EFFECT OF FERMENTATION ON THE CHEMICAL COMPOSITION OF WHEAT (*Triticum aestivum*) AND MAIZE (*Zea mays*) FLOURS AND SENSORY EVALUATION OF BISCUITS MADE FROM THEIR FLOURS

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ABSTRACT
Background: Fermentation improves the nutritional value, acceptability and safety of foods.
Objective: This study assessed the effect of fermentation on the chemical composition of wheat and maize flours and consumer acceptability of biscuits made from their flours.
Methods: Fermentation of wheat and maize: Wheat and maize grains were sorted respectively and were divided into five parts of 200g each. They were labelled as W_0,W_1,W_2,W_3 and W_4 for wheat and M_0,M_1,M_2,M_3 and M_4 for maize samples. Each sample was washed with tap water three times. W_0 and M_0 were not fermented while W_1,W_2,W_3 and W_4 and M_1,M_2,M_3 and M_4 were soaked in 500mls of water in a bowl and were fermented for 24 hours, 48 hours, 72 hours and 96 hours respectively. The flour of each sample was used for baking biscuits. Proximate, mineral and vitamin content of the flour samples and the sensory properties of the biscuits produced from their flour were evaluated using standard analytical methods. One way analysis of variance and Duncan's multiple range test were used to separate the means among the samples.
Result: The highest ash (2.14%), crude fibre (2.03%) and fat (4.24%) values were observed in sample M_0. Sample M_4, W_4 and W_0 had the highest moisture (9.67%), protein (11.62%) and carbohydrate (77.89%) values respectively. Sample M_0 had the highest magnesium (35.62mg), potassium (162.59mg) and sodium (13.79mg) values, M_1 had the highest iron (0.76mg) content while the highest calcium (18.77mg) zinc (0.75mg) and phosphorus (132.59mg) values were observed in sample W_0. The highest vitamin B_1 (0.59mg), vitamin B_3 (0.24mg), vitamin A (18.76µg) and folic acid (41.64mg) were observed in sample M_0 while the highest vitamin B_2 (0.04mg) value was found in both sample M_0 and sample M_1. Sample W_0 had the highest vitamin C (6.36mg) and vitamin B_6(1.87mg) content. There was no significant($p>0.05$) difference in the acceptability of the biscuit samples. However, the taste, aroma, texture and general acceptability of the biscuits produced from all the samples had appreciable ratings.
Conclusion: Fermentation improved the nutritional quality of cereals while biscuits produced from fermented cereals were generally acceptable.
Key words: Wheat, Maize, Fermentation, Biscuit.

INTRODUCTION

Cereal grains are the edible seeds of plants which belong to the monocotyledonous grass family*Poaceae*also referred to as *Gramineae* (1).The history of the use of cereals for food by human dates back to about 100 BC (2). Cereals are the staple foods of many people both in the developed and developing countries (3) and represent around 73% of the total world plant produce that is harvested annually (4). The major cereals consumed in Nigeria include maize, millet, sorghum, fonio, wheat and oat.Food products obtained from cereals include breakfast cereals, noodles, pasta, tortillas, beer, wine, bread and biscuits (5).

Cereal grains are significant sources of nutrients such as carbohydrates, proteins, vitamins and minerals as well as non-nutrients such as dietary fibre (6). They are also important sources of phytochemicals such ascarotenoids, tocophenols, flavonoids and tocotrienols (7).In addition to their nutrient content, cereals are beneficial in the maintenance of health and prevention of diseases such as cardiovascular diseases (8) and type 2 diabetes mellitus (9). These protective roles of cereals are however, linked to the colonic fermentation of their dietary fibre content.

Fermentation is among the oldest methods of processing food. It is a process by which chemical compounds are broken down by bacteria yeast or other microorganisms with the release of heat and production of effervescence. Fermentation improves the digestibility and breakdown of oligosaccharides and dietary fibre. It enhances the nutritional value, acceptability (11) and safety of foods (12). Fermentation also reduces the activity of antinutrients such as tannins, phytate and oxalate (10).

