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Proximate Composition, Protein Digestibility, Starch Digestibility, Physical Properties and Sensory Evaluation of Decorticated Sorghum and Maize Biscuits Supplemented with Chickpea Flour

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A B S T R A C T

The study was conducted to utilized decorticated sorghum and maize (90% extraction) to produce biscuits. Biscuits were formulated and developed by compositing sorghum and maize with chickpea flour at different ratio (10, 20, and 30% level), to establish the nutritional characteristics of biscuits, proximate composition, protein and starch digestibility, physical characteristics, and sensory evaluation of biscuits. The results showed moisture, ash, and fat content ranged between 5.11 to5.58 %, 1.52 to 1.95, and 18.68 to 22.30%, respectively. Therefore, protein, fiber, carbohydrates and energy ranged from 9.90 to 15.50%, 1.14 to 2.03%, 55.61 to 61.29%, and 455.64 to 477.14 kcal/100gm, respectively. Protein digestibility gained from 43.51 to 60.29%, starch digestibility varied from 46.81 to 60.36% and 62.65 to 67.16% for sorghum and maize, respectively. Spread ratio ranged between7.10 to 8.21cm. Hence, sorghum and maize – chickpea flour composite biscuits have a considerable potential as protein-rich supplementary food to alleviate the nutritional value. Its utilization will afford the consumer to have food with high nutritional value.

Introduction

Biscuits are ready-to-eat, cheap and convenient food product that is consumed among all age groups in many countries (Hussein *et al*., 2006; Iwegbue, 2012). Biscuits have been reported to be rich in fat and carbohydrate; hence they can be referred to as energy giving food as well as good sources of protein and minerals (Kure *et al*., 1998). The main ingredient generally used for biscuit production is wheat flour with other ingredients such as margarine (Shortening), sweeteners (sugar), leavening agents, eggs, milk, salt and flavours (Hui, 1992).

In many parts of sub-Saharan Africa and most especially Nigeria, advancing prosperity and urbanization coupled with tremendous increase in population in recent years have led to an increase in the consumption of wheat-based products especially biscuits and breads. However, the production of wheat in Nigeria is extremely low and far below domestic requirements. Compositing wheat flour with locally available cereals and root crops has been reported to be desirable (Oyarekua *et al*., 2009). It also encourages the agricultural sector and reduces wheat imports in many developing countries. Considerable efforts have been focused on the use of composite flour for bread and baked products in many wheat importing countries within the last two and half decades (Mohammed *et al*., 2011) Sorghum is one of the crops grown in many African countries primarily as food crop with less than 5% of the annual production commercially processed by the industry (Bohoua *et al*., 2007; Cheng *et al*., 2009; Rohrbach *et al*., 2001; Nidaye *et al*., 2008). Sorghum grain ranks third among the domesticated cereals for human consumption and is a staple food in many African countries, India and China (Elkhalifa *et al*., 2002; Awadalkareem *et al*., 2008; Atwater *et al*., 1902).

Materials and Methods

Samples Preparation

Sorghum, maize and chickpea samples were cleaned from dust, husk, and other impurities, then sorghum and maize decorticated to 90%, then all samples milled using laboratory Miller Type 120, No. 69444 Helsinki-Stockholm-Sweden into fine powder.

Chemical Composition

Moisture, ash, crude protein and fat contents were determined for sorghum, maize – chickpea supplemented products according to (AOAC, 2000) method. Fiber content was carried out on the samples according to (A. A. C. C., 2000) methods.

The carbohydrates were calculated by difference. The sum of moisture, fat, protein and ash contents were subtracted from 100 as it was described by (Vatsala, 1991). The energy values of the biscuits were calculated for protein, fat and carbohydrates based on Atwater factors.

Fat factor= 9.0 (kcal/g).
Protein factor= 4.0(kcal/g).
CHO factor= 4.0 (kcal/g).
1 kcal= 4.184 (kj).

