Current Science International
Volume: 11 | Issue: 01| Jan. - March| 2022

EISSN:2706-7920 ISSN: 2077-4435
DOI: 10.36632/csi/2022.11.1.10
Journal homepage: www.curresweb.com
Pages: 140-153

Cookies Processing From Composite Flours of Cereals with High Nutritional Value

Ashgan M. Ali and Hala H. Shaban

Department of Bread and Pasta Research, Food Technology Research Institute, Agricultural Research Center, Egypt

Received: 15 Feb. 2022 **Accepted:** 20 Mar. 2022 **Published:** 30 Mar. 2022

ABSTRACT

New healthy items were attempted by integrating new bioactive substituting various types of flour for wheat flour in bakery particularly cookies. Cookies were created with composite flour barley or oat substituted with various ratios of corn and sorghum in this investigation. To minimize phytate, whole grains were treated with vitamin C and an acetate buffer (pH 4.8). Treatments led to a significant reduction in phytate of loss percentages ranging from 79.77 to 85.34 for vitamin C and 81.04 to 85.59 for acetate buffer. Cookies samples were examined for physicochemical and sensory qualities. Increased corn and sorghum % increased weight, diameter, and spread ratio. Comparison with control, barley cookies had no significant differences in overall acceptability; in contrast, oat cookies had substantial differences. Protein declines as the percentage of corn and sorghum increases. Increased corn and sorghum ratios increased fat, fibre and ash contents. Calorific value of barley and oat biscuits (BC1 and OC1) was the lowest. Increasing proportions of corn and sorghum flour in cookies improved total, soluble, and insoluble dietary fibre. During storage periods (90 days), water activity of barley and oat cookies increased marginally, fracturability increased with barley blends compared to oat blends cookies. Changes in acid and peroxide values of cookies during storage produced slightly variable results, but control had the greatest value. Finally, cookies with high nutritious content and appropriate calories could contribute significantly to nutrient consumption by various customers.

Keywords: composite flours, healthy Cookies, anti-nutritional, phytic acid, Organoleptic evaluation

1. Introduction

Composite flour is the combination of different levels of flour other than wheat may come from cereals, pulses, roots or tubers with wheat flour or a mix of flours other than wheat flour (Okpala and Okoli, 2011). Composite flours are recently manufactured not only to improve the desired functional properties of end product based on them but also increase nutritional composition values (Ubbor and Akobundu, 2009). The substitution wheat with cereals is an economic step towards overcoming deficiencies in wheat flour and its nutrients with other cereals (Pena *et al*., 2006).

Barley is one of the richest and cheapest sources of vegetal protein, dietary fibre (beta-glucan that helps lower cholesterol through binding to gall acids and flushing them out of the body through the face), magnesium and selenium that can be used to improve the diets of millions of people, especially low-income earners in developing countries (Alka *et al*., 2017).

Oat grains (*Avena sativa* L.) have multifunctional uses including as human food, health care. The cultivation area of oats in the world is remarkably smaller than other cereals crop such as maize, wheat, rye or barley (Daryanto *et al.,* 2016). Oats tolerate wet weather and acidic soils far better than other cereals. Oat grain is characterized by a good taste, dietetic properties and an activity stimulating metabolic changes in the body (Huttner *et al.,* 2010). It is considered distinct among cereals being a rich source of proteins (globulins), phenolic compounds and dietary fiber in particular B-glucan and several vitamins and mineral components. Oats has attracted serious attention because of its prolamin composition and amino acid sequence (Ahmad *et al.,* 2014). The health benefit linked to oat has increased consumers awareness of this cereal, and the health claims approved both by FDA (2003).

Corresponding Author: Ashgan M. Ali, Department of Bread and Pasta Research, Food Technology Research Institute, Agricultural Research Center, Egypt.

Fortification of food products plays a critical role in increasing health-promoting functional components in bakery products to improve it and provide additional benefits to meet consumers 'demands (Świeca *et al*., 2017). Tasty and healthy food depends on the additions of high-quality ingredients (Vitali *et al*., 2009).

Maize and sorghum are ranked third and fifth respectively (Kadam *et al*., 2012 and Liu *et al*., 2012). Sorghum is used for production of bread, porridges, tortillas, crane couscous, spirits and non-alcoholic beverages (Kulamarva, 2005). Sorghum endosperm is a rich ingredient in starch, protein, vitamin B-complex respectively. Bran of sorghum is very good source of fiber, containing lesser amounts of ash and proteins. Phytochemicals as tannins, anthocyanin's, phenolic compounds, phytosterols etc. are important health maintains of sorghum flour (Hahn *et al*., 1984). Composite flour's glycemic index will be reduced by increasing sorghum flour levels and more effective for hypertension, diabetes and cardiac illness patients (Singh *et al*., 2012).100 g of raw sorghum supplies 329 energy calories, 72% carbohydrates, 4% fat and 11% protein. Sorghum provides many essential nutrients at elevated levels (20% or more of the Daily Value, DV), includes protein, vitamin B, niacin, thiamine and vitamin B6, and various dietary minerals, including iron (26% DV) and manganese (76% DV). Sorghum nutrients generally are similar to those of raw oats (Mutegi *et al*., 2010).

Phytate constitutes about 65–90% of the total phosphorous content in plants. It is degraded by the phytase enzyme as an inositol molecule and six inorganic phosphate molecules. Also, phytate is a strong chelating divalent cations and minerals such as $Ca^{2+,}$ Fe^{2+} and Zn^{2+} (Vats and Banerjee, 2004), preventing them from the absorption in the digestive system. Moreover, Phytate is famous for forming complexes with proteins in acidic and alkali pH conditions. These interactions had an impact on the protein structure, thereby reducing enzyme activity, protein solubility and proteolytic digestibility. And the phytase enzyme responds to the phytate complex; as a result, inositol, phosphate get released (Yao *et al*., 2011). Phytate is formed during maturation of cereal seeds and plays a major role in the composition of foods derived from cereals.

Depending on the quantity of different grain foods in diet and the grade of food processing, daily intake of phytate may be high, i.e., 4500 mg. Daily dose of phytate was estimated between 2000 and 2600 mg for vegetarian and other residents of rural areas of developing countries and between 150 and 1400 mg for mixed diets (Reddy, 2001).

Grains are rich in minerals but, presence of anti-nutrition factors as phytic acid inhibits biodiversity of these minerals (Valencia *et al.,* 1999), which is a major component in sorghum. Phytic acid has been called anti-nutriment, due to its ability to bind mineral proteins and starches, directly or indirectly and hence alter their soluble function and absorption (Nelson, 1967; Svanberg and Lorri, 1997).

Several methodologies have been developed to minimize phytic acid content and to improve the nutritional quality of grains that become poor because of these antinutrients. Genetic improvement and several pre-treatment methods such as fermentation, soaking, germination and enzymatic treatment of grains with phytase enzyme had been studied. Biofortification of basic crops using modern biotechnological techniques can potentially help in lowering malnutrition in developing nations (Gupta *et al*., 2015).

Cookies was become one of the most desirable snacks for children and the elderly because of their low manufacturing cost, greater convenience, long lifespan and serve as a vehicle for important nutrients. Consumption of bakery products has been increased as a result of urbanization and increase in the number of working women. Food industry can exploit this development by fabricating nutritious bakery foods (Hooda and Jood, 2005). Cookies represent the largest category of confectionery snacks in the world (Pratima and Yadava, 2000). Cookies are not considered as staple food as bread but are feasible fiber carriers because of their longer shelf-life and thus enable their large-scale productions and widespread distributions (Vratania and Zabik, 1978).