Major cereal products obtained by fermentation in Nigeria includebread, pap,alcoholic beverages such as beer, vodka and whiskey(13).Previous studies have explored the nutrients and probiotic microorganism associated with fermented foods (2; 4 and 6). However, there is paucity of data on the effect of fermentation on the nutrient composition and consumer acceptability of biscuit.

The general objective of this study was therefore, to evaluate the effect of fermentation on the chemical composition of wheat and maize flour and sensory evaluation of biscuits made from their flour. Specifically, this study examined the proximate, mineral and vitamin composition of wheat and maize flour before and after fermentation and evaluation ofthe sensory properties of biscuits produced from wheat and maize flour before and after fermentation

Materials and Methods

The wheat and maize grains as well as the ingredients used in producing biscuit such as granulated sugar, margarine, baking powder, milk powder and egg were purchased from Eke UkwuOwerri market in Owerri Imo State, Nigeria.

Fermentation of wheat and maize

Wheat and maize grains were sorted respectively and were divided into five parts of 200g each. They were labelled as W_0,W_1,W_2,W_3 and W_4 for wheat and M_0,M_1,M_2,M_3 and M_4 for maize samples. Each sample was washed with tap water three times. W_0 and M_0 were not fermented while W_1,W_2,W_3 and W_4 and M_1,M_2,M_3 and M_4 were soaked in 500mls of water in a bowl and were fermented for 24 hours, 48 hours, 72 hours and 96 hours respectively. The water in each sample was changed after each 24 hours.

Preparation of wheat and maize flours

At the end of fermentation, the wheat and maize samples were oven dried at 80^0C for 5 hour and milled into fine flour using still disc mill(model -2A milling machine) to pass through 250µm sieve. The flour samples were then stored in air tight containers for use.

Recipe for the preparation of Biscuits

The preparation of the biscuit was carried out using the rubbing in method according to Pickett(14) with slight modifications. The ingredients used for biscuit making were 250g flour (1 cup), 50g margarine, 2 table spoons of sugar, 1 medium sized egg, 1 teaspoon of baking powder, ½ teaspoon of salt and ¼cup of milk.

- Flour and margarine were thoroughly mixed together in a large bowl. Sugar and baking powder and salt were added into the mixture and were thoroughly mixed together. Thereafter, egg and milk were added and mixed together.
- The dough was kneaded on a surface that has been floured lightly to about 0.5cm tick, cut into rectangular shapes using cookie cutter and placed on a greased baking pan.
- The biscuit was baked in the oven at150^0C for approximately 15 minutes or till the biscuits turned golden brown. The biscuits were cooled on the tray and stored in tightly covered containers.

Chemical Analysis

The moisture, protein, fat ash and crude fibre contents of the flour samples were determined according to the official method of analysis described by the association of official and analytical chemist (15).The kjeldahl method was used to determine the protein content (15), fat was determined by the Soxhlet extraction method (15), moisture was determined using hot air oven method (15). Ash was determined by weighing 1g of each sample into a tarred porcelain crucible. It was incinerated at 600^0C for six hours in an ashing muffle furnace until ash was obtained (15). The carbohydrate content was determined by difference. The minerals phosphorous, calcium, magnesium, iron, and zinc were determined using Atomic Absorption Spectrophotometer described by Ranjiham and Gopa (16). Potassium and sodium were determined using flame photometer, the vitamins were determined using AOAC (17).

Sensory Evaluation

The sensory characteristics were carried out using one hundred panelists which comprises of both students and staff of the Nutrition and Dietetic Department, Imo State University Owerri, Nigeria. The parameters such as colour, flavour, taste, textureand overall general acceptability of the biscuit samples were analysed using a9 point hedonic scale. Where 9 = extremely liked, 8 = liked very much, 7 = liked moderately, 6 = like much, 5 = neither like nor dislike, 4 = dislike, 3 = dislike moderately, 2 = dislike very much, 1 = disliked extremely. They samples were served simultaneously in clean white plates. Tap water was provided for rinsing of mouth between samples

Statistical Analysis

The data obtained was subjected to analysis of variance (ANOVA) and least significant difference and Duncan's test were used to separate the means among the sample using Statistical Products for Service Solutions (SPSS) version

