# Effect of gluten-free flour on physical properties and quality characteristics of biscuits

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## ABSTRACT

Celiac disease is an autoimmune disorder characterized by intolerance to gluten. So, the aim of this study is to produce gluten-free biscuits for individuals with gluten allergy. Biscuits of rice flour, corn, sorghum and the mixture were prepared with mix 1 rice and corn (1: 1), mix2rice and sorghum (1: 1) and mix 3 rice, corn and sorghum (1: 1: 1). Chemical composition of flour samples moisture; protein, fat, ashand fiber were measured under this study. In the prepared biscuit samples, physical properties (length, width, thickness, weight, volume and specific ratio), color characteristics and sensory properties were measured. Wheat flour recorded the highest value of protein (12.9%) follow up Sorghum flour recorded (10.8%). Sorghum flour was the high level fiber (6.50%) in all flour. Protein sedimentation (22.0%) was high in sorghum flour then mixtures (mix 1, mix 2 and mix 3) were recorded 20, 21, and 19% of gluten free flour but wheat flour (33.0%). Wheat flour was the lowest value of falling number (401 sec) this result was highest Alfa amylase enzyme and prefers of baking then mix 3 (434 sec)but highest falling number was the lowest in Alfa amylase enzyme corn flour (634 sec). Highest water absorption (57.0%) was observed in wheat flour followed by rice flour (54.4%) while mixturesfree gluten flour had the lowest water absorption (45.70%, 45.70%and 45.90%) mix1, mix 2, and mix 3 respectively. Corn biscuit recorded the high in whiteness (37.80%) then wheat flour (33.66%) and lowest value was mix 3(23.46 %). The mix 3 biscuit was high physical properties and over all acceptability for the panel test after wheat biscuit.

***Key words***: *Rice flour, corn flour, sorghum flour and mixtures, gluten free biscuits, physicochemical properties, sensory properties, parameter of biscuits.*

## INTRODUCTION

Celiac disease or gluten sensitivity is entropathy is a chronic disease of the small intestine caused by exposure to gluten in genetically predisposed individuals **Laurine*et al.*, (2002).**The main agents responsible for celiac disease are gluten proteins from wheat and similar proteins in other closely related cereals such as barley, rye and oats **(Kasarda, 2001).**It is a continuous intolerance of gluten, gliadin and responsive prolamins that are present in wheat, rye and barley. When people with celiac disease eat foods containing gluten, their immune system responds by destroying the intestinal villi leading to the malabsorption of nutrients, thus adversely affecting all systems of the body **(Hill, *et al.*, 2005)**. The major characteristics of the disease are intestinal damage due to an immune defect (autoimmune disease) that occurs in people with a genetic background (**Amin *et al*., 2002**). This malfunction can appear at any age, but the classical symptoms are most frequently observed during infancy and early childhood, when foods containing gluten are introduced into the diet. Sometimes the disease develops during adolescence or adulthood (usually at age 30-40 years). Preliminary results based on seroepidemiologic studies suggest that each recognized case of celiac disease is accompanied by three to seven undetected cases (**Rewers, 2005**). Varieties of gluten-free productshave to be extended for coeliac patients to allow them tokeep a balanced diet. One possibility is to replace wheat flourin products by gluten-free ingredients, like e.g. corn and potato starch in tulumba dessert **(Yildiz and Bulut, 2017)** orrice in white bread **(Lopez *et al*., 2004).**

Gluten-free bakery products that are prepared with gluten-free flours often tend to have reduced quantities of fiber, proteins, iron and B vitamins compared with wheat products **(Matos and Rosell, 2011)**. Therefore, a re-design of the gluten-free bakery goods is needed for obtaining products with similar nutritional composition to that of their gluten counterparts. Rice is the main staple food for many countries, providing 20% of the food energy supply in the world. It is known as queen among cereals after wheat.

Rice is characterized by low prolamin, hypoallergenic activity, insipid taste, low sodium and high digestible carbohydrate contents, which is suitable to be incorporated into celiac diets (**Phimolsiripol, *et al.*, 2012**).

Rice flour has been utilized to prepare gluten-free bakery products, such as bread and cake, which are traditionally made with wheat flour. Rice is naturally gluten-free and contains proteins that are known to be nutritious and hypoallergenic **(Helm and Burks, 1996)**.

