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Alternative breads from cassava flour

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ABSTRACT

New and alternative nutritious breads, can be produced from cassava flour fortified with 20% raw or roasted soy flour using locally available margarine with egg white, together or without xanthan gum. Margarine with egg white, increased control loaf volumes by 29%; the subsequent addition of xanthan increased oven rise and volumes by 35%. Margarine, and more significantly, egg white reduced the extent of starch gelatinization and solubilization in the bread, rendering them less gummy. Loaf volume also depends on cassava variety—flours with relatively low diastatic activities/high maximum paste viscosities gave the best baked products. Flour diastatic activity depends on the moisture content of the harvested tuberous root. The breads are acceptable to Nigerian consumers, and have good keeping qualities.

INTRODUCTION

In recent years, the consumption of leavened wheat bread has risen enormously in many developing countries as a result of increasing populations, urbanization, and changing food habits. However, most developing countries, for climatic reasons, cannot grow wheat suitable for breadmaking and rely on wheat imports, paid for with scarce foreign currency. Early attempts to economize foreign exchange were aimed at the partial substitution of wheat flour with flour using indigenous crops such as cassava and yam, spearheaded by FAO's Composite Flour Programme in 1964. Although a substantial body of composite bread technology now exist, such breads still require up to 70% wheat flour to rise well (De Ruiter 1978; Satin 1988; Dendy and Trotter 1988) and implementation has been limited (Crabtree and James 1982). The ban on wheat imports into Nigeria in 1987 has also increased the need for a marketable alternative to wheatless bread in Nigeria.

Attempts have also been made to produce wheat- or gluten-free breads. Most of that work was carried out in the 1960s and early in the 1970s, but there is a recent revival of interest in this area (Satin 1988). Much basic research was actually initiated to gain insights into baking processes or to produce gluten-free breads for celiac patients. The problem is the replacement of the unique, functional viscoelastic properties of the wheat protein gluten. Researchers have reported the use of various gluten substitutes (Eggleston et al. 1991c), such as special self-emulsifying glycerol monostearate (GMS), wheat/rye pentosans, gums such as methyl cellulose and xanthan, and pregelatinized or extruded flours and starches. Unfortunately, there has been very limited or no implementation of the available wheatless bread technology in developing countries, probably because most gluten substitutes are rarely available locally or the equipment necessary to produce some of them is relatively expensive and also imported. Importation introduces another cost element which may outweigh the savings in imported wheat flour.

The present study therefore sought to identify gluten substitutes which could be found locally in Nigeria and other developing countries, or that might be produced locally at low cost, and which could improve cassava bread volume and structure. In preliminary studies, a variety of locally available gums—for example, the gum from okra (*Abelmoschus esculentus*) seed pods, or imported gums that could be found in developing countries—were tested (Eggleston 1992). Only xanthan, an anionic bacterial polysaccharide gum from *Xanthomonas campestris*, gave an improvement in loaf characteristics. Other materials, products, and processing variations were also tested (Eggleston 1992). Those included the addition of a pregelatinized portion (up to 20%) of the cassava flour, which did not improve cassava bread quality. The use of egg white (whole egg was not used because bread crumb structure and texture were less fine and soft, respectively) with an ordinary table margarine gave the most beneficial results as well as with those of xanthan (Eggleston et al. 1991c). The present paper reports further studies and a discussion on the effects of different cassava varieties on flour and breadmaking properties.

MATERIALS AND METHODS

Cassava tuberous roots. Tuberous roots of the IITA-improved cassava clone, TMS 90042, grown without fertilizer 1 m × 1 m apart, were harvested 13 months after planting.

Preparation of cassava flour. Flour was produced from peeled and washed unfermented tubers. The washed tubers were manually chipped, sun-dried (30 ± 3°C) for 48 h, and milled with a disc mill. The milled flour was sieved through a 250 μm-mesh sieve and contained 11.2% moisture.

