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Optimization of the extrusion process for the production of ready-to-eat snack from rice, cassava and kersting's groundnut composite flours

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ABSTRACT

Ready-to-eat extruded snack made from optimized composite flour comprising rice, cassava and kersting's groundnut flours was produced. The experimental design for the statistical optimization of the composite flour was carried out using optimum mixture model of response surface methodology. The responses were the proximate and the functional properties. The variables were percentages rice, cassava and kersting's groundnut flours. Experimental design for the extrusion process was also carried out using central composite design of response surface methodology. The variables were moisture content, barrel temperature and screw speed while the responses were throughput, lateral expansion and residence time. The result showed that the optimum composite flour blends consisted 58 g/100 g, 33 g/100 g and 9 g/100 g of rice, cassava and kersting's groundnut flours respectively. The optimum composite flour consisted 21.88 g/100 g protein, 8.15 g/100 g fat, 15.5 g/100 g moisture, 0.75 g/100 g fibre content, 1.97 g/100 g ash, 51.77 g/100 g carbohydrate, 0.805 g/cm^3 BD, 2.0 g/g WAC, 2.21 g/g OAC and 7.0 WSI. For the extrusion process, the optimum conditions were 20 g/100 g moisture content, 120 rpm screw speed and 97 °C. Microbiological analysis of the product showed that it is safe.

1. Introduction

The trend on the consumption of ready-to-eat, convenient and inexpensive snacks is increasing especially in developing countries (Akpapunam & Darbe, 1999; Kulkarni, 1997; Oluwamukomi, Oluwalana, & Akinbowale, 2011; Omoba, Awolu, Olagunju, & Akomolafe, 2013; Uzor-Peters, Arisa, Lawrence, Osondu, & Adelaja, 2008). Studies have been carried out on the functional and rheological properties of protein enriched gluten free composite flours (Marco & Rosell, 2008). The development of gluten-free product is meant to address people who are gluten-intolerant. In addition, the development of rice-based products is meant to address the high cost of wheat importation in many developing countries, and hence, to develop products with locally-sourced raw materials.

In order to improve the nutritional quality of gluten free snacks, different protein sources have been added. Marco and Rosell (2008) used soybean as a source of protein. In this study, Kersing's groundnut was used. Kersting's groundnut (*Mycotyloma geocarpa*) is an underutilized legume rich in essential minerals, protein and amino acids (FAO, Aremu, Olaofe, & Akintayo, 2006). It is an underutilized crop indigenous to Africa (Dakora, 1998). Its protein content is almost the same with that of soybean.

Extrusion is a unique food processing operation which utilizes high temperature short time (HTST) and high shear force to produce a product with distinct physical and chemical characteristics. Extruded snacks have great potential for growth among the snack foods since they can be made into varieties that capture the imagination of the consumers (Filli & Nkama, 2007; Priyanka, Aparna & Lakshmi, 2012).

The aim of this study was to develop composite flour comprising rice, kersting's groundnut and cassava flours, optimise the proximate and functional properties of the blends using optimum mixture model of response surface methodology and produce ready-to-eat extruded snack from the optimum blend. The extrusion process was subjected to statistical analyses using the central

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composite model of response surface methodology to evaluate the effect of moisture content, barrel temperature and screw speed on the throughput, lateral expansion and residence time. The microbiological analyses and of the product were also determined.

2. Materials and methods

2.1. Materials

Cassava (*Manihot esculenta Crantz*) and rice (*Oryza sativa* L) were purchased from Akure, Nigeria while kersting's groundnut (*Mycotyloma geocarpa Harms*) was purchased from Lagos, Nigeria. Salt, curry, and chilli pepper sourced from the local market. Food extruder locally fabricated by NASOD Engineering ltd., Ogun State, Nigeria was sourced in the Food Processing Laboratory of the Federal University of Abeokuta (FUNAAB). All reagents used were of analytical grade.

2.2. Methods

2.2.1. Experimental design for the preparation of composite flour

The experimental design for the production of rice, cassava and kersting's groundnut composite flours were carried out using the optimum mixture design of response surface methodology (Design-Expert software version 8.0.3.1, Stat-Ease Inc., Minneapolis, U.S.A) which gave 16 experimental runs. The variables were cassava, rice and kersting's groundnut flours while the responses were bulk density, water absorption capacity (WAC), oil absorption capacity (OAC), swelling index, swelling capacity, least gelation, emulsion capacity, and the proximate composition (moisture content, protein, fat content, carbohydrates, ash and fibre).