Acorns, the fruit of oak trees, have been an important part of traditional dietsof people throughout the world and are reported to have potentialhealth benefits **(PolimacandLukinac, 2015)**. Acorn flour isdesirable from a nutritional point of view, because of the content of fat (of which over 80% is unsaturated), proteins, and considerable amountof electrolytes (calcium, magnesium, potassium, and phosphorus), butlittle or no sodium, and is rich in iron, copper, and zinc.Acorn mealcould be a nutritionally functional ingredient in foods that use wheatflour such as cookies, muffins, breads, noodles, pastries, and desertswith a growing presence in the food industry to improve the eatinghabits of individual clients and the general population for health benefitsand disease prevention **(Polimac&Komlenic, 2015)**.

Maize is a major source of starch and gluten-free. Sorghum (sorghum bicolor) is a gluten-free grain with high potential in the gluten- free food processing. It is the 5$^{th}$largest crop produced worldwide and has been shown to be safe for celiac disease people **(Ciacci*et al*., 2007)**. Gluten makes them expand during baking, and helps to retain moisture for some time (**He and Hoseney, 1990; Rasmussen and Hansen, 2001**). Lack of gluten lead to changes of the shape, texture, smell and taste in bakery, as well as in quick drying of the crumb (**Gambus*et al.*, 2001; Gallagher *et al*., 2003a;Lazaridou*et al*., 2007**).

The preparation of gluten-free bakery products requires application of different flours in exchange for wheat flour, so the resulting taste very often does not resemble that of classical, gluten products. The role of food technologists is to design such as for gluten-free products, which would improve their expansion, structure and taste (**Gambus*et al*., 2001; Gallagher *et al*., 2003b, 2004**), and would help the people with celiac disease to fulfill the nutritional directions, which imply everyday consumption of dietary fiber, minerals and other food constituents (**Thompson, 2000; Case, 2005**).

Gluten-free products are usually protein-free products. Removal of proteins deprives the raw material of minerals and vitamins, which negatively impacts its nutritional value. This is the reason why gluten-free products should be supplemented by raw materials naturally free of gluten, and rich in additional nutrients (**Korus *et al*. 2006, Kiskini*et al.*, 2007**).

The dough made of gluten free products is difficult to shape, which is the main technological problem in the production of confectionary products (**Gambus*et al*., 2001; Gallagher *et al*., 2004; Lazaridou*et al*., 2007**). The final recipe must take into account both nutritional and technological issues.

Biscuits are a popular foodstuff consumed by a wide range of population due to their varied taste, long shelf life and relatively low cost. Gluten is known as "heart and soul" of bakery for providing the processing qualities familiar to both the home baker as well as the commercial food manufacturer **(Lubnaand Bashir, 2012)**. Since gluten plays a limited role in defining the process ability and end product quality of biscuits, it can be complemented through some alternate flours in various combinations **(Rai, , 2011).**

Gluten-free biscuits are typically round cakes of bread that are leavened with baking powder, baking soda or sometimes yeast. It may also refer to cookies or crackers. They are mostly sweet and in history they were used by travelers as they were long-lasting foods and easy to carry (**Mehta *et al*., 2014**).

The diet of celiac patients must be completely free of any gluten, so all the products from wheat, rye, barley and oat must be replaced with corn, rice, millet equivalents and various types of starch (corn, rice and potato) or appropriate mixtures (**Moore *et al*., (2006)**.Therefore, this work was design to study the effect of the present study was designed to study the effect of using some different gluten-free flour (rice flour, white corn flour, sorghum flour and their mixtures) on physical, rheological properties of the flour and quality parameters of the baked biscuits and sensory properties.

## MATERIALS AND METHODS

### Flour samples

Wheat, rice flour,corn (white corn) and sorghum *(sorghum bicolor)* shortening, sugar, eggs, salt and baking powder were purchased from the local market.

### Methods

### Preparation of Flour

Wheat was tempered to 16.5 % moisture and allowed to conditioning for 24 hours, then milled by laboratory mill CD1 auto Chopin, according to **AACC (2000).** Corn grains and sorghum grains were cleaned from foreign materials and milled using laboratory mill (3100, Perten Instruments, Sweden) to obtained whole sorghum flour. Corn and Sorghum flour was packed in polyethylene bags and stored at (−18˚C) until used (**Abdelghafor, *et al*., 2013).**

### Mixture flour

(Mix 1) = 50% Rice flour + 50% white corn flour. (Mix 2) = 50% Rice flour + 50% sorghum flour. (Mix 3) = Rice flour + white corn flour + sorghum flour (1:1:1).