Composite flour is good used for the production of cookies rather than bread due to their ready-to-eat shapes, prolonged shelf life, high consumption and good food quality. Cookies, which based on barley, rice, maize, rye, acha, amaranth and oatmeal, were returned by several researchers. Protein enrichment studies of cookies were conducted using spent grain from the brewer (Gernah *et al.,* 2010).

Present research has been conducted to inquire into increase of nutritional value and to determine the phytic acid after some treatments using simple processing methods such as soaking in acetate buffer and vitamin C to reduce phytic acid compound from oat, barley, corn and sorghum grains. Then, evaluation the sensory and physicochemical properties of cookies manufactured from composite flour.

2. Materials and Methods

2.1 Materials

White sorghum (*Sorghum vulgare* L. Dorado variety), naked barley (*Hordeum vulgare* L. Giza 131), corn (*Zea mays* L. *commercial hybrid Single Cross Giza 10*) and wheat (*Triticum aestivum* L. Sids 12). Samples were obtained from Field Crops, Institute, Agricultural Research Centre, Ministry of Agriculture, Giza, Egypt. Oat, Butter; sugar and baking ingredients were obtained from local markets.

2.2. Methods

Preparation of samples

Barley, oat, sorghum, corn and wheat samples were carefully cleaned to be free from broken grains and extraneous matter.

Phytic acid reduction treatments:

Barley, oat, sorghum, corn and wheat samples were carefully cleaned and subjected to reduce phytic acid as following procedures according to Fredlund *et al*. (1997). The whole grains as naked barley, sorghum, oat, corn and wheat (1kg) were cleaned and washed for 3-5 min in cold deionized water. The grains were wet- steeped in 2.5 volumes of acetate buffer (pH.4.8) which were incubated at 55 °C for oat, and 37°C about 24 h for other grains, was finally dried in a convection oven at 40–50 °C for 10 h, followed by 80 °C for 3 h, then milling, while vitamin C treatment ,150 mg of ascorbic acid was mixed with 1kg of the cleaned whole grains of the samples, then milled in a laboratory mill to obtain whole meal . After then the detection of phytic acid content will compared with non-treated whole grains.

Table 1: Formulas of blends barley/ oat used for production cookies

Ingredients (g)	Control	Barley Cookies					Oat Cookies				
		BC1	BC2	BC3	BC4	BC5	OC1	OC2	OC3	OC4	OC5
Barley/Oat	--	100	70	60	50	40	100	70	60	50	40
Corn	--	--	15	20	30	40	--	15	20	30	40
Sorghum	--	--	15	20	20	20	--	15	20	20	20
Wheat (Whole meal)	100	–	–	–	–	–	–	–	–	–	–
Sugar	50	50	50	50	50	50	50	50	50	50	50
Butter	50	50	50	50	50	50	50	50	50	50	50
Egg	20	20	20	20	20	20	20	20	20	20	20
Cocoa powder	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**
Baking powder	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Salt	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9

Water was added as the blends need

Preparation of cookies

The samples flour which was chosen for cookies preparation was derived from the grains subjected to vitamin C treatment because of it is easier, healthier and safety method.

Cookies were prepared by the method reported by A.A.C.C. (2000) as in Table (1). Cookie's dough prepared from 100% whole wheat flour (control). Sugar was creamed with Butter until a slight and fluffy constituency was obtained using Kenwood chef with initial minimum speed and the speed increased step wisely. Whole egg was added, followed by flour, baking powder, salt components were added and then water was added (as every blend need) and the batter made, with having optimum consistency. The batter was rolled on a floured board using rolling pin. The rolled dough was cut into circular shapes with a cutter and placed on a greased and baked at 160°C for 15 min. The cookies were brought out, cooled, and packed in polythene bags until used for laboratory analysis.

Physical properties of cookies.

Volume, weight, specific volume, thickness, width, and spread factor were determined according to the methods of A.A.C.C. (2000).

Sensory evaluation of cookies

Evaluation of cookies was carried out for the external sensory characteristics. Cookies were evaluated for color, flavor, taste, crispiness, and overall acceptability. The judgments were made through tasting products on a 20-point Hedonic Scale with corresponding descriptive terms which ranging from 20 "like extremely" to 1 "dislike extremely" according to the method described by Meilgard *et al*. (2007) to find out the most suitable blend for cookies production.

2.3. Chemical analysis

Moisture, protein, fats, crude fiber and ash contents of cookies samples have been determined using the procedures of A.O.A.C. (2005).

The total carbohydrate (CHO) was calculated by difference on dry weight bases

$$CHO = 100- (protein + fat + fiber + ash).$$

Energy value (kcal/100 g) has been determined in accordance with the method of Marero *et al*. (1998) using the factor (4 × %Protein) + (4 × %Carbohydrate) + (9 × % Fat).

Determination of total; Insoluble and soluble dietary fiber

Total and Insoluble dietary fiber content of cookies samples were determined according to the enzymatic methods of A.O.A.C. (2005). Soluble dietary fiber was calculated out of difference as follows:

Soluble dietary fiber = Total dietary fiber- Insoluble dietary fiber.

Determination of phytic acid for grains

Phytic acid was determined using the method described in Wheeler and Ferrel (1971) using a 2.0 g dried sample. A standard curve was prepared expressing the results in equivalents Fe $(No)_3$, phytate phosphorus was calculated using the standard curve assuming a 4:6 iron-phosphorus molar ratio.

Determination of keeping storage of cookies

Cookies were storage under conditions at room temperature (20- 25°C) for 3 months. Determination of keeping storage operated as follows:

Determination of Water activity (aw)

Water activity (a_w) was measured at 25°C using a Decagon A qualab Meter Series 3TE (Pullman, WA, USA). All samples of storage cookies were broken into small pieces immediately before water activity measurement.

Texture analysis

A texture analyzer (BROOKFIELD CT3 TEXTURE ANALYZER Operating Instructions Manual No. M08-372-C0113, Stable Micro Systems, USA) was used for the texture profile measurement of cookies in terms of Fracturability (N) of the samples following the method described in Chauhan *et al*., (2016).

Extraction oil from cookies

Samples of cookies (25-50g) were grounded and soaked in n- hexane or mixture (hexane: ethanol) (3:1). The collected oil was filtered. The solvent was vaporized under vacuum at 40-45°C in rotary-evaporator. The oil was kept in a refrigerator until analysis A.O.A.C., (2005).

Acid value

Acid value of the oil has been determined in accordance with the procedure A.O.A.C. (2005) as follows. Known weight (1-2g) of oil was disbanded in a neutral ethyl alcohol (30 ml). The mixture was boiled in a water bath for 2 min followed by titration with potassium hydroxide solution (0.1 N) in the presence of phenolphthalein as an indicator and calculated according to the following equation:

$$\text{Acid value (mg KOH per g of sample)} = \frac{S \times N \times 56.1}{Weight\ of\ sample(g)}$$

Where:
N = normality of KOH
S =ml of KOH

Peroxide value

The peroxide value was determined in accordance with the methodology described in A.O.A.C. (2005). A known weight of oil (2.5 g) was dissolved in a 30 ml mix of glacial acetic acid and chloroform (3:2 v/v). A newly prepared saturated solution of potassium iodide (1ml) was added and the contents of the flask were vigorously shaken exactly for 1 min. Distilled water (30 ml) was added and solution was titrated slowly with sodium thiosulfate solution (0.01 N) in the presence of starch solution (1%) and calculated according to the following equation.

$$\text{Peroxide value (as milli-equivalent of peroxide per 1000g of sample)} \ \frac{S \times N \times 1000}{Weight\ of\ sample(g)}$$

S = ml. of $Na_2S_2O_3$ (blank corrected)
N = Normality of $Na_2S_2O_3$ Solution.

