بسم الله الرحمن الرحيم

Sudan University of Science and Technology

College of Agricultural Studies

Department of Food Science and Technology

Using of Chickpea and Millet Flours in Cake Processing for Gluten Intolerant Individuals

استخدام دقيق الحمص والدخن في تصنيع الكيك لمرضى حساسية الجلوتين

A dissertation submitted in partial fulfillment of the requirements for the B.Sc. (Honors) Degree in Food Science and Technology.

By:

Asma Abubaker Osman Makkawi

Hiba Mohammed Alhassan Ibrahim Mohammed

Supervisor:

Dr. Ebrahim Alfaig Alnoor Alfaig

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الآية

بسم الله الرحمن الرحيم

{ فَلْيَنظُرِ الْإِنسَانُ إِلَى طَعَامِهِ{٢٤} أَنَّا صَبَبْنَا الْمَاء صَبّاً{٢٥} ثُمَّ شَقَقْنَا الْأَرْضَ شَقّاً{٢٦} فَأَنبَتْنَا فِيهَا حَبّاً{٢٧} وَعِنَباً وَقَضْباً{٢٨} وَزَيْتُوناً وَنَخْلاً{٢٩} وَحَدَائِقَ غُلْباً{٣٠} وَفَاكِهَةً وَأَبّاً{٣١} مَّتَاعاً لَّكُمْ وَلِأَنْعَامِكُمْ{٣٢}.

صدق الله العظيم

سورة عبس الايات (٢٤-٣٢)

Dedication

Every challenging work needs self efforts as well as guidance of elders especially those who were very close to our heart .

Everything I am, or ever will be, I owe it to my mother.

My success is because of her.

To you mother and this is just the beginning.

&

To my biggest supporter, who keeps saying ‘‘I am proud of you’’ in my failures before my successes.

To my father.

To our brothers, teachers and friends who support us every time.

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- We wish to express deepest gratitude and sincere thanks to our supervisor Dr. **Ebrahim Alfaig Alnoor Alfaig** for his helpful and continuous advice.
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Abstract

The aim of this study was to produce gluten free cake using millet and chickpea flours.

The combination of chickpea and millet flour is the percent of A (25:75), B (75:25), C (50:50) to produce three type of different cakes.

The proximate analysis of the chickpea flour was determined; the moisture content was (10.63%), ash (2.43%), protein (23.95%), fiber (1.34%), fat (1.98%) and carbohydrate (59.67%). And millet flour results were 11.22%, 2.37%, 14.7%, 1.34%, 5.57% and 64.8% for moisture, ash, protein, fiber, fat and carbohydrate, respectively.

The proximate analysis result of the processed cake in sample (A) was moisture (38.51%), ash (0.82%), protein (8.61%), fiber (0.75%), fat (6.52%) and carbohydrates (44.79%). In sample (B) was content 40.28%, 0.53%, 11.13%, 0.86%, 4.73% and 42.47% for moisture, ash, protein, fiber, fat and carbohydrates . In sample (C) was content moisture (42.80%), ash (0.85%), protein (9.7%), fiber (0.87%), fat (5.56%) and carbohydrates (40.22%).

The panel test results showed that sample B was the best in color, flavor, taste, texture and over all acceptance.

Based on these results the percent 75:25(chickpea: millet) was recommended for cake processing to give gluten free cake with acceptance quality.

الملخص

كان الهدف من هذه الدراسة هو إنتاج كيك خالي من الجلوتين باستخدام دقيق الدخن والحمص.

مزيج من دقيق الدخن ودقيق الحمص بالنسبة المئوية أ(٧٥:٢٥)، ب(٧٥:٢٥)، ج(٥٠:٥٠) على التوالي، لإنتاج ثلاثة أنواع مختلفة من الكيك.

تم تحديد التحليل التقريبي لدقيق الحمص. وكان محتوى الرطوبة(١٠،٦٣%) والرماد (٢,٤٣٪) والبروتين (٢٣,٩٥٪) والألياف (١,٣٤٪) والدهون (١,٩٨٪) والكربوهيدرات (٥٩,٦٧٪). وكانت نتائج دقيق الدخن ١١,٢٢٪ و ٢,٣٧٪ و ١٤,٧٪ و ١,٣٤٪ و ٥,٥٧٪ و ٦٤,٨٪ للرطوبة والرماد والبروتين والألياف والدهون والكربوهيدرات على التوالي.

نتيجة التحليل التقريبي للعجينة المعالجة في العينة (أ) كانت الرطوبة (٣٨,٥١٪) ، الرماد (٠,٨٢٪)، البروتين (٨,٦١٪) ، الألياف (٠,٧٥٪) ، الدهن (٦,٥٢٪) والكربوهيدرات (٤٤,٧٩٪). في العينة (ب) كان المحتوى ٤٠,٢٨٪ ، ٠,٥٣٪ ، ١١,١٣٪ ، ٠,٨٦٪ ، ٤,٧٣٪ و (٤٢,٤٧٪) للرطوبة ، الرماد، البروتين ، الألياف ، الدهون والكربوهيدرات. في العينة (ج) محتوى رطوبة (٤٢,٨٠٪) ، رماد (٠,٨٥٪) ، بروتين (٩,٧٪) ، ألياف (٠,٨٧٪) ، دهون (٥,٥٦٪) ، كربوهيدرات(٤٠،٢٢%).

