zinc and iron, respectively, by eliminating its outer layers where these metals are accumulated (Shetty *et al.*, 2006).

2.2. Sorghum:

Sorghum [*Sorghum Bicolor (L.)* Moench] is the world's fifth most important cereal, after wheat, rice, maize, and barley (Serna-Salvador and Rooney 1995). Sorghum is an important staple in the semi-arid tropics of Asia and Africa for centuries. Sorghum is still the principal sources of energy, protein, vitamins and minerals for millions of the poorest people in these regions, (FAO, 1995).

The five largest producers of sorghum in the world are the United States (25%), India (21 .5%), Mexico (almost 11%), China (9%) and Nigeria (almost 7%). Together these five countries account for 73% of total world production (FAO, 1995).

Sorghum is a major crop used for food, feed, and industrial purposes worldwide (Rooney and Awika, 2005).

Sorghum is consumed in the world in various ways ranging from stiff and thin porridge, leavened and unleavened bread, boiled sorghum, baked and steamed product, snack foods, alcoholic and non- alcoholic beverages (Keregero and Mtebe, 1994). In the Sudan Sorghum is the most important cereal crop where it is consumed in fermented forms, mainly as Kisra (local thin bread), aceda (thick porridge) and nasha (thin porridge), (FAO, 1995).

2.2.1. Chemical composition of sorghum:

Generally sorghum contains approximately 7-16% protein, 55-75% starch, 0.5- 5% lipids 1- 6% crude fiber, and 1- 4.5 % ash, on a dry weight basis (Serna- Saldivar and Rooney, 1995).

2.3 Baked products:

The term ‘baked products’ is applied to a wide range of food products, including breads, cakes, pastries, cookies and crackers and many other products, and it can be difficult to identify a common thread linking the members of such a diverse group (Cauvain and Young, 2006). Baked products are foods manufactured from recipes largely based on or containing significant quantities of wheat or other cereal flours which are blended with other ingredients, are formed into distinctive shapes and undergo a heat-processing step which involves the removal of moisture in an oven located in a bakery (Cauvain and Young, 2006).

Making baked products, particularly bread, is one of the oldest human activities (Edward, 2007).

Some products that are similar to baked products are either fried or boiled instead. Strictly, these products are outside the scope (Edward, 2007).

Baked products (Table 1) are made from milled wheat, rye and, to a lesser extent, other cereals by the addition of water, salt, a leavening agent and other ingredients (shortening, milk, sugar, eggs, etc.) (Belitz *et al.*, 2009).

Table 1: Classification of baked products:

Bread including small baked products (rolls, buns)	Made entirely or mostly from cereal flours; moisture content on average 15%. Addition of sugar, milk and/or shortenings amounts to less than 10%. Small baked products differ from bread only by their size, form and weight.
Fine baked goods, including long term or extended shelf life products such as biscuits crackers, cookies etc.	Made of cereal flours with at least 10% shortening and/or sugar, as well as other added ingredients. In baked goods for long shelf life the moisture content is greatly reduced.

Source: Belitz (2009)

2.3.1 Traditional basis for classifying baked products:

Despite (or because of) its long history, baking still has strong and deep roots in the craft and still struggles to develop its scientific credibility. Until it truly graduates to being a science a common taxonomy remains impossible. Common English dictionary definitions for groups of baked products include:

- Bread – *n.* food made of flour or meal (and) baked
- Cake – *n.* baked, sweetened bread
- Biscuit – *n.* dry, small, thin variety of cake
- Pastry – *n.* article of food made chiefly of flour, fat and water.

All of the above definitions illustrate the difficulties associated with defining the various groups of baked products (Cauvain and Young, 2006).

2.4 Bread:

Bread is an important staple food in both developed and developing countries. Bread is made by baking a dough which has for its main ingredients wheaten flour, water, yeast and salt. Other ingredients which may be added include flours Of Other cereals fat, malt flour, soya flour, yeast foods, emulsifiers, milk and milk products, fruit, gluten (Kent and Evers, 1994).

Bread has affected politics more recently in Russia and Eastern Europe. Former communist governments in these regions sometimes put a hold on bread prices, or even rolled them back, to keep their citizens from revolting (DiMuzio, 2010).

2.4.1 Definition of bread:

Bread is baked dough product made from cereal grains (mostly commonly wheat) ground into flour, moistened and kneaded into dough and then baked, Often leavened by the action of bakers yeasts or by addition of sodium bicarbonate (Merryweather *et al.*, 2005).

Bread is produced by making dough from wheat flour and aerating this with carbon dioxide produced by yeast fermentation. The proportion of water in the dough mixture varies with the type of equipment used but is normally within the range 55-65% of the flour weight (Ranken *et al.*,1997).

2.4.2 A Brief history of bread making:

Historical records have been found in ancient Egyptian tomb carvings dating from 3000 BC, which show fermented bread being made from wheat flour and baked in clay ovens (Brennan, 2006).