### Physical properties

Hardness, starch damage, falling number, color and gluten were determined in flours according to **AACC (2000).**

### Chemical Analysis

Wheat, rice, corn and sorghum flours were chemically analyzed for their moisture content, ash, crude protein, lipids and crud fiber contents according to the methods described in **AOAC (2005).** The nitrogen free extract (NFE) calculated by difference. Total carbohydrates were calculated by difference according to the following equation:

Carbohydrates = 100- (protein % +fat %+ ash %).Caloric value was calculated according the following equation (**FAO/WHO, 1974**).

### Determination of Tannins

Tannins determined according to **Hagerman (1987)** in sorghum flour.

**Rheological Properties**

Rheological properties of the various gluten-free blends consist of rice flour or corn flour or sorghum flour and mixtures were determined by Alveoconsistographe and the gluten determination for wheat flour (control)according to **AACC (2000)**.

**Biscuit making**

Biscuits were prepared according to the method that described by **Mohamed*et al.*, 2004)**with some modifications in **Table (1).**Vegetable shortening was mixed with sugar until receiving a uniform mixture. Egg was then added after added vanilla and the mixture was kneaded. The dry ingredients (flour and baking powder) were thoroughly mixed in a bowl by hand for 3 min and mixed with liquid materials until receiving a uniform mixture. The batter was rolled and cut with a 5-mm diameter biscuit cutter. The biscuits were placed on baking trays, and baked at 180°C for 10 min in a baking oven. Following baking, the biscuits were cooled at ambient temperature, packed in polyethylene bags and stored at 23°C prior to subsequent analysis. The blend consisted of 150 gm flour, 75 gm sugar, 45 gm vegetable shortening, 36 gm fresh egg, 0.5 gm vanillin, 8.0 gm baking powder.

**Physical Properties of Biscuits**

The diameter and thickness of biscuits were measured with a venire caliper. Width and length: five biscuit were placed edge to edge and their total width was measured. The average width was determined by taking the mean value **(Nouma, 2003**). Similarly the biscuits length was determined by placing the butt of five biscuits and taking the mean value. Thickness was measured by stacking five biscuits on top of each other and taking average thickness (cm).Weight of biscuits was measured as average of values of flour individual biscuits with the help of digital weighing balance.Spread ratio was calculated by dividing the average value of width by average of thickness of biscuits by the method of **Akubor**, ***et al.***, **(2003)**, using as following:

SR= W/T,W- Width biscuits (cm), T- Thickness biscuits (cm)

Volume (cm3) = L X WX TL= average length of biscuits (cm)W= average width of biscuits (cm)T= average thickness of biscuits (cm)Density was calculated by dividing weight (g) out volume (cm3) and expressed as (g/cm3**) Sneha, (2012).**

**Color Measurement of Gluten-Free biscuits**

Color of control and gluten-free biscuits was evaluated according to **Francis (1983)** by using Minolta CR-400 (Minolta Camera, Co., Ltd., Osaka, Japan).

**Sensory Evaluation of Gluten-Free biscuits**

Control and gluten-free biscuits samples were assessed for their quality after baking by ten members' preference taste panels of wheat and four department staff. They were asked to score the internal characteristics of biscuits samples i.e. mouth feel, grain, texture, crumb color, flavor and eating quality using the respect sheet according to **AACC (2000).**

**Statisticalanalysis**

The obtained data from chemical, physical and sensory evaluation were exposed toanalysis of variance (ANOVA). Duncan's multiple range tests at ($P \leq 0.05$) level was used to compare between means **SAS (1999)**.