أظهرت نتائج الاختبار الحسي أن العينة (ب) كانت الأفضل من حيث اللون والنكهة والمذاق والقوام وعلى الإطلاق.

بناءً على هذه النتائج، تمت التوصية بنسبة ٧٥:٢٥ (الدخن: الحمص) لمعالجة الكيك لإعطاء كيخالي من الغلوتين بجودة مقبولة.

CHAPTER ONE

1. INTRODUCTION:

Baked products have popularities in the populace because of their availability, ready to eat convenience and having good shelf life **(Kumar *et al*., 2013).**

Common bakery products includes: bread, rolls, cookies, pies, pastries, muffins and cake **(Hui *et al*., 2006).**

Cake is a form of sweet food made from flour, sugar, and other ingredients, that is usually baked. In their oldest forms, cakes were modifications of bread, but cakes now cover a wide range of preparations that can be simple or elaborate, and that share features with other desserts such as pastries, meringues, custards, and pies.

The most commonly used cake ingredients include flour, sugar, eggs, butter or oil or margarine, a liquid, and leavening agents, such as baking soda or baking powder. Common additional ingredients and flavorings include dried, candied, or fresh fruit, nuts, cocoa, and extracts such as vanilla, with numerous substitutions for the primary ingredients. Cakes can also be filled with fruit preserves, nuts or dessert sauces (like pastry cream), iced with butter cream or other icings, and decorated with marzipan, piped borders, or candied fruit.

Gluten intolerance person (Celica) allergic to gliadin, chickpeas are the gluten free there for, attempts are made for the formulation of cake in which wheat flour completely replaced with flour free gluten.

in this study we use chickpeas flour and millet flour .

Celica disease is an immune mediated condition affecting the small intestine that is triggered in genetically susceptible individuals by the consumption of the gliadin fraction of gluten **(Fasano *et al*., 2003).**

Chickpea is an ancient crop that belongs to the legume family. It has been grown in Africa, the Middle East, and India for centuries and is eaten as a dry pulse or green vegetable. Most U.S. production is in California and the Pacific Northwest. Chickpea (locally named kabkabi) is one of the Sudans most important winter cereal crops of high nutritional value . Chickpeas contain a range of nutrients, including protein, which is necessary for bone, muscle, and skin health **(Martin, 2006)**

Pearl millet is an important crop in arid and semi-arid tropics of Asia and Africa, where it is cultivated for food, fodder and building materials. As staple cereal, it represents the most common source of energy and micronutrients for millions of the world's poorest crop-livestock producers.

The objectives of the study:

The main objective of utilize chickpea and millet flour in making cakes free gluten, for gluten intolerant people.

Specific objectives are:

1. To determine the proximate composition of millet and chickpeas.
2. To determine the proximate composition of cakes.
3. To evaluate the organoleptic characteristics of cakes.

CHAPTER TWO

LITERAURE REVIEW

2.1 Baked products:

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The cake is a form of sweet food made from flour, sugar, and other ingredients, that is usually baked. In their oldest forms, cakes were modifications of bread, but cakes now cover a wide range of preparations that can be simple or elaborate, and that share features with other desserts such as pastries, meringues, custards, and pies **(Hui *et al*., 2006).**

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2.2 Cake and baked product ingredients:

Baking powder is probably the most common aerating agent in baked products like cakes. It is made up of bicarbonate of soda and cream of tartar. Baking powder is a chemical aeration agent.

Eggs are another basic ingredient in many baked products. They provide structure, aeration, flavour and moisture. They also tenderize cakes and add colour and nutritive value.

Oils generally oils mostly come from plants. In baking, butter, margarine, shortening and oils are commonly used. Their main functions are to shorten or tenderize the product, to trap air during creaming and so aerate the cake during baking to give good volume and texture, to assist with layering in puff pastry, to help prevent curdling by forming an emulsion, and to add flavor. They also provide some nutritive value. It is important to add the correct amount of oil as too much far will make the baked product greasy and unpleasant to eat, while too little fat will leave you with a product that lacks flavor and stales quickly.

Flour is the ingredient on which most baked products are based. Flour is made up of starch, protein, sugar and minerals. The protein content decides what the end use of the flour will be.

Milk is used in baked products to improve texture and mouth feel. The protein in milk also gives a soft crumb structure in cakes, and contributes to the moisture, color and flavor of a baked product. Cakes that contain milk also tend to have a longer shelf life.

Salt is usually only added in very small amounts to baked products, but it has a noticeable effect on the flavor of baked products. It not only provides its own flavor but brings out the natural flavor of other ingredients. Salt is also a good preservative as it absorbs water so there is less free water for bacterial and fungal growth.

Sugar gives cakes and other baked products sweetness and is used in many forms and many ways. In yeast raised products, sugar acts as food for the yeast. In cakes, sugar assists with the aeration and stabilising of batters.