In Vitro protein Digestibility (%)

In vitro protein digestibility of sample was carried out using enzymatic method of (22). Samples containing 100 mg protein were treated with 12.5 mg of pepsin in 50 ml of 0.1 N HCl at 37°C for 3 hours. After neutralization with 0.5 N NaOH, 6 mg of pancreatin dissolved in 25 ml of phosphate buffer (pH 8.0) was added and digestion continued for 24 hour at 37°C. The volume was made to 100 ml and 50 ml aliquot was treated with 10 per cent TCA, left overnight to precipitate the proteins. The suspensions were centrifuged at 4000 rpm. The undigested material was subjected to protein assay by micro kjeldahl method. Protein digestibility was calculated by difference.

In Vitro Starch Digestibility

In vitro starch digestibility was carried out using the method, described by (Mouliswar *et al*., 1993). The slurry of sample (2%) was cooked on a boiling water bath for 15 minutes. To a slurry sample of 50 ml, 30 ml of 0.2 M glycine-HCl buffer (pH 2.0) containing 10 mg of pepsin was added. It

was incubated at 37°C for 2 hours and neutralized with 0.2 N NaOH and the volume was made to 100 ml. To an aliquot of 10 ml of this sample 5 ml of 0.5 M phosphate buffer containing 15 mg of pancreatin and 15 mg amyloglucosidase was added and incubated for 2 hours at 37°C. The reaction was stopped at desired intervals (3 hours) by heating the samples for 5 minutes in boiling water bath. Aliquots of 0.5 ml of these samples were mixed with 2 ml of dinitrosalicylicacid reagent for determining reducing sugars. Glucose was used as a standard, while starch equivalent was calculated using the conversion factor of 0.9.

Processing of Biscuit Samples

Biscuits were prepared according to (Vatsala *et al*., 1991) method. Control sample of decorticated sorghum flour (90% extraction) and decorticated maize flour (90% extraction) (Non wheat flour) had been blended with chickpea flour substituting in ratio 0, 10, 20 and 30%. The formula used in biscuit processing were as follows:

Ingredient Quantity (gm)

Biscuit flour	100
Sugar powde r	30
Shortening	30
Skim milk powder	2
Sodium chloride	1
Sodium bicarbonate	0.4
Ammonium bicarbonate	1.5
Glucose	2
Water	15ml

The ingredients were weighed for 400gm of flour. Sugar powder, shortening, skim milk powder, and glucose were creamed in Hobart N-50 mixer with a flat beater for 3 min. at 61 rpm. Salt, ammonium bicarbonate and sodium bicarbonate were dissolved separately in part of required water added to the cream. Mixing was continued for 8min. at 125rpm to obtain homogenous cream. Finally, flour was added and mixed for 3min. at 60 rpm, and then the dough was sheeted to a thinness of 3.5mm with the help of an aluminum plate form and a frame. The piece dough was transferred to an aluminum tray. The biscuits were baked in electronic oven maintained at 205 °C for 8.5 min., the baked units were cooled, packed in polyethylene bags and stored for further analysis.

Biscuit Spread ratio

Biscuit were evaluated for the spread ratio according to the following equation:

$$\text{Spread ratio} = \frac{\text{Width of the biscuit}}{\text{Thickness of the biscuit}}$$

Sensory Evaluation of Biscuits

Evaluation of biscuits made from sorghum and maize flours with and without chickpea flour were carried out. Fifteen panelist assessors provided coded samples and asked to evaluate the general appearance, color, after taste, texture, and overall quality of the biscuits according to the scoring (Hedonic) scale of 5 point. Describe by (Ihekoronye *et al*., 1985). A key table was given to the panelists guided them to score according to it.

Statistical Analysis

The analysis of variance was performed to examine the significant effect in all parameters measured. Duncan Multiple Range Test was used to separate the means.

Results and Discussion

Proximate Composition

Table (1) shows proximate composition of biscuits prepared from decorticated sorghum

and maize supplemented with chickpea flour (10, 20 and 30% level). Data are expressed on dry matter bases (per 100gm materials). The moisture content of biscuits was assessed between 5.58 and 5.11%. These values are agreement with Omoba and Omogbemile (Omoba *et al*., 2013). Moisture content of sorghum biscuit enriched with defatted soy flour ranged from 3.2 - 6.1%. These values are comparable to values (5 – 10%) set by the Protein Advisory Group. The lower the moisture contents ofa product, the better the shelf stability of such product (Sanni *et al*., 2008). Hence, low moisture ensures higher shelf stability in dried products.

