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Research Article
Functional and Pasting Characteristic of Wheat, Yellow Maize and Beniseed Composite Flour

[1]O.O. Onabanjo, [1]I.O. Olayiwola, [1]M.O. Adegunwa, [1,2]D.A. Ighere, [3]A.O. Dave-Omoregie and [2]N.S. Abaku

[1]Federal University of Agriculture, Abeokuta, Nigeria
[2]National Centre for Genetic Resources and Biotechnology, South-South Zonal Office, Benin, Nigeria
[3]Nigeria Natural Medicine Development Agency, Nigeria

Abstract

Background and Objectives: Wheat importation has placed a burden on the economy of country that does not produce wheat, thus, leading to high cost of baked products. This study was designed to evaluate the functional properties of biscuits produced from wheat, beniseed and yellow maize (2009 TzE-OR1 D7 STR) composite flour. **Materials and Methods:** Maize and beniseed were processed into flour and mixed with wheat flour for biscuit production by substituting wheat flour at different proportion (100:0:0, 90:5:5, 80:15:5, 70:25:5 and 60:35:5) using standardized recipe. Functional properties evaluation of samples were determined by using standard laboratory procedures. Data obtained from laboratory evaluation were analyzed using one-way Analysis of Variance (ANOVA) to determine the significant difference between means. **Results:** Bulk density (0.23-0.65 g cm^{-3}), swelling power (5.82-6.86 g g^{-1}), water absorption capacity (5.96-6.98 g g^{-1}) and oil absorption capacity (0.31-0.74 g g^{-1}) results showed that 100% wheat flour was significantly different ($p \leq 0.05$) from that of composite flours. Results further showed that addition of maize composite flour significantly ($p \leq 0.05$) reduce the pasting parameters of the composite flours. **Conclusion:** Wheat, beniseed and yellow maize composite flour possess good functional properties that make it suitable for baking.

Key words: Beniseed, yellow maize, composite flour and functional properties, sensory properties

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Corresponding Author: D.A. Ighere, National Centre for Genetic Resources and Biotechnology, South-South Zonal Office, Benin, Nigeria

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Increase in population and urbanization has led to people consuming more biscuit and other baked products across the globe. Nigeria and other developing countries rely on importation to get wheat or wheat flour needed for making biscuits, bread, rolls and other pastry products. This has led to most developing countries to be interested in the possibility of replacing the wheat needed for making baked goods, wholly or partly with flour obtained from home grown products. Efforts have been focused on the use of composite flour for biscuit and other baked products in many wheat importing countries within the last decade[1,2]. Cassava, yam, maize, millet, soy, peanut, sorghum and other stables flours can be used as; composite flour. The composite flours from cereals such as maize are known to be rich in protein[3].

If other staple foods other than wheat flour are used in the production of bake foods, then the importation and over reliance on wheat for the production of baked foods will be reduced. In an attempt to reduce the use of wheat flour and to increase the utilization of indigenous root crops, other staples cultivated in Nigeria are used to supplement wheat flour which have contributed to reduction in the cost of bakery products[4]. Researchers have studied the physical and baking properties of composite biscuits from starchy staples like cassava, cocoyam and plantain[1]. In most of the studies where the starchy staples were used, it was found that the nutritional qualities decreased as the level of the starchy staples increased[5]. So, the inclusion of beniseed flour in the production of biscuit in this study will enhance the nutritional value of the biscuits that will be produced.

The cost of production of biscuits is high in Nigeria as a result of importation of wheat, the raw material used in producing biscuit. Therefore, there is need for further research into the use of other composite flour for baking of biscuits. Inadequate wheat is produced in Nigeria, as such; wheat is imported for the production of baked foods. In order to reduce the quantity of wheat flour that is imported and also to reduce the cost of baked foods in Nigeria, there is need to use locally available flour to substitute wheat flour in baking. A lot of maize and beniseed is produced in Nigeria, therefore, using yellow maize and beniseed flour in substituting wheat flour in biscuit production will help in reducing the cost of the finished product and at the same time increase the nutritional value of the biscuits, because beniseed contain high level of proteins and minerals and yellow maize contain high level of beta carotene a precursor of vitamin A. This research was designed to determine the functional properties of wheat, beniseed and yellow maize composite flour.