The ancient Hebrews distinguished between the leavened and unleavened forms of bread. Even today the unleavened bread is reserved for certain ceremonial occasions. Bread quickly took its place in the psyche of humankind in the ancient world, and the technology spread rapidly wherever wheat and other cereal grains could be grown. Later, as wheat and other grains began to be imported and exported around the ancient world, the art of baking either spread with the grain or was discovered in different locations. No doubt three thousand years ago bakers were developing their own distinctive style of bread based on their cultural beliefs or just for the simple reason of wanting to be different from their competitors(Cauvain and Young, 2006).

2.4.3 Bread types:

Baked bread may come in different forms such as regular yeast breads, flat breads, and specialty breads. Today, even retarded (chilled or frozen) dough's are available to meet consumers' preferences for a semblance of home cooked food. For countries or areas with less available energy, other forms of bread such as steamed bread and boiled breads are available. Fried breads are consumed mainly as breakfast or snack items (Hui *et al.*, 2007).

The main bread types can be divided into four broad categories:

- Pan breads – that is, products based on placing a piece of dough in a metal pan for the proving and baking stages. Commonly the pan will be rectangular, though round pan shapes are known. Sometimes the pan may have a separate lid fitted to more tightly control product shape. Examples are the sandwich loaf (lidded), open-top pan breads, pan coburgs (round، unlidded), milk rolls (round, lidded) and malt loaves (baked under inverted pans.
- Free-standing breads – that is where the dough product is proved and baked without the aid of a pan to constrain and support the sides of the dough. This approach leads to a crustier product. Examples of this type of product include bloomers, cottage loaves and coburgs.
- Baguettes, pain Parisien and other products made as long, stick-shaped loaves. Sometimes placed on indented trays for proving and baking. Typically these products will have a high degree of crust formation and characteristic surface markings.
- Rolls and other small fermented breads baked on trays or indented pans. These products will have higher levels of sugar and fat in the recipe and so typically will have a sweeter flavor and softer eating character. This movement of bread types between countries and cultures can pose problems for bakers. For example, the manufacture of French bread may be considered a challenge to bakers outside France. This is a challenge which can be overcome but does need an understanding of what makes French bread what it is.

2.4.4 Bread baking process:

Baking is at heart a process: the conversion of some relatively unpalatable ingredients (starch, gluten, bran, in the case of most cereals) into the aerated, open cell sponge structure we know as bread has taken millennia to develop (Brennan, 2006).

The bread making process are related to the ability of the dough to retain gas bubbles (air) and permit the uniform expansion of the dough piece under the influence of carbon dioxide gas from yeast fermentation during proof and baking. Bread is produced by making a dough from wheat flour and aerating this with carbon dioxide produced by yeast fermentation. The proportion of water in the dough mixture varies with the type of equipment used but is normally within the range 55-65% of the flour weight (Ranken *et al.*, 1997).

Each country has its own particular methods of baking, but in essence bread is made by simply mixing flour, water, yeast (and air) into a dough, allowing the yeast to ferment for some time to produce an expanding aerated foam and then setting the structure at high temperature in an oven to produce bread (Brennan, 2006).

2.4.5 The basic bread recipe:

Formulations for baked products will vary from country to country and from company to company. Many companies guard their formulations assiduously (Cauvain and Young, 2000).

The basic bread recipe is the “lowest common denominator” of bread recipes—the simplest one possible (Table 2). It gives new bread makers a simple recipe to use and illustrates that all recipes are derived from the same place. There is no secret to them—they all have basically the same percentages of water, yeast, and salt, adjusted to account for the other ingredients (Buehler, 2006).

Table 2: The basic bread recipe for a one kilogram (about two pound) loaf of bread:

Material	Percent	Weight
White flour	100%	0.580 kg
Water	70%	0.406 kg
Instant yeast	0.7%	0.004 kg
Salt	2%	0.012 kg
Total	172.7%	1 kg

Source: Buehler (2006)

2.4.6 Methods of bread production:

The manufacture of all baked products is based on complex interactions between ingredients, formulation and processing methodologies and capabilities – change one aspect of the relationship and the nature of the interaction changes, resulting in one or more changes in product quality. The processing methodologies used in the manufacture of baked products today are the result of many years of, mainly, trial and error research (Cauvain and Young, 2000). Generally, the production of bread and bakery products consists of several common steps, including:

1) Prepare basic and optional ingredients.

2) Prepare yeast or sourdough for inoculation.

3) Mix proper ingredients to make dough.

4) Ferment.

5) Re-mix dough (optional).

6) Sheet.

7) Mold and pan.

8) Proof in a temperature- and relative-humidity-controlled chamber.

9) Decoratively cut the dough surface (optional).

10) Bake, steam, fry, or boil.

11) Cool.

12) Pack.

13) Store.

Each step plays an important role in achieving high and consistent product quality (Hui *et al.*, 2007).

2.5 Emulsifiers:

Emulsions are two-phased systems in which one phase (disperse) is suspended as small droplets in the second phase (continuous). Substances that promote stability in emulsions are known as emulsifiers and they work by providing a bridge between the two phases. The two common types of emulsion are oil in water (salad dressings) and water in oil (margarines). Batters and doughs are complex emulsions and a number of different emulsifiers are used successfully to aid oil and, more critically, air dispersion and their stability during all stages of baking processes. Emulsifiers have become highly functional ingredients in the food industry. The functionality of emulsifiers depends on the particular emulsifier used and the concentration, formulation, and processing the final food product has experienced (Wassermann, 2009).