**Table 1: Formulations of biscuits**

| Ingredient (g) | Wheat control | Rice flour | Maize flour | Sorghum flour | Mix1 | Mix2 | Mix 3 |
|---|---|---|---|---|---|---|---|
| Wheat flour | 150 | - | - | - | - | - | - |
| Rice flour | - | 150 | - | - | 75 | 75 | 50 |
| Maize flour | - | - | 150 | - | 75 | - | 50 |
| Sorghum flour | - | - | - | 150 | - | 75 | 50 |
| sugar | 75 | 75 | 75 | 75 | 75 | 75 | 75 |
| Margarine | 45 | 45 | 45 | 45 | 45 | 45 | 45 |
| Egg | 36 | 36 | 36 | 36 | 36 | 36 | 36 |
| vanilla | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| Baking powder | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 |

## RESULTS AND DISCUSSION

### Physical and chemical properties of flour cultivars and their mixtures

Chemical composition of different flour used in this studywas given in **Table (2)** the flour moisture content of different varieties ranged from (11.7 to 13.00) for all studied samples. Wheat flour had the highest value while white corn had lowest value among all samples. As regards protein content, wheat flour had the highest protein content (12.90%) for contained gluten, followed by sorghum (10.80%) according to **Arbab (1997)**, while rice (7.10 %) had the lowest protein content. Additionally rice was lower oil (0.69) than other samples and white corn was higher oil content. Rice flour was lower in ash content (0.38) completely with other grains. Ash content of all grains was found quite close to each other. However, highest ash content was observed in sorghum (1.517%) these results were harmony with **Neucere and Sumrell, (1980)** and **Mohammed (2000)**.The ash content of whole mill is related to the amount of mineralin the powder and therefore to nutritional value, these results were contrast with **ES ,(2006)** of white flour for production of bread has the following requirement: protein content not less than 10.2%. Ash content not exceed than 0.9%. And the falling number showed exceed than 200 Sec.

Also shown that the fiber in sorghum had significant highest value (6.50%) while wheat flour had lowest value (1.09%). On other hand nitrogen free extracts (NFE) % ranged from 68.21% (sorghum) to 77.66% (rice). Total caloric values ranged between 329.54 to 357.30%for sorghum and white corn and these were agreement with the resultsthat obtained by**Hulse, *et al.*,(1980), NRC/NAS (1982), USDA/HNIS (1989), and Serna- Saldivar *et al.*, (1990).** The sorghum had the significant lowest value of tannic acid (0.185%) and their mixtures than the maximum level (3.0%) according to **USDA, (2006).**

**Table 2: proximate analysis for different flour wheat, rice, white corn, sorghum and their mixtures of gluten free flour**

| | Flours |
|---|---|

| Chemical composition | Wheat (control) | Rice | White corn | Sorghum | Mix 1 | Mix 2 | Mix 3 |
|---|---|---|---|---|---|---|---|
| M.C% | 13.0$^{a}$ | 12.2$^{ab}$ | 11.7$^{b}$ | 12.0$^{b}$ | 11.9$^{b}$ | 12.1$^{b}$ | 11.8$^{b}$ |
| Protein% | 12.9$^{a}$ | 7.1$^{d}$ | 9.0$^{c}$ | 10.80$^{b}$ | 7.8$^{cd}$ | 8.8$^{c}$ | 9.0$^{c}$ |
| Fat % | 1.15$^{bc}$ | 0.69$^{c}$ | 3.3$^{a}$ | 1.50$^{bc}$ | 2.00$^{b}$ | 1.10$^{bc}$ | 1.83$^{bc}$ |
| Ash% | 0.718$^{c}$ | 0.388$^{d}$ | 0.775$^{c}$ | 1.517$^{a}$ | 0.578$^{cd}$ | 1.131$^{b}$ | 1.075$^{b}$ |
| Fiber% | 1.09$^{g}$ | 1.96$^{f}$ | 2.3$^{d}$ | 6.50$^{a}$ | 2.13$^{e}$ | 4.23$^{b}$ | 3.59$^{c}$ |
| NFE% | 71.14$^{e}$ | 77.66$^{a}$ | 72.9$^{c}$ | 68.21$^{f}$ | 75.59$^{b}$ | 72.64$^{d}$ | 72.71$^{d}$ |
| Total caloric values% | 346.51$^{c}$ | 345.25$^{d}$ | 357.3$^{a}$ | 329.54$^{g}$ | 351.56$^{b}$ | 335.66$^{f}$ | 343.33$^{e}$ |
| Tannic acid% | * | * | * | 0.185$^{a}$ | * | 0.093$^{a}$ | 0.062$^{a}$ |

Means with the same letter in the same row are not significantly different at ($P \leq 0.05$).
**NFE =** Nitrogen free extracts
* = Not detected.