However, low residual moisture content in confectionaries is advantageous; resulting in a reduction in microbial proliferation and prolonged storage life if stored inside appropriate packaging materials under good environmental condition. The ash content (table1) of the biscuits ranged from 1.52 – 1.95%, respectively. These results significantly (P≤0.05) lower than the range of 2.3 – 3.5% stated by (Omoba *et al*., 2013). Lower ash content obtained resulted from sorghum and maize had been decorticated before utilizing. The fat content of biscuits ranged from 18.68 – 22.30%. These values are considered higher than the range of 12.0 – 18.1% stated by (Omoba *et al*., 2013). The fat content plays a role in determine the shelf life of the food. A high amount of fat could accelerate spoilage by promoting rancidity which could lead to the production of off flavours and odours. The protein content of biscuits is given in table (1) results, however, showed values ranged from 9.9 – 15.5% , highest value observed in maize biscuit with 30%chickpea flour (M3), and the lowest value gained by sorghum biscuit (S) (without chickpea flour). Protein content significantly increased (P≤0.05) gradually after chickpea inclusion in sorghum and maize flour with 10, 20, and 30% level. The fiber content analysis of the biscuits table (1) showed the values obtained ranged between 1.14 – 2.03%, high fiber values were observed in maize biscuit with 30%chickpea flour (M3) and sorghum biscuit with 30%chickpea flour (S3), respectively. These values favorably agree with the recommended value of 2.0 – 3.8% by (Omoba *et al*., 2013). Carbohydrate content of biscuit viewed in (table1) ranged from 55.61 - 61.29%. The results appeared carbohydrate decreased significantly (P≤0.05) in sorghum and maize biscuits. The calculated energy values of biscuits ranged from 455.64 - 477.14 kcal/100gm. The energy density of biscuits in the study was enhanced by inclusion of fat in the formulation. The results obtained of energy meet the recommended minimum value of 1674kj/100gm for supplementary food for young children. High dietary energy is important for sparing protein for body building and repairing body tissues avoiding diversion to provide energy.

In Vitro Protein Digestibility

In vitro protein digestibility of biscuits prepared from sorghum and maize supplementing with chickpea flour (10, 20, and 30% level). Table (2) showed the in vitro protein digestibility ranged from 43.51 – 60.29%. Lowest value obtained by sorghum biscuit without chickpea flour (S), maize biscuit with 30% chickpea flour gained the highest value. These results showed in vitro protein digestibility increase significantly (P≤0.05) with increasing the level of chickpea flour in sorghum and maize biscuit, respectively. Generally, protein digestibility values of sorghum biscuits seemed to be low. These results obtained agree with who reported effect of cooking on protein digestibility at the three level of organization, cooking caused a

significant reduction in protein digestibility for both sorghum varieties (high and low tannins).Maize biscuits in vitro protein digestibility values increased significantly (P≤0.05) with increasing the level of chickpea flour from 46.59 – 60.20 %, respectively. The relatively low protein digestibility maybe attributed to the influence of anti-nutrients such as enzyme inhibitors, tannins, and phytates which inhibits protein digestion and also due to presence of protein structures that resist digestion (Mrooj, 2011).

Starch Digestibility

Table (2) showed the in vitro starch digestibility of sorghum biscuits which was blending with chickpea flour (10, 20, and 30% level). Starch digestibility ranged from 46.81 – 60.36%, respectively. The results obtained shows starch digestibility significantly increase (P≤0.05) with increasing the level of chickpea flour. Most starch related foods are cooked before consumption and consequent starch gelatinization and retro gradation play important roles in the quality and digestibility of the many resultant food products (Hu *et al*., 2004).