Sugars improve the crust color of baked products, improve flavor and help to retain moisture, keeping products softer for longer and so reducing staling. Examples of sugar forms are granulated sugar, castor sugar and icing sugar. Sugar also comes in liquid forms such as syrup, treacle, corn syrup, honey and caramel **(URL1).**

2.3 Types of cake flour:

Wheat Flour A fine-textured, soft-wheat flour with a high starch content. It has the lowest protein content of any wheat flour, 8% to 10% protein (gluten). It is chlorinated (a bleaching process which leaves the flour slightly acidic, sets a cake faster and distributes fat more evenly through the batter to improve texture. This flour is excellent for baking fine-textured cakes with greater volume and is used in some quick breads, muffins and cookies **(Stradley and Linda, 2004).**

Chickpea Flour (Gluten Free) Made from dried chickpeas ground into flour. Used in many countries, it is a staple ingredient in Indian, Pakistan, and Nepal cuisines. You can use this flour as an egg substitute in vegan cookery. You can substitute up to half the amount of all-purpose flour called for in a recipe with chickpea flour. It is also very easy to make your own Chickpea Flour by processing dried chickpeas in your blender or food processor. **(Stradley, Linda. 2004).**

Millet Flour (Gluten Free) Millet is one of the oldest foods known and possibly the first cereal grain to be used for domestic purposes. Millet flour is most commonly used in desserts and sweet breads largely because of the grain's naturally sweet flavor. **(Stradley and Linda. 2004).**

2.4 Celiac disease:

Celiac disease is a syndrome characterized by damage to the mucosa of the small intestine caused by ingestion of certain wheat proteins and related protein in rye and barley **(Fasano and Catassi, 2001)**. The gliadins of wheat gluten contain protein sequences toxic to person with celiac disease (**Kagnoff *et al.*, 1982)**. Recent work has also shown that glutenins of wheat contain toxic sequences (Van de Wal et al., 1999 and wiser et al., 2004). Modern screening studies showed that celiac disease is much more prevalent than previously thought, the average worldwide prevalence is estimated as high as 1:266 **(Fasano and Catassi, 2001).**

2.5 Chickpea:

The chickpea is an annual legume of the family Fabaceae. Its different types are variously know as gram or bengal gram , garbanzo , or garbanzo bean , Egyptian pea . Chickpea seeds are high in protein . It is one of the earliest cultivated legumes, and 7500 year old remains have been found in the Middle East **(Emmanuel and Smartt 2012).**

2.5.1 Scientific classification of chickpeas:

Kingdom: Plantae.
Division: Magnoliphyta.
Class:Magnoliopsida .
Order: Fabales.
Family : Fabaceae
Subfamily : Faboideae.
Genus : Cicer.
Species : arietinum.

2.5.2 History:

Chickpea is an ancient crop that belongs to the legume family . It has been grown in Africa , the Middle East , and India for centuries and is eaten as a dry pulse or green vegetable . Most U.S. production is in California and the Pacific Northwest .

Chickpea also grow in East Africa (Sudan, Eritrea, Ethiopia, Kenya, Tanzania).

Chickpea (locally named kabkabi) is one of the Sudan's most important winter cereal crops of high nutritional value .

Chickpea was introduced on productive scale as cash crop at the jezira scheme in the 1990s.

Chickpeas contain a range of nutrients, including protein, which is necessary for bone, muscle, and skin health.

For people who are cutting down on meat consumption, a dish of chickpeas and rice, for example, can contribute a significant amount of protein to the diet. A cup of chickpeas provides almost one-third of an adult's daily protein needs **(Martin , 2006)**

2.5.3 The health benefits of chickpea seeds:

Diabetes:

One cup of chickpeas, weighing 164 grams (g), provides 12.5 g of fiber.

Fiber may benefit people with diabetes, and the American Diabetes Association recommend chickpeas as a source of dietary fiber.

A 2014 study concluded that eating at least 30 g of fiber per day could help reduce inflammation in people with type 1 diabetes

A 2018 review of meta-analyses found that a high fiber diet may help lower blood glucose levels and reduce the risk of developing type 2diabetes.

The Dietary Guidelines for Americans recommend that adults consume 25.2–28.0 g of fiber a day, depending on age and sex.

Chickpeas can play a role in a healthful diabetes meal plan. See our 7-day plan here **(Megan and Mohi, 2019)**.

Blood pressure:

To prevent high blood pressure, experts recommend limiting the intake of added sodium, or salt, and increasing the intake of potassium.

Current guidelines recommend that adults consume at least 4,700 milligrams (mg) of potassium per day.

A cup of chickpeas, weighing 164 g, provides 474 mg of potassium.

People who use canned chickpeas should check how much sodium the manufacturers have added. Cooking with dry chickpeas can help limit the amount of salt in a meal.

Adults should keep their sodium intake below 2,300 mg per day, while people aged 51 or over and those with risk factors for cardiovascular disease should consume less than 1,500 mg per day **(URL2).**

Heart health:

The fiber, potassium, B vitamins, iron, magnesium, and selenium in chickpeas all support heart health.

Fiber helps decrease the risk of heart disease by lowering cholesterol levels in the blood. Chickpeas contain no cholesterol **(URL2).**

Cholesterol:

A small 2006 study found that participants had less low density lipoprotein (LDL), or "bad," cholesterol in their blood when they ate a diet with added chickpeas, compared with a diet with added wheat, for 5 weeks.