**Physical properties of flour obtained from wheat control, rice, white corn, sorghum and their mixtures of gluten free flour.**

The data in **Table (3)** and **Fig (1)**presented physical properties of flour obtained from wheat, rice, white corn, sorghum flour and their mixture of gluten free flour that the highest hardness was in white corn (80.0) while rice was the lowest (54.0), the highest starch damage was in wheat flour (4.57%) while sorghum flour was the lowest (0.97%).From the same **Table (3)** it can be concluded that the percentage of protein sediment ranged from 12 to33%, wheat flour was highest sediment ratio which had good characteristics to produce bread. Falling number which indicated enzyme activity of Alfa amylase activity. In case of falling number, white corn has highest falling number (634.0 sec.) and lowest enzyme activity. Wheat flour (401.0 sec.) had lower values and highest enzyme activity Means with the same letter in the same row are not significantly different.Specification of the Economic European community recommended that the falling number of flour should exceed than 230sec **Milatovie and Mondelli, (1991)**.

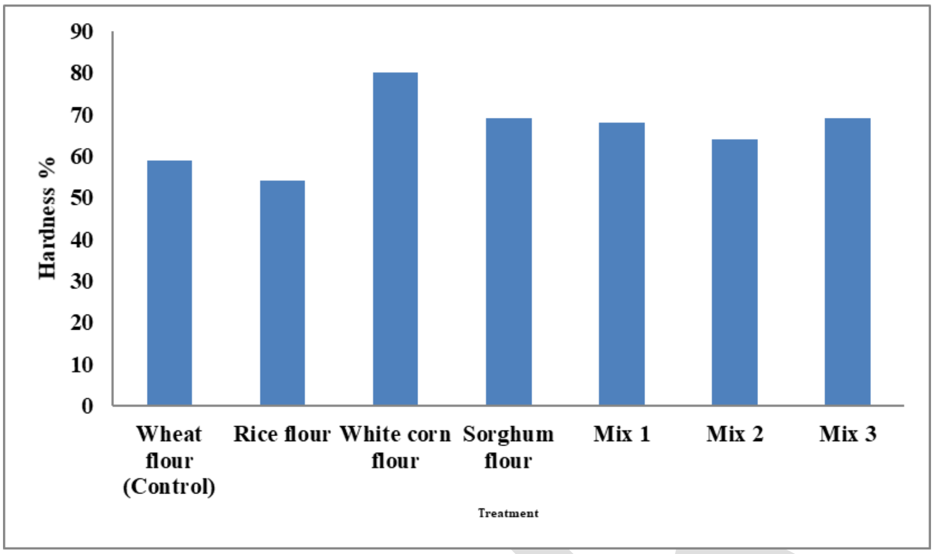


**Fig (1): The hardness of different flour wheat, Rice, white corn, sorghum and mixtures of gluten free flour.**

**Table 3: physicochemical properties of different flour wheat, rice, white corn, sorghum and mixtures of gluten free flour.**

| Samples | Analysis | | | |
|---|---|---|---|---|
| | Hardness% | Starch damage % | Protein sediment ml | Falling Number Sec. |
| Wheat flour (Control) | 59.0$^{cd}$ | 4.57$^{a}$ | 33.00$^{a}$ | 401.0$^{f}$ |
| Rice flour | 54.0$^{d}$ | 3.67$^{b}$ | 12.0$^{f}$ | 458.0$^{b}$ |
| White corn flour | 80.0$^{a}$ | 1.29$^{f}$ | 18.0$^{e}$ | 634.0$^{a}$ |
| Sorghum flour | 69.0$^{b}$ | 0.97$^{g}$ | 22.0$^{b}$ | 436.0$^{de}$ |
| Mix 1 | 68.0$^{b}$ | 3.01$^{c}$ | 20.0$^{cd}$ | 443.0$^{cd}$ |
| Mix 2 | 64.0$^{bc}$ | 2.62$^{d}$ | 21.0$^{bc}$ | 447.0$^{c}$ |
| Mix 3 | 69.0$^{b}$ | 1.96$^{e}$ | 19.0$^{de}$ | 434.0$^{e}$ |

Means with the same letter in the same colum are not significantly different at ($P \leq 0.05$).