MATERIALS AND METHODS

Production of raw materials: The gathering of raw materials for the study, started in April, 2017 and analysis on biscuit was carried out in December, 2017.

Production of maize flour: Yellow maize used for this research work (2009 TzE 1 D7 STR) was collected from the International Institute for Tropical Agriculture (IITA), Ibadan. Yellow maize was processed into flour as shown in Fig. 1, using the method described by Mbata *et al.*[6]. Maize flour was stored in a plastic container with lid and kept in a refrigerator from where samples were drawn for biscuit production.

Beniseed: Beniseed was purchased from Dugbe market in Ibadan and processed into flour using the method described by Ayinde *et al.*[7] as shown in Fig. 2. The beniseed flour was stored in a plastic container with cover and kept in a refrigerator from where samples were drawn for analysis and biscuit production.

Wheat: Wheat flour use in biscuit production was purchased from Dugbe market in Ibadan, Nigeria.

Production of biscuit: Preparation of biscuit samples were carried out in Food Processing Laboratory, Nutrition and Dietetic Department of Federal University of Agriculture, Abeokuta. Yellow maize was used to substitute wheat flour at 0, 5, 15, 25 and 35%, while, beniseed flour was kept constant at 5%, the quantity of wheat and pro-vitamin A maize flour was varied. Beniseed was kept constant so that the nutrient

Yellow maize
↓
Cleaning
↓
Soaking (24 h)
↓
Germination (48 h)
↓
Dehulling
↓
Sun-drying (48 h)
↓
Milling
↓
Sieving
↓
Maize flour

Fig. 1: Flow chart of yellow maize flour preparation

Beniseed
↓
Cleaning
↓
Soaking (24 h)
↓
Dehulling
↓
Roasting (70°C)
↓
Milling
↓
Defatting
↓
Sun drying (24 h)
↓
Sieving
↓
Beniseed flour

Fig. 2: Flow chart of beniseed flour preparation
Source: Ayinde *et al.*[7]

Weighing of ingredients
↓
Mixing of all weighed ingredients
↓
Soft dough was prepare with all ingredients mixed together in adequate amount of water
↓
Dough was spread into sheet and cut into suitable shape and size
↓
Cut pieces were gently place on baking tray
↓
Tray was placed in oven for approximately 15 min at 160°C
↓
Baked biscuit were removed from oven and cooled

Fig. 3: Flow chart for biscuit production
Source: Khaliduzzaman *et al.*[8]

contribution will be constant. The recipe as described in Table 1 and the steps illustrated in Fig. 3 where adopted in preparation of the biscuit.

Functional properties:

Bulk density: Flour sample (50 g) was put into a 100 mL measuring cylinder. The cylinder was tapped several times on a laboratory bench to a constant volume. The volume of sample is recorded by using following equation[9]:

$$\text{Bulk density (g cm}^{-3}\text{)} = \frac{\text{Weight of sample}}{\text{Volume of sample after tapping}}$$

Water absorption capacity: Distilled water (15 mL) was added to 1 g of the flour in a weighed 25 mL centrifuge tube. The

Table 1: Recipe used for biscuit production

	Samples (g)				
Ingredients	A	B	C	D	E
Wheat	100	90	80	70	60
Maize flour	0	5	15	25	35
Beniseed	0	5	5	5	5
Powdered sugar	30	30	30	30	30
Shortening	15	15	15	15	15
Milk powder	5	5	5	5	5
Soybean oil	10	10	10	10	10
Salt	0.5	0.5	0.5	0.5	0.5
Baking powder	1.5	1.5	1.5	1.5	1.5
Egg	30	30	30	30	30

Source: Khaliduzzaman *et al.*[8]

tube was agitated on a vortex mixer for 2 min. It was centrifuged at 4000 rpm for 20 min. The clear supernatant was decanted and discarded. The adhering drops of water was removed and then reweighed. Water absorption capacity was expressed as the weight of water bound by 100 g dried flour[10].

