

Available online at [GSC Online Press Directory](https://www.gsconlinepress.com/)

GSC Biological and Pharmaceutical Sciences

e-ISSN: 2581-3250, CODEN (USA): GBPSC2

Journal homepage: <https://www.gsconlinepress.com/journals/gscbps>

(RESEARCH ARTICLE)



Maize cob as dietary fiber source for high-fiber biscuit

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Publication history: Received on 24 June 2020; revised on 10 July 2020; accepted on 13 July 2020

Article DOI: <https://doi.org/10.30574/gscbps.2020.12.1.0203>

Abstract

The potential use of maize cob as source of dietary fiber, for high-fiber biscuits was investigated in this work. Dry maize cob was boiled, meshed, dried, milled and sieved to obtain the soft fraction of maize cob (SFMC) which was incorporated into a master mix of biscuit at 50 g, 100 g and 150 g to produce high-fiber biscuit samples B, C and D respectively. Sample A served as control which contained no maize cob fiber. The maize cob was analyzed for proximate composition, dietary fiber and antinutritional contents while the biscuits samples were analyzed for Total carbohydrate and mineral (Mg, Zn, Fe, Ca, P) contents. The biscuits samples were subjected to sensory evaluation with another set (E, F G) that contained the same levels of wheat bran incorporation. Results showed that the maize cob contained 2.79 %, 78.53 % and 81.32 %, of soluble, insoluble and total dietary fiber respectively. It contained 0.59 % protein, 1.83 % fat and less than 1 mg/100 g of all the anti-nutrients analyzed except saponins (2.23 mg/100 g). The maize cob caused significant reduction in total carbohydrate and in all the minerals analyzed as well as significant increase in soluble, insoluble and total dietary fibers among the biscuit samples. The sensory result showed that the biscuits containing maize cob were preferred in colour but were the same in flavor and crispness when compared with that containing wheat bran.

Keywords: Maize cob; Dietary fiber; Biscuits

1. Introduction

Chronic diseases have been on the increase in different parts of the world [1, 2, 3] and research findings have shown that glycemic index of foods remains a potential important factor in the treatment and prevention of chronic diseases [4, 5, 6].

On the basis of glycemic index (GI) which is a physiological assessment of the available carbohydrate content of a food and its effect on postprandial glycemia [7]; carbohydrate-based foods have been classified into high GI (> 70), medium GI (56-69), low GI (20-55) and free foods (< 20) [8]. High GI foods have been associated with higher risk of chronic diseases [9, 10] and over the years efforts in lowering the GI value of foods have centered more on increment of fiber content of foods [11, 12, 13, 14]. This could be attributed to the effect of dietary fiber in reducing postprandial blood glucose and pre-prandial cholesterol [15, 16] as well as maintaining healthy digestive system by improving bowel function, preventing constipation, stimulating colonic fermentation and increasing fecal bulk [12, 13].

Cho and Prosky [17] and Nelson [18] have shown that among the fiber enriched foods, breakfast cereal and cookies are the commonest and most consumed foods. Biscuit on the other hand, is a common snack among all ages. It is relatively cheap, nutritious and shelf stable. The glycemic Index of biscuit depends on its ingredients [19] and being a common snack, effort in reducing its glycemic index has resulted to various high-fiber biscuits which are available on market shelves today.

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The major sources of dietary fiber for food industrials are usually wheat bran, rice bran, corn bran, soy and oat dietary fiber and powdered cellulose [14, 20] with no importance given to other potential sources. However, Katz [21] has shown that dietary fiber can be sourced from materials (wheat straw, oat hull, corn stalk and cob, spent brewer's grain and waste portions of fruits and vegetables) otherwise considered as waste products. These novel sources of dietary fiber have been shown to offer new opportunities and applications in food industries [22].

Maize cob is a waste generated from maize processing which has little or no end use other than fuel in most parts of the world. It is a lignocelluloses biomass containing a total dietary fiber content of 90g/100g d.m; made up of cellulose (45 %-55 %), hemicelluloses (25 %-35 %), and lignin (20 %-30 %) as affected by stage of maturity, cultivar, soil and method of production [23, 24]. About 50 % of hemicelluloses contained in maize cob has been shown to be xylan which has unique hydrophilic and hydrophobic interactions and together with cellulose impute considerable water-holding properties resulting to bulking of digesta when consumed [25, 26].

Little or no information is available on the incorporation of maize cob in human diet. However, when incorporated into animal feed, had similar effects with those of wheat bran, lupin hull and lucerne stems on feed intake, nutrient digestibility, viscosity of intestinal digesta, gut fermentation and metabolism and visceral organs [25, 26].

