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Maximizing the incorporation of Cassava flour as an adjunct in bread baking in Nigeria

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A B S T R A C T

Bread is popular around the world and is one of the world's oldest foods. Bread is usually made from common wheat-flour dough. Till date most people are not familiar with other types of bread apart from that made from 100% wheat flour. When a part of wheat flour is replaced with flours from other food sources (yam, cassava, etc) the wheat gluten is automatically reduced. This study aimed at re-examining the approval of ten percent (10%) cassava flour inclusion in bread baking in Nigeria and evaluating higher % substitutions, with a view to increasing cassava carrying capacity for producing acceptable bread. The water absorption capacity (WAC) of wheat, cassava and composite flours ranged from 62.7 to 79% while oil absorption capacity (OAC) ranged from 4.5 to 72%. As cassava percent inclusion increased both WAC and OAC increased. Bread loaves produced from 10-20% inclusions without egg white had sensory scores of 3.2 to 3.9 and were significantly ($p<0.05$) better than 25-30% wheat cassava composite bread loaves. In all sensory attributes, 10 - 20% cassava inclusion, with added egg white, produced bread loaves which were as good as 100% wheat bread. In terms of taste, colour, odour and texture 25-30% composite bread loaves had identical sensory values. This study showed that bread of acceptable quality can be produced from wheat flour substituted with up to 30% cassava flour.

Capsule Summary: Wheat flour substituted with 30% cassava produced flour bread of acceptable quality.

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INTRODUCTION

Bread is popular around the world and is one of the world's oldest foods. Bread is the staple food in Europe, European-derived cultures such as the Americas, the Middle East and North Africa, as opposed to East Asia whose staple is rice. Bread is usually made from common wheat-flour dough that is cultured with yeast, allowed to rise, and finally baked in an oven. Bread wheat is known for high levels of gluten which gives the dough sponginess and elasticity (Adams et al., 2009). Bread is universally accepted as a convenience food that has desirability to all population, both the rich and the poor, rural and urban. Bread may be served in different forms at any meal of the day, eaten as a snack and is also used as an ingredient in other food preparations. Being a basic food worldwide, bread has come to play important role from being mere nutrition to a great significance in religious rituals, secular cultural life, and languages.

Bread has become the second most commonly consumed non-indigenous food products after rice in Nigeria. Bread, once baked, can subsequently be toasted, most commonly eaten either by itself or as a carrier for other foods. Bread can be dipped into liquids such as gravy, olive oil, stew or soup. It can be topped with various sweet and savory spread or used to make sandwiches containing myriad varieties of meats, cheese, vegetables, and condiment (El Tamiz, 2012).

Bread making

Till date most Nigerians have not been used to other types of bread apart from that made from 100% wheat flour. Wheat flour is best used for bread making because it contains gluten in the right quantity to make the spongy loaf (Curtis and Mcpherson, 2002). Gluten, the wheat protein is a tough insoluble elastic substance that forms a network of inter-woven strands. This network of dough is aerated by carbon dioxide produced by the action of yeast and sugar during fermentation. When a part of wheat flour is replaced with flours from other food sources (yam, cassava, etc) the wheat gluten is automatically reduced. This implies that the baking power of 'adulterated' wheat flour (the elasticity of its gluten together with dough's capability to hold enough carbon dioxide within its matrix) is concomitantly reduced. These composite flours may be suitable for bread, cake and biscuits where weaker flours are desirable (Yetunde et al., 2009).

The extent to which the dough can be distended by and retain the carbon dioxide produced by sugar-yeast reaction is dependent on the quality and quantity of gluten in the flour. In speaking of wheat bread as perfect food it must be made of flour rich in gluten (Harding, 2012).

Shelf Life of Bread

About twenty percent of bread is discarded due to shelf life issues. In 2009 a natural preservative for lengthening the shelf life of bread for up two weeks as opposed to a few days was pioneered by Professor Elke Arendt at the University College Cork (UCC) by incorporating into the bread lactic acid bacteria strain, this has been found to also produce a fine crumb texture while improving the flavor, volume and nutritional value of the food as well (Ring, 2009).