The researchers noted that the fiber in chickpeas may be responsible for the reduction in LDL cholesterol **(URL2).**

Digestion and regularity:

Fiber helps keep the digestive tract healthy and promotes regularity. Chickpeas are a good source of fiber **(URL2)**

Anemia:

Without iron, the body cannot deliver oxygen to its cells, and this can lead to iron deficiency anemia. Symptoms include weakness and tiredness. In severe cases, life threatening complications can arise. **(URL2).**

A cup of chickpeas contains 4.7 mg of iron, or between a half and one-fifth of a person's daily requirement, depending on the individual. It also provides some vitamin C, which helps the body absorb iron. **(Megan and Mohi, 2019).**

2.6.4 Nutrition of chickpea seeds:

The following table shows the amount of each nutrient in 1 cup of chickpeas, according to the United States Department of Agriculture. (**Sotelo *et al*, 1987).**

It also shows how much of each nutrient a person should consume each day, according to the Dietary Guidelines for Americans. The requirements vary, however, according to age and sex. (**Sotelo *et al* , 1987).**

Table (1): shows the amount of each nutrient in 1 cup of chickpeas:

Nutrients	Amount in 1 cup of chickpeas (164 g)	Requirements per day
Energy (calories)	267	1,800-3,200
Protein (g)	14.4	46-56
Fat (g)	4.2	20–35% of daily calories should be fat
Carbohydrates (g)	44.7, including 7.8 g of sugar	130
Fiber (g)	12.5	22.4-33.6
Calcium (mg)	80.4	1,000-1,300
Iron (mg)	4.7	8-18
Magnesium (mg)	78.7	310-420
Phosphorus (mg)	274	700-1,250
Potassium (mg)	474	4,700
Zinc (mg)	2.5	8-11
Copper (mcg)	0.6	890-900
Selenium (mcg)	6.1	55
Vitamin C (mg)	2.1	75-90
Folate (mcg)	280	400
Choline (mg)	69.7	425-550
Beta carotene (mcg)	26.2	700-900
Vitamin E (mg)	0.6	15
Vitamin K (mcg)	6.6	75-120

Source: **(URL2).**

Weight Control:

In general, diets high in fiber, low in energy density and glycemic load, and moderate in protein are thought to be particularly important for weight control . In the NHANES 2003–2010 dataset, chickpea/hummus consumers were 53% less likely to be obese and 51% less likely to have an elevated glucose level. Likewise, consumers had a lower body mass index (BMI) (26.4 ± 0.5 vs. 28.6 ± 0.1) and waist circumference (92.2 ± 1.3 vs. 97.9 ± 0.3 cm) compared to non-consumers . This could be somewhat due to other healthy lifestyle patterns that one might expect individuals that have higher intakes of pulses such as chickpeas to exhibit (NHANES is observational data and cannot assess causality). Pulse o exhibit (NHANES is observational data and cannot assess causality). Pulse consumption, alone or included in a dietary pattern , has also been associated in epidemiologic studies with reduced body weight, waist circumference, and risk of overweight and obesity. Consumption of chickpeas/hummus has additionally been suggested as affecting markers of both metabolic syndrome and cardiovascular disease in both human and animal intervention studies (discussed below), **(URL2).**

Table (2): Chemical composition of chickpea seeds:

Constituent	Content (/100g dry seeds0
Protein (g)	22.0
Fat(g)	4.5
Carbohydrates (g)	70.8
Ash (g)	2.7
Calcium (mg)	114
Phosphorus (mg)	387
Iron (mg)	6.2
Magnesium (mg)	168
Sodium (mg)	30
Copper (mg)	2.3
Zinc (mg)	3.6
Thiamine (mg)	0.3
Riboflavin (mg)	0.2
Niacin (mg)	2.0

Source: **Noah *et al.* (2019).**

Table (3) Essential amino acid composition of chickpea seed proteins (g/16g N):

Amino acid	Chickpea content (g/16g N)	FAO reference protein
Lysine	7.3	5.5
Isoleucine	5.3	4.0
Leucine	9.6	7.0
Tryptophan	0.8	1.0
Methionine +cysteine	2.6	3.5
Phenylalanine +tyrosine	9.0	6.0
Threonine	3.7	4.0

Source: **Emmanuel and Smartt, (2012).**

2.6.5 Use of chickpea:

Chickpeas are usually rapidly boiled for 10 minutes and then simmered for a longer period. Dried chickpeas need a long cooking time (1–2 hours) but will easily fall apart when cooked longer. If soaked for 12–24 hours before use, cooking time can be shortened by around 30 minutes. Chickpeas can also be pressure cooked or sous vide cooked at 90 °C (194 °F), **(URL2).**

Mature chickpeas can be cooked and eaten cold in salads, cooked in stews, ground into flour, ground and shaped in balls and fried as falafel, made into a batter and baked to make farinata or cecina, or fried to make panelle. Chickpea flour is known as gram flour or besan in South Asia and used frequently in South Asian cuisine, **(URL2).**

In Portugal, chickpeas are one of the main ingredients in rancho, eaten with pasta and meat or with rice. They are used in other hot dishes with bacalhau and in soups, meat stews, and salads mixed with tuna and vegetables, olive oil, vinegar, hot pepper and salt. In Spain, they are used cold in tapas and salads, as well as in cocido madrilène, **(URL2).**

Animal feed:

Chickpeas serve as an energy and protein source as animal feed.

Raw chickpeas have a lower trypsin and chymotrypsin inhibitor content than peas, common beans, and soybeans. This leads to higher nutrition values and fewer digestive problems in nonruminants. Nonruminant diets can be completed with 200 g/kg of raw chickpeas to promote egg production and growth of birds and pigs. Higher amounts can be used when chickpeas are treated with heat, **(URL2).**

2.7 Millet:

Millets are a group of highly variable small-seeded grasses, widely grown around the world as cereal crops or grains for fodder and human food **(Oxford Dictionaries, 2017)**

The various millet species can be divided into two broad categories: pearl millet and "small" millets. The latter group, with the exception of proso millet, have smaller grains than pearl millet.

