بسم الله الرحمن الرحيم

Sudan University of Science and Technology

College of Agricultural Studies

Department of Food Science and Technology

Comparison Study of the effect of adding composite corn/millet flour to breakfast flaks product

دراسة مقارنة لتأثير إضافة دقيق الذرة الشامية / دقيق الدخن المركب إلى منتج رقائق الإفطار

A Dissertation Submitted to Sudan University of Science and Technology in partial Fulfillment for the Requirement of B.S.c (Honours) Degree in Food Science and Technology

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الآية

قال تعالى:

(يَرْفَعِ اللَّهُ الَّذِينَ آمَنُوا مِنكُمْ وَالَّذِينَ أُوتُوا الْعِلْمَ دَرَجَاتٍ وَاللَّهُ بِمَا تَعْمَلُونَ خَبِيرٌ)

صدق الله العظيم

(11) سورة المجادلة

Dedication

To our parents and brothers

To our teachers and friends

To everyone who supported us encouraged us and believed in our arrival

To ourselves before university and ourselves now on the threshold of graduation

Acknowledgement

Thank you first and foremost to god for our success and for reaching where we are now

And all thanks and gratitude to our supervisor:**Dr. MahaFadul Mohammed El-Baloula**For our Support and supervision

Then appreciation is given to each of the department of food science and technology at Sudan University of Science and Technology

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Abstract

This study was conducted for the purpose of making breakfast flakes from pearl millet flour and maize flour (gluten-free breakfast flakes).

The approximate dietary analysis of whole millet flour was performed and contained 15.33% protein, 5.42% fat, 0.98% fiber, 3.38% ash, 10.94% moisture, 63.26% carbohydrates.

Two samples of breakfast flakes were made in different proportions as follows:

100% pearl millet flour, 50% pearl millet flour and 50% maize flour.

The chemical ingredients of each type of breakfast flakes were also studied and the study proved that breakfast flakes with a higher percentage of pearl millet have a high nutritional value compared to the other types.

Sensory evaluation of only millet breakfast flakes gained the highest score of general acceptability.

ملخص الدراسة

أجريت هذه الدراسة بغرض صناعة رقائق إفطار من دقيق الدخن اللؤلؤي و دقيق الذرة الشامية (خالي من الغلوتين).

لقد أجري التحليل التقريبي للعناصر الغذائية لدقيق الدخن الكامل وكان يحتوي على 15.33% بروتين، 5.42% دهن، 0.98% ألياف، 3.38% رماد، 10.94% رطوبة، 63.26% كربوهيدرات.

تمت صناعة عينتان من رقائق الإفطار بنسب مختلفة كالآتي:

100% دقيق دخن لؤلؤي، 50% دقيق دخن لؤلؤي و 50% دقيق ذرة شامية.

أيضا تمت دراسة المكونات الكيميائية لكل نوع من رقائق الإفطار حيث أثبتت الدراسة أن رقائق الإفطار المحتوية على نسبة أعلى من الدخن ذات قيمة غذائية عالية مقارنة بالأنواع الأخرى.

التقييم الحسي لرقائق الإفطار المصنوعة من الدخن فقط قد حصلت على أعلى تقييم في القبول العام.

CHAPTER ONE

INTRODUCTION

Celiac disease (CD) is a common multi- system autoimmune disease, affecting approximately 1% 0f worldwide. Predisposed individual develop an immune response to gluten, a protein found in the cereal grain: wheat, barley and ray. Autoimmune intestinal damage is the cardinal feature of CD, and typically involvesvill0us atrophy, crypt hyperplasia, and increased intraepithelial lymphocytes. Symptoms may be subclinical varying from gastrointestinal upset to severe mal-absorption. Skin, nervous system, and multisystem involvement is also recognized. Strict avoidance of gluten-containing foods can reverse both enteric and extra-intestinal manifestations of the disease CD unique in that its treatment consists of dietary intervention: lifelong exclusion of gluten. A gluten free diet (GFD) is highly effective at improving symptoms of CD in the majority of patient. Nevertheless a significant remains symptomatic and lack of strict adherence to GFD is primary cause **(Carlo Catassi and AlessioFasano, 2014).**

Baked product is applied to a wide range of food product, including breads, cakes, pastries, cookies and many other products, and it can be difficult to identify a common thread linking the member of such a diverse group. The most commonly-identified link is that they all use recipes that are based on wheat flour. This definition, though, would need to be expanded to include baked goods such as gluten-free product, used by people with celiac digestive disorders, or rye bread, which are still considered to be baked product even though they are based on cereals other than wheat **(Stanley P. Cauvain, Lioda S Young, 2006).**

Pearl millet is one of important millet grown in tropical and semi arid region of the world. Millet is indigenous African cereals that un like wheat or rice are well adapted to African semi arid and sub tropical agronomic condition. Millet grows under difficult ecological condition and tolerate poor soil and a certain degree of drought batter than any other cereal crop **(Obilana, 2003).** Pearl millet is a good source of protein, minerals and energy except lysine deficiency, pearl millet has well-balanced protein, with higher threonine and lower leucine content than sorghum protein.

