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Comparative evaluation of cassava composite flours and bread

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Abstract. *Abu MS. 2023. Comparative evaluation of cassava composite flours and bread. Asian J Nat Prod Biochem 21: 13-17.* Wheat imports into Nigeria have a high monetary value of NGN 635 billion annually. The recent data from the National Bureau of Statistics (NBS) trade report shows that Nigeria has spent NGN 258.3 billion on wheat imports in the first three months of 2021, despite the government continuing to encourage local production, such as composite flour. Composite flour combines several flours from roots, tubers, cereals, and legumes with or without adding wheat flour. This study evaluated the functional properties of composite flour produced from potato, cassava, and soybean and the effect of fortification on microbial growth on the produced bread. The flour variations were prepared at 50: 50 (%w/w), then the proximate composition, mineral contents, and functional properties were analyzed. The composite flour comprises WCF = 400 g wheat flour + 400 g cassava flour. CPF = 400 g of cassava + 400 g of sweet potatoes. CSF = 400 g of cassava + 400 g of soybean. The dry ingredients for making dough were 800 g of flours/composite flours, 100 g of butter, 100 g of sugar, and 5 g of yeast thoroughly mixed with warm water to obtain the dough. Exactly 110 g of the dough was placed in the baking pan and kept at room temperature for 20 minutes to ripe. The ripe dough was baked in the oven for 15 minutes. The bread was allowed to cool for further analysis, including the sensory evaluation and the microbial load of the finished products. Bread production uses CP, CS, WC flours, whole wheat, and cassava flours. The Swelling Capacity (SWC) showed that the Wheat Flour (WF) (11.00 ± 1%) was significantly ($p<0.05$) higher than Cassava Flour (CF) (6.33 ± 0.58%) and Cassava-Soybean Flour (CSF) (6.67 ± 0.58%). On the other hand, Water Absorption Capacity (WAC) revealed that the Wheat Flour (WF) (1.74 ± 0.24 g H_2O/g flour) was significantly ($p<0.05$) lower than CF (2.10 ± 0.08 g H2O/g flour) and Cassava-Potato Flour (CPF) (2.16 ± 0.07 g H2O/g flour). The Oil Absorption Capacity (OAC) showed that wheat flour (WF) (1.80 ± 0.15 g oil/g flour) was significantly ($p<0.05$) lower than CF (2.41 ± 0.07 g H2O/g oil), CPF (2.21 ± 0.81 g oil/g flour) and CSF (2.15 ± 0.10 g oil/g flour). The microbial density was higher on the Wheat-Flour Bread, WFB, followed by cassava flour bread, CFB. There was a lower microbial growth in cassava-potato flour bread, CPFB. The functional properties and the sensory evaluation of the composite flour bread indicated substantial feasibility of using legume/tuber composite flours in bread production.

Keywords: Cassava flour, composite four, functional properties, proximate, sensory evaluation

INTRODUCTION

Functional properties are intrinsic physico-chemical of food proteins that interact with other food constituents directly or indirectly, affecting food processing applications, quality, and general acceptability (Berchie et al. 2010). Food proteins are expected to possess vital functional characteristics such as water and oil absorption capacities, nitrogen solubility, bulk density, and emulsifying and foaming properties. It determines the acceptability of novel proteins as food supplements and components for formulating new food items (Kiin-Kabari et al. 2015).

Cassava (*Manihot esculenta* Crantz) is an important root and tuber crop, especially in Africa. In areas where cassava is a main staple, people have processed it into storable products such as tapioca, starch, dough, and gari (Dixon 2002). It significantly alleviates the African food crisis because of its efficient production, year-round availability, and tolerance to extreme stress conditions (Hahn 1987). Cassava has some attractive characteristics, especially for smallholder farmers in Ghana (Bokanga 1992).

Cassava provides the primary source of dietary calories for about 500 million people, many of them in Africa (Yeoh et al. 1998). Of all the tropical root crops, cassava is the most widely distributed and cultivated in different parts of Africa (Onwueme and Sinha 1991). It is crucial in those areas where the food supply is constantly threatened by environmental constraints, such as drought and pest outbreaks, because of its ability to grow under conditions considered suboptimal for most food crops (El-Sharkawy 2004; Berhanu and Feyissa 2020.). It can be harvested 6 to 24 months after planting and left in the ground as a food reserve for household security during famine, drought, and war.