2.7.1 Pearl millet

Pearl millet (*Pennisetum glaucum, P. typhoides, P. tyhpideum, P. americanum*) is the most widely grown of all millets. It is also known as bulrush millet, babala, bajra, cumbu, dukhn, gero, sajje, sanio or souna **(FAO *et al*.,1996).**

Pearl millet has been recently introduced as a grain crop in the southeastern coastal plain of the United States, where it has been used as a summer forage. Pearl millet can be grown on poor, sandy soils in dry areas that are unsuitable for maize, sorghum or finger millet. It is a summer cereal grass with large stems, leaves and heads. It is more efficient in its utilization of moisture than sorghum or maize.

The grain grows on condensed panicles (spiked) 10 to 150 cm in length. Pearl millet has the highest yield potential of all millets under drought and heat stress.

Tabel (4): Classification of Pearl millet:

- *Pennisetum glaucum* (L.) R.

Rank	Scientific Name and Common Name
Kingdom	Plantae – Plants
Subkingdom	Tracheobionta – Vascular plants
Superdivision	Spermatophyta – Seed plants
Division	Magnoliophyta – Flowering plants
Class	Liliopsida – Monocotyledons
Subclass	Commelinidae
Order	Cyperales
Family	Poaceae/Gramineae – Grass family
Genus	*Pennisetum* Rich. ex Pers. – fountaingrass
Species	*Pennisetum glaucum* (L.) R. Br. – pearl millet

Source: **U.S.D.A**.

Table (5): Nutrients, Chemical composition of millet seeds:

Portion100g

Name	Amount	Unit
Water	8.67	G
Energy	378	Kcal
Energy	1582	Kj
Protein	11.02	G
Total lipid (fat)	4.22	G
Ash	3.25	G
Carbohydrate, by difference	72.85	G
Fiber, total dietary	8.5	G
Calcium, Ca	8	Mg
Iron, Fe	3.01	Mg
Magnesium, Mg	114	Mg
Phosphorus, P	285	Mg
Potassium, K	195	Mg
Sodium, Na	5	Mg
Zinc, Zn	1.68	Mg
Copper, Cu	0.75	Mg
Vitamin C, total ascorbic acid	0	Mg
Thiamin	0.421	Mg
Riboflavin	0.29	Mg
Niacin	4.72	Mg
Pantothenic acid	0.848	Mg
Vitamin B-6	0.384	Mg
Tryptophan	0.119	G
Threonine	0.353	G
Isoleucine	0.465	G
Leucine	1.4	G
Lysine	0.212	G
Methionine	0.221	G
Cystine	0.212	G
Phenylalanine	0.58	G
Tyrosine	0.34	G

Source: Lost crops of Africa volume (1) grain(1996).

2.7.2 Uses of pearl Millet:

Pearl millet has been used as a food crop for thousands of years in a variety of food products, and continues to be used as a staple grain by approximately 90 million people in Africa and India **(Gulia *et al*., 2007).** It contains more nutrients than rice or wheat, but is considered a subsistence crop for poorer countries **(Kajuna, 2001)**. Pearl millet grain contains higher gross energy than corn, higher concentrations of amino acids, and 27–32% more protein **(Gulia *et al*., 2007)**. As a gluten-free food product, pearl millet is becoming popular in the growing healthfood market **(Gulia *et al*., 2007).**

2.7.3 Region of Cultivation:

Pearl millet is one of the two major crops grown to feed people living in the semi-arid, low input dryland agriculture regions of Africa and southeast Asia. People in northern Nambia are almost entirely dependent on pearl millet for food. Four countries in the Sahel of Africa, with a total population of 38 million, depend on pearl millet to provide over 1,000 calories per person per day (Dendy 1995). Pearl millet is adapted to poor, droughty, and infertile soils because it will produce more reliably under these conditions than most other grain crops. However, it readily responds to high fertility and moisture. Pearl millet grows best in light well-drained loamy to sandy soils. It can tolerate acid subsoils to as low as pH=4 and high in aluminum content (National Research Council 1996). Annual rainfall in the areas where this crop is mainly grown ranges from 250 to 700 mm but can be as high as 1500 mm. Pearl millet is an annual, sexual diploid (2n=14 chromosomes) with the A genome, **(Jauhar and Hanna 1998)**.

Primary breeding research efforts on pearl millet for grain have been carried out at Tifton, Georgia by USDA/ARS scientists Wayne Hanna, Glen Burton, and colleagues, and at the University of Nebraska by David Andrews and John Rajewski.

Pearl millet is grow in the Sudan on the sandy soils of Darfur and Kordofan and in upper Nile, Bahr ELgzal and Equatoria. it ia cultivated in small patches in Damazin, Gederif and Gezira states in some parts of the eastern state in produced by flood irrigation, **(Hassan and Hussein ,2005).**

CHAPTER THREE

MATERIALS AND METHODS

3.1 Materials:

3.1.1Food materials:

Chickpeas seed and millet flour were purchased from local market in Khartoum North. Also the baking material and Vanilla extract were obtained from local market in Khartoum North.

3.2Methods:

3.2.1Sample preparation:

Firstly Chickpea seeds cleaned from the dirts and atrophied grains. Secondly, the grains were soaked in water for an hour, and then they were dried in the sun for 4 hours, then dried in oven for half an hour at 180 degrees, after that, it is ground and sieved.