Fresh bread is prized for its taste, aroma, quality, appearance and texture. Retaining its freshness is essential to keep it appealing. Bread that is stiff or dried past its prime is said to be stale. Modern bread is at times wrapped in paper or plastic film or kept in a container such as a breadbox to reduce drying. When bread is kept in warm and moist environments, it is likely to grow mold easily. Bread kept at low temperatures, in a refrigerator for example, will grow mold more slowly than bread kept at room temperature, but will turn stale quickly as a result of retrogradation. The succulent, inner part of bread is known to bakers and other culinary professionals as the crumb, which is not to be mistaken with small bits of bread that often fall off, called crumbs. The outer hard portion of bread is called the crust (Almazan, 1990).

Cassava

Cassava (*Manihot esculenta*) which is also called manioc native to South America, is extensively cultivated as an annual crop in the tropical as well as subtropical regions for its edible starchy, tuberous root, a major source of carbohydrates. It is a staple food in developing world (FAO, 1995), the third-largest source of food carbohydrates in the world and one of the most drought-tolerant crops, capable of growing on marginal soils. Nigeria is the world's largest producer of cassava (Claude and Denis, 1998).

Cassava contains anti-nutritional factors and therefore must be properly processed before it is eaten. Improper processing of cassava can leave residual cyanide enough to cause acute cyanide toxicity, goiters, ataxia or partial paralysis. It was also discovered that farmers often prefer the bitter varieties because they deter pests, animals, and thieves (Linley et al*.,* 2002). The more-toxic varieties of cassava are a fall-back resource (a "food security crop") during famine in some places.

Uses of Cassava

In Nigeria and several other West African countries, including Ghana, Benin, Togo, Ivory Coast, and Burkina Faso, cassava tuber is converted into different traditional foods such as gari, fufu, lafun and tapioca. The fermentation processes involved in these cassava derived foods reduce the level of anti nutrients, making cassava safer for human consumption (Agunbiade and Adanlawo, 2007; Oboh et al*.,* 2007). Industrial uses of cassava include starch used in pharmaceutical industries and manufacture of glucose syrup used as sweetner in food industry. As cassava is a gluten-free, natural starch, it is becoming commonly used in Western cuisine as a wheat alternative for sufferers of celiac diseases. In many countries, significant research has begun to evaluate the use of cassava as ethanol bio-fuel. Million US gallons (120,000m^3) a year of bio-ethanol from cassava plants is produced (Cassava bio-ethanol, 2008). Cassava chips have gradually become a major source for ethanol production (Soyre et al., 2011).

This study aimed at re-examining the approval of ten percent (10%) cassava flour inclusion in bread baking in Nigeria and evaluating higher % substitutions, with a view to increasing cassava carrying capacity for producing acceptable bread.

MATERIAL AND METHODS

Sources of raw materials

Table 1: Wheat Cassava Composite Flour (%)

Wheat	Cassava	Total
100	0	100 Standard
90	10	100 Experimental
80	20	100 Experimental
75	25	100 Experimental
70	30	100 Experimental

Table 2: Functional properties of wheat flour, cassava flour, and composite flours

Flour samples	(WAC)	Capacity (OAC)	(WOAI)
Wheat flour	70.22±5.36	46.47±0.80	1.5
Cassava flour	62.67±2.07	46.51±0.91	1.35
10% Cassava flour	63.70±2.53	47.07±1.08	1.35
20% Cassava flour	68.12±3.02	54.10±1.82	1.26
25% Cassava flour	73.51±3.14	66.54±2.74	1.11
30% Cassava Flour	79.01±4.73	72.19±3.14	1.09

Values are means ± standard error of triplicate determinations

The cassava flour used for the study was obtained from cassava Mosaic Disease (MD) resistance clone (T-419) of the International Institute of Tropical Agriculture (IITA), Nigeria. Wheat flour was obtained from Eagle flour mill in Ibadan, Oyo state, Nigeria. Other materials, including granulated sugar, baking fat and table salt, were all sourced from an open Alesinloye market, in Ibadan, Nigeria. Composite cassava- wheat flour preparations were 10-30% substitution levels for bread baking.