On the other hand, starch digestibility of maize blending with chickpea flour (10, 20, and 30% level) presented in table (2), the results showed starch digestibility increased significantly (P≤0.05) from 62.65 – 67.16%with the addition of chickpea flour. These result is high than (Hernández-Salazar *et al*., 2006) stated that commercial maize – bean tortilla digestible starch content of 60.3gm/100gm was reported, but the ratio is not declare.

Physical Characteristics of Biscuits

Table (3) shows the physical properties of sorghum and maize biscuits supplemented with chickpea flour(10, 20, and 30% level). The results observed appeared a significant difference (P≤0.05) in diameter, thickness, and spread ratio of sorghum and maize biscuits supplemented with chickpea flour.

The diameter values ranged from 5.24 – 5.50cm.the least diameter observed in (S1) sorghum biscuit incorporated with 10%chickpea flour inclusion. Whereas, the high diameter obtained by (M2) maize biscuit supplemented with 20%chickpea flour. Thickness of biscuits made from sorghum and maize incorporated with chickpea flour (10, 20, and 30% level) varied from 0.065 – 0.75cm.

Spread ratio of the biscuits ranged from 7.10 to 8.21cm. Biscuit having higher spread ratio are considered the most desirable. M2 is therefore considered as the most desirable. The spread ratio increased significantly (P≤0.05) with increasing the chickpea flour in biscuits of both sorghum and maize. Spread ratio could have been affected by the competition of ingredients for the available water and other functional properties of proteins and fat. Invariably, this might affect the texture and eating quality of the biscuits. There is a relationship between the spread ability, thickness of differently biscuits, the thinner the biscuit the lesser its ability to with stand stress/load.

Sensory Evaluation of Biscuits

The organoleptic properties of the biscuit including colour, odour, taste, texture, and general acceptability were assessed by a 10-member panelists who are familiar with the product, nine point hedonic scale with 1 representing the least score (poor) and 9 the highest score (excellent) analysis of variance (ANOVA) was performed on the data to determine differences, while the Duncan multiple range test was used to separate means where significant difference existed.

Table.1 Proximate Composition of Biscuit Samples

Samples	Moisture content (%)	Ash content (%)	Fat content (%)	Crude protein (%)	Crude fibre (%)	Carbohydrate (%)	Energy (kcal)/100gm
S	5.36^{c} ±0.02	1.64^{d} ±0.03	20.60^{d} ±0.01	9.90^{g} ±0.10	1.20^{e} ±0.01	61.29^{a} ±0.07	470.32^{c} ±0.35
S_1	5.52^{ab} ±0.02	1.75^{c} ±0.02	21.93^{b} ±0.01	11.43^{e} ±0.16	1.43^{d} ±0.05	57.94^{c} ±0.18	474.81^{b} ±0.35
S_2	3.57^{a} ±0.01	1.81^{b} ±0.01	21.44^{c} ±0.01	12.79^{d} ±0.19	1.78^{c} ±0.08	56.60^{e} ±0.26	470.55^{c} ±0.22
S_3	5.29^{c} ±0.02	1.85^{b} ±0.05	21.40^{c} ±0.43	13.92^{c} ±0.05	1.92^{b} ±0.06	55.61^{f} ±0.34	470.73^{c} ±2.33
M	5.30^{c} ±0.01	1.52^{e} ±0.02	21.46^{c} ±0.01	11.14^{f} ±0.28	1.14^{e} ±0.05	59.44^{b} ±0.26	475.46^{b} ±0.29
M_1	5.58^{a} ±0.01	1.62^{d} ±0.04	22.30^{a} ±0.02	12.86^{d} ±0.06	1.39^{d} ±0.00	56.25^{e} ±0.03	477.14^{a} ±0.26
M_2	5.11^{d} ±0.07	1.73^{c} ±0.03	19.40^{e} ±0.01	14.40^{b} ±0.01	1.78^{c} ±0.06	57.57^{d} ±0.12	462.52^{d} ±0.45
M_3	5.46^{b} ±0.09	1.95^{a} ±0.02	18.68^{f} ±0.01	15.50^{a} ±0.12	2.03^{a} ±0.03	56.37^{e} ±0.07	455.64^{e} ±0.28
$Lsd_{0.05}$	0.07741^{*}	0.05474^{*}	0.2625^{*}	0.2508^{*}	0.07741^{*}	0.3374^{*}	1.519^{*}
SE±	0.02582	0.01826	0.08756	0.08367	0.02582	0.1125	0.5066

Values are meanSD

Mean(s) having different superscript(s) in a column are significantly different (P≤0.05) according to DMRT.