**Rheological properties of different flour obtained from wheat flour control and different flour of rice, white corn and sorghum**

rheological properties of wheat flour dough was tested by wet and dry gluten, gluten Index and Alveoconsistograph and the results indicated that the wet and the dry gluten of wheat flour wet gluten recorded 25.6, gluten index 95.9, dry gluten 8.7 but different flour and mixtures was free gluten. Alveoconsistograph studies were conducted to determine the rheological properties of different flour wheat, rice, white corn, sorghum and mixturesof gluten free flour(**Table 4**). Highest water absorption (57.0%) was observed in Wheat flour followed by rice flour (54.40%) while flour hadthe lowest water absorption (45.7%) mix 1 and mix2. Water absorption is considered to be an important characteristic of flour. Strong wheat flours have the ability to absorb and retain more water as compared to weak flours. Higher water absorption is required for good bread characteristics which remain soft for a longer time. Differences in alveoconsistographe characteristics among different wheat flour varieties may be due to variations in protein quantity and quality. All these values indicated relatively strong characteristics of wheat flour. Appositive correlation between dough rheology and hydration properties with a confidence of 99.9 % was found, which suggest that the water absorption of the mixture affects the dough rheology.

**Color parameter of flour and biscuits produced them**

**Table (5)** reviewed that the rice flour had the highest value of whiteness color for seven color then wheat flour 65.3 % and 34.4 % than the sorghum flour which is less in whiteness. After baking white corn biscuit was highest whiteness then wheat flour and sorghum biscuit was low whiteness. Wheat flour was highest yellowness and mix 2 was lowest in yellowness. The grains of many sorghum varieties have a dark layer in the central part containing the embryo sac, which gives a sour, bitter taste, and a dark unattractive color to flour produced from them. Yellow grains without the dark layer, however, give good quality flour, although the flour is sometimes coarse **(Kordylas, 1991).** Flour color, a measure of bran contamination, is measured with the Kent-Jones and Martin colorimeter. Flour color was important to the Romans, who prided themselves on making the finest, whitest flours. Even today many people still equate flour color with quality for use in food products.

If sorghum is to compete with wheat and corn products in urban areas, highly refined product will be required (**Murty and Rooney, 1981).** In general, white sorghum grains produced the most acceptable colored food products, but considerable variation in color of some products was acceptable. Thus it is important to measure color of grain, flour, and the food products in an efficient mannerthat your results were agreement with the previous studies**(Murty and Rooney, 1981).**

**Table 4: Rheological properties of different flour obtained fromdifferent flour of wheat and rice, white corn, sorghum and mixturesof gluten free flour.**

| Flour | | wheat | Rice | White corn | Sorghum | Mix 1 | Mix 2 | Mix 3 |
|---|---|---|---|---|---|---|---|---|
| **Alveoconsistograph test** | **Water absorption %** | **57.0$^{a}$** | **54.40$^{b}$** | - | - | **45.70$^{c}$** | **45.70$^{c}$** | **45.90$^{c}$** |

**(-) =** Not determined

Means with the same letter in the same row are not significantly different at (P ≤ 0.05).

**Table 5: Color parameter of flour and biscuits produced them.**

| Samples | Flour | Biscuits |
|---|---|---|

| | | | | |
|---|---|---|---|---|
| | White | yellow | White | yellow |
| Wheat | 34.4 c | 14.6 d | 33.66 b | 52.02 a |
| Rice | 65.3 a | 6.7 f | 27.72 e | 46.28 d |
| White corn | 26.0 d | 16.2 b | 37.80 a | 51.80 a |
| Sorghum | 13.3 e | 19.8 a | 24.88 f | 46.54 c |
| Mix 1 | 42.1 b | 11.9 e | 30.60 c | 40.02 f |
| Mix 2 | 26.9 d | 15.4 c | 29.22 d | 48.64 b |
| Mix 3 | 25.9 d | 15.9 bc | 23.46 g | 40.62 e |

Means with the same letter in the same colum are not significantly different at ($P \leq 0.05$).

**Physical properties and baking quality of biscuits**

**Table (6) and fig (2)**indicated the physical properties and baking quality of biscuits results of length, width, thickness, weight, volume, spread ratio and density of biscuits made with different flour obtained from wheat flour and different flour of rice, white corn, sorghum and mixtures of gluten free flour. The length and width was highest in wheat flour biscuit and thickness was higher in mix 1 and mix 2. Whitecorn biscuit was highest in weight and lowest in mix 2 biscuit. **Fig (2)** shows volume of biscuit from different flour and mixtures the highest volume was control and lowest volume with rice flour and mix1. Excellent wheat flour gives biscuits with high spread ratio (diameter/thickness), volume, than poor flour. **Fig (3)**showsdensity of biscuit from different flour and mixtures gluten free flour.