l-balanced protein, with higher threonine and lower leucine content than sorghum protein. Tryptophan levels are generally higher in pearl millet than in other cereal **(Chung and Pomeranz, 1985).**

Maze is indeed a strange and marvelous grass. Strange because by human selection the plant can no longer sow its own seeds and is therefore dependent on human cars for survive, and marvelous not only because of its stately stature but also because of its importance as a food plant. There is also a mystery to corn, becauseit is one of the most studied plants on this planet, yet we cannot 20+ accounts with certainty for its complete origin. The one aspect that student of this plant agree on is that corn is the plant of the Americas. At the time Columbus, corn was cultivated from Gaspe in Canada to Chile in South American, mostly on forest land that could be cleared by salash-and-burn agriculture followed by several years of fallow **(C.**

Wayne Smith et al., 2004).

Corn flakes are one of the most popular breakfast cereals in the world. According to the Kellogg Company .it is probable that most modern-day cereal eaters don't associate their morning meal with real going, but corn flakes started life as health life.

General Objective:

Using pearl millet flour to prove a product with high nutritional value to those suffering from wheat allergy.

Specific Objective:

1. To determine the proximate composition of pearl millet.
2. To determine the proximate composition of breakfast flakes from pearl millet.
3. To evaluate the organoleptic characteristics of breakfast flakes.

CHAPTER TWO

LITERATURE REVIEW

2.1 Pearl millet:

The term “millet” is applied to various grass crops whose seeds are harvested for human food or animal feed. Sorghum is called millet in many parts of Asia and Africa, and broomcorn is called broom millet in Australia. Compared to other cereal grains, millets are generally suited to less fertile soils and poorer growing conditions, such as intense heat and low rainfall. In addition, they require shorter growing seasons. The most common millets grown in New Mexico include foxtail and hybrid pearl varieties. Millets are generally considered minor crops except in parts of Asia, Africa, China, and the Soviet Union. As a group, millets are used for both forage and grain. When used as grain, they are considered a cereal, but in the United States they have lost a great deal of importance in favor of other cereal crops such as wheat or rice **(R.D. Baker, 2003)**

2.1.1 Classification:

Kingdom: plants

Sub Kingdom: Tracheobionta (vascular plants)

Super division: Spermato photo (seed plant)

Division: Mangnoliophyta

Class: Liliopsida. Monocotyledons

Sub class: Commelinidae

Order: Cyperales

Family: Poaceae. Grass Family

Genus: Pennisetum. Fountain grass

Species: Pennisetum glacum **(Baker, 2003)**

2.1.2 Origin and history:

The native home of pearl millet is not known. It belongs to a genus of grasses {Pennisetum) which is widely distributed in tropical and sub-tropical regions of the Old World, and to a lesser extent in South America and Central America. From the number of species which occur in Africa, and the extent to which pearl millet is cultivated there, it seems probable that tropical Africa is its native home. In India and adjacent regions, in Arabia, in Egypt, and in all the warmer parts of Africa, it has been known in cultivation for more than three hundred years as a forage and food plant. The grain is used very largely for human food and the whole plant for forage. It is also cultivated extensively in southern Europe. It was probably carried by the Spaniards to Mexico and South America at a very early date. The specimen described by Clusius in 1601 was supposed by him to have come from Peru. Pearl millet was very probably introduced into the United Statesin the early fifties, at or about the same time that sorghum was brought to this country. It has certainly been cultivated in the Southern States since that time. Little attention was paid to it, however, and it was not until 1875 or later that its cultivation became at all general in that section. In 1878 a few samples of seed were sent out from the United States Department of Agriculture to private experimenters in several widely separated States. Most of these experimenters returned very favorable reports of its growth and value **(Carleton R. Ball, 1903).**

2.1.3 Sudanese pearl millet

Pearl millet is growing in the Sudan on the sandy soils of Darfur and Kordofan and in upper Nile, Bahr Elgazaal and Equatoria. It is cultivated in small peatches in Damazin, Gedarif and Gezira states in some parts of the eastern and South East state it is produced on clay plains under rains. However, Pearl millet is major cereal crops in western Sudan. Over 90% of Sudanese pearl millet is growth in kordofan and Darfur states **(Hassan and Hussein, 2015).**

2.1.4 Uses:

2.1.4.1 Pearl Millet used as food:

His grow mainly for the grain which serves as the staple food for the inhabitants of those parts of the country. The grain is grounded in to flour and eaten as bread, porridge and native beers (***Dep. Agricultural Economics, Annual report, 2004***).