Emulsifiers contain both hydrophilic and lipophilic parts, resulting in their ability to be useful in foods at very low levels (Baker, 2010).They are used at very low amounts in foods, many times at fractions of a percent, yet can greatly affect the final products' performance. For example, emulsifiers can aerate foams and batters, extend shelf-life, promote fat agglomeration, and improve texture in foods. In addition to potential interactions with oils, liquids and gases, emulsifiers may play a role in starch-complexing (anti-staling) and interact with proteins (Cauvain and Young, 2000).

Natural surfactants (emulsifiers) do occur in nature but many are the result of manufacturing technologies available today. In such cases the emulsifier is more powerful than the fat on a weight -for- weight basis at promoting many of the required properties, for example batter aeration and gas-bubble stability. Gum arabic is widely used for emulsifying the flavor bases used in beverages (Williams and Phillips, 2004).

2.5.1 Gum arabic: gum acacia E414:

Gum arabic is produced from two acacia varieties, which are found to a varying intensity in the gum belt of Sub-Saharan Africa. These varieties are *Acacia senegal* and *Acacia seyal*. Gum from *A. senegal* aqueous solutions are levorotatory Gum from *A. seyal* aqueous solutions are dextrorotatory.

2.5.2 Definition of gum arabic:

Gum arabic is defined by the FAO/WHO Joint Expert Committee for Food Additives (JECFA) as: "a dried exudate obtained from the stems and branches of *Acacia senegal (L.)* Willdenow or *Acacia seyal* (Fam. *Leguminosae*)" In a wider sense, the name gum arabic is also used to denominate gums produced by other Acacia species, like for example *A. karroo*, and is sometimes referred to as gum acacia (Verbeken *et al.*, 2003).

Gum arabic accoding to the Codex Alimentarius Commission at its 23rd Session in Rome, 28 June - 3rd July 1999 adopted the following substantive definition: "Gum arabic is a dried exudation obtained from the stems and branches of *Acacia senegal* (L) or *Acacia seyal* (fam. Leguminosae)." Previous attempts (by JECFA) to set analytical parameters included a specified range of optical rotation. In 1990 it was decided that the specific optical rotation should be within -26 to -*340* (Williams and Phillips, 2004).

2.5.3 Structure of gum arabic:

Gum arabic analyzed and found that moisture content of 15%, ash content of 3.56%, nitrogen content of 0.35% protein content of 2.31% and with no tannin content. Minerals content of the gum arabic (g/100 g) are Ca 0.7, Mg 0.2, Na 0.01, K 0.95, Fe 0.001 and P 0.6 (Hemeda and Mohamed, 2010).

Total dietary fiber content of gum acacia ranges from 80–90% (Hui *et al.*, 2007).

The proportion varies significantly depending on the Acacia species. Gum arabic is a mixture of closely related polysaccharides, with an average molecular weight range of 260–1160 kdal. The main structural units, with molar proportions for the gum exudate *A. senegal* given in brackets, are L-arabinose, L-rhamnose, D-galactose and D-glucuronic acid. Most of the gum had a very low protein content (0.35%) and was referred to as an arabinogalactan (AG). It represented 88.4% of the total gum and was found to have a molecular mass of 3.8×105 Da. The second fraction represented 10.4% of the total gum and was referred to as an AG–protein complex (AGP) with a molecular mass of 1.45×106 Da. The protein content of the AGP was 11.8%. The smallest fraction (1.2% of total gum) was referred to as a lowmolecular- weight glycoprotein (GP) with a molecular mass of 2.5×105 Da and a protein content of 47.3%, (Table 3) gives an overview of some chemical characteristics of the gum from *Acacia senegal* (Verbeken *et al.*, 2003).

Three principal fractions have been identified by hydrophobic affinity chromatography: a lowmolecular- weight arabinogalactan (AG), a very highmolecular- weight arabinogalactan-protein complex (AGP) and a low-molecular-weight glycoprotein (GI). These components represent 88%, 10% and 1% of the molecule, respectively, and they contain 20%, 50% and 30% of the polypeptides, respectively.

The protein is located on the outside of the AGP unit. The overall conformation of the gum Arabic molecule is described by the ‘wattle blossom’ model in which approx. five bulky AG blocks, ~200,000 Daltons each, are arranged along the GI polypeptide chain which may contain up to 1,600 amino-acid residues (Nussinovitch, 2010).

Table 3: Analytical data for the gum obtained from Acacia Senegal:

PARAMETER	RANGE
Moisture content (%)	12.5–16.0
Specific rotation	From -32.7o to -27.0o
Nitrogen (%)	0.22–0.39
Protein (%)	1.5–2.6
Galactose (%)	39–42
Arabinose (%)	24–27
Rhamnose (%)	12–16
Glucuronic acid (%)	15–16
Equivalent mass (Da)	1,118–1,238

2.5.4 Use of gum arabic in bread baking:

Gum arabic is unique in the very high gum concentrations which can be used to prepare solutions. Thus, large amounts of gum can be used in a variety of food products (Nussinovitch, 2010).