3.2.2Analytical methods:

The determination of moisture, ash, fat, crude fiber and crude protein were carried out according to the standard official methods of analysis AOAC (2003).

3.2.2.1 Moisture determination:

Moisture content was determined according to the Association of official's analytical chemists AOAC (2003) as follows: Two grams of each sample were weighed in clean dry and pre-weighed crucible and then placed in an oven at 105C˚ and left overnight. The crucible was transferred to desiccators

and allowed to cool and then weighed. Further placement in the oven was carried out until constant weight was obtained.

Moisture content was calculated using the following formula:

$$MC\% = \frac{(W2-W1)-(W3-W1)}{W2-W1} \times 100$$

Where:

Mc: moisture content,

W1: weight of empty crucible

W2: weight of crucible with the sample,

W3: weight after drying.

3.2.2.2 Ash content:

Ash content of the sample was determined according to the method of AOAC (2003) as follows: Tow grams of sample were placed in a clean dry pre-weighed crucible, and then the crucible with its content ignited in a muffle furnace at about 550c for 3hours or more until light gray ash was obtained. The crucible was removed from the furnace to a esiccators to cool and then weighed. The crucible was reignited in the furnace and allowed to cooling until a constant weight was obtained. Ash content was calculated using following equation:

$$AC\% = \frac{W2-W1}{W3} \times 100$$

Where:

Ac: ash content.

W1: weight of empty crucible.

W2: weight of crucible with ash.

W3: weight of sample.

3.2.2.3Crude protein:

Crude protein of the sample was determined by using the micro-Kjeldahl method according to AOAC (1990) as follows:

1. Digestion:

0.2 gram of sample was weighed and placed in small digestion flask (50 ml). About 0.4 gram catalyst mixture (96% anhydrous sodium sulphate and 3.5% copper sulphate) was added, 3.5 ml of approximately 98% of H2SO4was added. The contents of the flask were then heated on an electrical heater for 2 hours till the color changed to blue-green. The tubes were then removed from digester and allowed to cool.

2. Distillation:

The digested sample was transferred to the distillation unit and 20 ml of NaOH (40%) were added. The ammonia was received in 100 ml conical flask containing10 ml of 2% boric acid plus 3-4 drops of methyl red indicator. The distillation was continued until the volume reached 50 ml.

3. Titration:

The content of the flask were titrated against 0.02 N HCL. The titration reading was recorded. The crude protein was calculated using the following equation;

$$CP\% = \frac{(T - B) \times N \times 14 \times 100 \times 6.25}{Ws \times 1000}$$

Where:

CP = crude protein

T = Titration reading

B = Blank titration reading

N = normality of HCL

Ws = sample weight

1000 = to convert to mg

3.2.2.4 Fat content:

Fat was determined according to the method of AOAC (1990) using soxhlet apparatus follows:

An empty clean and dry exhaustion flask was weighed. About 2 gram of sample was weighed and placed in a clean extraction thimble and covered with cotton wool. The thimble was placed in an extractor. Extraction was carried out for 8 hours with petroleum ether. The heat was regulated to obtain at least 15 siphoning per hour. The residual ether was dried by

evaporation. The flask was placed in an oven at 105°C till it dried completely and then cooled in a desiccators and weighed. The fat content was calculated using the following equation:

$$FC\ (\%) = \frac{W2 - W1}{Ws} \times 100$$

Where

FC= Fat content

W1= Weight of extraction flask

W2= Weight of extraction flask with fat

Ws= Weight of sample

3.2.2.5 Crude 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:

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

Where:

CF = Crude fiber

W1 = Weight of crucible with sample before ashing

W2 = Weight of crucible with sample after ashing

Ws = weight of sample

3.2.2.6Total carbohydrates content:

Total carbohydrates were calculated by difference. The summation of moisture, ash, crude protein, crude fiber and crude fat contents was subtracted from 100 to obtain the carbohydrates by difference.

3.2.2.7Food metabolized energy value:

The energy value of cakes was calculated based on Atwater factors for protein , fat , and available carbohydrates as indicated by Leng (1968).

Fat factor = 8.37 (Kcal/g)

Protein factor = 3.87 (Kcal/g)

Carbohydrates factor = 4.12 (Kcal/g)

1cal = 4.184 (kj)

3.2.3 Table (6): Preparation of millet and chickpea cake:

Ingredient	**A**	**B**	**C**
Chickpea flour (g)	63	187	125
Millet flour(g)	187	63	125
Sugar(g)	200	200	200
Baking powder (g)	13	13	13
Vegetable oil (ml)	120	120	120
Milk (ml)	235	235	235
Table egg	2 piece	2 piece	2 piece
Vanilla extract (g)	2-3	2-3	2-3

A = 25% Chickpea flour +75% Millet flour.

B= 75% Chickpea flour + 25% Millet flour.

C = 50% Chickpea flour + 50% Millet flour.

Procedure:

The cake mixer was prepared according to **Anita Tull (1996)** with some modification.

Eggs, salt, vinegar, vanilla and sugar were placed in mixing bowl and mix until homogeneity, then after that, milk and oil were added and mixed, finally flour and baking powder were added. Then the mixture was placed in the preparation trays and entered into an electric oven at a temperature of 180 ° C for 35 minutes.

the cake was taken out of the oven and left to cool down at room temperature.