Preparation of roasted soy flour. Cassava flour was supplemented with soy flour to increase the nutritional status of the bread. Raw or roasted soy flour was preferred to defatted soy flour because the defatting procedure would increase the cost, time, and energy required in production. Dehulled soybean seeds were washed, dried, and milled in a hammer mill. The milled flour was sieved through a 355 μm-mesh sieve in an oven at 150°C for 10 min, and contained 3.7% moisture.

Ingredients. Food grade xanthan gum (Keltrol®) was obtained from Kelco Ltd. (London, UK). The fat used was Blue Band® margarine, produced by Lever Brothers of Nigeria, who reported that it contained 16% moisture and 80% vegetable oils (with at least 80% palm oil), and between 0.3% and 0.5% emulsifier monoglycerol palmitate (MGP), non-fat milk solids, preservative, citric acid; vitamins A, B_1, B_2, and D; flavorings and beta-carotene in trace amounts. The margarine melting, slip, and clear points were 37.3, 38.4, and 41.1°C, respectively. Large sized eggs, salt, granulated sugar, and Fermipan® (Gist Biocades, Delft, Holland) instant dried yeast were all bought locally in Ibadan, Nigeria.

Baking formula and process. The baking formula (*table 1*) and processing conditions (*figure 1*) were developed to suit the tropical climate (28 ± 5°C; 84 ± 14% rh), and the social and economic conditions prevalent in southern Nigeria. The minimum sugar and fat concentrations were identified by trained taste panels. The egg white was separated by hand from the yolk and whisked for 2 min at a high speed (no. 2 setting) in a Philips mixer. All the dry ingredients, including the gum (if used), were mixed in a Kenwood high-speed mixer at low speed for 1 min, using a flat K beater. The water the whisked egg white (if used) were added at this stage, and all the ingredients were mixed at high speed for 10 min. Next, the slightly cohesive and viscous batter was deposited into a Shogren-type baking pan and smoothed down with a plastic spatula. The batter was fermented at 30°C (85–90% rh) for 60 min in a fermentation chamber and baked at 200°C for 30 min in a reel-type oven. Loaf weights and volumes were measured by rapeseed displacement after the baked loaves cooled to room temperature (28 ± 2°C).

Bread crumb analyses. Crumb structure of the cassava breads was qualitatively evaluated for the number of gas cells, cell wall thickness, uniformity, and texture. Crumb moisture content was measured using the AACC method 44-15A (AACC 1981). Crumb-hydration capacities and "blue values" were measured with the method of Yasunaga et al. (1968) to ascertain the amount of solubilized starch in the cooked product.

Analysis of results. Results, where appropriate, were subjected to ANOVA, using a SuperANOVA (Abacus Concepts Inc., Berkeley) software package.

Table 1. Basic cassava bread formula

Ingredient	Amount (g)
Cassava flour	80[a]
Raw or roasted soy flour	20[a]
Dried yeast	1.5
Salt	1.5
Sugar	6
Oil (margarine)	4–10
Water	110[b]
Whisked egg white	48[c]
or	
Xanthan gum	1

[a] Based on 14% moisture content.
[b] 112 ml of water was added for the xanthan formula.
[c] Based on 12% dry-matter content. The water contained in the egg white is taken into account in the total water added.