Gum arabic is widely used in the backing industry for its viscosity and adhesive property (Jilani, 1993).

The addition of gum arabic concludes in increased loaf volume and bread characteristics. The improvement of bread external appearance and its internal characteristics such as texture, cell wall structure, color and softness were also described (Hemeda and Mohamed, 2010).

Gum arabic and CMC improved loaf volume, internal and external appearance of bread, Gum Arabic gave the better results than CMC (Asghar *et al.*, 2005).

Gum acacia is likely to be encountered in bakeries in small quantities when it has been used to make emulsions of citrus oils as a bakery flavor (Edward, 2007). Gums like guar, carboxy-methylcellulose, xanthan, and gum arabic improve machinability, decrease dough stickiness, delay staling, improve rollability and water holding capacity, improve freeze/thaw stability and decrease moisture loss (Gritsenko, 2009). Arabic gum is added into wheat dough to slow aging of bakery products, to improve volume of bakery products, to milder consistence in ice creams and in confectionery to stop sugar crystallization (Mikuš *et al.*, 2011).

The use of gum arabic and CMC, both at 3% on a flour weight basis, improved the quality of the frozen pizza dough (Nussinovitch, 2010).

The effects of different hydrocolloids on the gelatinization behavior of hard wheat flour, Gum Arabic lowers the peak viscosity, reduces breakdown during heating and thus provides increased stability during cooking (Alam *et al.*, 2009).

In general, however, it is the highly soluble fibers (those that are highly branched or are relatively short-chain polymers, such as gum arabic, isolated arabinogalactans, inulin and oligosaccharides) that have low viscosities. These low-viscosity fibers have low GI and are generally used to modify texture or rheology, manage water migration, influence the solution properties of the food system, and improve the marketability of the food product as a health-promoting or functional food product. These fiber sources can be used in food products at relatively high levels, as they typically enhance the food product’s taste, mouth feel and shelf-life without significantly altering the specific application characteristics. For example, they can be used in sugar-free and fat-free products, increasing the potential for a high fiber claim (Kent and Evers, 1994). Gum arabic can also be regarded as a source of soluble fiber, being unaffected by passage through the stomach but broken down by the large intestine (Emerton and Choi, 2008).

Flavor emulsions are flavor oils dissolved in water with the aid of a starch or gum. The starch or gum—often gum arabic or xanthan gum—acts as an emulsifier, allowing the oil to blend more easily with other ingredients. This makes flavor emulsions easier to add to batters and doughs, for example (Figoni, 2008).

The maximum % usage level of specific gums in bakery foods, based on the Code of Federal Regulations in the U.S. Gum acacia may be used at 0.8% gum level in baked goods (Williams and Phillips, 2004).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Materials:

sorghum (Tabat) and maize grain were obtained from A Flour Mills – Industrial zone Omdurman . Main specification of flour is without any additives, that sample was taken from process line. Flour was kept in temperature below °50 C during period of experiment.

Gum arabic was obtained from Henelie Industries Ltd. Which is provide gum arabic (Spray-dried gum arabic and kibbled gum), Industrial zone – Albagair. Type of gum arabic (Hashab) gum, that gum was purchased from Alobeid market. Weights of samples of gum arabic were taken as percentage of flour (w/w %), the sample of gum Arabic was kept in temperature below °50 C during period of experiment.

- Baker yeast from local market, Levure instant yeast, made in Turkey by Ozmaya San. A.S. (a Lesaffre company).
- Salt from Alrasheed factory, khartoum, local market.
- Sugar from Dal group company package 1 kg.

3.2 Methods:

3.2.1 Proximate analysis :

Was carried out for samples consist of mixture of sorghum flour and maize flour were treated by gum Arabic.

3.2.1.1 Determination of moisture content:

The determination of moisture was carried out according to AOAC (2000) methods. The main steps were as follows:

Three grams of well-mixed samples were weighed accurately in clean preheated moisture dish of known weight by using sensitive balance.

The uncovered dishes with the samples were kept in an air oven provided with a fan at 130°C for 1 hour.

The dish was then covered and transferred to desiccators and weighed after cooled to room temperature.

The loss of weight was calculated as percent of sample weight and expressed as moisture content:

$$Moisture\ content\ \% = \frac{Wt1 - Wt2}{Sample\ wt}$$

Where:

Wt1 = Weight of sample + dish before oven dry.

Wt2 = Weight of sample + dish after oven dry.

3.2.1.2 Determination of fat content:

Crude fat was determined according to the standard method of AOAC (1990). A sample of 5 g was weighed into an extraction thimble and covered with cotton; that was previously extracted with hexane (BP60-70°C), and then the sample and a pre-dried and weighed Erlenmeyer flask containing about 50 ml were attached to extraction unit for 45 minutes. At the end of distillation period, the solvent was recovered from the oil. Later, the flask with the remaining crude hexane extract was put in an oven at 105 °C for about an hour. Cooled in a desiccators, reweighed and dried extract was recorded as crude fat% (DM) according to the following formula:

$$Crude\ fat\ \%\ (DM)\ = \frac{Dry\ extract\ w.t\ (g)\ x\ 100\ x\ 100}{wt.sample(100 - \%moisture)}$$

All the analyses were replicated three times and the means were reported.