21.0 **RESULTS**

The proximate composition of the fermented and unfermented wheat and maize flour is presented in table 1. There was significant ($p < 0.05$) drop in the fat and crude fibre content of the samples while moisture content was significantly increased after fermentation in both the wheat and maize samples. The highest ash (2.14%), crude fibre (2.03%) and fat (4.24%) values were observed in sample M_0. Sample M_4, W_4 and W_0had the highest moisture (9.67%), protein (11.62%) and carbohydrate (77.89%) values respectively. Sample W_4 had the lowest ash (1.68%), crude fibre (1.77%) and fat (1.77%) values. Sample M_0had the lowest protein (10.79%) and moisture (5.51%) content while sample M_4 had the lowest carbohydrate (71.19%) content.

Sample (%)	Moisture (%)	Ash (%)	Crude Fibre (%)	Fat (%)	Protein (%)	Carbohydrate (%)
W_0	[illegible]$^{b}\pm0.11$	$1.93^{f}\pm0.01$	$1.89^{g}\pm0.02$	$1.87^{d}\pm0.01$	$10.87^{a}\pm0.04$	$77.89^{a}\pm0.01$
W_1	$6.20^{c}\pm0.02$	$1.83^{d}\pm0.01$	$1.87^{e}\pm0.01$	$1.86^{e}\pm0.01$	$11.26^{a}\pm0.04$	$77.09^{a}\pm0.01$
W_2	$6.22^{d}\pm0.02$	$1.77^{c}\pm0.01$	$1.84^{d}\pm0.02$	$1.85^{c}\pm0.01$	$11.39^{a}\pm0.07$	$77.05^{a}\pm0.01$
W_3	$7.71^{c}\pm0.15$	$1.75^{b}\pm0.04$	$1.81^{b}\pm0.01$	$1.81^{b}\pm0.01$	$11.50^{a}\pm0.14$	$75.74^{a}\pm0.01$
W_4	$7.87^{f}\pm0.03$	$1.68^{a}\pm0.01$	$1.77^{a}\pm0.01$	$1.77^{a}\pm0.07$	$11.62^{a}\pm0.24$	$75.22^{a}\pm0.06$
M_0	$5.51^{a}\pm0.12$	$2.14^{j}\pm0.01$	$2.03^{j}\pm0.01$	$4.24^{j}\pm0.01$	$10.79^{a}\pm0.01$	$75.79^{a}\pm0.02$
M_1	$7.71^{c}\pm0.12$	$2.11^{i}\pm0.05$	$1.93^{i}\pm0.02$	$4.19^{i}\pm0.01$	$10.87^{a}\pm0.09$	$73.52^{a}\pm0.02$
M_2	$8.46^{g}\pm0.37$	$2.07^{h}\pm0.01$	$1.91^{h}\pm0.01$	$3.90^{h}\pm0.05$	$10.85^{a}\pm0.09$	$72.66^{a}\pm0.26$
M_3	$8.56^{h}\pm0.19$	$1.95^{g}\pm0.01$	$1.88^{f}\pm0.02$	$3.89^{g}\pm0.01$	$11.32^{a}\pm0.10$	$72.43^{a}\pm0.02$
M_4	$9.67^{i}\pm0.04$	$1.88^{e}\pm0.01$	$1.82^{c}\pm0.11$	$3.52^{f}\pm0.11$	$11.46^{a}\pm0.04$	$71.19^{a}\pm0.01$

Table 1: Proximate composition of unfermented and fermented wheat and maize samples

Values are means ± standard deviation of the triplicate determinations. Means with same superscript within the same column are not significantly different ($p>0.05$) while different superscript within the same column are significantly different ($p\leq0.05$).

Key:

W_0=0hrs of wheat fermentation — M_0 =0hrs of maize fermentation
W1=24hrs of wheat fermentation — M_1=24hrs of maize fermentation
W2=48hrs of wheat fermentation — M_2=48hrs of maize fermentation
W3=72hrs of wheat fermentation — M_3= 78hrs of maize fermentation
W4=96hr of wheat fermentation — M_4= 96hrs of maize fermentation

Table 2 shows the mineral content of the fermented and unfermented wheat and maize samples. There was no significant ($p>0.05$) difference among the samples. Sample M_0 had the highest magnesium (35.62mg), potassium (162.59mg) and sodium (13.79mg)values, M_1 had the highest iron (0.76mg) contentwhilethe highest calcium (18.77mg) zinc (0.75mg) and phosphorus (132.59mg) values were observed in sample W_0.The lowest calcium (11.29mg), zinc (0.48mg) and phosphorus (124.52mg) content were observed in sample M_4. The lowest sodium (8.44mg) value was observed in both W_4 and W_3. SampleW_4had the lowest magnesium (28.50mg) and potassium (148.15mg) values while W3 had the lowest iron (0.49mg) content.