The increasing cassava demand due to fast-expanding feed and starch markets as well as other cassava-based industries across the globe and rising prices of close substitutes such as rice and maize are rapidly re-ordering the dynamics of the cassava market in the tropics [Africa, Asia, and Latin America] (Ikuemonisan and Akinbola 2019). Cassava was known for its wide ecological adaptability and could perform relatively well, although other crops may not be able to produce reasonable yield (Otekunrin and Sawicka 2019). Because of these characteristics, cassava can be a reliable food security for farming households in the tropics (Ikuemonisan and Akinbola 2019) and a livelihood for millions of farmers and traders worldwide (FAO 2018). In Nigeria, cassava is an integral part of the household diet. The emerging market dynamics may disrupt the availability of foodstuffs to consumers, which is of concern to policymakers and researchers (FAO 2018).

Wheat (*Triticum aestivum* L) is the world's most extensively grown cereal crop, covering about 237 million hectares annually, accounting for 420 million tonnes (Olabanji and Omeje 2007). It is an annual grass growing between ½ to 1 ¼ meters in height, with a long stalk that terminates in a tightly formed cluster of plump kernels enclosed by a beard of bristly spikes (Smith 2010). It is a global commodity, with about 150 MT (metric tonnes) traded annually (World Agricultural Outlook Board 2014). The increased global demand for wheat was due to increasing consumption, industrialization, and westernization. In particular, the gluten protein fraction's unique properties allow wheat processing to produce bread, other baked foods, noodles and pasta, and a range of functional ingredients (Shewry and Hey 2015). These products may be more convenient to produce or consume than traditional foods and as part of a "Western lifestyle."

Notably, the contribution of wheat to total energy in terms of kilo calories increased significantly in Nigeria (from less than 1% to 6.64%), India (11.85% to 20.41%), and China (12.20% to 17.83%) (Shewry and Hey 2015). However, the percentage contributions of all cereals declined in these three countries. Hence, in these three countries, increased wheat consumption occurred at the expense of other cereals, particularly minor cereals (millets and sorghum) (Shewry and Hey 2015). Increased wheat production has been accompanied by decreased imports in the UK, China, and India, but wheat imports have risen dramatically in African countries, Turkey and Mexico, despite increased production.

Nwanekezi (2013) states that wheat imports into Nigeria reach NGN.635 billion annually. However, the recent data from the National Bureau of Statistics (NBS) trade report shows that Nigeria has spent NGN.258.3 billion on wheat import during the first three months of 2021, despite the government's continuous to encourage local production. Despite being a major market for wheat products, Nigeria only produces 400,000 million tons annually out of a total demand of 3.6 million metric tons, according to data from the Federal Ministry of Agriculture. In recent years, the Boko Haram insurgency has obstructed efforts to increase local wheat production. Wheat farmers in Borno, the country's major producing state, had abandoned their farmlands and fled to other areas or took residency at the Internally Displaced Person's (IDP) camp (Business Day 2021).

Nigeria and several developing countries have encouraged the initiation of programs to evaluate the feasibility of alternative locally available flour as a substitute for wheat flour. Composite flours may be considered as blends of wheat and other flours or fully non-wheat combinations of flours for producing leavened bread, unleavened baked products, pasta, porridges, and snack. On the other hand, composite flour could be defined as a mixture of flours from starch-rich tubers (e.g., cassava, yam, sweet potato) and protein-rich flours (e.g., soy, peanut) and cereals (e.g., maize, rice, millet, buckwheat), plus or minus wheat flour (Suresh et al. 2015). Therefore, this study was designed to fortify cassava flour with local non-wheat flour to produce bread/other confectioneries products and enhance the nutritional content of such products in Nigeria.

MATERIALS AND METHODS

Materials

Refined wheat (*Triticum aestivum* L.) flour, Full-fat soy (*Glycine max* (L.) Merr.) flour, potato (*Solanum tuberosum* L.) flour, and cassava (*M. esculenta*) flour, Sugar, Yeast, and Butter were obtained from the local market.