2.2.2. Production of kersting's groundnut flour

Exacly 1.8144 kg of kersting's groundnut seeds were parboiled for 30 min, manually dehulled and the dehulled seeds oven dried. The dried seeds were milled to fine powder using harmer mill.

2.2.3. Production of rice flour

Broken rice (5 kg) was dry-milled into fine powder and stored under room temperature for 3 days prior to use.

2.2.4. Production of cassava flour

Cassava roots (55 large pieces) were manually peeled, washed until the adhering dirts were completely removed, grated, dewatered and pulverized manually before it was sun dried until constant moisture content was observed. The cassava was later milled, ground into fine sizes and sieved to obtain uniformity.

2.2.5. Proximate analysis of the composite flour

This was carried out using Association of Official Analytical Chemists (AOAC, 2005) methods in order to determine the percentages of moisture contents, protein, crude fibre, fat and carbohydrate in the extrudate samples.

2.2.6. Determination of functional properties of the composite flour

2.2.6.1. Bulk density (BD). Bulk density was estimated as described by Maninder, Kawaljit, and Narpinder (2007). The flour samples were gently filled into 10 ml graduated cylinders. The bottom of each cylinder was tapped gently on a laboratory bench several times until diminution of the sample level ceases after filling to the 10 ml mark. Bulk density was then calculated as weight per unit volume of sample (g/cm^3) using the Eq. (1).

$$Bulk\ density\ (g/ml) = \frac{weight\ of\ sample}{volume\ of\ sample} \quad (1)$$

2.2.6.2. Water and oil absorption capacities. Water and oil absorption capacities of flours blends were measured according to the centrifugation method (AOAC, 2005), and equation presented in Eqs. (2) and (3).

$$WAC = \frac{weight\ of\ water\ absorbed\ (g) \times density\ of\ water}{sample\ weight} \quad (2)$$

$$OAC = \frac{weight\ of\ oil\ absorbed \times density\ of\ oil}{sample\ weight} \quad (3)$$

Water and oil absorption capacities are expressed as grams of water or oil bound per gram of the sample on a dry basis.

2.2.6.3. Water solubility index. The method of Leach, McCowen, and Schoch (1959) was used. One gram of flour sample was weighed into 100 ml conical flask, hydrated with 15 ml of distilled water and shaken for 5 min on a shaker. The conical flask with its contents were put in a shaking water bath maintained between 80 and 85 °C for 40 min. After heating, the sample was quantitatively transferred into centrifuge tube by washing with 7.5 ml distilled water and centrifuged at 542 × g for 20 min. The supernatant was decanted into a pre-weighed moisture can and dried at 100 °C to a constant weight. The sediment was weighed and solubility calculated as follows:

$$Solubility\ index = \frac{weight\ of\ soluble \times 100}{weight\ of\ sample} \quad (4)$$

2.2.7. Processing of the flours for extrusion

The extrusion experiment was carried out on a single screw extruder which was locally fabricated. The configuration are 304:18.5 L/D ratio, 18 mm screw diameter, 1.74 kW power and 304 mm barrel length. The die plate had one circular hole with 0.8 cm die diameter, the speed of the extruder varies from 0 to 120 rpm. During extrusion the feed composition, moisture content, temperature, and screw speed were varied. Raw materials were fed into the extruder through the feed hopper. The feed blend for the extrusion consisted 58 g/100 g rice flour, 33 g/100 g cassava flour and 9 g/100 g kersting's groundnut flour; being the optimized. The complete formulation is shown in Table 1.

2.2.8. Experimental design for extrusion process

Central composite design (CCD) of response surface methodology (RSM) (Design expert 8.0.6 trial version) design was used for the experimental design. The independent variables were feed

Table 1
Blend preparation.

Ingredients	Mass (g)
Rice flour	58.0
Cassava flour	33.0
Kersting's groundnut flour	9.0
Sugar	5.0
Curry	0.2
Chilli pepper	0.3
Butter	5.0
Egg white	5.0