3.2.1.3 Determination of crude protein:

The determination of crude protein was carried out on the samples according to AOAC (1984) methods.

The steps were as follows:

A 0.2 gram of sample, plus 0.4 gram catalyst mixture (potassium sulfate + cupric sulfate 10:1 by wt), and 7 ml concentrated nitrogen free sulfuric acid, were mixed in a small Kjeldahl flask (100 ml).

The mixture was digested for two hours, then cooled, diluted, and placed in the distillation apparatus.

Fifteen milliliters 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 10 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 to convert nitrogen into protein as follows:

$$Nitrogen\ content\ \%\ = \frac{TV \times N \times 14.00 \times 100}{1000 \times wt.of\ sample}$$

Protein content % = (nitrogen content %) X F

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.

3.2.1.4 determination of fiber :

Crude fiber was determined according to AOAC (1990). Two grams of defatted sample were treated successively with boiling solution of H_2SO_4 and KOH (0.26 N and 0.23 N, respectively). The residue was then separated by filtration, washed and transferred into a crucible then placed into an oven adjusted to 105°C for 18 – 24 hours. The crucible then with the sample was weighed and ached in a muffle furnace at 500°C and weighed. The crude fiber was calculated using the following equation:

$$CF(\%) = \frac{\mathrm{W1} - \mathrm{W2 \times 100}}{\mathrm{WS}}$$

Where:

CF = Crude fiber

W1 = Weight of crucible with sample before ashing

W2 = Weight of crucible with sample after ashing

Ws = weight of sample

3.2.1.5 Determination of ash:

The determination of ash was carried out according to AOAC (2000) methods.
The steps were as follows:
Three grams were weighed in empty crucible of known weight. The sample was heated in a Muffle-Furnace at 550°C until its weight is stable. The residue is

cooled to room temperature after removed from a Muffle-furnace and placed in a desiccator then weighed.

The process was repeated until constant weight was obtained.

% Ash content was calculated using the following equation:

$$Ash\ content\ \% = \frac{(\mathrm{Wt1} - Wt2)\ x\ 100X100}{Sample\ wt.x\ (100 - m)}$$

Where:

Wt_1 = Weight of crucible with ashed sample.

Wt_2 = Weight of empty crucible.

m = % moisture.

3.2.1.6 determination of carbohydrate:

Total carbohydrates were calculated by subtracting the sum of percentages of moisture, fat, protein and ash contents from 100% as described by **West *et al*. (1988).**

$$Total\ carbohydrates\ \% = 100\ \% - (Moisture\ \% + fat\% + protein\% + ash\ \%)$$

3.3 Bread making processes:

The bread making process was divided into three processes as follow:

1) Bread (A) from flour Contain 75%maize (M) ,25% Tabat (T) were treated by gum arabic.

2) Bread (B) from flour 25% maize (M) , 75% Tabat (T) were treated by gum arabic.

3) Bread (C) from flour 50% maize (M) , 50% Tabat (T) were treated by gum arabic.

4) Bread (N) from flour intended use for bread making (W) for comparing.

3.3.1 The bread recipes:

The bread recipes which was used in the study are just different in some additives (See table 4)

Table 4: Basic recipe:

Ingredient	Quantity
sorghum flour	250 gm
Sugar	3.0 gm
Baker's yeast	2.5 gm
Common Salt	2.0 gm
Gum Arabic	0.5% (w/w) flour
Water	165 ml

3.3.2 Weighing of raw material:

All raw materials weighed by sensitive balance (6 digits) which provided by glass box protected from air current, raw materials prepared before starting the process.

3.3.3 Mixing:

sorghum flour was added in mixer bowl first and the mixer was started then baker's yeast and sugar were added after one minute of dry mixing Water was added then other ingredients were added, Mixing was running until there was no dry flour left and mixer was running for total time three minutes.

3.3.4 Fermentation:

Fermentation process was implemented in two steps:
Firstly, after mixing the bread ingredients (flour, water, salt, sugar, yeast and gum Arabic) the dough was taken out from the mixer and put on the table after that it was given code numbers and covered and kept to rest for 60 minutes at room temperature.