Oil absorption capacity: Refined corn oil (10 mL) was added to 1 g of the flour in a weighed 25 or 80 mL centrifuge tube. The tube was agitated on a vertex mixer for 2 min. It was centrifuged at 4000 rpm for 20 min. The volume of free oil was recorded and decanted. Oil absorption capacity was expressed as mil of oil bound by 100 g dried flour[10].

Swelling power: About 1 g of the sample was weighed into a conical flask. It was hydrated with 15 mL distilled water, shook for 5 min with mechanical shaker at low speed. Heating was done for 40 min at 80-85°C with constant stirring in a water bath. The content was transferred into a clean, dried and pre-weighed centrifuge tube. Distilled water (7.5 mL) was added and centrifuged[11] at 2200 rpm for 20 min. The supernatant was decanted into a pre-weighed can and dried at 100°C to a constant weight. The sediment was weighed in the centrifuge:

$$\text{Swelling power} = \frac{\text{Weight of paste}}{\text{Weight of dry flour}}$$

Pasting properties: Pasting properties was determined using Rapid Visco Analyzer. Flour samples (2.5 g) were weighed into a dried empty canister; then 25 mL of distilled water was dispensed into the canisters containing the samples. The suspension was thoroughly mixed and the canister was fitted into the Rapid Visco Analyzer. Each suspension was kept at 50°C for 1 min and then heated up to 95 at 12.2°C per min and held for 2.5 min at 95°C. It was then cooled to 50°C at 11.8°C per min and kept for 2 min at 50°C. Peak viscosity, trough, breakdown, final viscosity, set back, peak time and pasting temperature were read from the pasting profile with the aid of thermo cline for windows software connected to a computer[12].

Statistical analysis: The data obtained were subjected to analysis of variance (ANOVA, SPSS version 17) in order to determine the significant difference between mean of the various parameters.

RESULTS

Results of functional properties of wheat, beniseed and maize composite flour: Table 2 presented the results of functional properties of wheat, beniseed and maize composite flour mixed. The results showed that bulk density value ranged between 0.23±0.001 and 0.65±0.02 g cm^{-3}. The lowest value was recorded in 100% wheat flour (sample A) while, the highest value was recorded in composite flour containing 60% wheat flour, 5% beniseed and 35% maize flour (sample E). Water absorption capacity value of wheat, beniseed and maize composite flour as shown in Table 2 ranged from 5.96±0.045 to 6.98±0.14 g g^{-1}. The highest value was recorded in 60% wheat flour, 5% beniseed and 35% maize composite flour (sample E), while the lowest value was recorded in 100% wheat flour (sample A). Results on oil absorption capacity of composite flour of wheat, beniseed and maize ranged from 0.31±0.002 to 0.74±0.002 g g^{-1}. The highest value was recorded in composite flour that was formulated with 60% wheat flour, 5% beniseed and 35% maize flour (sample E), while, the lowest value was recorded in 100% wheat flour (sample A). Swelling power values of the composite flour ranged between 5.82±0.014 and 6.86±0.014 g g^{-1}. The lowest value was recorded in 100% wheat flour (sample A), while the highest value was recorded in composite flour that was formulated with 60% wheat flour, 5% beniseed and 35% maize flour (sample E).