2.4. Statistical analysis

Data were statically analyzed using MSTAT-C v.2.1 (Michigan State University, Michigan, USA) and mean comparisons were based on the least significant difference (LSD at 5%) test according to Maxwell and Delaney, (1989).

3. Results and Discussion

3.1. Reduction phytic acid of raw materials

Phytic acid binds minerals and makes them unavailable as nutritional factors. Absorption of iron and Zn was found to be inhibited when the phytic acid-metal ratio was greater than 10 (Gharib *et al.,* 2006). Results from research on humans have shown that high levels of this anti-nutrient may cause Zn deficiency (Martinez *et al*., 2002). Limited bioavailability of minerals in grains due to relatively low levels of minerals and the presence of phytic acid and other antinutritional factors that reduce their bioavailability to 5-15% pose challenges from a nutritional point of view (Das *et al.,* 2011).

The results obtained from identification of phytic acid in whole flour before and after treatments with two methods (Vitamin C. and Acetate buffer) are present in Table (2).The results showed that the phytic acid content of whole flour recorded high value in whole wheat compared with other types of flour (3.07±0.063), the result indicated a significant decrease (p>0.05) of phytic acid of all the processed treatments, whole flour of sorghum had higher sensitive for two processed treatments, which registered the loss percentage (85.34; and 85.59) which the value of phytate reduced from 0.805±0.002 to 0.118±0.002 and 0.116±0.001 for Vitamin C. and acetate buffer treat, respectively. These results were due to phytic acid was hydrolyzed by phytases found in certain plants, micro-organisms and animal tissues. Cereal phytases activated at pH optimum in the range 4·5–6·0 (Tijskens *et al.,* 2001). This result accordance with Omara, (2017) who reported that used five methods of process to reduce phytic acid from Sudanese sorghum local name Feterita Gadarif (F.G), the highest loss of phytate recorded in germination method (98%) followed by vitamin C treatment (86.2%). Also, Omara, (2017) reported that vitamin C is strong enhancer of plant iron can overcome the inhibitors in plant foods. Fredlund *et al*., (1997) stated that reduction of phytate during hydrothermal processing of wheat, rye, hulled barley and dehulled barley, husked oats and naked oats were incubated with water or acetate buffer (pH 4.8) at 55°C for 24 hrs except oats, which incubated to 37°C phytate in wheat, rye and barley was reduced from 46% to 77% when water was used and from 84% to 99% when acetate buffer was used. Citric acid and citrate buffer were used to adjust pH in some experiments, and their use caused less phytate reduction than when acetate and lactic acid were used.

Table 2: Phytic acid reductions of raw materials by vitamin C and acetate buffer treatments.

Samples	Phytic acid values g/100g (dw)				
	Raw sample	**Vit. C t.**	**Loss %**	**Acet. Buff. t.**	**Loss %**
Wheat	3.07±0.063**a**	0.621±0.009**a**	**79.77**	0.582±0.003**a**	**81.04**
Barley	2.78±0.028**b**	0.51±0.005**b**	**81.65**	0.49±0.005**b**	**82.37**
Oat	2.81±0.005**b**	0.49±0.001**b**	**82.56**	0.47±0.002**b**	**83.27**
Corn	1.23±0.086**c**	0.205±0.006**c**	**83.33**	0.201±0.01**c**	**83.66**
Sorghum	0.805±0.002**d**	0.118±0.002**d**	**85.34**	0.116±0.0005**d**	**85.59**
L.S.D$_{0.05}$	0.179	0.024		0.023	

Means in the same column with different letters are significantly different ($p\leq$ 0.05), each mean value is followed by ± SE (standard error).

3.2. Physical properties of cookies

Physical properties of barley cookies BC and oat cookies OC were found in Table (3), there were no significant differences between BC and control (whole wheat) in volume and specific vol. but control and BC1 had lowest score. For oat composite cookies there were significant differences between OC5 and other cookies in volume and specific volume. Spread ratio and diameter of cookies had been used to determine the quality of flour for producing cookies (Gaines, 1994).

Table 3: Physical properties of barley BC and oat OC cookies

Samples	Volume (cm^3)	Weight (g)	Specific vol. (cm^3/g)	Diameter (cm)	Thickness (cm)	Spread ratio
Cont.	38.50±0.8**ab**	20.71±0.01**bc**	1.86±0.04**ab**	6.10±0.06**a**	1.67±0.01**c**	3.66±0.1**a**
BC1	38.75±2.1**ab**	20.96±0.02**ab**	1.85±0.10**ab**	5.03±0.01**d**	1.93±0.03**a**	2.61±0.3**bc**
BC2	45.50±0.2**a**	20.99±0.13**ab**	2.17±0.03**a**	5.34±0.05**c**	1.87±0.06**a**	2.87±0.6**b**
BC3	43.25±1.2**a**	20.68±0.10**ab**	2.06±0.07**a**	5.27±0.03**c**	1.78±0.05**ab**	2.98±0.9**b**
BC4	43.50±2.0**a**	21.22±0.01**a**	2.05±0.09**a**	5.54±0.02**b**	1.90±0.00**a**	2.94±0.1**b**
BC5	46.50±0.8**a**	21.41±0.04**a**	2.17±0.04**a**	5.51±0.01**b**	1.82±0.04**ab**	3.04±0.8**b**
L.S.D$_{0.05}$	5.55	0.28	0.27	0.12	0.09	0.28
Cont.	38.50±0.8**b**	20.71±0.01**a**	1.86±0.04**d**	6.10±0.06**c**	1.67±0.01**b**	3.66±0.1**a**
OC1	47.50±0.2**b**	21.19±0.04**a**	2.24±0.02**c**	5.97±0.06**c**	1.95±0.10**a**	3.09±2.0**b**
OC2	49.25±1.5**b**	20.31±0.39**ab**	2.43±0.03**b**	6.32±0.09**a**	1.78±0.03**b**	3.55±1.1**a**
OC3	49.00±1.1**b**	20.06±0.12**ab**	2.45±0.07**b**	6.28±0.10**ab**	1.73±0.01**b**	3.62±0.7**a**
OC4	50.75±1.2**b**	20.56±0.26**a**	2.47±0.03**b**	6.42±0.03**a**	1.77±0.01**b**	3.64±0.3**a**
OC5	55.00±0.0**a**	20.94±0.04**a**	2.63±0.01**a**	6.48±0.07**a**	1.77±0.01**b**	3.67±0.7**a**
L.S.D$_{0.05}$	4.04	0.79	0.15	0.16	0.16	0.32

Means in the same column with different letters are significantly different ($p\leq$ 0.05), each mean value is followed by ± SE (standard error).