Table 2: Mineral content of unfermented and fermented wheat and maize samples

Sample	Calcium (mg/100g)	Magnesium (mg/100g)	Iron (mg/100g)	Potassium (mg/100g)	Sodium (mg/100g)	Zinc (mg/100g)	Phosphorus (mg/100g)
W_0	$18.77^{a}\pm0.01$	$31.71^{a}\pm0.12$	$0.59^{a}\pm0.01$	$154.87^{a}\pm0.04$	$9.57^{a}\pm0.04$	$0.75^{a}\pm0.01$	$132.59^{a}\pm0.01$
W_1	$17.43^{a}\pm0.01$	$32.62^{a}\pm0.24$	$0.52^{a}\pm0.01$	$154.83^{a}\pm0.09$	$9.81^{a}\pm0.04$	$0.71^{a}\pm0.01$	$130.59^{a}\pm0.01$
W_2	$16.26^{a}\pm0.02$	$32.47^{a}\pm0.38$	$0.51^{a}\pm0.02$	$152.51^{a}\pm026$	$9.51^{a}\pm0.12$	$0.62^{a}\pm0.01$	$128.67^{a}\pm0.09$
W_3	$16.23^{a}\pm0.04$	$28.72^{a}\pm1.24$	$0.49^{g}\pm0.01$	$150.78^{a}\pm0.02$	$8.84^{a}\pm0.08$	$0.58^{a}\pm0.01$	$126.77^{a}\pm0.03$
W_4	$15.85^{a}\pm0.09$	$28.50^{a}\pm0.36$	$0.53^{a}\pm0.01$	$148.15^{a}\pm1.10$	$8.44^{a}\pm0.21$	$0.54^{a}\pm0.02$	$125.82^{a}\pm0.02$
M_0	$12.34^{a}\pm0.08$	$35.62^{a}\pm0.24$	$0.72^{a}\pm0.01$	$162.59^{a}\pm0.15$	$13.79^{a}\pm0.01$	$0.59^{a}\pm0.01$	$127.64^{a}\pm0.22$
M_1	$12.28^{a}\pm0.16$	$34.29^{a}\pm0.01$	$0.76^{a}\pm0.02$	$161.72^{a}\pm0.16$	$13.32^{a}\pm1.06$	$0.61^{a}\pm0.01$	$127.57^{a}\pm0.01$
M_2	$11.86^{a}\pm0.01$	$33.67^{a}\pm0.04$	$0.68^{a}\pm0.01$	$161.52^{a}\pm0.10$	$12.87^{a}\pm0.04$	$0.54^{a}\pm0.01$	$125.31^{a}\pm0.72$
M_3	$12.13^{a}\pm0.04$	$32.85^{a}\pm0.09$	$0.63^{a}\pm0.02$	$158.77^{a}\pm0.34$	$12.87^{a}\pm0.04$	$0.52^{a}\pm0.02$	$126.79^{a}\pm0.01$
M_4	$11.29^{a}\pm0.01$	$32.77^{a}\pm0.04$	$0.57^{a}\pm0.04$	$156.57^{a}\pm0.38$	$12.48^{a}\pm0..31$	$0.48^{a}\pm0.01$	$124.52^{a}\pm0.25$

Values are means ± standard deviation of triplicate determinations
Means with same superscript within the same column are not significantly different (p>0.05) while different superscript within the same column are significantly different (p≤0.05).