Methods

Composite flour preparation and bread production

The composite flours were produced in the ratio of 1: 1. WCF = 400 g of wheat flour + 400 g of cassava flour. CPF = 400 g of cassava + 400 g of sweet potatoes. CSF = 400 g of cassava + 400 g of soybean. And then, 800 g of flours/composite flours, 100 g of butter, 100 g of sugar, and 5 g of yeast were thoroughly mixed with warm water to obtain the dough. Exactly 110 g of the dough was placed inside the baking pan and kept at room temperature for 20 minutes to ripe. The ripe dough was taken to the oven and baked for 15 minutes. The bread was allowed to cool for further analysis.

Swelling capacity

The swelling capacity was determined by the method described by Okaka and Potter (1977). A 100 mL graduated cylinder was filled with the ripe dough to the 10 mL mark, and the distilled water was added to give a total volume of 50 mL. The top of the graduated cylinder was tightly covered and mixed by inverting the cylinder. The suspension was inverted again after 2 minutes and left to stand for a further 8 min. The volume occupied by the sample was taken after 8 minutes.

Water Absorption Capacity (WAC) and Oil Absorption Capacity (OAC)

WAC and OAC were determined according to the slightly modified method described by Niba et al. (2001). Next, 2 grams of each sample were put into a centrifuge tube, and 50 mL of water was added. The mixture was shaken for about 5 minutes at room temperature. The mixture was kept in a water bath for about 15 minutes and centrifuged at 5,000 rpm for 15 minutes. The supernatant was decanted and discarded, the adhering drops of water/oil were removed, and the resultant sediment was reweighed. WAC and OAC were calculated as the weight of the residue (M2) divided by the initial weight of the sample (M1) (g/g).

$$\text{WAC/OAC} = \frac{M2}{M1}\, g/g$$

Determination of bread weight or baking loss

Weight loss was determined by weighing the ripe dough of each sample before baking (M1) and the bread sample after sufficient cooling (M2). Weight loss was expressed as a percentage.

$$\text{Weight Loss} = \frac{M1 - M2}{M1} x100$$

Determination of microbial density

Accurately 1 g of the sample was weighed into a test tube containing 9 mL of distilled water (Ekici et al. 2019). The test tubes were arranged in ascending order from 1 to 10. The first test tube containing the sample was shaken vigorously till homogenous. Next, 1 mL of the mixture from the first tube was transferred to the second test tube and shaken. The same was done to the last test tube. All the test tubes were labeled from 1^1 to $1^{10,}$ respectively.

$$\text{Colony forming unit (C.F.U)} = \frac{No\ of\ count}{100} \times unit\ factor$$

RESULTS AND DISCUSSION

Functional properties of flours/composite flours

Table 1 showed that the wheat flour (WF) had a swelling capacity (11.00 ± $1^{\%}$) significantly ($p<0.05$) higher than the cassava flour (CF) (6.33 ± $0.58^{\%}$) and cassava-soybean flour (CSF, (6.67 ± $0.58^{\%}$).

The water holding/water absorption capacity (WHC/WAC) of the wheat flour, (WF), (1.74 ± 0.24 g H_2O/g flour) is significantly ($p<0.05$) lower than the cassava flour (CF) (2.10 ± 0.08 g H_2O/g flour) and the cassava-potato flour (CPF) =2.16 ± 0.07 (g H_2O/g flour).

The oil absorption capacity (OAC) showed that the wheat flour (WF) (1.80 ± 0.15 g oil/g flour) was significantly ($p<0.05$) lower than the cassava flour (CF) (2.41 ± 0.07 g H_2O/g oil), cassava-potato flour (CPF) (2.21 ± 0.81 g oil/g flour) and cassava-soybean flour, CSF (2.15 ± 0.10 g oil/g flour).

Bacterial growth of raw materials of flour and finished product after cooling

The population density of bacteria on raw material is presented in Figure 1. It demonstrated a higher bacterial population on Cassava Flour (CF) and lower growth on Cassava-Potato Flour (CPF).

Also, the growth on the bread showed a higher bacterial population on Wheat-Flour Bread (WFB) and lower on Cassava-Soya Bean Flour Bread, CSFB.