Cookies prepared from whole wheat flour had a higher spread ratio (3.66 ± 0.10) compared to barley BC1 and composite barley cookies that have been reduced with the substitution of more barley flours, this could be due to the nature of starch present in wheat and other used flours (Mir *et al.,* 2015). While for oat composite flour, spread ratio and diameter had no significant different value in comparison with whole wheat cookies, except oat cookies (OC1) only had significant different value

(3.09±2.0). The weight, diameter and the spread ratio of the cookies followed the same trend in which an increase in corn and sorghum percentage increases the physical parameters, these results were agreement with Adebowale *et al.,* (2012) and Adeyeye, (2016), but spread ratio was increased with reduced sorghum flour in the cookies (Ayo and Gaffa, 2002).

3.3. Sensory Evaluation of Cookies

Sensory evaluation is a scientific method that uses human senses, such as vision, taste, smell and touch, to evaluate the characteristics of foods (Tuorila, 2015). Mean score of color, flavor, crispiness, taste and overall acceptability of barley supplemented cookies developed by various composite of barley flour, corn and sorghum which were subjected to vitamin C. treatment, were presented in Table (4) and Fig (1). There are no significant differences between cookies samples compared with control which recorded for color, flavor and overall acceptability. While in taste, BC4 and BC5 samples were have the highest scores 19.51 and 19.44 respectively. Above that, BC3, BC4, BC5 and control recorded no significant differences between them in crispiness attribute.

Mean score of oat supplemented cookies developed by various composite of oat, corn and sorghum flour which were subjected to vitamin C. treatment, were presented in Table (5) and Fig (2). Color, taste, crispiness and overall acceptability recorded significant differences for oat cookies (OC) compared with control, while there are no significant differences for all cookies in flavor attribute. Tosh *et al*., (2008) stated that market values of oat and barley β-glucan based foods are already tested in various formulations with commercial success. In contrast Amir *et al*., (2015) showed that statistical results the addition of sorghum, corn and a combination of these whole meals had a very significant effect ($p<0.01$) on the sensory characteristics of the cookies.

Table 4: Sensory Evaluation of Barley Cookies (BC)

Sample	Color	Flavor	Taste	Crispiness	Overall acceptability
Cont.	18.05±0.15 a	18.80±0.26 a	18.02±0.14 c	18.81±0.27 a	18.43±0.19 ab
BC1	18.04±0.13 a	19.03±0.18 a	18.99±0.19 b	18.05±0.15 b	18.60±0.19 a
BC2	18.07±0.18 a	18.98±0.22 a	19.00±0.19 ab	18.10±0.10 b	18.62±0.17 a
BC3	18.07±0.21 a	18.99±0.19 a	19.01±0.15 ab	18.87±0.22 a	19.01±0.16 a
BC4	18.20±0.19 a	19.01±0.16 a	19.51±0.12 a	18.98±0.22 a	19.01±0.15 a
BC5	18.25±0.18 a	19.00±0.19 a	19.44±0.14 a	18.99±0.16 a	19.00±0.19 a
L.S. $D_{0.05}$	0.50	0.58	0.46	0.55	0.52

Means in the same column with different letters are significantly different ($p\leq 0.05$), each mean value is followed by ± SE (standard error).

Table 5: Sensory Evaluation of Oat Cookies (OC)

Sample	Color	Flavor	Taste	Crispiness	Overall acceptability
Cont.	18.05±0.15 b	18.80±0.26 a	18.02±0.14 b	18.81±0.27 b	18.43±0.19 b
OC1	18.99±0.13 a	18.97±0.14 a	19.55±0.13 a	19.57±0.14 a	19.62±0.11 a
OC2	19.02±0.15 a	19.04±0.18 a	19.66±0.09 a	19.60±0.15 a	19.64±0.10 a
OC3	19.01±0.12 a	19.02±0.18 a	19.66±0.11 a	19.64±0.11 a	19.62±0.11 a
OC4	19.02±0.20 a	19.02±0.15 a	19.57±0.13 a	19.62±0.11 a	19.57±0.13 a
OC5	19.02±0.16 a	19.00±0.17 a	19.55±0.11 a	19.60±0.12 a	19.57±0.13 a
L.S. $D_{0.05}$	0.47	0.52	0.34	0.45	0.40

Means in the same column with different letters are significantly different ($p\leq 0.05$), each mean value is followed by ± SE (standard error).