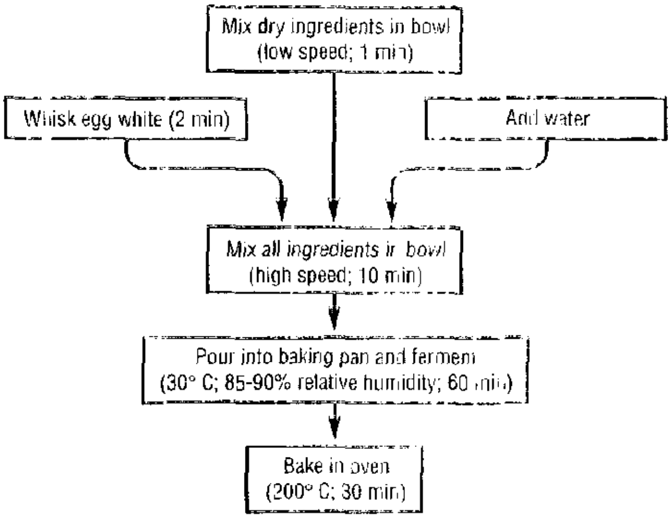

Figure 1. Cassava bread processing flowchart

Cassava bread texture and keeping quality. Baked loaves were stored at ambient temperature (26 ± 2°C) in airtight polyethylene bags. Loaves were first cut 1 h after baking. Bread texture was measured as the resistance to an applied shear force using a Standard Bread Shear-Compression Cell attached to the Model T1 Texturometer of the Food Technology Corp., Maryland, USA.

Cassava bread sensory evaluation. A 15-member, trained taste panel, comprising IITA males and females representative of low and middle income groups in Nigeria, evaluated the products. Cassava bread quality attributes include: texture, sweetness, taste, crumb color and structure, and general acceptability. The results were subjected to ANOVA, using a software package (SAS Institute Inc., Cary, North Carolina, USA). Comparative degrees of significance were determined with Duncan's Multiple Range Test.

RESULTS AND DISCUSSION

Influence of different additives on loaf volumes and crumb characteristics. The cassava bread loaves were baked in various combinations of fat, egg white, and xanthan. The effects of the additives on loaf volumes, specific volumes, and crumb structure are presented in *table 2*.

Cassava bread baked without fat or any other additive (or control) collapsed in the oven and had a typically coarse and irregular crumb structure with a gummy texture. The subsequent addition of 4 g fat slightly improved the loaf and crumb characteristics. Margarine increases the amount of air entrapped in the bread batter at the mixing stage, lowering the batter densities, which subsequently increased the maximum gas retention (Eggleston et al. 1991b).

The addition of egg white and 10 g fat to the control formula significantly improved the bread with a volume increase of 29% and prevented the loaf from collapsing. It also promoted very uniform and fine crumb structure, enhanced crumb color, removed the inherent gumminess of the cassava, and gave a very soft texture. Egg white acts primarily as a stabilizer (Eggleston et al. 1991c) for the relatively unstable batter.

The addition of xanthan to the basic bread formula prevented the loaf from collapsing and improved oven rise and loaf volume. The preservation of structure and reduction in loss of entrapped gas can be attributed to the unusually ordered conformation of the polysaccharide giving an intermolecular network which, at the salt level present in the batter, would be stable at very high temperatures (Norton et al. 1984). However, the best loaf (with a 35% rise in volume) was produced with 10 g fat and egg white together with xanthan. The loaf most resembled a normal wheat loaf in appearance and softness.

Table 2. Loaf volume characteristics

Additive	Loaf volume (ml)	Loaf specific volume (ml/g)	Crumb character
Nil (Control)	393	2.06	Large gas cells, uniform crumb, slightly gummy, slight depression
4 g fat	413	2.21	Fine gas cells, uniform crumb slightly gummy, slight depression, soft texture
4 g fat + xanthan	418	2.03	Fine gas cells, uniform crumb, slightly gummy, slight oven rise
10 g fat + xanthan	436	2.05	Fine gas cells, partially uniform crumb, slightly gummy, soft and spongy texture, good oven rise
10 g fat + xanthan	531	2.46	Fine gas cells, very + egg white uniform crumb, not gummy, good oven rise, very soft and spongy texture
10 g fat + egg white	508	2.45	Very fine gas cells, uniform crumb, not gummy, very soft and spongy texture

Bread crumb properties. The extent of starch gelatinization in bread is important for (a) determining the distribution of moisture in the baked loaf, and (b) its effect on bread crumb quality and in the changes that occur after baking. Previous workers (Kim and De Ruiter 1968) acknowledged the need to retard gelatinization of cassava starch in cassava-soy breads so as to avoid an excessively rubbery final product. As the hydration capacity and blue values of bread crumbs have been used by earlier workers (Yasunaga et al. 1968), those properties were also used to compare the extent of starch gelatinization and solubilized starch, respectively in the cassava breads.