Key:

W_0=0hrs of wheat fermentation	M_0 =0hrs of maize fermentation
W1=24hrs of wheat fermentation	M_1=24hrs of maize fermentation
W2=48hrs of wheat fermentation	M_2=48hrs of maize fermentation
W3=72hrs of wheat fermentation	M_3= 78hrs of maize fermentation
W4=96hr of wheat fermentation	M_4= 96hrs of maize fermentation

Table 3 shows the vitamin content of the fermented and unfermented wheat and maize samples. There was no significant (p>0.05) difference among the samples. The highest vitamin B_1 (0.59mg), vitamin B_3 (0.24mg), vitamin A (18.76μg) and folic acid (41.64mg) were observed in sample M_0 while the highest vitamin B_2 (0.04mg) value was found in both sample M_0 and sample M_1. Sample W_0had the highest vitamin C (6.36mg) and vitamin B_6(1.87mg) content. Sample W_4 had the lowest vitamin B_1 (0.29mg),vitaminB_2 (0.01mg), vitamin A (4.57 μg) and folic acid (28.01mg) while sample M_4 had the lowest vitamin B_3 (0.11mg), vitamin B_6 (0.68mg) and vitamin C (3.18mg).

Table 3: Vitamin content of unfermented and fermented wheat and maize samples

Sample	Vitamin B_1 (mg/100g)	Vitamin B_2 (mg/100g)	Vitamin B_3 (mg/100g)	Vitamin C (mg/100g)	Vitamin A (μg/g)	Vitamin B_6 (mg/100g)	Folic (mg/100g)
W_0	$0.46^a±0.01$	$0.02^a±0.00$	$0.13^a±0.02$	$6.36^a±0.02$	$5.77^a±0.01$	$1.87^a±0.01$	$38.77^a±0.04$
W_1	$0.42^a±0.01$	$0.02^a±0.00$	$0.16^a±0.01$	$6.22^a±0.03$	$5.25^a±0.03$	$1.75^a±0.01$	$38.47^a±0.31$
W_2	$0.38^a±0.02$	$0.02^a±0.00$	$0.14^a±0.01$	$5.47^a±0.01$	$4.71^a±0.01$	$1.67^a±0.00$	$35.61^a±0.26$
W_3	$0.32^a±0.01$	$0.02^a±0.00$	$0.16^a±0.01$	$4.77^a±0.02$	$4.66^a±0.05$	$1.41^a±0.02$	$32.86^a±0.02$
W_4	$0.29^a±0.01$	$0.01^a±0.00$	$0.12^a±0.01$	$4.77^a±0.04$	$4.57^a±0.02$	$1.36^a±0.02$	$28.01^a±0.55$
M_0	$0.59^a±0.01$	$0.04^a±0.00$	$0.24^a±0.01$	$5.87^a±0.03$	18.7a±0.02	$0.85^a±0.01$	$41.64^a±0.01$
M_1	$0.56^a±0.04$	$0.04^a±0.00$	$0.21^a±0.04$	$5.43^a±0.02$	$15.13^a±0.01$	$0.82^a±0.01$	$39.27^a±0.74$
M_2	$0.48^a±0.01$	$0.03^a±0.00$	$0.19^a±0.01$	$4.86^a±0.05$	$13.76^a±0.01$	$0.78^a±0.01$	$38.67^a±0.09$
M_3	$0.45^a±0.02$	$0.03^a±0.00$	$0.14^a±0.01$	$3.34^a±0.07$	$13.22^a±0.02$	$0.74^a±0.01$	$36.52^a±0.33$
M_4	$0.40^a±0.02$	$0.02^a±0.00$	$0.11^a±0.01$	$3.18^a±0.01$	$12.34^a±0.02$	$0.68^a±0.01$	$34.78^a±0.02$

Values are means ± standard deviation of the triplicate determinations.
Means with same superscript within the same column are not significantly different (p>0.05) while different superscript within the same column are significantly different (p≤0.05).