Fungal growth on bread on day 3

Fungal growth on day 3 showed that the Wheat-Cassava Flour Bread (WCFB) was higher, followed by Wheat-Flour Bread (WFB). There was no fungal growth on the Cassava-Potato Flour Bread (CSPB), as shown in Figure 2.

Baking loss of finished product

The baking loss was evaluated by analyzing moisture loss. Moisture loss of the samples is presented in Figure 3. The result shows that moisture loss in Wheat-Flour Bread (WFB) was the highest, while Cassava-Potato Flour Bread (CPFB) had the lowest.

Sensory evaluation of bread

The results of the sensory evaluation of bread are presented in Table 2. The individual flour bread, i.e., Wheat-Flour Bread (WFB) and Cassava Flour Bread (CFB), showed that WFB had the highest score in color (5), flavor (5), taste (5), texture (5), and acceptability (5). Meanwhile, the composite flour bread showed that Wheat-Cassava Flour Bread (WCFB) had the highest score in color (4), flavor (4), taste (4), texture (4), and acceptability (5) compared to the Cassava-Potato Flour Bread (CPFB) (4,3,4,4 and 4) and Cassava-Soybean Flour Bread (CSFB) (4,4,4,4 and 3).

Table 1. Functional properties of various flours

Sample	SWC (%)	WHC (g H_2O/g flour)	OAC (g oil/g flour)
WF	11.00 ± 1^b	1.74 ± 0.24^a	1.80 ± 0.15^a
CF	6.33 ± 0.58^a	2.10 ± 0.08^b	2.41 ± 0.07^b
WCF	10.00 ± 1^b	1.83 ± 0.05^a	2.03 ± 0.07^a
CPF	12.33 ± 1.15^b	2.16 ± 0.07^b	2.21 ± 0.81^b
CSF	6.67 ± 0.57^a	1.98 ± 0.05^a	2.15 ± 0.10^b

Note: n= 3; values in mean ±STD, means with different superscripts varies significantly at $p<0.05$ down the column; WF: 100% wheat flour; CF: 100% cassava four; WCF: 50% wheat flour: 50% cassava flour; CPF: 50% cassava flour: 50% sweet potatoes; CSF: 50% cassava flour: 50% soybean flour