Generally, crumb moisture content was only slighly lower than the respective baking absorptions, a condition which could be attributed to evaporation on baking. However, the breads which contained egg white had significantly ($P < 0.01$) lower moisture content, and were less gummy or rubbery.

Among the cassava breads, the baking absorption was higher by 2 ml for the xanthan formulation than for the others. The hydration capacity was also higher, indicating that xanthan gum was not fully hydrated in the bread, and could still imbibe more water.

There was a notable difference in the relatively low hydration capacity and blue value of the bread which contained egg white. That could be attributed to the emulsification properties of the egg white proteins (Davies 1986), which could delay and therefore reduce gelatinization. It is more likely, however, that the protein network formed by coagulated proteins of whisked egg white in the early stages of baking acted as a barrier to the limited water supply available in the bread from reaching the starch granules, thus hindering starch gelatinization and swelling (Eggleston et al. 1991c).

Sensory evaluation. A multi-comparison scoring differences test showed perceived difference among the cassava breads and a locally bought wheat bread with a specific volume of 3.64 ml/g.

The test showed that there were significant differences ($P < 0.05$) in bread quality and that the cassava bread control (no additives) and loaf with 10 g fat and xanthan had significantly ($P < 0.05$) lower quality scores.

General acceptability was much less for the cassava bread control compared to loaves with egg white and 10 g fat or egg white, 10 g fat, and xanthan. That is mainly attributable to the improved loaf textures and crumb strutures. Despite the excellent–very good acceptability score of the local wheat bread, the cassava breads had a good score. Moreover, comparison with wheat bread is limited because these products result from a baking technology different from conventional wheat/dough procedures. Their marketability would succeed even more if they were simply viewed as new alternative bread products.

Keeping qualities. The loaves with egg white and 10 g fat (or egg white, 10 g fat, and xanthan) had 4-day keeping qualities and compared well with the locally bought wheat bread. By the 5th day, the wheat bread was stale and the cassava breads had spoiled.

Effect of varietal differences on breadmaking quality. The results presented in this paper have been produced with the use of a single cassava clone: TMS 90042. However, the variety (or clone) of cassava used to produced flour, significantly affect bread quality. Those flours with a relatively high diastatic activity (i.e., above 150 mg maltose), and indirectly low maximum paste viscosity, produce dense, pudding-like structures and are unsuitable in breadmaking (Eggleston et al. 1991a, b).

In a previous experiment (Eggleston et al. 1991a, b) in which seven IITA improved cassava varieties and the local variety Antiota had been screened for breadmaking ability, diastatic activities ranged widely from 115–208 mg maltose. Those values were substantially higher than the value of 2.5 observed by Rasper et al. (1974) for a flour prepared from Ankra, the most popular cassava in Ghana at that time. That difference suggests that the diastatic hydrolytic enzymes a and b amylases vary considerably with genotype, although preharvest age of the cassava was not reported by Rasper. Furthermore, the diastatic activity appears to depend on the moisture content of the freshly harvested tuberous root ($r = 0.80$, $P < 0.02$), owing most likely to water which activates the enzymes (Eggleston et al. 1991 a, b).

We recently studied the effect of preharvest age on flour properties. The diastatic activity of cassava flours changed substantially over an 18-month cultivation period (August 1989–January 1991). That pattern of change correlated with the moisture contents of their respective tuberous roots. Therefore, at those times of the year when tuber moisture contents are high, for example in the rainy season, flour diastatic activities are high and potential baking properties less.

The method of flour drying may also be critical. We compared sun-drying (32 ± 2°C) and oven-drying (55°C). The sundried flour had a diastatic activity (46 mg of maltose) about one-quarter of that of the oven-dried flour (182). Sundrying may, therefore, be a more effective method for reducing diastatic activity. Drying effects may warrant further investigation.

Cassava flour diastatic activities and maximum paste viscosities can thus be used as screening parameters by cassava breeders for cassava improvement. The results also suggest that (a) cassava should preferably be harvested at those times of the year when the moisture content of the tuberous roots is relatively low and (b) flour should be sundried, to maximize baking qualities.

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