Key:

W_0=0hrs of wheat fermentation	M_0 =0hrs of maize fermentation
W1=24hrs of wheat fermentation	M_1=24hrs of maize fermentation
W2=48hrs of wheat fermentation	M_2=48hrs of maize fermentation
W3=72hrs of wheat fermentation	M_3= 78hrs of maize fermentation
W4=96hr of wheat fermentation	M_4= 96hrs of maize fermentation

Table 4 shows the sensory properties of the biscuits. There was no significant(p>0.05) difference in thesensory properties of the biscuit samples. The highest taste (7.84), aroma (8.03), texture (7.82), colour (7.97) and general acceptability (8.08) were observed in sample W_0. Sample M_2had the lowest taste (6.15) and colour (6.62) values. The lowest aroma (6.06) was observed in both sample W_2 and W_3. The lowest texture (6.35) value was observed in sample W_1 while the lowest general acceptability (7.14) value was observed in both sample W_2 and M_2.

Table 4: Sensory attributes of unfermented and fermented biscuits samples

Sample	Taste	Aroma	Texture	Colour	General acceptability
W_0	$7.84^a \pm 0.05$	$8.03^a \pm 0.01$	$7.82^a \pm 0.02$	$7.97^a \pm 0.01$	$8.08^a \pm 0.01$
W_1	$6.64^e \pm 0.02$	$6.14^a \pm 0.01$	$6.35^a \pm 0.02$	$6.93^a \pm 0.04$	$7.39^a \pm 0.02$
W_2	$7.24^a \pm 0.01$	$6.06^a \pm 0.03$	$6.88^a \pm 0.02$	$6.67^a \pm 0.04$	$7.14^a \pm 0.02$
W_3	$7.00^a \pm 0.01$	$6.06^a \pm 0.03$	$6.80^a \pm 0.01$	$6.82^a \pm 0.01$	$7.63^a \pm 0.03$
W_4	$6.65^a \pm 0.01$	$6.14^a \pm 0.02$	$6.83^a \pm 0.01$	$7.12^a \pm 0.01$	$7.28^a \pm 0.07$
M_0	$7.64^a \pm 0.01$	$7.14^a \pm 0.01$	$6.92^a \pm 0.01$	$7.83^a \pm 0.02$	$7.94^a \pm 0.01$
M_1	$6.64^a \pm 0.01$	$6.62^a \pm 0.02$	$6.64^a \pm 0.01$	$7.36^a \pm 0.02$	$7.53^a \pm 0.02$
M_2	$6.15^a \pm 0.03$	$7.62^a \pm 0.01$	$6.93^a \pm 0.02$	$6.62^a \pm 0.03$	$7.14^a \pm 0.02$
M_3	$6.62^a \pm 0.01$	$6.72^a \pm 0.02$	$7.13^a \pm 0.02$	$6.81^a \pm 0.01$	$7.19^a \pm 0.01$
M_4	$7.27^a \pm 0.04$	$6.74^a \pm 0.03$	$7.65^a \pm 0.01$	$7.65^a \pm 0.02$	$7.84^a \pm 0.05$

Values are means ± standard deviation of the 100 panelists.
Means with same superscript within the same column are not significantly different ($p>0.05$) while different superscript within the same column are significantly different ($p<0.05$).

Key:
W_0=0hrs of wheat fermentation M_0 =0hrs of maize fermentation
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W2=48hrs of wheat fermentation M_2=48hrs of maize fermentation
W3=72hrs of wheat fermentation M_3= 78hrs of maize fermentation
W4=96hr of wheat fermentation M_4= 96hrs of maize fermentation

DISCUSSIONS

In this study, the effect of fermentation on the chemical composition of wheat and maize flours and sensory evaluation of biscuits made from their flour was investigated. There was significant ($p<0.05$)increase in the moisture content of the wheat and maize samples from 5.68% and 5.51% before fermentation to 7.87% and 9.67% after 96 hours of fermentation respectively. This increase in their moisture contentment could be associated with the absorption of water used for fermentation. The marked decrease in the ash content of the samples with fermentation is in agreement with report by Michodjehourn *et al* (18) and also similar observation by Apena (19) reported a reduction in the ash content of maize, sorghum and millet after 72 hours of fermentation. This may be due to the leaching of some of the minerals into the aqueous medium used for the fermentation, which was discarded.