3.3.5 Baking process:

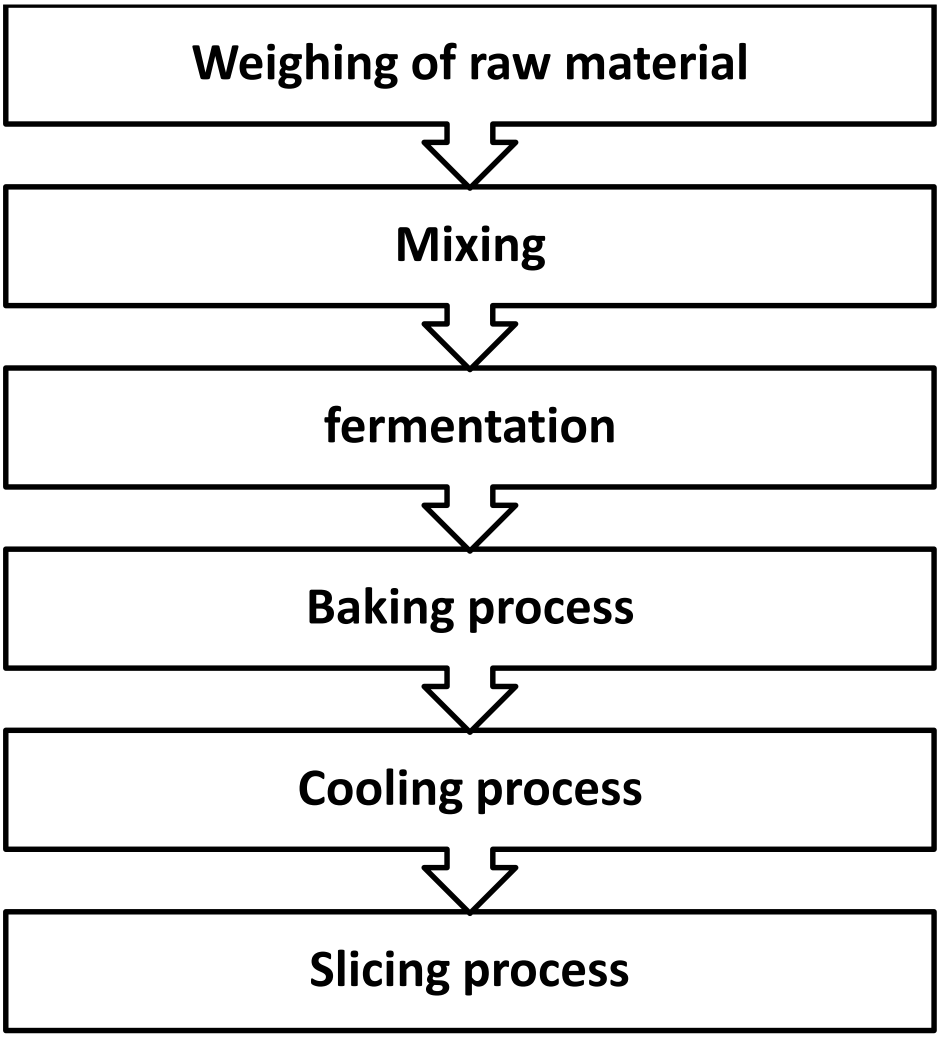
After fermentations process all templates were transferred to Oven at 2500 C, provided with rotation shelf to distribute heating. Baking time of samples were (same) . different in A1 and A2 flour, B flour sample was maintained stable.

3.3.6 Cooling process:

Bread was transferred from the Oven to table and then were removed from the templates and kept to cool. After 15 minutes all bread reached the room temperature.

3.3.7 Slicing process:

After cooling process the bread pieces sliced to carry out sensory evaluation by electric knife to obtain uniform slices of 1 cm thickness.



Bread making processes Fig (1)

3.4 Sensory evaluation:

The bread samples were sliced with electric knife and prepared for sensory attributes evaluation after bread samples were reached room temperature. Sensory evaluation was done using Ranking method by Trained panelists. The panelists received three samples and were asked to rank them for the intensity of some specific characteristics. Panelists were presented with several blind coded samples. They are asked to assess the samples in the order provided and placed them in order of intensity for a specified attribute.

The surrounding conditions were kept the same all through the panel test. All sensory evaluations were carried out individually for each experiment.

3.4.1 Statistical Analysis:

Statistical software "Statistix 8 for Windows was used to perform statistical analysis (ex. Analysis of Variance, Correlation Matrix, Principal Component Analysis and Multiple Regression).

ANOVA permits a decision maker to conclude whether or not all means of the populations under study are equally based upon the degree of variability in the sample data. In statistics, the term "population" means the total of any kind of units under consideration (N) by the statistician and a "sample" is any portion of the population selected for study (n). ANOVA is based on two hypotheses (null: H0 and alternative: H1). According to the "null hypotheses", all the population means are same. On the other hand, if there are significant differences among the sample means are not same, "alternative hypothesis".

Correlation coefficient is an index of the degree of relationship between two sets of measures and is always between -1.00 to +1.00. A correlation coefficient of -1.00 is indicative of a perfect negative correlation; zero is indicative of no correlation; +1.00 is indicative of a perfect positive correlation,

Correlation coefficients will be determined for this study to assess the correlations between gum Arabic treatment and other parameters of the experiment.

Descriptive analysis was performed, using standard statistical methods.

A five-item Liker scale was used as the highest grade was given 5 degrees, the lowest grade given one degree and the degrees sorted in descending order (1, 2, 3, 4, 5). The range was calculated for the scale as 5-1 = 4, then dividing the range by the number of categories (5) gave 4/5 = 0.80, which was the length of each category of the five scales.

Sample	Color	Flavor	Taste	Texture	Overall acceptance

5 = Excellent

4 = Very good

3 = Good

2 = Acceptable

1 = Unacceptable

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Chemical composition of Tabat, Maize and Wheat flour:

4.1.1 Moisture content:

Table 5 shows that there was no significant difference in the moisture content between the sorghum flour samples (T - M), but there was a significant difference between the wheat flour sample (W) and the sorghum flour sample (T – M).This is due to the fact that the moisture content of wheat flour is higher than the moisture content of sorghum flour.