Analytical procedures

Determination of Physico-Functional Characteristics of Wheat Flour, Cassava Flour, and Composite Flours: Except otherwise stated all calculations were based on triplicate determinations of all parameters.

Water Absorption Capacity (WAC) and Oil Absorption Capacity (OAC): The water absorption capacity and oil absorption capacity were estimated using the methods of Solsuski and McCurdy (1987); Agunbiade and Longe (1996). WAC was estimated as the gram of moisture absorbed by 100g sample. OAC on the other hand was estimated as oil absorbed and retained per 100 gram multiplied by oil specific gravity (0.92) as modified by Agunbiade, 1992.

Water-oil absorption index (WOAI): The water-oil absorption index was determined according to the method of De Kanterewiz et al (1987); calculated as the ratio of water absorption capacity to oil absorption capacity.

Baking experiment

Pilot- Standard bread baking procedure: Five hundred gram (500g) weight of each formulated composite wheat-cassava flour was used for bread baking. Each was discharged into mixing bowl with a pinch of salt, 10g of margarine, 10g of yeast, 75ml of water, 20g of sugar, were all mixed into a dough. The dough was removed and placed on a wooden board lightly sprinkled with flour and kneaded manually for about one minute. The dough was rolled into a ball-like structure and then transferred to a bowl greased with margarine and covered with a clean damp cloth. It was kept in a warm place for about 60 minutes, or until it was twice its original size. The dough was mechanically, divided into equal sizes, moulded (molded) into cylindrical shape and introduced into baking pans. The dough was allowed to proof in a baking pan for another 30minutes. It is then finally baked in a pre-heated oven at 180-200 degree Celsius for 30minutes.

Sensory evaluation

Bread rolls produced in the laboratory were tasted and compared by a 10 member taste panel drawn from a group of 15 trainees after several test runs. The preceding training was to pick panel members whose ratings were dependable. Five (5) hedonic rating scale was used to measure the sensory qualities of the bread rolls. Rating was Excellent (5), Good (4), Fairly good (3), Fair (2), and Very poor (1). The scores of panel members were subjected to analysis of variance (ANOVA) and multiple range test using SPSS package.

Improved cassava-wheat composite bread baking: For improved bread making, the conventional procedure was adopted except that egg white (a spoon full) was used to improve 10-30% wheat substituted cassava flour. The resulting improved bread rolls were similarly organoleptically tasted and compared by the 10 member taste panel.

RESULTS AND DISCUSSION

The water absorption capacity (WAC) of wheat, cassava and composite flours ranged from 62.7 to 79% while OAC ranged from 4.5 to 72%. As cassava percent inclusion increased both WAC and OAC increased. The water–oil absorption indices (WAOI), calculated from ratios of WAC to OAC, with all having close values ranging from 1.09-1.50, were consistently lower than 2.

Table 3 shows that the standard bread loaf was significantly ($p<0.05$) better than composite bread loaves without egg white in all sensory attributes. There were apparent decline in all sensory characteristics, as cassava flour inclusion rates increased. Bread loaves produced from 10-20% inclusions without egg white had sensory scores of

Table 3: Sensory Evaluation of Breads from wheat flour and graded wheat-cassava composite flour in conventional bread baking

Cassava flour substitution	Appearance	Taste	Colour	Odour	Texture
Standard (100%) wheat	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}
10% Cassava Flour	3.80±0.37^{b}	3.90±0.18^{b}	3.90±0.18^{b}	3.80±0.29^{b}	3.70±0.34^{b}
20% Cassava Flour	3.30±0.30^{c}	3.20±0.25^{c}	3.40±0.29^{c}	3.00±0.47^{c}	3.20±0.39^{c}
25% Cassava Flour	2.40±0.31^{d}	2.45±0.22^{d}	2.40±0.34^{d}	2.44±0.27^{d}	2.40±0.37^{d}
30% Cassava Flour	2.40±0.26^{d}	2.30±0.21^{d}	2.40±0.26^{d}	2.30±0.15^{d}	2.40±0.27^{d}

Values are means ± standard error of duplicate results. Mean values vertically differently superscripted are significantly ($P < 0.05$) different (this should be replicated for table 2). Sensory scores lower than 2.5 of the 5 hedonic rating scale is unacceptable.