This study observed a reduction in the carbohydrate and crude fibre contents of the cereals after fermentation. This decrease in carbohydrate and crude fibre content of maize and wheat grains after fermentation suggests that they are good substrates for the fermenting microorganisms. It also indicates that fermentation of cereals could be beneficial in managing the symptoms of irritable bowel syndrome (IBS) in individuals whose symptoms of IBS are worsened by consumption of fermentable oligosaccharides, disaccharides, monosaccharides and polyols (FODMAPS) foods (20). The marked reduction in the fat content of the selected cereal samples suggests that fermentation of cereals could be of interest to overweight and obese individuals in weight management.The increased protein content of the cereals after fermentation is similar to the findings of (21) who reported increased protein content in fermented maize flour and (19) who reported increased protein in maize sorghum and millet grains after 72 hours of fermentation. This increase in protein content could be linked with the activities of proteolytic enzymes produced by microorganisms during fermentation (21).

There were insignificant drops in the values of all the micro nutrients investigated in this study after fermentation for 96hours. This is related to the findings of (19). The lowest calcium (11.29mg), zinc (0.48mg) and phosphorus (124.52mg) content were observed in the maize sample after 96 hours of fermentation. The lowest sodium (8.44mg) value was observed in the wheat samples at both 72 hours and 96 hours of fermentation. The lowest magnesium (28.50mg) and potassium (148.15mg) values were observed in the wheat sample after 96 hours of fermentation while the lowest iron (0.49mg) content was observed in wheat sample after 72 hours of fermentation.

This considerable decrease in the values of minerals could be associated with the leaching of these mineral elements into the aqueous medium as the period of fermentation increases. The reduction of the sodium content of the cereals after 96 hours of fermentation suggests that consuming fermented foods could be beneficial in the prevention and management of high blood pressure as salt intake has been shown to be associated with the risk of having high blood pressure and stroke.

All the vitamins investigated in this study were significantly reduced after fermentation for 96hours. This is related to the findings of (18). The lowest vitamin A (4.57μg) vitamin B_1 (0.29mg), vitamin B_2 (0.01mg), and folic acid (28.01m) were observed in the wheat sample after 96 hours of fermentation while the lowest vitamin B_3 (0.11mg) vitamin C (3.18mg) and vitamin B_6 (0.68mg) were observed in the maize sample after 96 hours of fermentation. Like the minerals, the marked reduction in the vitamin content of the wheat and maize samples after 96 hours of fermentation could be related to the leaching of these mineral elements into the aqueous medium as the period of fermentation increases. More so, it could have been utilized by the fermenting microorganisms since an important function of vitamins and minerals is to aid in metabolism (22).

The result of the sensory evaluation indicated that all the samples had appreciable ratings for taste, aroma, texture, colour and general acceptability. However, the unfermented wheat sample had higher preference in all the attributes tested.

Conclusion

The nutritional composition of wheat and maize flours were considerably improved by fermentation in this study. Acceptable biscuits were produced from both the fermented and unfermented wheat and maize flour samples. Fat is an important ingredient used in baking biscuits. It is usually the third largest component after flour and sugar. The fermentation of cereals in a bid to reduce the fat content of flour used for baking biscuit is likely to be beneficial in the maintenance of healthy nutritional status. Therefore, fermentation of cereal grains should be encouraged as a means of improving the nutritional quality of baked products.