4.1.2 Fat content:

Table 5 shows that there was no significant difference in the lipid content between the sorghum samples (T - M), but there was a significant difference between the wheat flour sample (W) and the sorghum flour sample (T - M). This is due to the fact that the fat content of wheat flour is higher than that of sorghum flour. And the lipid concentration affects the increase in energy values.

4.1.3 Protein content:

There were significant differences between the three samples in the protein content. The highest protein content was for the wheat flour sample (N), followed by the corn flour samples (T - M), respectively. as shown in (Table 5).

4.1.4 Crude fibers:

Crude fibers were detected in samples (T-M) of sorghum flour and there was no significant difference between them, but in wheat flour crude fibers were detected but it is very low 0.36. This means that there is a significant difference in the crude fiber content between wheat flour and sorghum flour, We can deduce from this that corn flour has a higher Crude fiber content than wheat flour as shown in (Table 5).

4.1.5 Ash content:

Ash content in a sample is a measure of its total inorganic mineral content As shown in (Table 5), there is evidence indicating that there is a significant difference in the ash content between a sample of wheat flour (W) and two samples of sorghum flour (T-M), which do not have a significant difference between them.

4.1.6 Carbohydrate content:

There were no significant differences in the carbohydrate content of the sorghum flour samples between them (T - M), and there was no significant difference in the carbohydrate content between the sorghum flour and wheat flour (W) As shown (Table 5).

4.1.7 Energy value:

All samples of sorghum flour (T, M) had higher energy values than wheat flour (W). This indicates that there is a significant difference between sorghum flour and wheat flour in the energy values. The energy value of the sorghum flour samples (T, M) increased (Table 5). This can be attributed to the increased concentration of fats which contribute significantly to the energy value. The lower energy value of the wheat flour samples (W) this could be attributed to the lower fat concentration which reduces the energy value.

Table (5): Proximate composition of flours:

Sample	MOISTURE	FAT	PROTEIN	FIBER	ASH	CHO	ENERGY
W	$12.67^{a}\pm0.025$	$0.94^{c}\pm0.006$	$10.55^{a}\pm0.032$	$0.36^{b}\pm0.010$	$0.94^{b}\pm0.010$	$74.54^{a}\pm0.508$	$334.4^{b}\pm1.93$
T	$6.9^{b}\pm0.01$	$4.58^{a}\pm0.45$	$9.40^{bc}\pm0.82$	$1.42^{a}\pm0.03$	$1.5^{a}\pm0.12$	$76.2^{a}\pm0.53$	$383.9^{a}\pm2.9$
M	$7.10^{b}\pm0.21$	$5.19^{a}\pm0.04$	$8.73^{c}\pm0.12$	$1.28^{a}\pm0.07$	$1.3^{a}\pm7.07$	$76.4^{a}\pm1.73$	$387.2^{a}\pm1.73$

Values are the mean±SD of three determinations (n=5).
a-c Within each column, means with different superscripts are significantly different (P <0.05).
W=wheat flour ,T=tabat flour and M= maize flour.

4.2 The compositions of the bread samples tested in this study (A,B and C) were comparable with bread product from wheat flour(N) :

4.2.1 Moisture content:

The **moisture** values of all of the bread samples were high. The baking temperature (175oC to 200oC) and baking time (≥ 30 min) used in this study led to a loss of appreciable amounts of moisture compared to the raw samples. However, different food substances have different capacities for absorbing/retaining moisture, leading to occluded or absorbed water. Therefore, it can be deduced that, even at the high baking temperature used in this study, some moisture will still be found in some samples (Table 6).

4.2.2 Fat content:

All of the sorghum bread samples(A,B and C) had higher **fat contents** than the 100% wheat bread (N), Because the different of fat content in raw material (T,M,W).As show in (Table 6)

4.2.3 Protein content:

Substituting wheat flour with a mixture of sorghum in different proportions (T-M) (i.e. 75-25%, 50-50% and 25-75%) to produce the sorghum bread samples (A-B-C) resulted in a decrease in the **protein content** of the bread samples. (Table 6). However, 100% wheat bread (N) contained higher amounts of protein than the sorghum bread samples examined. This is due to the higher protein content of wheat flour compared to sorghum flour (Table 6).

4.2.4 Crude fibers:

Crude fiber, which consists of cellulose and lignin, is used as an indicator of dietary fiber content. Dietary fiber is the indigestible/unavailable carbohydrate present in the diet. Diets rich in dietary fiber decrease the re absorption of bile acids, thus reducing circulating cholesterol levels and increasing glucose tolerance. Crude fiber was detected in the A, B, and C sorghum bread samples and they had not significant different between it's ,but in the 100% wheat bread Crude fiber was detected but quite low . This means that there is a significant difference in the raw fiber content between wheat bread and sorghum bread as show in (table 6).

4.2.5 Ash content:

The ash content of a sample is a measure of its total inorganic mineral content. As shown in (Table 6), There is no indication that there is a significant difference between all the bread samples A, B, C and N.