Key: S = Biscut made from decorticated sorghum.**,** **S_1** = Biscuit made from decorticated sorghum with 10% chickpea flour in the formulation.**,** **S_2** = Biscuitmade from decorticated sorghum with 20% chickpea flour in the formulation, .**S_3** = Biscuit made from decorticated sorghum with 30% chickpea flour in the formulation. **,** **M** = Biscuit made from decorticated maize, **M_1** = Biscuit made from decorticated maize with 10% chickpea flour in the formulation.**M_2** = Biscuit made from decorticated maize with 20% chickpea flour in the formulation, **M_3** = Biscuit made from decorticated maize with 30% chickpea flour in the formulation.

Table.2 Biscuits Protein and Starch Digestibility (%)

Sample	Protein digestibility%	Starch digestibility%
S	43.51^{h} ±0.02	46.81^{h} ±0.03
S_1	45.49^{g} ±0.02	48.81^{g} ±0.03
S_2	47.13^{e} ±0.03	50.63^{f} ±0.03
S_3	58.60^{b} ±0.03	60.36^{e} ±0.03
M	46.59^{f} ±0.02	62.65^{d} ±0.03
M_1	48.13^{d} ±0.02	63.56^{c} ±0.21
M_2	50.20^{c} ±0.02	65.30^{b} ±0.03
M_3	60.29^{a} ±0.02	67.16^{a} ±0.04
$Lsd_{0.05}$	0.0005474*	0.1341*
SE±	0.0001826	0.04472

Values are meanSD

Mean(s) having different superscript(s) in a column are significantly different (P≤0.05) according to DMRT

Table.3 Spread Ratio of Biscuit

Sample	Width (cm)	Thickness (cm)	Spread ratio (cm)
S	5.26^{f} ±0.03	0.75^{a} ±0.02	6.99^{c} ±0.20
S_1	5.24^{h} ±0.01	0.73^{d} ±0.01	7.15^{c} ±0.05
S_2	5.36^{b} ±0.02	0.74^{b} ±0.01	7.21^{c} ±0.14
S_3	5.31^{d} ±0.01	0.65^{h} ±0.00	8.16^{a} ±0.02
M	5.25^{g} ±0.02	0.74^{c} ±0.02	7.10^{c} ±0.19
M_1	5.30^{e} ±0.00	0.70^{e} ±0.00	7.57^{b} ±0.00
M_2	5.50^{a} ±0.00	0.67^{g} ±0.02	8.21^{a} ±0.21
M_3	5.35^{c} ±0.01	0.69^{f} ±0.02	7.80^{b} ±0.17
$Lsd_{0.05}$	0.0005474*	0.0005474*	0.2567*
SE±	0.0001826	0.0001826	0.08563

Values are meanSD

Mean(s) having different superscript(s) in a column are significantly different (P≤0.05) according to DMRT.