EISSN: 2706-7920 ISSN: 2077-4435 **DOI: 10.36632/csi/2022.11.1.10**

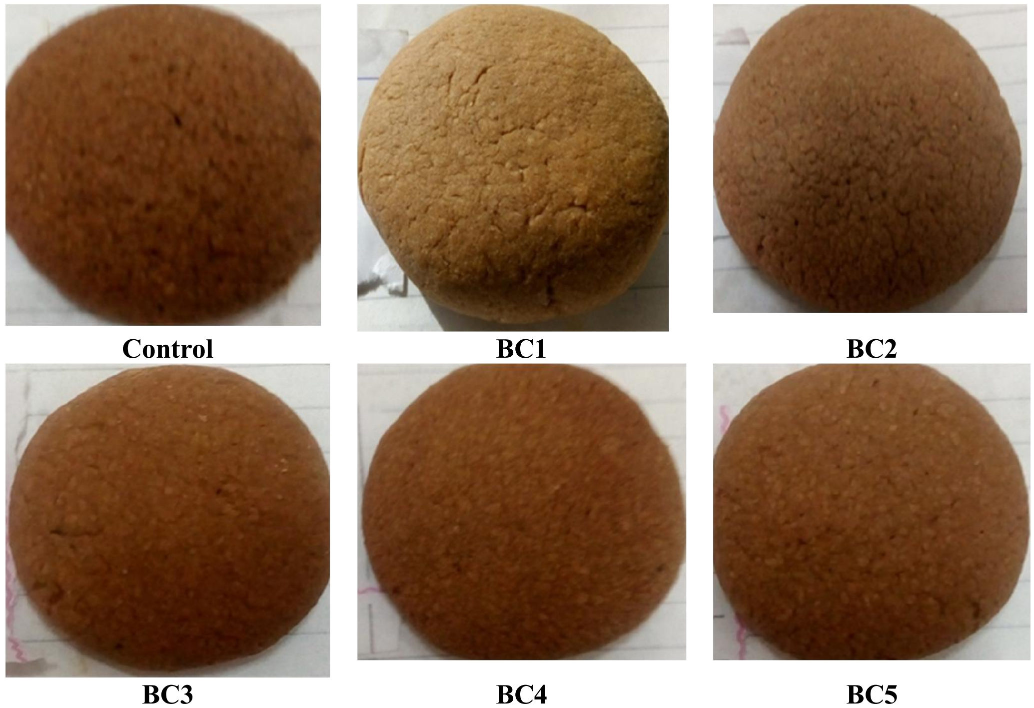

Fig 1: Control (whole wheat flour), barley and barley composite cookies

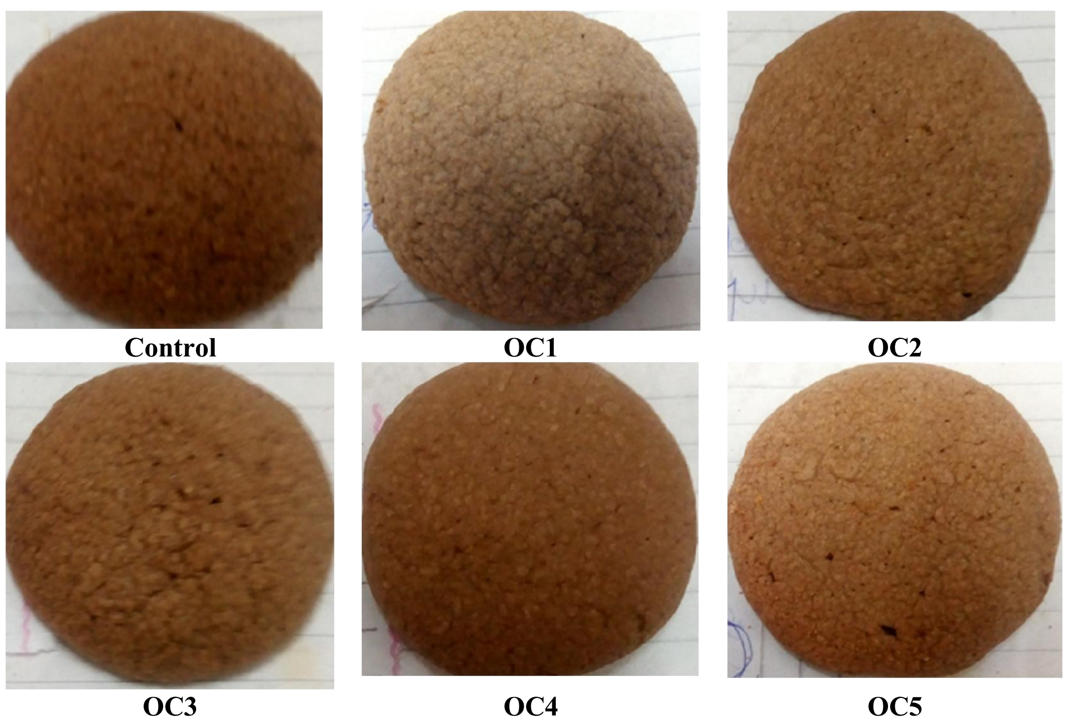

Fig 2: Control (whole wheat flour), oat and oat composite cookies

3.4. Chemical composition of cookies

Chemical compositions of Barley and oat cookies were registered in Table (6). Protein contents decrease by increasing supplementation percent of barley and oat flour by corn and sorghum flour. BC5 had the lowest value of proteins (8.24±0.03), but oat cookies OC1 had the highest protein value

(9.51±0.02). These results are supported by the results of Yaseen *et al*., (2010). Crude fat contents showed no significant affects (p<0.05) between barley cookies BC2, 3, 4 and 5 but control cookies and BC1 recorded significant different value. While, oat blends recorded no significant different between them, whereas there is a significant different corresponding to control and OC1. Crude fiber and ash contents were increased by increasing the percentage of corn and sorghum flour. Results are in accordance with the results of Giwa and Victor, (2010). Amir *et al*., (2015) reported that the chemical analysis of different whole flour (maize, sorghum and wheat) and their acceptable mixtures have demonstrated that the cereal mixture significantly increased the fat, fiber and ash percentages with the substitutions of both cereals. Total carbohydrates recorded significant different between (control and BC1) and other barley cookies, all oat cookies had less values than control cookies.

The energy value of the cookie samples ranged between 494.65±0.47and 507.43± 3.47 kcal/100 g; the energy values of the composite cookies were no significantly (p < 0.05) different from the reference sample, while cookie samples (BC1 and OC1) had the lowest energy value, The protein, fat and carbohydrate constituents of the blend contributed to the energy value of the cookies. Cookies are energy-giving foods that are consumed mostly in-between meals by both young and old.

Table 6: Chemical composition of cookies (on dry weight basis)

Samples	Protein %	Crude Fiber %	Ether extract %	Ash %	Total carbohydrate* %	Energy value (kcal/100 g)
Cont.	9.23±0.02**a**	0.55±0.02**ab**	20.33±0.06**c**	1.2±0.05**cd**	68.69±0.05**a**	494.65±0.47**ab**
BC1	9.13±0.01**a**	0.56±0.01**a**	21.22±0.10**b**	1.31±0.01**c**	67.78±0.27**a**	498.62±2.06**a**
BC2	8.99±0.16**b**	0.58±0.01**a**	21.52±0.01**ab**	1.42±0.01**c**	67.49±0.09**b**	499.60±0.07**a**
BC3	8.61±0.05**c**	0.58±0.02**a**	21.59±0.06**ab**	1.65±0.01ab	67.57±0.22**b**	499.03±1.73**a**
BC4	8.48±0.05**c**	0.59±0.01**a**	21.98±0.18**a**	1.72±0.02**a**	67.23±0.21**b**	500.66±1.06**a**
BC5	8.24±0.03**d**	0.62±0.01**a**	22.54±0.32**a**	1.85±0.02**a**	66.75±0.21**bc**	502.82±3.62**a**
L.S.D$_{0.05}$	**0.179**	**0.069**	**0.636**	**0.111**	**0.762**	**7.47**
Cont.	9.23±0.02**b**	0 .55±0.02**ab**	20.33±0.06**c**	1.2±0.05**d**	68.69±0.05**a**	494.65±0.47**ab**
OC1	9.51±0.02**a**	0.58±0.01a	22.00±0.14**b**	1.38±0.05**bc**	66.24±0.17**b**	501.00±0.23**a**
OC2	9.48±0.01**a**	0.59±0.01a	22.55±0.32**ab**	1.44±0.01**b**	65.94±0.02**b**	504.63±2.92**a**
OC3	9.36±0.04**ab**	0.6±0.01a	23.05±0.03**a**	1.66±0.01**a**	65.33±0.17**bc**	506.21±1.24**a**
OC4	9.25±0.05**b**	0.61±0.01a	23.31±0.29**a**	1.67±0.01**a**	65.16±0.27**c**	507.43±3.47**a**
OC5	9.12±0.01**bc**	0.63±0.01a	23.36±0.21**a**	1.75±0.01**a**	65.14±0.31**c**	507.28±0.72**a**
L.S.D$_{0.05}$	**0.136**	**0.055**	**0.795**	**0.130**	**0.774**	**7.64**

Means in the same column with different letters are significantly different ($p \leq 0.05$), each mean value is followed by ± SE (standard error). *Calculated by difference [100 – (Protein+ ash+ ether extract +Crude Fiber)]

3.5. Total, Soluble, and Insoluble Dietary Fiber of cookies

Total, soluble and insoluble dietary fiber of cookies were presented in Table (7). The three parameters of dietary fiber contents were increased by increasing the percentage of corn and sorghum flour. Barley cookies (BC5) and oat cookies (OC5) recorded high significant values of total, soluble and insoluble dietary fiber which were 34.80±0.31, 8.03±0.075, 26.77±0.24 and 35.85±0.23, 8.27±0.051, 27.58±0.25 respectively. Li and Komarek (2017) and El-Salhy *et al*., (2017) said that dietary fibers are polysaccharides of immense interest in nutrition. They can be useful in preventing and treating chronic diseases like diabetes, obesity, glycemic and cholesterol control, irritable bowel syndrome, and colon cancer.

3.6. Product keeping quality

3.6.1. Water activity and Fracturability of cookies before and after storage period

Water activities of Barley and oat cookies were presented in Table (8). Water activity ranged between 0.453±0.006 and 0.572±0.002 for OC3 and BC1 cookies samples, respectively in zero time, while recorded slightly increasing by end storage period (90 days). The samples of cont. andOC4 recorded highest value for water activity in end storage period (90 days) 0.506±0.005 and 0.506±0.001, respectively. Water activity was decreased by increasing the percentage of corn and sorghum flour. This might be due to different chemical structure of starch in sorghum and corn flour, also increasing water activity in all samples due to using whole grain in cookies making, and specially, β- glucan as fiber source in barley and oat which have water absorption ability.