3.2.4Sensory evaluation of cakes:

This test included 20 untrained panelists ranging from20 to 40 years of age from the faculty of Agriculture University of Sudan. Prior to sensory evaluation the chickpea and millet cake, to that of the wheat cake .The three samples were given random 3-digit codes and served .Where 1 was the lowest (Unacceptable) and 5 was the highest score (Excellent). Flavor attributes were also surveyed by asking panelists to evaluate the samples regarding the color, flavor, taste, texture, or overall acceptance.

3.2.5Statistical analysis:

In this study Microsoft office Excel was used in the calculations of the Mean and Stander deviation.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Proximate composition of pearl millet flour:

The chemical composition of pearl millet is shown in table (7). The result are expressed on dry basis.

4.1.1Moisture content:

The data showed that the moisture content of pearl millet flour was 11.22%. The result is within the range reported by **Agarwal and Sinha (1964)** who reported that the moisture content for pearl millet was 12%.

4.1.2 Ash content:

The ash content was found to be 2.37%. The result is within the range reported by **Burton et al. (1972)** who reported values 1.2% -3.4% higher than values.

4.1.3 Protein content:

The protein content was found to be 14.7 % the result within the range reported by **Khater (1990)** who reported that the protein content for pearl millet ware 14.2% - 14.7.

4.1.4 Fat content:

The fat content was found to be 5.57% the value within the range reported by **Hadimani et al. (1995)** who reported values 3.4% -7.4%.

4.1.5 Crude fiber:

The fiber content of pearl millet flour was found to be 1.34% the values are lower than the value reported by **Eltinay et al.(2005)** who reported values 2.4% and 8.6%.

Table (7): Proximate composition (%) of millet flour and chickpea flour (on wet and dry basis).

Parameter	Pearl millet		Chickpea	
	% on wet basis.	% on dry basis.	% on wet basis.	% on dry basis.
	N= 3±SD			
Moisture or dry matter	11.22±0.61	-	10.63±0.31	-
Ash	2.37±0.16	2.67±0.18	2.43±0.22	2.72±0.25
Protein	14.7±0.14	16.56±0.18	23.95±0.48	26.80±0.45
Fat	5.57±0.25	6.28±0.25	1.98±0.66	2.21±0.74
Crude Fiber	1.34±0.14	1.52±0.17	1.34±0.29	1.50±0.34
Total Carbohydrate	66.12±0.38	74.49±0.37	61±0.57	68.26±0.84

Values are mean ± SD

N=Number of independent determination.

SD= Standerd deviation

4.1.6 Carbohydrate content:

Carbohydrate was 64.85 for pearl millet. The value is lower than reported by **Hulse *et al*. (1980)** who reported value 75% in pearl millet flour.

4.2 Proximate composition of chickpea flour:

4.2.1Moisture content:

The data showed that the moisture content of chickpea flour was 10.63%. The result is within the range reported by **Aisha and El-Tinay(2004)** found moisture content was 6.54%.

4.2.2 Ash content:

The ash content was found to be 2.43%. The result is within the range reported by **Aisha and El-Tinay (2004)** who reported values 3.17% higher than values.

4.2.3 Protein content:

The protein content was found to be 23.95% the result within the range reported by **Ijabadeniyi and Adebolu (2005)** who reported that the protein content for pearl millet ware 23.18%

4.2.4 Fat content:

The fat content was found to 1.98% the value within the range reported by **Ikrany el al.,(2010)** who reported values 3.80%.

4.2.5 Crude fiber:

The fiber content of chickpea flour wad found to be 1.34% the values are lower than the value reported by **Ijabadeniyi and Adebolu (2005)** who reported values 6.50%.

4.2.6 Carbohydrate content:

Carbohydrate was 59.67% for chickpea flour. The value is lower than reported by **Ijabadeniyi and Adebolu (2005)** who reported value 56.74%.

4.2 Chemical characteristics of cake containing different levels of pearl millet flour and chickpea flour:

4.2.1 Proximate composition:

The chemical composition of chickpea is shown in table (7). The result are expressed on dry basis.

4.2.1.1 Moisture content:

Table (9) shows the proximate composition of cake had different level of chickpea and millet flour.

The moisture content of control cake wheat flour was found to be 47.20% this value is higher than the cake sample (A) 38.51%, (B) 40.28%, (C) 42.80%.

These results were compare with data which reported by (**Udoidem and Enwere, 2012).**

4.2.1.2 Ash content:

The ash content of (B) was 0.53% the value was lower than cake (A) 0.83%, (C) 0.85%, compare with the control biscuits that had ash 1.83%.

These results were compare with data which reported by (**Dhingra and JOOD, 2001).**

4.2.1.3 Fat content:

The fat content of control cake was 10.44% the value was higher than sample (B) 4.73%, (C) 5.56% and (A) 6.52%.

These results were compare with data which reported by (**Udoidem and Enwere, 2012).**

4.2.1.4 Fiber content:

The fiber content of control biscuit was 0.69% and it was lower than the sample (A) 0.75%, (B) 0.86% and (C) 0.87%.

These results were compare with data which reported by (**Aljak, 2009)**

4.2.1.5 Protein content:

The protein content of control cake was 18.05%, it was higher than sample (A) 8.61%, (C) 9.7% and (B) 11.13%.

(**Udoidem and Enwere, 2012).**

4.2.1.6Carbohydrate content:

The carbohydrate content of cake sample (C) was 40.22% the value is lower than sample (B) 42.47% and (A) 44.79%.