Table.4 Sensory Evaluation of Biscuits

Sample	Colour	Odour	Taste	Texture	General acceptability
S	3.07^{e} (±2.15)	3.60^{c} (±2.13)	3.40^{c} (±2.26)	4.13^{d} (±2.13)	3.47^{d} (±2.36)
S_1	4.20^{de} (±2.18)	3.73^{c} (±1.83)	3.60^{c} (±2.03)	4.07^{d} (±1.83)	3.67^{d} (±1.84)
S_2	5.27^{cd} (±2.12)	4.33^{c} (±1.88)	4.47^{bc} (±2.20)	4.60^{cd} (±1.80)	4.67^{cd} (±1.95)
S_3	5.47^{bcd} (±1.30)	4.93^{bc} (±1.28)	5.40^{ab} (±1.50)	5.20^{bcd} (±1.32)	5.47^{bc} (±1.36)
M	6.27^{abc} (±1.91)	6.67^{a} (±1.63)	6.73^{a} (±1.53)	6.60^{ab} (±1.55)	6.87^{a} (±1.60)
M_1	7.33^{a} (±1.23)	6.40^{a} (±1.92)	6.87^{a} (±1.55)	6.73^{a} (±1.75)	6.93^{a} (±1.62)
M_2	6.60^{abc} (±0.91)	5.93^{ab} (±1.79)	6.27^{a} (±1.53)	6.07^{ab} (±1.87)	6.27^{ab} (±1.44)
M_3	6.80^{ab} (±1.61)	6.00^{ab} (±2.04)	6.33^{a} (±1.99)	5.87^{abc} (±2.10)	6.53^{ab} (±1.88)
$Lsd_{0.05}$	1.257^{*}	1.323^{*}	1.339^{*}	1.311^{*}	1.289^{*}
SE±	0.4487	0.4722	0.4778	0.468	0.46

Values are mean±SD.

Mean value(s) sharing same superscript(s) in a column are not significantly different (P≤0.05).

The scores of sensory biscuit samples made from sorghum flour and maize flour with and without addition flour of chickpea with different levels (10, 20 and 30%). The results of colour appeared that sorghum substitution with 30% level of chickpea flour gained 5.47 score. There also, sorghum with the addition of 10 and 20% levels of chickpea flour gained 4.20 and 5.27 scores respectively. No significant differences were obtained. The lowest score was appeared in sorghum without chickpea added. On the other hand, results of maize flour with and without inclusion of chickpea flour gave 6.27, 7.33, 6.60 and 6.80 scores respectively. No significant differences were noticed, these results were considered better than the results obtained with sorghum.

Where as, odour scores results of biscuits mentioned that odour scores of sorghum flour and its treatments levels ranged between 3.60 and 4.93 scores. Maize flour with and without chickpea flour scores ranged between 6.67 and 5.93 scores from the results no significant difference was appeared between sorghum with30%chickpea flour and maize flour with and without chickpea flour in all levels which studied. The results were better than those obtained by sorghum flour with and without chickpea flour (0, 10 and 20% level).

It's obviously taste scores of sorghum flour with 30% chickpea flour and maize with and without chickpea flour 10, 20 and 30% levels gained highest scores 5.40, 6.73, 6.87, 6.27 and 6.33 scores respectively, and no significant differences were observed. Whereas, sorghum with zero, 10 and 20 % level gave the lowest scores 3.40, 3.60, and

4.47, respectively. No significance differences were noticed.

Table (4) showed that texture scores of biscuits produced from sorghum and maize with and without incorporation of chickpea flour with 10, 20 and 30% level. Theresults indicated that highest scores obtained were 6.60, 6.73, 6.07 and 5.87, respectively, from maize and its levels of chickpea flour.

No significant differences were noticed among maize and incorporated levels of chickpea, so, there were no significant differences between maize and sorghum in 30%level of chickpea. From results the least scores were appeared in sorghum 4.13 and 4.07 score with zero and 10%level respectively.

The results of general acceptability scores of biscuits appeared that maize and its levels of chickpea flour gained the highest scores 6.87, 6.93, 6.27 and 6.5, respectively. No significant differences were obtained. Lowest scores were observed from sorghum with zero, 10 and 20% level of chickpea flour. The results mentioned that no significant differences were noticed between sorghum and sorghum with different levels of chickpea.

Conclusion and Recommendations

Decorticated sorghum and maize biscuits supplemented with chickpea flour at 10,20 and 30% imparts positive characteristics such as increased spread factor and crispy texture and reduced hard. Sorghum and maize biscuits, made from staples fortified with chickpea have a moderately high acceptability.

Hence, decorticated sorghum and maize – chickpea flour composite biscuits have a considerable potential as protein-rich supplementary food to elevate the nutritional value. Its utilization will afford the consumer to have food with high nutritional value.

It is recommended that using the chickpea with sorghum and maize to produce biscuits for people who suffer from celiac disease as safe food.

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