Water activity (a_w) and moisture content are always important parameters influencing stability of biscuits during storage, in particular the resistance against microbes and rheological properties of the products. Typical of biscuits is not only low moisture content but also a rather low value of aw. Foods with aw<0.60 are considered as microbiologically stable, although some of their constituents may undergo chemical reactions (Leung, 1987).

Table 7: Total, Soluble, and Insoluble Dietary Fiber of cookies

Samples	TDF	SDF	IDF
Cont.	12.28±0.19**d**	2. 90±0.001**d**	9.38±0.20**d**
BC1	16.00±0.17**c**	3.76±0.005**c**	12.24±0.17**c**
BC2	16.75±0.33**c**	3.89±0.077**c**	12.86±0.25*c*
BC3	31.87±0.24**b**	7.41±0.057**b**	24.47±0.18**b**
BC4	32.80±0.31**b**	7.71±0.075**b**	25.09±0.24**b**
BC5	34.80±0.31**a**	8.03±0.075**a**	26.77±0.24**a**
L.S. $D_{0.05}$	**1.066**	**0.23**	**0.86**
Cont.	12.28±0.19**f**	2.89±0.001**f**	9.38±0.20**e**
OC1	17.33±0.02**e**	3.73±0.005**e**	13.59±0.02**d**
OC2	20.86±0.03**d**	4.50±0.005**d**	16.36±0.02**c**
OC3	32.53±0.04**c**	7.02±0.008**c**	25.50±0.03**b**
OC4	33.80±0.02**b**	7.94±0.007**b**	25.85±0.02**b**
OC5	35.85±0.23**a**	8.27±0.051**a**	27.58±0.25**a**
L.S. $D_{0.05}$	**0.499**	**0.086**	**0.437**

TDF: Total dietary fiber; SDF: Soluble dietary fiber; IDF: Insoluble dietary fiber
Means in the same column with different letters are significantly different ($p \leq 0.05$), each mean value is followed by SE (standard error).

Table 8: Water activity and fracturability of cookies before and after storage

Samples	Water activity (a_w)				Fracturability (N)	
	Zero t	**Temp (℃)**	**90 days**	**Temp (℃)**	**Zero t**	**90 days**
Cont.	0.486±0.001de	16.24	0.506±0.005a	17.84	50.96	43.05
BC1	0.572±0.002 a	16.66	0.496±0.002b	18.50	61.64	68.27
BC2	0.506±0.001 c	17.49	0.493±0.002bc	18.92	58.03	67.85
BC3	0.503±0.001 c	17.55	0.503±0.001a	18.83	57.62	63.95
BC4	0.494±0.0003d	17.63	0.499±0.001ab	18.72	50.98	63.42
BC5	0.519±0.001 b	17.57	0.504±0.001a	18.56	47.75	60.45
OC1	0.494±0.003 d	16.41	0.503±0.001a	17.89	38.92	33.75
OC2	0.487±0.002de	16.46	0.478±0.003d	17.89	34.26	28.63
OC3	0.453±0.006f	16.81	0.490±0.001c	18.25	29.42	28.09
OC4	0.495±0.005d	16.83	0.506±0.001a	18.41	27.78	26.54
OC5	0.494±0.005d	16.50	0.498±0.001ab	18.10	26.63	25.65
$LSD_{0.05}$	**0.007**		**0.005**	**-**	**-**	**-**

Means in the same column with different letters are significantly different ($p \leq 0.05$), each mean value is followed by SE (standard error).

Fracturability (which measures the resistance of a sample to bend before it breaks) was significantly increased with barley blends cookies compared to oat blends cookies which, it was decreased by increasing the percentage of corn and sorghum flour, it was might be due to the different chemical structure of starch in sorghum and corn, also recorded slightly increase in end storage period (90 days) in barley flour composite cookies. BC1had the highest value in fracturability in zero time and end storage period (61.64and 68.27), respectively. This might be due to the different structure of starch and protein type in barley. The results clearly registered decreasing with similar to the one reported by Adebowale *et al.,* (2012) for cookies made from mixtures of sorghum -wheat and wheat-oat flour blends (Chavan and Kadam 1993), respectively. Hardness of cookies is due to the interaction of proteins with starch by hydrogen bond. As opposed to a conclusion was agreed with that reported by Okaka and Isieh (1997) and Ayo *et al.,* (2007) for the utilization of composite flours in cookies to reduce its break strength. Also, Adebowale *et al.* (2012) reported that increase in rigidity is due to increase in carbohydrate/starch granules, which is responsible for gel and structure formation in baked goods.

3.6.2. Changes in fat content indices of cookies during storage

Lipid oxidation causes the formation of a grease hydro peroxide (primary oxidation products at the propagation stage), which is tasteless, odorless and highly unstable and decomposes to form secondary oxidation products such as aldehydes, ketones and carbonyls that adversely affect to food flavor quality (Angelo, 1996). Lipid oxidation is known to cause rancidity in many types of foods, including low moisture food (water activity lower than 0.5) (Kumar *et al.,* 2014) and had small amounts of lipids less than 1% (Barden, 2014).

Table (9) show acid values in barley and oat cookies, results indicated that no significant different value between all cookies in zero time except OC4 and OC5, while control and BC1, BC3 recorded highest value (1.15±0.005 and1.145±0.002), respectively. Additionally, storage period (90 days) noticed increase value for all cookies, while control and BC2 had highest value in end storage (2.41±0.00 and 2.40 ±0.00). Also, Table (9) displays high significant differences in peroxide values of all cookies in zero-time, control recorded the highest value (12.23±0.01) compared to the others. At the end of storage period (90 days) slightly significant differences between peroxide values, control recorded highest value (14.84±0.09). This might be due to using whole meal flour enriched with polyphenolic compound which concentrate in external coating of cereals.

Peroxide values are used as indicators of rancidity development during storage. The delay in peroxides formation at early months of storage was happen at low environmental temperature as it was at the rainy season. High temperatures accelerate the rate of oxidative rancidity and peroxide formation, also, oils stored at 40 ^{O}C showed higher peroxide values than those stored at 25 ^{O}C (Magda *et al*., 2008). No development of rancidity was observed in cookies made up to 60 days of storage, odor and flavor associated with typical oxidative rancidity are due to carbonyl type compounds (Seevaratnam *et al*., 2012). Peroxide values of fresh oil are often lower 10 milli-equivalent/kg, and if the peroxide value is between 30 and 40 milli-equivalent/kg, a rancid taste is highly noticeable (Chakrabarty, 2003).