2.1.4.2 Health benefits of millets:

2.1.4.1 Millets and diabetes:

Lower incidences of diabetes have been reported in millet-consuming population. Millet phenol inhibits like alpha-glycosidase, pancreatic amylase reduce postprandial hyperglycemia by partially inhibiting the enzymatic hydrolysis of complex carbohydrates (***Shobana et al.,***

2009). Inhibitors likealdose reeducates prevents the accumulation of sorbitol and reduce the risk of diabetes induced cataract diseases (***Chethan et al., 2008***).

Finger millet feeding controls blood glucose level improves antioxidant status (***chethan et al., 2008)*** and hastens the dermal wound healing process in diabetic rats (***Rajasekaran et al., 2004).***

2.1.4.2 Millets and celiac disease:

Celiac disease is immune-mediated enteropathy triggered by the ingestion of gluten in genetically susceptible individuals. Millets are gluten-free, therefore an excellent option for people suffering from celiac disease and gluten-sensitive patients often irritated by the gluten content of wheat and other more common cereal grain (***Saleh et al., 2013).***

2.1.4.3 Millets and cardiovascular disease:

Millets are good sources of magnesium that is known to be capable of reducing the effect of migraine and heart attack. Millets are rich in photo-chemicals containing phatic acid which is known for lowering cholesterol. (***Coultably et al., 2011)*** Finger millet may prevent cardiovascular disease by reducing plasma triglycerides in hyperlipidemic rats (***lee et al., 2010).***

2.1.4.4 Millets and cancer:

Millets are known to be rich in phenolic acid, tannins, and phytate that act as “ant nutrients” however; these nutrients reduce the risk for colon and breast cancer in animal. It is demonstrated that millet phenolics may be effective in the prevention of cancer initiation and progression in vitro (**Chandrasekhar and shahidi, 2011).**

The straw is used as animal feeding, fuel and for making fences and the stalks are used for thatching and building ***(Dep. Agricultural Economics, Annual report, 2004).***

2.1.5 Nutritional value

The nutritional properties of pearl millet have received more attention that those of the other common millets, because it is the largest-seeded, most widely grown type (***Hoseney et al., 1989).*** Pearl millet is low in lysine, tryptophan, threonine and the sulfur-containing amino acids. In an evaluation of several cereals, methionine content was found to be highest in prosody, followed by sorghum, pearl millet, and maize.

The level of lysine content of pearl millet grain on a dray matter basis was 0.357%, 21% greater than corn and 36% greater than low-tannin sorghum (***Sullivan et al., 1990). With*** icrearising protein, lysine as a percent of protein decreases, but as yields go up, the total lysine per hectare will increase. Generally the amino acid profile of pearl millet compares favorably with that of wheat, barley and rice (***Hulse et al., 1980).*** Seed proteins of pearl millets showed the essential amino acid leucine is the highest, but threonine, lysine and the sulfur containing amino acid were lower. The results indicate that this grain has a good nutritive value (***Basahy, 1996).***

Biological value of millet protein alone was 63.8 and was 84.2 when supplemented with lysine and threonine (***Nishizawa et al., 1989).***

Sorghum and millet cultivars were evaluated for nutritive values as affected by maturity, results indicated positively with lignin and other cell will constituents, but negatively with crude protein, degradability of dry meta and inorganic nutrients. There was no significant deference in the nutritive values of sorghum and millet cultivars (***Aganga et al., 1996).***

In comparison between sorghum and pearl millet, the phosphorus content was high in both grains while calcium was low; also they were low in sulphur amino acid and lysine. Sorghum and millet were similar in their proximate constituents (***Nwokolo, 1987).***

Milling of pearl millet grains affected its gross composition, while milling and heat treatment during chapatti (an unleavened bread) making significantly lowered polyphenols and phitic acid and significantly improved the protein and starch digestibilites, but baking did not significantly affect the nutrient content of row pearl flour (***Chowdhury and punia, 1997).***

2.1.6 Chemical composition of pearl millet

The moisture content of pearl millet ranged from 7.8 to 14.2% as reported by (**Hoseney, 1986**). The moisture content of local Sudanese millet varieties ranged from 10.6 to 11.7% as reported **by khatir (1990). Eltayeb (2006),** reported values of 5.4% and 6.48% for moisture content of two Sudanese pearl millet cultivars.

Among millet contains a higher protein content and better amino acid balance than sorghum. Large variation in protein content from 6% to 12% has been observed (***Serna-Saldivar et al., 1991***). The higher ratio of germ to endosperm was found to be responsible for the higher protein content of peal millet (***Dendy,1995; Abdullah et al., 1998 and Subramanian et al., 1986)*** reported that the protein content of pearl millet genotype ranged from 8.5 to15% and from 8.6 to15.6%,respectively. **Abdullah (2003*)*** reported 12.5 and 13.6% protein content two pearl millet cultivars. **Khatir (1900),** found the protein content of local Sudanese varieties ranging between 14.2 to 15.5% which is higher than sorghum maize and rice.