4.2.1.7: Energy content:

The energy content was determined in cake sample (A) was found to be 275.5% the value is higher than cake (B) 261.14%, (C) 253.34%.

Table (8): Proximate composition (%) of cake prepared from different levels pearl millet flour and chickpeas flour on dry basis:

Parameter	A	B	C
	On dry basis		
	N= ±SD		
Moisture	-	-	-
Ash	1.33± 0.05	0.89± 0.27	1.49 ± 0.09
Protein	10.62± 0.6	18.64 ±0.66	17.03 ±0.52
Fat	1.33± 0.05	7.92 ±0.30	9.74 ±0.39
Crud fiber	1.23± 0.13	1.44 ± 0.13	1.52 ± 0.04
Total carbohydrate	86.72± 0.56	72.54± 0.95	71.75 ± 0.87
Energy (k cal/100g)	275.5±3.03	261.14 ± 3.42	253.34 ± 2.57

Values are mean ± SD

N= Number of independent determination.

SD = Standard deviation.

Table (9): Proximate composition (%) of cake prepared from different levels pearl mille flour and chickpeas flour on wet basis:

Parameter	A	B	C
	On wet basis		
	N= ±SD		
Moisture	38.51± 1.02	40.28± 0.58	42.80± 0.74
Ash	0.82± 0.04	0.53± 0.15	0.85± 0.06
Protein	8.61± 0.08	11.13±0.28	9.73± 0.20
Fat	6.52± 0.25	4.73± 0.18	0.13 ±0.17
Crud fiber	0.75 ±0.07	0.90±0.05	0.87± 0.02
Total carbohydrate	45.53±1.28	43.32±0.99	41.04±0.96

Values are mean ± SD

N= Number of independent determination.

SD = Standard deviation.

4.3 Sensory evaluation results of the processed cake:

Figure 1, showed the sensory analysis of the processed cake regarding the color the treatment (B) score the best color and flow by sample (C) and then sample (A).

The best flavor were found in sample (B) then flow by sample (A) and then

Sample (C).

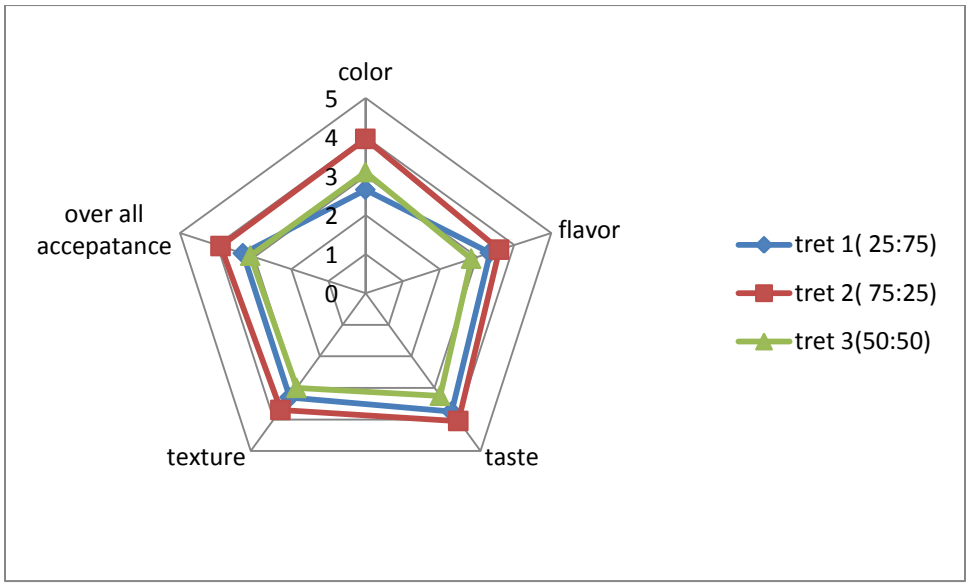
The best taste were found in sample (B) then flow by sample (A) and then sample (C).

The best texture found in sample (B) then flow by sample (A) and then sample (C).

The panelist is preferred sample (B) regarding the overall 3.9%.

Based on the panelist sample (B) was the best one.

Figure1: Sensory evaluation results of the processed cake:



Treatment 1= 25% Chickpea flour + 75% Millet flour.

Treatment 2=75% Chickpea flour + 25% Millet flour.

Treatment 3=50% Chickpea flour +50% Millet flour.

CHAPTER FIVE

CONCULSIONS AND RECOMMENDATIONS

5.1 Conclusions:

1. The study showed the possibility of using millet flour and chickpea flour for processing of cake with acceptable quality level.
2. The result of the sensory evaluation showed that cakes containing more chickpea flour were the most acceptable and of the best nutritional value.
3. Adding chickpea flour to the product formulation enhanced protein content.

5.2 Recommendations:

1. Chickpea and Millet flours can be a good choice for the gluten intolerance individuals.
2. Chickpea and millet flours based convenience cake food product can be popularized through proper marketing strategies.
3. Composite flour made of chickpea flour and millet flour could be used as replacement to wheat flour cake for people who suffer from celiac disease.
4. further studies are needed to investigated the keeping quality of gluten free product.

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APPENDICES

Appendix(1):75:25 % Millet: Chickpea

Appendix(2):25:75 % Millet: Chickpea

Appendix(3):50:50 % Millet: Chickpea