Maize cob when ground separate into hard or woody and soft fractions. The soft fraction consists of glumes, cores, grain clippings and fine dust. Use of the soft fraction of maize cob which seems to meet all the criteria needed for dietary fiber (colour, dietary fiber content, cost and water absorption) stipulated by Kurek and Wyrwicz [20] poses a potential dietary fiber source for bakery products.

In this work therefore, the performance of maize cob (soft fraction) as dietary fiber source for the production of high fiber biscuit was evaluated. The success of this work will not only provide another ready source of dietary fiber for biscuits and other foods but will go a long way in adding economic value to maize cob which has remained a waste product in many parts of the world.

2. Material and methods

2.1. Source of raw materials

The materials used in this work were purchased from Owerri main market and the production and analysis of the maize cob (soft fraction) and the high-fiber biscuits samples were carried out in the Department of Food Science and Technology, FUT, Owerri and FAB Ama Laboratory, Enugu, all in Nigeria.

2.2. Production of Soft Fraction of Maize Cob (SFMC)

Maize Cob used was dry Zea mays variety which was boiled (30 mins), meshed, oven-dried, milled and sieved using 70 µm mesh size to obtain the soft fraction of maize cob.

2.3. Production of High Fiber Biscuit Samples

The dry ingredients as indicated on Table 1 (flour, with or without maize cob, sugar, baking powder, salt) were mixed together separately to form mixture 'A' while the other ingredients (milk, egg, vanilla, butter) were also mixed together to form mixture 'B'. Mixture 'B' was poured into mixture 'A' and all mixed together to form the dough which was kneaded to a smooth dough, flattened into 2 mm thickness, cut into shape using biscuit cutter and baked at 350 °F for 8 minutes to produce the high-fiber biscuits samples B (containing 50 g maize cob), C (containing 100 g of maize cob), D (containing 150 g of maize cob) and sample A (without maize cob).

Another set of high-fiber biscuits E (containing 50 g wheat bran), F (containing 100 g of wheat bran) and G (containing 150 g of wheat bran) containing wheat bran in place of maize cob were produced using the same composition of ingredients and method. This set of high-fiber biscuits E, F and G were used to compare with those containing maize cob (B, C, D) in sensory evaluation.

Table 1 Composition of the high-fiber biscuit samples

| Sample | Wheat Flour (g) | Maize Cob (g) | Wheat Bran (g) | Butter (g) | Sugar (g) | Milk (g) | Whole Egg (g) | Vanilla Flavor (ml) | Baking powder (g) | Salt (g) |
|--------|-----------------|---------------|----------------|------------|-----------|----------|---------------|---------------------|-------------------|----------|
| A | 500 | - | - | 250 | 125 | 100 | 40 | 2.5 | 20 | 1.5 |
| B | 500 | 50 | - | 250 | 125 | 100 | 40 | 2.5 | 20 | 1.5 |
| C | 500 | 100 | - | 250 | 125 | 100 | 40 | 2.5 | 20 | 1.5 |
| D | 500 | 150 | - | 250 | 125 | 100 | 40 | 2.5 | 20 | 1.5 |

2.4. Analysis Carried Out

The soft fraction of maize cob (SFMC) used was analyzed for proximate composition, dietary fiber and anti-nutritional factors while the biscuit samples were analyzed for total carbohydrate, dietary fiber and mineral contents. The biscuits samples were also subjected to sensory evaluation using a twenty semi-trained panelists who were asked to compare the high-fiber biscuit samples B, C and D (containing maize cob) with the set of high-fiber biscuits E, F and G containing 50 %, 100 % and 150 % of wheat bran in place of maize cob. The parameters compared were colour, crispness, taste, flavor, mouth-feel and after taste perception using a 9-point hedonic scale with 9 as liked extremely and 1 as disliked extremely.

2.4.1. Total carbohydrate content (CHO)

Total carbohydrate contents of the high-fiber biscuit samples B, C and D were determined using anthrone reagent method as described by Adeyeye [27].

2.4.2. Total Dietary Fiber (TDF)

Soluble Dietary Fiber (SDF) and Insoluble Dietary Fiber (IDF): These were determined using Enzymatic-Gravimetric method in line with the standard recommended by FAO/WHO [28].

2.4.3. Mineral Contents

The official method of AOAC [27] was adopted for the analysis of magnesium, zinc, iron, calcium and phosphorus contents of the high-fiber biscuit samples B, C and D.

2.4.4. Anti-nutritional Components

The anti-nutritional components of the soft fraction of the maize cob and the high-fiber biscuit samples (oxalates, tannins, phytates, trypsin inhibitor and cyanogenic glucoside) were determined as described by Munro [29], Jaffe [30], Russell [31], Griffiths [32] and Railes [33] respectively.

3. Results and discussion

The results of the analysis of the soft fraction of the maize cob (used in the production of the high-fiber biscuits samples) and the high-fiber biscuit samples B, C and D are shown in the tables below.