Pearl millet varies in ash content from 1.2 to 3.4% ***Barton et al., (1972)*** gave range from 1.46% to 3.88%. For Sudanese cultivars ***Abdullah et al., (1996),*** reported a range from 1.6 to 2.4% for two pearl millet cultivars. ***Eltinay et al. (2005)*** reported 1.8%and 1.6% and ash content for two pearl millet cultivars.

The fiber of Sudanese local varieties ranged from 3.18% to 3.67% **(Khatir, 1990). Eltinay et al. (2005)** reported 2.4 and 8.6% fiber for two pearl millet cultivars**. Abdullah (1996)** reported values between 2.6% to 4% fiber content.

In contrast of other cereal pearl millet has highest content due to the large proportion of the germ to the endosperm. Ether-extractable lipids ranged from 3 to 7.4% they are mostly in the germ ***(Hulse et al., 1980). Eltinay et al. (2005)*** investigated two pearl millet cultivars and reported 6.1% and 5.4% oil content.

Hadimani et al. (1995) found oil content in the range of 3.4 to 7.4%.

In general carbohydrate component is about 75% of the content of cereal. The cereal major groups of carbohydrate are sugar, starches and cellulose and related materials ***(Hulse et al., 1980). Abdullah et al. (1998)*** stated that the carbohydrate content of pearl millet ranged from 58.5% to 70.67% for ten pearl millet cultivars. ***Eltayeb (2006)*** investigated two pearl millet cultivars and reported 73.67% and 68.55% carbohydrate content.

2.2 Maize

Maize is indeed a strange and marvelous grass. Strange because by human selection the plant can no longer sow its own seeds and is therefore dependent on human cars for survive, and marvelous not only because of its stately stature but also because of its importance as a food plant. There is also a mystery to corn, becauseit is one of the most studied plants on this planet, yet we cannot account with certainty for its complete origin. The one aspect that student of this plant agree on is that corn is the plant of theAmericas. At the time Columbus, corn was cultivated from Gaspe in canada to Chile in South America, mostly on forest land that could be cleared by salash-and-burn agriculture followed by several years of fallow ***(C. Wayne Smith et al., 2004).***

2.2.1 Origin and History

Maize domesticated in southern Mexico around 4000 BC. Early civilization of the Americas depended on maize cultivation. When the Europeans arrived in the Americas, maize had already spread from Chile to Canada. Maize was reported for first time in west Africa in 1498, six years after Columbus discovered the west India. The Portuguese brought floury grain type from central and South America to Sao Tome, from where they spread to the west African coast. Portuguese and Arab traders introduced Caribbean flint maize. The U.S. Corn Belt monoculture that replaces the tall grassland of the midcentral United States is recently developed (ca. 150 years) corn-production region with its own landrace .Corn Belt dent. Corn is this country's single largest harvest and a $25 billion farm product. The United states product 40% of the world's corn harvest, and it takes 25 corn plants per person per day to support the American way of life. This plant is found in more than the breakfast table. Corn oil is in the margarine, corn syrup sweeteners in the marmalade, corn syrup solids in the instant nondaidr coffee creamer, and corn was fed to the cows that made the milk ***(C. Wayne Smith et al., 2004).***

2.2.2 Chemical Composition

The composition of mature white maize grain per 100 g edible portion is: water (10.4 g), energy (1527 kj (365 kcal)), protein (9.4 g), fat (4.7 g),

carbohydrate (74.3 g), dietary fiber (7.3 g), Ca(7 mg), Mg (127 mg), P (210 mg), Zn (2.7 mg), thiamin (0.39 mg), riboflavin (0.20 mg), niacin (3.6 mg), vitamin B6 (0.62 mg), folate (19 μg), and ascorbic acid (0) ***(C. Wayne Smith et al., 2004).***

2.2.3 Nutritive value

Maize provides approximately 1400 Kcal/100 g (on a dry basis) of energy that is sufficient to maintain the equilibrium. This energy is also used to perform different types of physiological task. Maize or corn can be consumed as a source of energy in the form of breakfast cereals as cornflakes, chapattis, tortillas, etc. Maize also contains an appreciable amount of fat content that helps in the carrier of fat-soluble vitamins A, D, E and K. The presence of fat in maize or corn is responsible for much of the texture and flavor of food. Thus it helps in increasing the palatability. The fat content beneath the skin known as the subcutaneous fat also serves as an insulating material for the body and is effective in preventing heat loss. Moreover, fat content also acts as a body reservoir for energy conservation purpose. Another important component in maize after fat is dietary fiber and is defined as the portion of food derived from plant cell, which is resistant to hydrolysis or digestion by the elementary enzyme system in human beings. However, some of the bacteria in the large intestine can degrade some components of fiber releasing products that can be absorbed into the body and also used as a source of energy. Crude fiber is the residue remaining after the treatment with hot sulphuric acid, alkali and alcohol. The major component of crude fiber is a polysaccharide called cellulose and a part of dietary fiber. Insoluble fibers are indigestible and insoluble in water, while soluble fibers are indigestible but soluble in water. Total fiber is the sum of

insoluble and soluble fibers. Dietary fiber is isolated and extracted from a synthetic fiber that has proven health benefits. Resistant starch also functions as dietary fiber [6, 7, 8].