Table 4: Sensory Evaluation of improved Bread loaves produced from wheat substituted cassava flour fortified with egg white

Cassava flour substitution	Appearance	Taste	Colour	Odour	Texture
Standard (100%) wheat flour	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}
10% Cassava flour	5.00±0.00^{a}	4.60±0.37^{a}	4.80±0.37^{a}	4.70±0.35^{a}	5.00±0.00^{a}
20% Cassava Flour	5.00±0.00^{a}	4.60±0.26^{a}	4.60±0.30^{a}	4.60±0.37^{a}	5.00±0.00^{a}
25% Cassava Flour	4.90±0.41^{a}	3.70±0.31^{b}	4.40±0.25^{b}	4.30±0.32^{b}	4.40±0.19^{b}
30% Cassava Flour	4.30±0.32^{b}	3.40±0.27^{b}	4.00±0.38^{b}	4.20±0.32^{b}	3.90±0.46^{c}

Values are means ± standard error of duplicate determinations. Mean values vertically differently superscripted are significantly ($p < 0.05$) different. Sensory values lower than 2.5 are unacceptable.

3.2 to 3.9 and were significantly ($p<0.05$) better than 25-30% wheat cassava composite bread loaves.

In all sensory attributes, 10 - 20% cassava inclusion, with added egg white, produced bread loaves which were as good as 100% wheat bread. In terms of taste, colour, odour and texture 25-30% composite bread loaves had identical sensory values; they were, however, significantly ($P<0.05$) lower than the standard bread and 10-20% composite breads in all organoleptic attributes except for the colour of 25%cassava bread with added egg white. All the sensory attributes have appreciated as a result of egg white addition. As none of the trials had sensory score less than 2.5 all of them are adjudged acceptable.

The raw samples (wheat and cassava flours) as well as wheat- cassava composite flours, having exhibited water-oil absorption indices of less than two are lipophilic in accordance with previous reports (De kanterewicz et al.; 1987Agunbiade, 1992). The water-loving sites of flours were therefore not exposed by processing and therefore all exhibited lipophilic property.

In all sensory attributes the standard bread made from 100% wheat flour is still the best for bread making and this is corroborated by the findings of Curtis and McPherson (2002). Result of the sensory evaluation (Table 3) of normal bread making indicated that bread samples substituted with 10% cassava flour were generally acceptable for all evaluated parameters. Bread produced from composite flour substituted with 20% cassava flour without egg white was only fairly acceptable. The bread samples from 25-30% cassava flour substitution were significantly ($p<0.05$) poorer than 100% flour by adopting standard bread baking method without egg white.

The sensory evaluation of bread rolls with added egg white clearly showed that all bread samples obtained from 10-30% substituted cassava flour were generally acceptable. The 10- 20% improved composite breads in all organoleptic parameters exhibited no significant ($p>0.05$) difference, compared with 100% wheat bread. Bread samples from 25-30% cassava flour replacement showed only slight significant differences ($p<0.05$) in organoleptic properties compared with the standard wheat bread. The sensory scores of 3.4 to 3.9 at 30% substitution level for taste and texture were equally acceptable for being above 2.5, the minimum acceptable sensory rating. The egg white inclusion in the study has been shown to be an improved.

CONCLUSION

This study showed that bread of acceptable quality can be produced from wheat flour substituted with up to 30% cassava flour which may be named cassava/wheat bread to avoid error of branding. The success advanced in this study can boost Nigeria's foreign earning in that it will increase chances of advantageous incorporation of available cassava varieties in bakery industry. The embrace of the composite is advantageous in individuals that are sensitive to high level of gluten in food.

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