4.2.6 Carbohydrate content:

The carbohydrate content ranged in the sorghum bread samples From 38.5% to 45.3% while the carbohydrate content of wheat bread was about 30.38 (Table 6). High in carbohydrates was the values found in the sorghum bread samples (A, B, C) From 100% wheat bread (N). This is due to the presence of the highest carbohydrate content in sorghum flour compared to wheat flour, Which led to a significant difference between the products.

4.2.7 Energy value:

The energy value of the sorghum bread samples(A,B and C) increased (Table 6). This could be attributed to the increase in the concentration of lipids, which contribute significantly to the energy value . All of the sorghum bread samples (A,B and C)had higher energy values than the 100% wheat bread N. Which indicates that there is a significant difference between sorghum breads and wheat bread.

Table (6): Proximate composition of bread samples :

Sample	MOISTURE	FAT	PROTEIN	FIBER	ASH	CHO	ENERGY
N	52.89^{a} ±1.75	2.69^{b}±0.06	11.19^{a}±0.80	0.34^{b}±0.075	1.65^{a} ±0.09	30.38^{c}±0.52	224.27^{b}±0.72
A	45. 58^{b} ±009	4.89^{a}±0.01	8.32^{c} ±0.14	1.2^{a} ±0.02	1.51^{a} ±0.04	38.5^{b}±0.02	232.5^{b}±0.83
B	44.34^{b} ±0.14	4.55^{a} ±0.01	9.03^{bc}±0.09	1.35^{a} ±0.02	1.53^{a} ±0.02	39.2^{b} ±0.04	236.2^{b}±0.02
C	36.62^{c} ±0.05	4.59^{a} ±0.04	10.69^{b} ±0.10	1.3^{a} ±0.02	1.5^{a} ±0.04	45. 3^{a} ±0.07	265.40^{a} ±0.98

.

Values are the mean±SD of three determinations (n=5).
a-c Within each column, means with different superscripts are significantly different (P <0.05).
Control (N), 100% wheat bread; A,B and C, bread containing 25%~75% mixture sorghum flour.

4.3 sensory evaluation:

4.3.1 color:

There is a significant difference between samples of the sorghum bread mixture, with regard to the best color, sample (A), then sample (C), and finally sample (B) were chosen .as shown in (Table 7).

4.3.2 Flavor:

There is a significant difference between the sorghum bread mixture samples, with regard to the best flavor, sample (A), then sample (C), and finally sample (B) were chosen as shown in (Table 7).

4.3.3 Taste:

There is no significant difference in taste between sample (A) and sample (C), but there is a significant difference between these samples (A - C) and sample (B), which is considered the least acceptable in terms of taste. as shown in (Table 7).

4.3.4 Texture:

There is no significant difference in taste between sample (A) and sample (C), but there is a significant difference between these samples (A - C) and sample (B), which is considered the least acceptable in terms of texture. as shown in (Table7).

4.3.5 Overall Acceptance:

There is a significant difference between samples of the sorghum bread mixture, with regard to the overall acceptance, sample (A), then sample (C), and finally sample (B) were chosen .as shown in (Table 7).

Table (7):statistical analysis of sensory evaluation:

Sample	Color	Flavor	Taste	Texture	Overall Acceptance
A	3.87^{a} ±0.83	2.73^{a} ±0.79	2.60^{a} ±0.73	3.20^{a} ±1.08	3.13^{a} ±0.74
B	3.00^{b} ±1.51	2.07^{b} ±1.09	1.93^{b} ±0.70	1.87^{b} ±0.63	2.27^{b} ±0.88
C	3.53^{ab} ±0.83	2.40^{ab} ±0.73	2.93^{a} ±0.88	2.60^{a} ±0.82	2.80^{ab} ±0.86
CV%	30.44	34.01	31.29	37.19	31.93
SE±	0.40	0.32	0.28	0.31	0.30
$LSD_{0.05}$	0.81*	0.65*	0.58*	0.64*	0.61*

A= (75% maize flour- 25% tabat flour), B= (25% maize flour- 75% tabat flour). C= and (50% maize flour- 50% tabat flour) .

the ranking scores are :

5 = Excellent

4 = Very good

3 = Good

2 = Acceptable

1 = Unacceptable

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions:

The following conclusions could be considered from the preceding work:

- Sorghum and maize flours has higher fat, ash, carbohydrates and fiber values, and lower protein and moisture values compared to wheat flour.Sorghum breads formulated from sorghum flours mixture has higher fat, ash, fiber, and carbohydrates values and lower protein, moisture values compared to Wheat bread. sorghum bread formulated from (50:50) maize, tabat respectively has higher protein, carbohydrates values, compared by sorghum breads formulated from 75:25 maize, tabat and sorghum bread formulated from 25:75 tabat , maize. Therefore, it is closest to wheat bread in protein content.
- Organoleptics characteristic of the products proved the braed formulated from 75 maize: 25tabat it is the more acceptance. While braed formulated from 75 tabat : 25 maize it is the lest acceptance.

5.2 Recommendations:

- Further studies are needed to improve rheological characteristic in sorghum flour.
- These products can be used for people suffering from Celiac disease.
- Recommend Sudan government to use sorghum flour as alternative for wheat flour in bread production.

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