(Total fiber = dietary fiber + functional fiber)

The effect of fiber on the gastrointestinal tract (Table 1) is influenced by the characteristics of the fiber itself, the particle size, the interaction between fiber and other dietary components and the bacteria flora. Maize also contains a significant quantity of insoluble fiber found in the cell wall of the constituent [9]. The insoluble fiber present in maize or corn has a physiological effect in preventing constipation, diverticulitis and even cancer of the large intestine as presented in Table 2. Maize is also considered as a booster of nutrient like carbohydrates, fats, proteins and insoluble fibers that helps in providing sufficient energy to meet the human daily dietary requirements [10]. The proximate composition of maize is presented in Table 3. Maize contains 8–11% of protein that is made from different components like albumin, globulin, no nitrogen substance, prolamin, etc. The quality of maize protein depends upon its agronomic practices and genotype as well. The quality of maize protein is not of good quality as compared to other cereal grains like rice, wheat, barley, etc. Recent researches have shown that with genetic modification, the quality of maize protein can be improved .

2.2.4 Uses

Maize grain is used for three main purposes: as a staple food, as feed for livestock and poultry, and as a raw material for many industrial products. In tropical Africa nearly all maize grain is used for human food, prepared and consumed in many ways. It may be eaten fresh on the cob and simply roasted, but the grain is usually ground and the meal isboiled into porridge or fermented into beer. The main industrial products obtained from maize are breakfast products such as cornflakes, starch, sugar and oil. The main product is starch that is used for human consumption or made into syrup, alcohol, but also among others as as laundry starch and as a source material for many chemical product. Unripe cobs are consumed as vegetable or green maize, boiled or roasted. Very young female inflorescence (baby cobs) is a fancy vegetable in Western countries and in Asia. The fiber and steam and the inner leaves surrounding the cob are made into paper. These cob leaves are often used to wrap foods. Maize has a range of uses in traditional African medicine ***(Shikha Bathla et al., 2019.***

2.3 Celiac Disease

Gluten intolerance, Celiac Disease, and Wheat Allergy it is difficult for those who eat wheat with impunity to truly relate to, or understand, the live of those who have celiac disease, gluten intolerance, or wheat allergy. Observing the shelf during a simple trip to the grocery store will demonstrate just how intertwined our lives are with wheat and other grains such as barley and rye. The histories of wheat and humans are indeed inseparable and have resulted in a food supply that could be described as in hospitable to those who cannot consume foods containing wheat, rye, or barley or ingredients derived from these common cereals. However, recent interest in gluten –free diets has resulted in increased option and variety for those who are celiac patients or have gluten intolerance, even thought the primary market force for this proliferation has been those who can eat gluten but are selecting a gluten–free diet for the reasons.

Product requirements for foods marketed to those with celiac disease do not differ from foods specifically marketed for gluten intolerance. Despite this, it is important to product developers to understand the differences between celiac disease, gluten intolerance, and wheat allergy because these differences give context to the requirements of the end consumer ***(Jeffery L Casper, William A Atwell,2016)***

2.3.1 Gluten:

Common wheat flour is approximately 7-15%on a14% moisture basis.

Most protein in wheat can be considered “storage protein” which is utilized by the germinating andgrowing seedling. Protein that are considered “gluten” make up approximately 80% of the total storage protein in the wheat kernel. The common protein fraction in wheat include water-soluble protein (albumin),protein s soluble in salt solution (globulins),protein soluble in 70% aqueous ethanol (prolamins),and proteins soluble in dilute acids and bases(glutelins) (***Jeffery L Casper, William A Atwell2016***).gluten is a fundamental component for the overall quality and structure of wheat bakery products, particularly yeast leavened ones. The gluten complex is composed of two main protein groups; gliadin and glutenin. Glutenins are apparently responsible for the dough’s resistance to extension ***(Hoseney,1994).*** `

2.3.2 Symptoms of celiac disease

Celiac disease has no typical signs or symptoms. Most people with the disease have general complaints, such as abdominal pain, bloating, inter-mitten diarrhea, and stools with unusually foul odor or oily consistency. Celiac disease may also present itself in less obvious ways, including irritability or depression, anemia ,upset stomach, joint pain, muscle cramps, skin rash, mouth sores, dental and bone disorders and tingling in the legs and feet **(*Jeffery L Casper, William A Atwell, 2016*).**

2.3.3 Diagnosis of Celiac Disease

The onset of celiac disease can occur at any age. Its diagnosis is often the end result of living with the effects of the disease; however, asymptomatic people should seek testing if a relative has been diagnosed with disease. After reviewing the health and diet, generally the first step in diagnosis is a serological antibody test. such tests require that the individuals still have gluten in his or her diet, and for this reason, individuals who suspect they have celiac disease should seek a medical assessment while still contests are for anti-tissue transglutaminase and for antibodies to immunoglobulins A and G. If positive serological tests indicate celiac disease, biopsy may be performed. the biopsy helps identify the degree of damage to the smale intestine(***Jeffery L Casper, William A Atwell,2016***).