Table 3 showed the pasting properties of wheat, beniseed and maize composite flour that was used in producing biscuit. The values recorded for peak viscosity ranged from 56.9±9.90 to 97.7±6.36 RVU, 100% wheat flour (sample A) have the highest value and the lowest value was seen in sample E. The values recorded for trough ranged between 38.9±8.49 to 56.6±1.41 RVU. The highest values was seen in 100% wheat flour (sample A), while sample E has the lowest value for trough. Breakdown values as shown in Table 3 ranged from 16.2±1.41to 40.7±7.78 RVU, while the values recorded for final viscosity ranged between 99.5±5.66 and 131.8±2.83 RVU. Setback values as shown in Table 3 ranged from 60.7±2.83 to 74.8±4.24 RVU, while peak time values as recorded ranged between 5.33±0.19 and 5.90±0.05 min and pasting temperature values ranged from 88.03±0.04 to 88.43±0.54°C.

DISCUSSION

Functional properties are those characteristics that govern the behavior of food constituents during processing, storage and preparation as they affect food quality and acceptability[13]. The result on bulk density suggested that the composite flours will be more desirable due to great ease of

Table 2: Functional properties of wheat, beniseed and maize composite flour

Parameters	A	B	C	D	E
BD (g cm^{-3})	0.23±0.001^{a}	0.32±0.00^{ab}	0.33±0.00^{ab}	0.37±0.001^{c}	0.65±0.002^{c}
WAC (g g^{-1})	5.96±0.045^{c}	6.21±0.014^{a}	6.48±0.021^{b}	6.62±0.14^{a}	6.98±0.014^{b}
OAC (g g^{-1})	0.31±0.002^{a}	0.51±0.004^{c}	0.39±0.005^{b}	0.56±0.004^{d}	0.74±0.002^{e}
SP (g g^{-1})	5.82±0.014^{a}	6.31±0.028^{c}	6.00±0.014^{b}	6.51±0.007^{c}	6.86±0.014^{d}

Mean values having the same superscript within a row are not significantly different $p \geq 0.05$, BD: Bulk density, WAC: Water absorption capacity, OAC: Oil absorption capacity, SP: Swelling power, A: 100% wheat, B: 90% wheat, beniseed 5 and 5% maize flour, C: 80% wheat, beniseed 5 and 15% maize flour, D: 70% wheat, beniseed 5 and 25% maize flour, E: 60% wheat, beniseed 5 and 35% maize flour

Table 3: Pasting properties of wheat, beniseed and maize composite flour

Parameters	A	B	C	D	E
Peak viscosity (RVU)	97.7±6.36^{a}	81.5±4.95^{b}	68.1±9.19^{c}	59.8±5.66^{d}	56.9±9.90^{e}
Trough (RVU)	56.6±1.41^{a}	54.8±7.78^{d}	41.8±7.78^{c}	39.9±0.71^{d}	38.9±8.49^{e}
Break down (RVU)	40.7±7.78^{a}	25.9±12.73^{b}	26.3±1.41^{b}	20.0±6.36^{c}	16.2±1.41^{d}
Final viscosity (RVU)	131.8±2.83^{a}	121.6±12.73^{b}	103.7±5.66^{c}	101.0±0.71^{c}	99.5±5.66^{c}
Set back (RVU)	74.8±4.24^{a}	66.8±9.90^{b}	61.9±2.12^{c}	61.2±1.41^{c}	60.7±2.83^{c}
Peak time (min)	5.90±0.05^{a}	5.70±0.14^{a}	5.33±0.00^{b}	5.27±0.00^{b}	5.33±0.19^{b}
Pasting temp. (°C)	88.04±0.04^{a}	88.40±0.49^{a}	88.43±0.53^{a}	88.43±0.54^{a}	88.03±0.04^{a}