The proximate composition of the soft fraction of the maize cob is shown in Table 2. The soft fraction of the maize cob contained 81.32 % dietary fiber but very low percentages of protein, fat and carbohydrate thus proofing it a good dietary fiber source as suggested by Aniola [34] who also showed that maize cob has lower levels of heavy metal (mercury, lead, cadmium) contaminations when compared with wheat bran, apple and raspberry pulp. However, the variation of the result obtained in this work to that (TDF 89.9 %, protein 2.85 %, fat 0.59 %, ash 1.50 %) reported by Aniola [34] could be attributed to the portion of the maize cob that was sieved out (hard fraction), effects caused by variation in soil and environment, variety of the maize cob as well as stage of maturity when harvested [23, 24].

Table 2 Proximate composition of maize cob (SFMC) (%)

| Parameter | Composition (%) |
|-----------|-----------------|
| Moisture | 4.37±0.43 |
| Protein | 0.59±0.04 |
| Fat | 1.83±0.17 |
| Ash | 5.10±0.08 |
| CHO | 6.78±0.12 |
| TDT | 81.32±0.12 |

The result of the dietary fiber contents of the maize cob (SFMC) is shown in Table 3. The result shows that the soft fraction of the maize cob contains more insoluble dietary fiber than the soluble counterpart hence suggesting it as a good factor for increment of fecal bulk, reduction of intestinal transit time and healthy bowel function [13]. The levels of the anti-nutrients analyzed (Table 4) were all lower than those found in wheat bran, rice bran, barley bran and oat bran which were all sources of dietary fiber used in high-fiber foods today [35].

Table 3 Dietary fiber content of maize cob (SFMC) (g/100g)

| Dietary fiber | Content (g/100g) |
|---------------|------------------|
| TDF | 81.24±0.02 |
| SDF | 2.77±0.12 |
| IDF | 78.53±0.47 |
| Lignin | 7.05±0.02 |
| Hemicellulose | 40.71±0.21 |
| Cellulose | 26.96±0.18 |

Table 4 Anti-nutritional components of maize cob (SFMC) (mg/100g)

| Components | Content (mg/100g) |
|-------------------|-------------------|
| Oxalate | 0.03±0.01 |
| Phytate | 0.80±0.02 |
| Tannins | 0.03±0.01 |
| Saponins | 2.23±0.07 |
| Alkaloids | 0.04±0.01 |
| Trypsin inhibitor | 0.24±0.03 |
| HCN | 0.06±0.02 |

Table 5 shows the results of the carbohydrate and dietary fiber contents of the high-fiber biscuit samples B, C and D. Sample A which was the control sample that contained no maize cob fiber had the highest value of carbohydrate content and the lowest values of SDF, IDF and TDF. The high-fiber biscuits; B (5 % of maize cob fiber), C (10 % of maize cob fiber) and D (15 % of maize cob fiber) showed increase in SDF, IDF, TDF contents and decrease in carbohydrate content as level of maize cob incorporation increases indicating replacement of carbohydrate by the maize cob fiber thus suggesting maize cob as a potential source of dietary fiber. However, the results of the mineral contents of the high-fiber biscuits (B, C and D) when compared with the control sample (A) showed reduction in all the minerals (Mg, Zn, Fe, Ca and P) analyzed. This could be attributed to the diluting effect of the maize cob fiber which has been shown to contain low levels of these minerals [36, 37].

Table 5 CHO/Dietary fiber contents of the high-fiber biscuit samples

| Samples | CHO | SDF g/100g | IDF | TDF |
|------------|-------------|-------------|-------------|-------------|
| A | 78.55±0.52a | 0.60±0.04d | 5.92±0.22d | 6.52±0.30d |
| B | 68.96±0.83b | 0.98±0.02c | 14.86±0.28c | 15.84±0.27c |
| C | 66.79±0.49c | 1.85±0.09b | 16.41±0.77b | 18.26±0.75b |
| D | 61.81±1.16d | 2.18±0.16a | 19.37±0.77a | 21.55±0.92a |
| LSD | 1.5 | 0.18 | 1.08 | 1.16 |

($p > 0.05$). A= Control Sample without maize cob, B= Sample with 50g maize cob, C= Sample with 100g maize cob, D=Sample with 150g maize cob, LSD = Least Significant Difference. Samples in the same column with the same superscripts are not significantly different while those with different superscripts are significantly different.