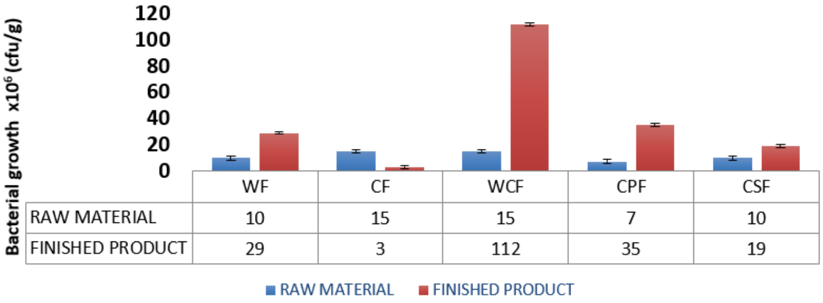

Figure 1. Bacterial density in flour and bread

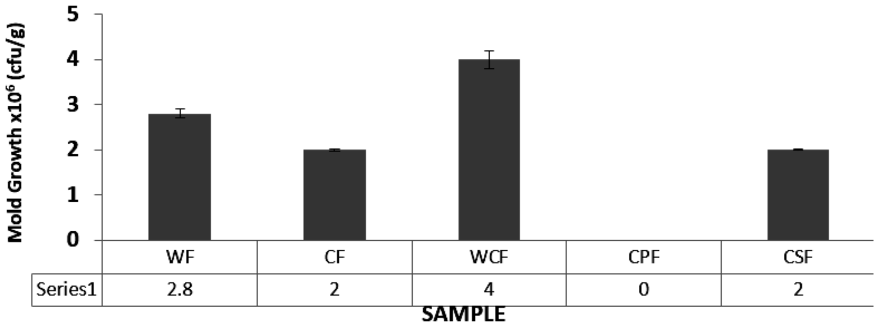

Figure 2. Fungal growth on bread using various flours

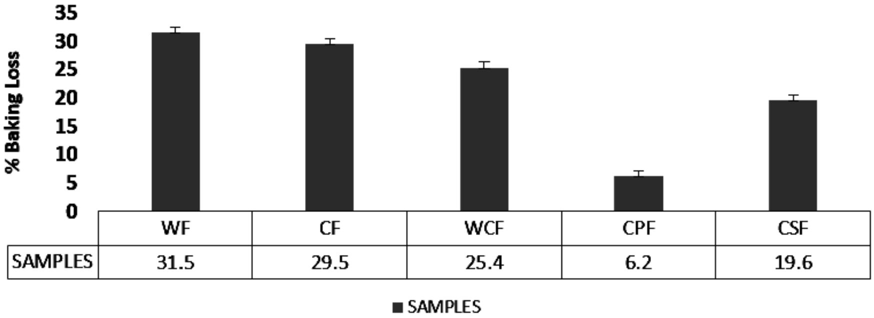

Figure 3. Baking loss in bread using various flours

Table 2. Sensory evaluation of bread using various flours

Sample	Color	Flavor	Taste	Texture	Acceptability
WFB	5	5	5	5	5
CFB	4	4	4	4	3
WCFB	4	4	4	4	5
CPFB	4	3	4	4	4
CSFB	4	4	3	4	3

Note: no: 50; 5: excellent, 4: very good, 3: good, 2: fair, 1: poor; WF: 100% wheat flour; CF: 100% cassava four; WCF: 50% wheat flour: 50% cassava flour; CPF: 50% cassava flour: 50% sweet potatoes; CSF: 50% cassava flour: 50% soybean flour

Discussion

The higher swelling capacity in WF than the CF is likely due to the gluten in wheat flour that forms continuous fine strands when immersed in water. The low swelling capacity of CF can be attributed to the large particle size or decreased interaction of the granules (Camel et al. 2019). However, swelling capacity improved when cassava flour was mixed with soybeans and sweet potatoes flours.

Water absorption capacity is defined as the ability of the flour or starch to hold or retain water against gravity that comprises bound water, hydrodynamic water, capillary water, and physically entrapped water (Andres et al. 2006). The increased water absorption of cassava flour and its addition reflects that a large amount of water is needed to prepare doughs with cassava flour. The loss interaction between amylose and amylopectin in the original starch granules and the weak binding forces cause the cassava flour to absorb more water (Ajatta et al. 2016). This property is essential for rapid dough formation while processing bakery products such as bread.

Oil absorption capacity is a process that involves the physical entrapment of oil by food products or materials when mixed with oil. It indicates the rate of protein or protein attachment to fat in food fortifications and is useful since fat acts as a flavor retainer and enhances the taste of food. The results showed composite flour CPF and CSF resisted oil absorption better than WF. A study by Althea-ann and Shuryo (1983) showed that the higher the amount of heat treatment to a protein, the more hydrophobic the protein, resulting from a higher number of hydrophobic groups exposed through the unfolding of the protein molecules.

The baking loss was analyzed in terms of the moisture loss of the bread, and the moisture content of the control bread was higher than the bread using composite flour. The loss of moisture content decreases with an increased proportion of composite flour during the baking process, and therefore, baking loss also decreases on composite flour bread.

All samples showed microbial growth. The composite of wheat-cassava flour bread has higher microbial density than other samples. The microbial density gradually increased during the three days of storage, probably due to the fat hydrolysis. The result of this study agrees with a previous study by Sewald and DeVries (2003) that hydrolysis of glycerides caused increased microbial growth on stored bread. The low growth observed in the Cassava-Potato Flour Bread (CPFB) after three days of storage than the other composite flour due to low-fat content. It implied Cassava-Potato Flour Bread (CPFB) could be stored longer with good quality because its long shelf life is associated with low microbial growth.

The organoleptic test and sensory evaluation showed that wheat flour and composite flour bread were more satisfying. Sensory evaluation revealed that the composite bread had lower scores than the standard bread regarding color, flavor, taste, texture, and acceptability. However, there was no significant difference between wheat flour and the three composite flour bread regarding color, flavor, taste, texture, and acceptability.

In conclusion, based on the functional properties of the bread using composite flour, it can be concluded that mixed flour of legume/tuber or composite flours could be used in bread formulations. The organoleptic evaluation also showed that the experimental bread using various composite flour was acceptable to the panelists.

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