Mean values having the same superscript within a row are not significantly different $p \geq 0.05$, A: 100% wheat, B: 90% wheat, beniseed 5 and 5% maize flour, C: 80% wheat, beniseed 5 and 15% maize flour, D: 70% wheat, beniseed 5 and 25% maize flour, E: 60% wheat, beniseed 5 and 35% maize flour dispersibility and reduction of paste thickness which is associated with higher bulk density[14]. Flour sample of 60% wheat, 35% yellow maize and 5% beniseed flour have the highest value for water absorption capacity and thus, has higher affinity for water. The lose structure of starch polymers causes it to possess high water absorption capacity while, products with low value indicated the compactness of such product structure[15]. Oil absorption capacity is due to binding of fat by non-polar side chains of proteins. High oil absorption of the protein is required in baked foods for improve taste[16], this suggested that 60% wheat, 35% maize and 5% beniseed flour product will taste better than products from 100% wheat flour due to its high oil absorption capacity. The swelling power reflected the hydration capacity of the starch insoluble fraction in water and expressed in grams of water absorbed per gram of insoluble fraction[17]. High swelling power indicated high digestibility and enhance use of flour in solution, suggested improve dietary properties and wide range of dietary application[18]. Therefore, this study suggested that the composite flour will have improve dietary properties, wider dietary application and enhance use of flour in solution due to their high swelling power. There was significant difference in bulk density, water absorption capacity, oil absorption capacity and swelling power between 100% wheat flour and wheat, beniseed and maize composite flour (sample B, C, D and E).

Pasting properties is an important index in determining the cooking and baking qualities of flours[19]. The addition of yellow maize composite flour significantly reduced the peak viscosity, trough, breakdown, final viscosity and set back value of the composite flours. This could be attributed to the reduction in starch gelatinization[20]. This affirmed why 100% wheat flour has the highest peak viscosity and carbohydrate value than all the composite flours. There result suggested that 100% wheat flour will swell freely than the other composite flours. Peak viscosity is an index of the ability of starch-based fruits to swell freely before their physical break down[21]. Trough has the minimum viscosity value in the constant temperature phase of the RVA pasting profile and it measures the ability of the paste to withstand break down during cooling[15]. This result suggested that 100% wheat flour paste has a better capacity to withstand breakdown during cooling than the composite flours. Break down viscosity is the ability of flour to withstand heat and shear stress during cooking[22]. The addition of maize flour increased the ability of the composite flour to withstand heat and shear stress. Hence, there is a decrease in breakdown viscosity of all the composite flour as the percentage of maize flour increases. Final viscosity indicated the ability of the flour to form a viscous paste after cooking and cooling[15]. The result suggested that 100% wheat flour will form a viscous paste after cooking and cooling than the other composite flour as result of its high final velocity. Setback value decreases as the percentage of maize flour increases in the flour, the higher the setback viscosity the lower the retro-gradation of the flour paste during cooling and the lower the staling rate of the product made from the flour[23]. This result suggested that 100% flour has lower retro-gradation of paste during cooling and lower staling rate than the other composite flour. The peak time is a measure of the cooking time with 100% wheat flour having the highest value. High pasting temperature is an indication of higher water binding capacity, higher gelatinization tendency and lower swelling property of starch-based flour as a result of high degree of association between starch granules[24]. There was no significant difference in the pasting temperature of 100% wheat flour and wheat, beniseed and maize composite flour. The reduction in the pasting parameters of the composite flours is due to a decreased in their carbohydrate content and also the higher protein value attributed to the composite flour, protein form complex with starch thereby preventing it from releasing exudates which then lower the viscosity of the flour[25].

CONCLUSION

Wheat, beniseed and yellow maize composite flour possess good functional properties that make it suitable for baking. Supplementing wheat with beniseed and yellow maize flour in biscuits production will reduce over reliance on the use of wheat flour in biscuits production and other baked products and it will enhance the commercial utilization of beniseed and yellow maize in the Nigeria. Also, the use of these composite flours has the potentials to strengthen the economy of any nation that produce beniseed and maize.

SIGNIFICANCE STATEMENT

This study discovered that biscuits with good functional properties were produced from wheat, beniseed and yellow maize composite flour. The use of these composite flours in baking will help in reducing the quantity of wheat being used in baking and it will enhance the commercial utilization of beniseed and yellow maize in the Nigeria. This study will help researchers to uncover the critical area of using yellow maize and beniseed flours in baking. Thus, a new flour product that can be used in supplementing wheat flour in baking has been developed.

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