Addition of sorghum flour affects the spread ratio of biscuits, than poor flour and these results were agreement with **(Ibtihag, 1992) , Cronin and Preis (2000).**

**Table (6): Physical properties of biscuits.**

| Samples | Physical properties | | | | | | |
|---|---|---|---|---|---|---|---|
| | Length (cm) | Width (cm) | Thickness (cm) | Weight (g) | Volume (c) | Spread ratio (cm) | Density (g/cm$^3$) |
| Wheat flour (Control) | 9.40 a | 4.30 a | 0.80 a | 9.02 b | 32.34 a | 5.38 a | 0.28 a |
| Rice flour | 8.00 b | 3.60 b | 0.80 a | 7.74 e | 23.04 f | 4.50 b | 0.34 a |
| White corn flour | 9.20 ab | 3.60 b | 0.80 a | 9.38 a | 26.50 c | 4.50 b | 0.35 a |
| Sorghum flour | 9.00 ab | 3.40 bc | 0.80 a | 8.60 c | 24.48 d | 4.25 c | 0.35 a |
| Mix 1 | 9.00 ab | 3.20 c | 0.80 a | 7.82 de | 23.04 f | 4.00 d | 0.34 a |
| Mix 2 | 8.40 ab | 3.10 c | 0.90 a | 6.66 f | 23.44 e | 3.44 f | 0.28 a |
| Mix 3 | 9.20 ab | 3.40 bc | 0.90 a | 7.94 d | 28.15 b | 3.78 e | 0.28 a |

Means with the same letter in the same colum are not significantly different at ($P \leq 0.05$).