Table 6 Mineral contents of the high-fiber biscuit samples

| Samples | Mg | Zn Mg/100g | Fe | Ca | P |
|------------|--------------|-------------|-------------|-------------|--------------|
| A | 102.44±1.69a | 5.51±0.51a | 4.62±0.13a | 47.39±1.32a | 290.98±3.65a |
| B | 90.56±0.56b | 4.34±0.24b | 3.88±0.06b | 38.52±1.29b | 248.19±3.45b |
| C | 85.45±0.43c | 3.88±0.12bc | 3.56±0.06c | 32.06±0.58c | 238.76±1.23c |
| D | 78.52±0.52d | 3.52±0.15c | 3.23±0.09d | 28.38±0.38d | 232.89±1.20d |
| LSD | 1.81 | 0.55 | 0.17 | 1.85 | 5.00 |

($p > 0.05$). A= Control Sample without maize cob, B= Sample with 50g maize cob, C= Sample with 100g maize cob, D=Sample with 150g maize cob, LSD = Least Significant Difference. Samples in the same column with the same superscripts are not significantly different while those with different superscripts are significantly different.

The sensory evaluation result contained in Table 7 showed that, the high-fiber biscuit samples B, C and D containing maize cob fiber competed favorably with that containing wheat bran. The high-fiber biscuits containing 50 g and 100 g maize cob fiber were preferred to those containing 50 g and 100 g wheat bran in colour. In addition, there was no significant difference in flavor, crispness, mouth-feel and taste between the samples containing 100 g maize cob fiber and that containing 100 g wheat bran. However, the sample that contained 150 g of maize cob was the least preferred in all the parameters evaluated.

Table 7 Sensory scores of the high-fiber biscuit samples

| Sample | Colour | Flavour | Crispness | Mouthfeel | Taste | After Taste Perception |
|------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| A | 7.80±0.95 ^a | 7.50±0.82 ^a | 7.45±1.28 ^{ab} | 7.70±1.03 ^{ab} | 7.60±0.99 ^{ab} | 7.45±1.09 ^{ab} |
| B | 7.30±1.22 ^{ab} | 7.30±0.73 ^{ab} | 6.85±1.18 ^b | 7.30±1.13 ^b | 7.00±1.17 ^b | 6.70±1.30 ^{bc} |
| C | 7.65±0.81 ^a | 6.70±1.12 ^b | 6.65±1.09 ^b | 6.70±1.08 ^{bc} | 6.35±1.18 ^{bc} | 6.15±1.18 ^c |
| D | 6.65±1.31 ^b | 6.30±1.26 ^b | 6.15±1.18 ^b | 6.15±1.22 ^c | 5.90±1.33 ^c | 5.55±1.73 ^c |
| E | 7.20±1.11 ^{ab} | 7.30±1.26 ^{ab} | 8.05±0.89 ^a | 8.10±0.91 ^a | 7.95±0.76 ^a | 7.90±1.02 ^a |
| F | 6.50±1.05 ^b | 6.70±0.86 ^b | 6.65±1.23 ^b | 6.90±1.29 ^b | 6.90±0.79 ^{bc} | 7.10±1.07 ^b |
| G | 6.80±1.15 ^b | 6.60±0.75 ^b | 7.25±0.91 ^b | 6.85±1.04 ^b | 6.25±1.21 ^c | 6.20±1.01 ^c |
| LSD | 0.69 | 0.63 | 0.7 | 0.7 | 0.68 | 0.77 |

($p > 0.05$). A= Control Sample without maize cob or wheat bran, B= Sample with 50g maize cob, C= Sample with 100g maize cob, D=Sample with 150g maize cob, E= Sample with 50g wheat bran, F= Sample with 100g wheat bran and G= Sample with 150g wheat bran, LSD = Least Significant Difference. Samples in the same column with the same superscripts are not significantly different while those with different superscripts are significantly different.

4. Conclusion

Maize cob contains about 81.24 % total dietary fiber. Incorporation of maize cob into a master mix of biscuit resulted to a significant increase in soluble, insoluble and total dietary fiber of the biscuit samples. Biscuit samples containing maize cob fiber competed favourably with that containing wheat bran as source of dietary fiber in sensory assessment. The biscuits containing maize cob fiber were preferred in colour but had the same score with that containing wheat bran in

taste and crispness. However, maize cob fiber caused significant reduction in mineral contents of the biscuits at all levels of incorporation.

Compliance with ethical standards

Acknowledgments

The authors acknowledge the input of the technologists of the Department of Food Science and Technology, Federal University of Technology, Owerri and the technicians of FAB Ama Laboratories, Enugu all in Nigeria who contributed in one way or the other towards the success of this work.

Disclosure of conflict of interest

This work has no conflict of interest.

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How to cite this article

Bede EN, Mmuoasinam BC, Onuegbu NC, Ahaotu NN and Peter-Ikechukwu AI. (2020). Maize cob as dietary fiber source for high-fiber biscuit. GSC Biological and Pharmaceutical Sciences, 12(1), 138-144.