Table 9: Changes in fat content indices of cookies during storage

Samples	Acid value (mg KOH/g)		Peroxide value (milli eq. /1000g)	
	Zero t	90 days	Zero t	90 days
Cont.	1.15±0.005**a**	3.675±0.01**a**	12.23±0.01**a**	14.84±0.09 **a**
BC1	1.145±0.002**a**	3.66±0.03**a**	11.03±0.05**de**	14.18±0.04**bc**
BC2	1.14±0.005**a**	3.755±0.03**a**	11.13±0.00**d**	14.36±0.02 **b**
BC3	1.145±0.002**a**	3.565±0.03**ab**	10.71±0.01**f**	14.11±0.01**bc**
BC4	1.14±0.00**a**	3.47±0.02**b**	11.26±0.02**d**	14.23±0.01 **b**
BC5	1.13±0.00**ab**	3.375±0.01**b**	11.33±0.005**d**	14.17±0.02**bc**
OC1	1.135±0.002**ab**	3.55±0.03**ab**	11.63±0.01**b**	14.29±0.02 **b**
OC2	1.135±0.002**ab**	3.6±0.00**ab**	11.56±0.01**b**	13.71±0.02 **d**
OC3	1.14±0.00**a**	3.4±0.00**b**	10.65±0.09**f**	14.16±0.01**bc**
OC4	1.125±0.002**b**	3.375±0.01**b**	11.51±0.01**bc**	14.22±0.005**b**
OC5	1.115±0.002**b**	3.275±0.01**b**	11.66±0.04**b**	14.31±0.01 **b**
$LSD_{0.05}$	**0.013**	**0.076**	**0.147**	**0.142**

Means in the same column with different letters are significantly different ($p\leq 0.05$), each mean value is followed by SE (standard error).

4. Conclusion

This study has revealed that all ratio blends of cookies of acceptable and desirable physical properties and chemical composition comparable to 100% whole wheat flour cookies could be produced from barley or oat –corn and sorghum composite flour. The composite flour cookies could be of health benefits to different consumers.

References

A.A.C.C., 2000.Approved methods of the American Association of Cereal Chemists," in *American Association of Cereal Chemists*, Inc St Paul, Minnesota, USA.

Adebowale, A.A., M.T. Adegoke, S.A. Sanni, M.O. Adegunwa, and G.O. Fetuga, 2012. Functional properties and biscuit making potentials of sorghum–wheat flour composite. American Journal of Food Technology, 7: 372–379. http://dx.doi.org/10.3923/ajft.2012.372.379

Adeyeye, S.A.O., 2016.Assessment of quality and sensory properties of sorghum–wheat flour cookies. Cogent Food & Agriculture, 7:1- 10. http://dx.doi.org/10.1080/23311932.2016.1245059

Ahmad, M., G. Zaffar, Z.A. Dar, and M. Habib, 2014.A review on oat (*Avena sativa* L.) as a dual-purpose crop. Sci. Res. Essays, 9: 52–59.DOI: 10.5897/SRE2014.5820.

Alka, V., P. Boora, and N. Khetarpaul, 2017. Grab a healthy bite: Nutritional evaluation of barley-based cookies, Asian J.Dairy & Food Res, 36 (1): 76-79.DOI:10.18805/ajdfr.v36i01.7464

Amir, B., G. Mueen-ud-din, M. Abrar, S. Mahmood, M. Nadeem, and A. Mehmood, 2015. Chemical composition, rheological properties and cookies making ability of composite flours from maize, sorghum and wheat. Journal of Agroalimentary Processes and Technologies, 21(1): 28-35.

Angelo, A. J. St., 1996. Lipid oxidation in foods Critical Reviews in Food Science and Nutrition, 36 (3): 17-224.

A.O.A.C., 2005.Official Methods of Analysis of the Association of Official Analytical Chemists.18th Edition, Washington DC.

Ayo, J.A., V.A. Ayo, I. Nkama, and R. Adeworie, 2007. Physiochemical, *in vitro* digestibility and organoleptic evaluation of acha-wheat biscuit supplemented with soybean flour. Nigerian Food Journal, 25: 15–17.

Ayo, J.A., and T. Gaffa, 2002. Effect of undefeated soybean flour on the protein content and sensory quality of Kunnu Zaki. Nigerian Food Journal, 20: 7–9.

Barden, L.M., 2014. Understanding lipid oxidation in low-moisture food. PhD Thesis, University of Massachusetts Amherst, 2014.

Chakrabarty, M.M., 2003. Chemistry and Technology of Oils and Fats. Volume I Ist Edition. Allied Publishers India.

Chauhan, A., D.C. Saxena, and S. Sukhcharn, 2016. Physical, textural, and sensory characteristics of wheat and amaranth flour blend cookies. Cogent Food & Agriculture, 2(1): 1125773- 80.

Chavan, J.K., and S.S. Kadam, 1993. Nutritional enrichment of bakery products by supplementation with non-wheat flours.Critical Reviews in Food Science and Nutrition, 33: 189–226.

Daryanto, S., L. Wang, and P.A. Jacinthe, 2016. Global Synthesis of Drought Effects on Maize and Wheat Production. PLOSONE, 11(5): 1–15. DOI: 10.1371/journal.pone.0156362.

Das, A., U. Raychaudhuri, and R. Chakraborty, 2011. Cereal based functional food of Indian subcontinent: a review. J. Food Sci. Tech., 49(6): 665–672. doi:10.1007/s13197-011-0474-1

El-Salhy, M., S.O. Ystad, T. Mazzawi, and D. Gundersen, 2017. Dietary fiber in irritable bowel syndrome (Review).International Journal of Molecular Medicine, 40(3): 607–613.

FDA, Food and Drug Administration, 2003. Food labelling: Health claims; soluble dietary fiber from certain foods and coronary heart disease. Federal Register, 68: 44207–44209.

Fredlund, K., N.-G. Asp, M. Larsson, I. Marklinder, and A.-S. Sandberg, 1997. Phytate Reduction in Whole Grains of Wheat, Rye, Barley and Oats after Hydrothermal Treatment. Journal of Cereal Science, 25: 83–91.

Gaines, C., 1994. Objective assessment of cookie and cracker texture. In H. Faridi (Ed.), The science of cookie and cracker production, 455–495.New York, NY: Chapman and Hall.

Gernah, D.I., I.A. Senger, and J.O. Audu, 2010. Physico-chemical and sensory evaluation of cookies produced from wheat and brewers spent grain composite flour. Nigerian Food Journal, 28: 440–447.

Giwa, E.O. and A.O. Victor, 2010. Quality characteristics of biscuits produced from composite Flours of wheat and quality protein maize. African Journal of Food Science and Technology, 1(5): 116-119.

Gharib, A.G., S.G. Mohseni, M. Mohajer, and M. Gharib, 2006. Bioavailability of essential trace elements in the presence of phytate, fiber and calcium. J. Radioanal. Nucl. Chem., 270: 209-215. Doi: 10.1007/s10967-006-0330-3

Gupta, K.R., S.G. Singh, and N.S. Kumar, 2015.Reduction of phytic acid and enhancement of bioavailable micronutrients in food grains. J. Food Sci. Technol. , 52(2): 676–684.

Hahn, D.H., L.W. Rooney, and Earp, C.F., 1984.Tannins and phenols of sorghum. Cereal foods World, 29(12): 776-779.

Hooda, S. and S. Jood, 2005.Organoleptic and nutritional evaluation of wheat biscuits supplemented with untreated and treated fenugreek flour. Food Chemistry, 90: 427-35.

Huttner, E.K., F.D. Bello, and E.K. Arendt, 2010.Rheological properties and bread making performance of commercial wholegrain oat flours. J. Cereal Sci., 52: 65–71. DOI: 10.1016/j.jcs.2010.03.004.

Kadam, D.M., P. Barnwal, S. Chadha, and K.K. Singh, 2012. Biochemical properties of whole and degermed maize flours during storage. American Journal of Biochemistry, 2(4): 41-46. doi: 10.5923/j.ajb.20120204.01

Kulamarva, A., 2005. Rheological and Thermal Properties of Sorghum Dough. M.S thesis. Department of Bioresource Engineering McGill University Montreal, Canada.