2.3.4 Nutritional Deficiencies and Related Condition attributable to celiac disease

People with celiac disease deal two key issues regarding nutrition intestinal damage that impairs nutrient absorption and the nutritional inadequacy of much gluten – containing grains. While damage to the small intestine can be resolved through adherence to strict gluten –free foods with adequate nutrition is often poor.

The nutritional profiles of such foods need to be considered by manufactures of gluten- free products. Understanding nutritional needs is an important aspect of gluten –free product development. Unfortunately, many gluten free products on the market do not help alleviate the deficiencies resulting from the disease. Most of them are starch-based on whole grains containing the micronutrient density and fiber that would be of great benefit to the celiac patient **(*Jeffery L Casper, William A Atwell,2016*).**

2.4 Corn flaks

Corn flakes are one of the most popular breakfast cereals in the world. According to the Kellogg Company .it is probable that most modern-day cereal eaters don't associate their morning meal with real going, but corn flakes started life as health life.

The whole grain is crushed between the large metal rollers to remove the bran from the outer layer and then mixed with seasoning agents (salt, sugar, flavors and fortified minerals) and water in a large rotating pressure cooker. The physiochemical properties like time, temperature and speed of rotation vary with the type of grain being cooked. The cooked grain is moved to a conveyor belt which passes through a drying oven. In this process, soft and solid mass is obtained which can be molded into desired shapes. Then these cooked grains are allowed to cool, and stabilizing the moisture content is known as 'tempering'. Then the tempered grains are flattened between large metal rollers under tons of pressure, and the resulting flakes are further conveyed to ovens with blast of very hot air to remove reaming moisture and to toast them to desirable flavors. Cornflakes are also processed from extruded pellets in a similar way***(Shikha Bathla et al., 2019).***

2.5 Baked product

Baked product is applied to a wide range of food product, including breads, cakes, pastries, cookies and many other products, and it can be difficult to identify a commonthread linking the member of such a diverse group. The most commonly-identified link is that they all use recipes that are based on wheat flour. This definition, though, would need to be expanded to include baked goods such as gluten-free product, used by people with celiac digestive disorders, or rye bread, which are still considered to be baked product even though they are based on cereals other than wheat. However, the same leniency of definition could hardly be extended to include meringues, which contain no cereal-based material at all, let alone wheat flour, their main components being sugar and egg white. It may be more appropriate to consider that baked product are those products which are manufactured in a bakery, that is the place of manufacturing defines the product rather than ingredient, recipe or process feature **(Stanley P. Cauvain, lindaS.Young 2006).**

One view is that baked products should be defined as having undergone heat processing – baking – which causes change in both form and structure. This is certainly true for the many different base product manufactured in bakeries. Some exception to this definition might include Chinese steamed breads, some steamed puddings and doughnuts, which are fried, though all of these product do undergo a heat-conversion process. By using the presence of a heat- processing step to characterize bakery goods we can capture some composite product, such as fruit and meat pies, since the fillings in such products do undergo physical and chemical changes as the result of the input of heat. Not captured in the heat-processed definition of those products Made in bakeries would be the filling and toppings that are applied or used after baking. In this category will fall creams and icings, even though they will become part of the product offered in the shop or store **(Stanley P. Cauvain, lindaS.Young 2006).**

2.6 Gluten- free cereal foods

Only a few studies have been conducted on the natural quality of gluten-free foods. One study (Thompson, 1996) assessed the thiamin, riboflavin and niacin contents of gluten-free cereal foods to determine how they compared nutritionally to the enriched gluten/containing products they were intended to replace. Of the 64 gluten-free product assessed for nutrient content, 39 contained lower amounts of thiamin, riboflavin and niacin than there enriched wheat-containing counterparts. Fourteen gluten-free productcontained lower amounts of two of the nutrients and six contained low amount of one nutrient. The enrichment states of 368 gluten-free rice flours, breads (ready/made products and mixes), bastes and ready-to eat-breakfast cereals was also assessed. Only 35 of this product were enriched, including 5 of 95 bread mixes, 26 of 157 ready-made bread products and 4 of 21 ready to eat breakfast cereal. According to the codex standers for gluten-free foods, gluten-free foods that are dietary staples (e.g. flour, bread) should contain approximately the same amount of vitamins and minerals as the foods they are supposed to replace (Joint FAO/WHO food standards Program, Codex Commission, 1994). Manufacturers of gluten-free cereal foods have a wide variety of gluten-free whole grains to work with, including millet, wild rice, sorghum, round rice, whole-grain corn, buck wheat, amaranth, quinoa and oats. For the most part, this grain are all good source of fiber, iron and some B vitamins **(Eimear Gallagher, 2009).**

CHAPTER THREE

MATERIALS AND METHODS

3.1 Materials

Pearl millet flour, corn flour, and packing materials were obtained from Bahry local market Sudan. Glucose syrup was obtained from Omdurman local market.