REFERENCES

1. Morrice, P.Cannd Bryce, J. H. (2000). *Cereal biotechnology.* Cambridge, United Kingdom. WoodHead.
2. Hammes, W. P., Brandt, M. J., Francis, K. L., Rosenheim, J., Seitter, M. F. H., andVogelmann, S. A. (2005). Microbial ecology of cereal fermentations. *Trends in Food Science & Technology, 16*(1–3), 4-11. Retrieved from http://dx.doi.org/10.1016/j.tifs.2004.02.010
3. Topping, D. (2007). Cereal complex carbohydrates and their contribution to human health. J. cereal Sci. 46:220- 29.
4. Charalampopoulos, D., Pandiella, S., and Webb, C. (2002). Growth studies of potentially probiotic lactic acid bacteria in cereal-based substrates. *Journal of Applied Microbiology, 92*(5), 851-859. doi: 10.1046/j.1365-2672.2002.01592.x
5. Swanson, K. M. (2011). Cereals and Cereal Products. *Microorganisms in Foods 8* (pp. 209-225): Springer. Retrieved from http://link.springer.com/chapter/10.1007/978-1-4419-9374-8_15#page-1
6. Katina, K., Arendt, E., Liukkonen, K. H., Autio, K., Flander, L., and Poutanen, K. (2005). Potential of sourdough for healthier cereal products. *Trends in Food Science & Technology,* 16(1–3), 104-112. http://dx.doi.org/10.1016/j.tifs.2004.03.008
7. McKevith, B. (2004). Nutritional aspects of cereals. *Nutrition Bulletin,* 29(2), 111-142. doi: 10.1111/j.1467-3010.2004.00418.x
8. Flight, I., and Clifton, P. (2006). Cereal grains and legumes in the prevention of coronary heart disease and stroke: a review of the literature. European Journal of Clinical Nutrition, 60(10), 1145-1159. Retrieved from http://www.nature.com/ejcn/journal/v60/n10/pdf/1602435a.pdf
9. Venn, B., and Mann, J. (2004). Cereal grains, legumes and diabetes. European Journal of Clinical Nutrition, 58(11), 1443-1461. doi:10.1038/sj.ejcn.1601995
10. Kalui, C. M., Mathara, J. M., and Kutima, P. M. (2010). Probiotic potential of spontaneously fermented cereal based foods–A review. *African Journal of Biotechnology,* 9(17), 2490-2498.
11. Kulp, K., and Ponte Jr, J. G. (2000). Handbook of cereal science and technology (Vol. 99): CRC Press. Retrieved from http://books.google.co.uk/books?hl=en&lr=&id=gtqEWcA73BEC&oi=fnd&pg=PR7&dq=Handbook+of+cereal+science+and+technology&ots=HxEghzPDwf&sig=DsOrRyOK3a-q3vRx5v9X3fUQw-A#v=onepage&q=Handbook%20of%20cereal%20science%20and%20technology&f=false
12. Dyson, S. and Mcshane, R. (2009). Fermented foods: The benefits and necessity of fermenting as a process. Retrieved from http://www.foodtourist.com/ftguide/Content/I4777.htm
13. Maraz, A. (2011). Food fermentationsby yeasts and filamentous fungi. Retrieved from http://www.mf.uni-mb.si/mf/instituti/IPweb/html/Food_fermentations_yeasts-Maraz.pdf
14. Pickett, J. (2015). Basic Biscuits. Retrieved fromhttp:/www. allrecipes.com/recipe/basicb-biscuits
15. Association of Analytical Chemists Chemists (AOAC) (2004). Official methods of analysis of the AOAC International. 15th Ed D.C, U.S.A.
16. Ranjiham, S.K., and Gopal, K. (1980). Wet chemical digestion of biological materials for mineral analysis, in laboratory manual for nutrition research. Official Methods of Analytical Chemist Vikas publication house, PVT limited, New Delhi India.
17. Association of Analytical Chemists Chemists (AOAC) (2005). Official methods

of analysis of the AOAC International, 17th Ed. Washington D.C, U.S.A.

18. Michodjehoun, L., Hounhouigan, J.D. Dossou, J. and Christian, M. (2005). Physical, chemical and microbiological changes during natural fermentation of "gowe" a sprouted or non-sprouted Sorghum beverage from West Africa. *African Journal of Biotechnology* 4(6): 487-496

19. Apena, A., Opeolu, S.O., Bamidele, F. A. and Shittu, A. (2015). Nutrient changes during fermentation of some selected cereals. Sky Journal of Biochemistry Research 4(2): 10-12

20. Lee, Y.K., Salminen, S. (2009). *Handbook of probiotics and prebiotics*. (2nd ed.). New Jersey, United States of America. Wiley

21. Amankwah, E.A., Barimah, J., Acheampong, R., Addai, L.O. and Nnaji, C.O. (2009). Effect of fermentation and malting on the viscosity of maize-soyabean weaning blends. *Pakistan Journal of Nutrition* 8(10): 1671-1675

22. Igbabul, B. D., Bello, F. A. and Ani, E. C. (2014). Effect of fermentation on the proximate composition and functional properties of defatted coconut (*Cocos nucifera L.)* flour. Sky Journal of Food Science 3(5): 034 - 040