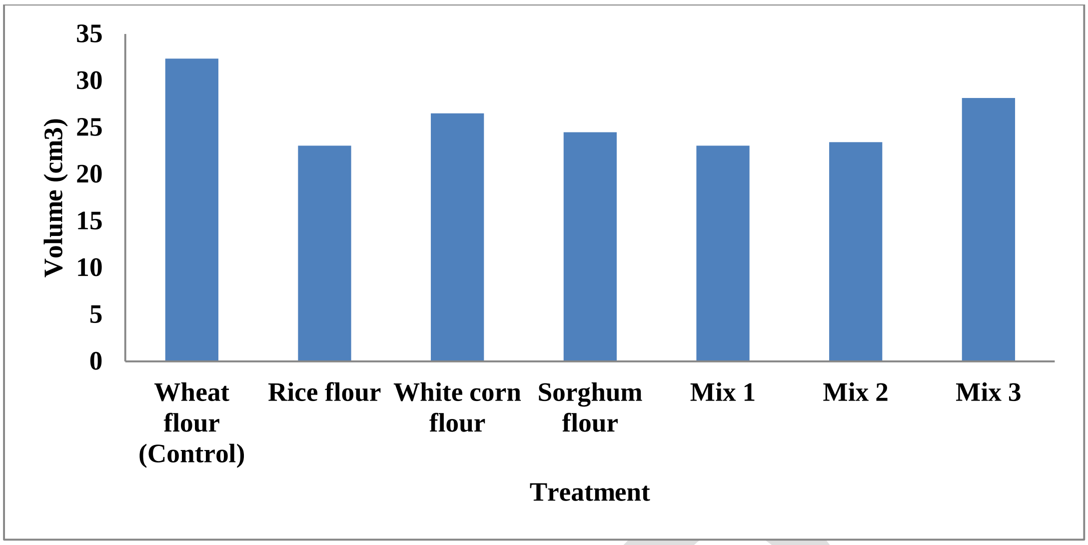


**Fig (2): Volume of biscuit from different flour and mixtures of gluten free flour.**

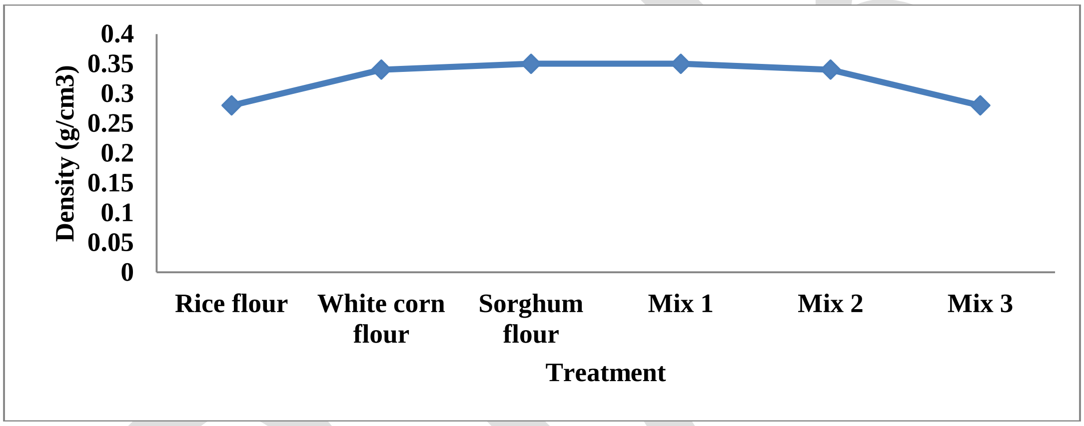


**Fig (3): Density of biscuit from different flour and mixturesof gluten free flour.**

### Sensory evaluation of biscuits made from rice, white corn, sorghum and their mixtures of gluten free flour

Results of sensory evaluation of biscuit which made from different flour are shown in **Table (7).** The statistical analysis for color was significantly differences between all biscuits making from different flour which ranged from 10.66 to 18.88%.

Highest value of color (18.88) was obtained by (control) wheat biscuit whereas (sorghum) got the lowest score (10.66). Lowest value of color may be due to high ash content, which affects the color of biscuit consumers prefer yellow color and not dark yellow biscuit. For texture highest mean score with control then mixtures 3 then 2 then 1 and lowest value was white corn biscuits (19.33, 18.00, 17.33, 17.00, and 11.66, respectively). Maximum taste score (18.3) was obtained by control then mix 3 while (white corn) biscuit received the minimum score (12.0).

The high odor score was mix 3 after control (17.00- 17.66) and the lowest score was white corn biscuit. Aroma score was high mix 3 after control biscuit and the lowest score was white corn biscuit. With respect to total score of biscuithighest score (87.66) for mix 3 after control (95.66) was obtained and thus regarded as more acceptable than other biscuit and mixture while lowest score (64.98) was obtained by (white corn) biscuit thus considered least acceptable. These results that obtained by **Yaseen *et al.*, (2010).**

**Table (7): Sensory evaluation of biscuits made from rice, white corn, sorghum and their mixtures of gluten free flour**

| Samples | Sensory properties | | | | | |
|---|---|---|---|---|---|---|
| | Color 20 | Texture 20 | Taste 20 | Odor 20 | Aroma 20 | Total Score 100 |
| wheat | 18.88[a] | 19.33[a] | 18.80[a] | 19.66[a] | 18.99[a] | 95.66[a] |
| Rice | 18.33[b] | 12.00[e] | 13.33[e] | 16.00[c] | 13.00[f] | 72.66[e] |
| White corn | 17.66[cd] | 11.66[e] | 12.00[f] | 12.66[f] | 11.00[g] | 64.98[g] |
| Sorghum | 10.66[f] | 12.66[d] | 16.66[c] | 14.33[e] | 14.00[e] | 68.31[f] |
| Mix 1 | 17.33[de] | 17.00[c] | 15.66[d] | 15.00[d] | 16.00[c] | 80.99[d] |
| Mix 2 | 17.00[e] | 17.33[c] | 16.66[c] | 15.33[d] | 15.66[d] | 81.98[c] |
| Mix 3 | 18.00[bc] | 18.00[b] | 18.00[b] | 17.00[b] | 16.66[b] | 87.66[b] |

Means with the same letter in the same colum are not significantly different at ($P \leq 0.05$).

**CONCLUSION**

Use of gluten – free flours had considerable effects on physical, chemical and sensory properties of biscuits. That obtained the results it could be concluded that, it is feasible to produce gluten free biscuit samples from rice, white corn, sorghum flours and their mixture (1.2.3). Mix 3 was high physical and sensory characteristics nearest to biscuit samples from wheat flour (100% gluten). From the technological, nutritional and sensory perspectives, the utilization of mix of rice and corn and sorghum are viable and recommended in the food industry to partially substitute the flour of other gluten-free cereals and diversifying the bakery market. The prepared biscuit samples could be used for celiac patients who cannot consume diets containing gluten.

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