3.2 preparation of Material

Pearl millet and maize grains were cleaned from any foreign materials and then milling to flour by commercial mill. After that the flours were packed in polyethylene bags and stored until needed for further investigation.

Sugar, salt, and baking powder were added to 108 g of millet flour. Then glucose was added and mixed. Then water was added to get dough and shaped, then baked the flakes n oven. The baked flakes were cooled at room temperature

3.3Methods

3.3.1 The proximate analysis

3.2.1.1 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.

3.2.1.2 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 desiccators 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.

3.2.1.3 Crude protein:

Crude protein of the sample was determined by using the micro-Kjeldahl method according to AOAC (2003) 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 $H_2SO_4$was 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 containing10ml 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

W_s = sample weight

1000 = to convert to mg

3.2.1.4 Fat content:

Fat was determined according to the method of AOAC (2003) 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

3.2.1.5 Crude fiber:

Crude fiber was determined according to AOAC (2003). 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

3.2.1.6 Total carbohydrate content

Total carbohydrate was calculated by difference. The summation of moisture, ash, crude protein, crude fiber and crude fat content was subtracted from 100 to option the carbohydrate by difference.

3.2.2 Preparation of millet flakes

A Millet flakes was generally prepared according to**Vatsala**and**HaridsRao (1991)** method**.**

Table (1): Component of samples

Ingredient	**Quantity (g)**
Corn flour	106.5 g
Millet flour	108 g
Glucose	51.43 g
Salt	1.04 g
Sugar	34.68 g

Baking powder	1.45 g
Water	18.53 g

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3.2.5 Sensory evaluation of breakfast flakes

Including untrained twenty panelists ranging from 20 to 50 of years old , from faculty of Agricultural Studies of Sudan University.

3.2.6 Statistical analysis

Statistix 8.0were preformed to examine significant different between normally distribution data of replicated measurement. Probability levels of less than 0.05 were considered significant different ($p \leq 0.05$).

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Proximate composition of flour

The chemical composition of pearl millet flour was shown in table (2). The results are expressed on dry basis.

4.1.1 Moisture content

The data showed that the moisture content of flour pearl millet was 10.94%. The result is within the range reported by (Khatir, 1990) who reported that the moisture content for pearl millet in rang 10.6% to 11.7% respectively.

4.1.2 Ash content

The data showed that the ash content of flour pearl millet was 3.38%. The result is within the range reported by (Barton et al, 1972) who reported that the ash content for pearl millet in rang 1.2% to 3.4% respectively.

4.1.3 Protein content

The data showed that the protein content of flour pearl millet was 15.33%. The result is within the range reported by (Abd-Allah, 2003) who reported that the protein content for pearl millet in rang 12.5% and 13.6% respectively.

4.1.4 Fat content

The data showed that the fat content of flour pearl millet was 5.41%. the result is within the range reported by (El-Tinay et al, 2005) who reported that the fat content for pearl millet in rang 6.1% and 5.4% respectively .

4.1.5 Crude Fiber

The data showed that the fiber content of flour pearl millet was 0.98%. the result is within the range reported by (Khatir, 1990) who reported that the fiber content for pearl millet in rang 3.18% to 3.67% respectively .

4.1.6 Carbohydrate content

The data showed that the carbohydrate content of flour pearl millet was 63.26%. the result is within the range reported by (Abd- Allah et al, 1998) who reported that the carbohydrate content for pearl millet in rang 58.5% to 70% respectively.

4.2 Chemical characteristics of flakes from maize flour and flakes from different levels of pearl millet and flour

4.2.1 Proximate composition

Table (3) shows the proximate composition of 100% pearl millet flour and different level of millet flour and maize.

4.2.1.1 Moisture content

The moisture content of sample (A) was found to be 7.95%, this value is lower than sample (B) which reported as 8.47%.The statistical analysis showed significant different ($P \leq 0.05$) between sample (A) and sample (B). These result are contrary with data which reported by ***Sahar Y. et al. 2012*** who found lower moisture content 3.22%.

4.2.1.2 Ash content

The ash content of sample (A) was found to be 3.73%, this value is lower than sample (B) which reported as 8.47%.The statistical analysis showed that there are significant different ($P \leq 0.05$) between sample (A) and sample (B). These result are contrary with data which reported by ***Sahar Y. et al. 2012*** who found lower moisture content 0.24%.