Kumar, P., R.S. Manohar, A.R. Indiramma, and A.G. Krishna, 2014. Stability of oryzanol fortified biscuits on storage. Journal of Food Science and Technology, 51: 2552-2559.

Leung, H.L., 1987. Influence of water activity on chemical reactivity. In: Rockland, L.B. - Beuchat L.B.(Ed.): Water activity: theory and application to food. New York: Marcel Dekker, 27-53.

Li, Y.O. and A.R. Komarek, 2017. Dietary fibre basics: Health, nutrition, analysis, and applications. Food Quality and Safety, 1(1): 47–59.

Liu, L., T.J. Herald, D. Wang, J.D. Wilson, S.R. Bean, and F.M. Aramouni, 2012. Characterization of sorghum grain and evaluation of sorghum flour in a Chinese egg noodle system. Journal of Cereal Science, 55(1):31-36. doi: 10.1016/j.jcs.2011.09.007

Magda, R.A., A.M. Awad, and K.A. Selim, 2008. Evaluation of Mandarin and Navel orange peels as natural sources of antioxidants in biscuit.Journal of Food Science and Technology, (special conference volume):75-82.

Martínez, D.B., M.V.G. Ibáñez, and F.L. Rincón, 2002. Acidofitico: aspectosnutricionales e Implicacion esanaliticas. Arch. Latinoam. Nutr., 52: 219-231.

Marero, L.M., E.M. Payumo, E.C. Librando, W.N. Laine, M.D. Gopez, and S. Homma, 1998. Technology of using food formulations prepared from germinated cereals and legumes. Journal of Food Science, 53: 1391–1395.

Maxwell, S.E., and H.D. Delaney, 1989.Designing experiments and analyzing data. Belmont CA: Wads Worth Publ.Com.

Meilgaard, M.C., G.V. Civile, and B. Thomas Carr, 2007. Sensory evaluation techniques, 4th ed. C.R.C. Press L.L.C., New York, USA.

Mir, N.A., K. Gul, and C.S. Riar, 2015. Techno functional and nutritional characterization of gluten-free cakes prepared from water chestnut flours and hydrocolloids. Journal of Food Processing & Preservation, 39: 978–984.doi:10.1111/jfpp.12311

Mutegi, E., F. Sagnard, M. Muraya, B. Kanyenji, B. Rono, C. Mwongera, C. Marangu, J. Kamau, H. Parzies, S. De- Villiers, K. Semagn, P.S. Traore, and M. Labuschagne, 2010. Ecogeographical distribution of wild, weedy and cultivated Sorghum bicolor (L.) Moench in Kenya: Implications for conservation and crop-to-wild gene flow. Genetic Resources and Crop Evolution, 57: 243–253.doi:10.1007/s10722-009-9466-7

Nelson, T.S., 1967. The utilization of phytate –phosphorus by poultry: a review- poultry sci., 46:862-871.

Okaka, J.C., and M.I. Isieh, 1997. Development and Quality evaluation of Cowpea-wheat biscuit.Nigerian Food Journal, 8: 56–62.

Okpala, L.C. and E.C. Okoli, 2011. Nutritional evaluation of cookies produced from pigeon pea, cocoyam and sorghum flour blends. African Journal of Biotechnology, 10(3): 433-438.

Omara, O.E.A., 2017. Reducing Phytic Acid from Sudanese Sorghum Bicolor (F.G) Using Simple Technique Methods. International Journal of Research Studies in Agricultural Sciences, 3(12): 1-7.

Pena, E., A. Bernardo, C. Solar, and N. Juove, 2006. Do tyrosine crosslinks contribute to the formation of the gluten network in common wheat dough? Journal of Cereal Science, 44(2): 144-153. doi:10.1016/j.jcs.2006.05.003

Pratima, A. and M.C. Yadave, 2000. Effect of incorporation of liquid dairy by-product on chemical characteristic of soy fortified biscuits. Journal of Food Science and Technology, 37: 158-161.

Reddy, N.R., 2001. Occurrence, distribution, content, and dietary intake of phytate. In: Food phytates. CRC Press, Boca Raton, 25–51.

Seevaratnam, V, P. Banumathi, M.R. Premalatha, S.P. Sundaram, and T. Arumugam, 2012. Studies on the preparation of biscuits incorporated with potato flour. World Journal of Dairy and Food Science, 7 (1): 79-84.

Svanberg, U. and W. Lorri, 1997. Fermentation and Nutrition Availability. Food cont., 8:319-327.

Singh, K.P., A. Mishra, and H.N. Mishra, 2012. Fuzzy analysis of sensory attributes of bread prepared from Millet-based composite flours. Journal of Food Science, 48(2): 276-282.doi:10.1016/j.lwt.2012.03.026

Świeca, M., U. Gawlik-Dziki, D. Dziki, and B. Baraniak, 2017. Wheat bread enriched with green coffee – In vitro bio accessibility and bioavailability of phenolics and antioxidant activity. Food Chemistry, 221: 1451-1457.

Tijskens, L.M.M., R. Greiner, E.S.A. Biekman, and U. Konietzny, 2001. Modeling the effect of Temperature and pH on Activity of enzymes: The case of phytases. Biotechnology and Bioengineering, 72(3): 323- 330.

Tosh, S.M., Y. Brummer, T.M.S. Wolever, and P.J. Wood, 2008. Glycemic response to oat bran muffins treated to vary molecular weight of β-glucan. Cereal Chemistry, 85(2): 211–217.

Tuorila, H., 2015. From sensory evaluation to sensory and consumer research of food: An autobiographical perspective. Food Quality and Preference, 40: 255–262.

Ubbor, S.C. and E.N.T. Akobundu, 2009. Quality characteristics of cookies made from composite flours of watermelon seed, cassava and wheat. Pakistan Journal of Nutrition, 8: 1097-1102.

Valencia, S., U. Svanberg, A.S. Sanberg, and J. Ruals, 1999. Processing of quinoa (*Chenopodium quinoa*, Willd).Effects on *in vitro* iron availability and phytate hydrolysis. International Journal of Food Sciences and Nutrition, 50: 203–208.

Vats, P. and U.C. Banerjee, 2004. Production studies and catalytic properties of phytases (myo-inositol hexakisphosphate phosphohydrolases): an overview. Enzyme Microb. Tech.

Vitali, D., I.V. Dragojević, and B. Šebečić, 2009. Effects of incorporation of integral raw materials and dietary fibre on the selected nutritional and functional properties of biscuits. Food Chemistry, 114: 1462–1469.

Vratanina, D.L. and M.E. Zabik, 1978. Dietary fiber sources for baked products: Bran in sugar-snap cookies. Journal of Food Science, 43: 1590-1594.

Wheeler E.L. and R.E. Ferrel, 1971. A method for Phytic Acid Determination in wheat and wheat fractions. Cereal Chemistry, 48: 312-320.

Yao, M.Z., Y.Z. Zhang, W.L. Lu, M.Q. Hu, W. Wang, and A.H. Liang, 2011. Phytases: crystal structures, protein engineering and potential biotechnological applications. J. Appl. Micro., 112:1–14.

Yaseen, A.A., A.A. Shouk, and M.T. Ramadan, 2010. Corn-Wheat Pan Bread Quality as Affected by Hydrocolloids. Journal of American Science, 6(10): 721-727.