4.2.1.3 Fat content

The fat content of sample (A) was found to be 4.97%, this value is lower than sample (B) which reported as 4.34%.The statistical analysis showed significant different ($P \leq 0.05$) between sample (A) and sample (B). These result are contrary with data which reported by w***Sahar Y. et al. 2012*** ho found lower moisture content 3.65%.

4.2.1.4 Fiber content

The fiber content of sample (A) was found to be 1.22%, this value is lower than sample (B) which reported as 0.95%.The statistical analysis showed no significant different ($P \leq 0.05$) between sample (A) and sample (B). These result are contrary with data which reported by ***Sahar Y. et al. 2012*** who found lower moisture content 0.77%.

4.2.1.5 Protein content

The protein content of sample (A) was found to be 16.17%, this value is lower than sample (B) which reported as 11.44%.The statistical analysis showed significant different ($P \leq 0.05$) between sample (A) and sample (B). These result are contrary with data which reported by w***Sahar Y. et al. 2012*** ho found lower moisture content 10.5%.

4.2.1.6 Carbohydrate content

The carbohydrate content of sample (A) was found to be 7.95%, this value is lower than sample (B) which reported as 8.47%.The statistical analysis showed significant different ($P \leq 0.05$) between sample (A) and sample (B). These result are contrary with data which reported by ***Sahar Y. et al. 2012*** who found lower moisture content 81.5%.

4.3 sensory evaluations of breakfast flakes

The result of sensory characteristics was mentioned in table (4). In general, all of breakfast flakes were highly acceptable by the panelists. On other hand, there are significant differences in the flavor between the two products.

Table (2) : Chemical composition of pearl millet flour and maize flour (on wet basis).

Sample	Moisture	Ash	Protein	Fiber	Fat
A (maize)	10.45[b]±0.22	2.86[b] ±0.44	10.41[b] ±0.39	1.2[a] ±0.57	2.44[b] ±0.06
B (pearl millet)	10.94[a] ±0.36	3.38[a] ±0.17	15.37[a] ±0.38	0.98[a] ±0.11	5.41[a] ±0.21

Values are mean ±SD

SD= Standard deviation

Table (3): Proximate composition (%) of breakfast Flakes from millet flour and 50% millet and 50% maize (on wet basis)

Sample	Moisture	Ash	Protein	Fiber	Fat
A **100% pearl millet**	7.953[b] ±0.16	3.73[a] ±0.54	16.17[a] ±0.05	1.22[a] ±0.34	4.97[a] ±0.26
B **50% pearl millet** **50% maize**	8.47[a] ±0.23	2.54[b] ±0.34	11.59[b] ±0.28	0.95[a] ±0.13	4.34[b] ±0.06

Value is means (±standard deviation)

Mean value having different superscript letters in the same column are significant different ($p \leq 0.05$)

Where:

A= 100% millet flour

B= 50% millet and 50% maize

Table (4) sensory evaluation of breakfast flakes.

Sample	Flavor	Color	Taste	Appearance	Texture	Overall
A	3.40^{b} ±0.99	4.20^{a} ±0.83	3.50^{a} ±0.95	3.70^{a} ±0.92	3.85^{a} ±1.04	3.85^{a} ±0.88
B	3.8^{ab} ±0.89	3.95^{a} ±0.83	3.95^{a} ±1.00	3.90^{a} ±0.72	3.80^{a} ±1.20	3.95^{a} ±1.00
Control	4.2^{a} ±0.98	4.1^{a} ±0.99	3.95^{a} ±1.09	3.9^{a} ±0.96	3.9^{a} ±0.96	4.3^{a} ±0.86

Values are means (± standard deviation)

Mean values having different superscript letters in the same column are significant different ($p \leq 0.05$)

Where:

A= 100% pearl millet flour

B= 50% pearl millet flour + 50% maize flour

C= control

Scale:

1= unacceptable

2= acceptable

3= good

4= very good

5= excellent

CHAPTER FIVE

CONCULSIONS AND RECOMMENDATION

5.1 Conclusions

- The result of sensory evaluation showed that flakes containing more pearl millet flour were the most acceptable.

- The result of approximate analysis showed that flakes contain more amount of pearl millet has a high nutritive value.

5.2 Recommendation

1. Pearl millet flour can be a good choice for development of quality and nutritious convenience of breakfast flakes product.

2. Pearl millet could be recommended for addition to other cereal flour due to its relatively high protein content.

3. People who suffer from celiac disease can be consumed pearl millet flour as substituted of wheat flour.

4. Serving different flavors from the usual breakfast flakes.

5. Research needs to be increased in the aspect of inexpensive row material that can be replacing more expensive row material such as millet.

6. Breakfast flakes are a product required by consumers, so it can be considered as successful trade for factories; however it is imported from abroad. Therefore, a representative industry must be established within the country.

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Sample (A) 100% Millet Flour

Sample (B) 50% Millet Flour and 50% Maize

Sample (C) Control