PJN
ISSN 1680-5194

PAKISTAN JOURNAL OF NUTRITION

ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorpjn@gmail.com

OPEN ACCESS **Pakistan Journal of Nutrition**

ISSN 1680-5194
DOI: 10.3923/pjn.2019.538.547

Research Article
Physico-Functional and Sensory Properties of Flour and Bread Made from Composite Wheat-Cassava

[1,2]Camel Lagnika, [3]Paul A.F. Houssou, [3]Valère Dansou, [3]Abel B. Hotegni, [2]Abdou Madjid O. AMOUSSA, [1]Flora Y. Kpotouhedo, [1]Sanni A. Doko and [2]Latifou Lagnika

[1]Ecole des Sciences et Techniques de Conservation et de Transformation des Produits Agricoles de Sakété, Université Nationale d'Agriculture, Bénin
[2]Laboratoire de Biochimie et des Substances Naturelles Bioactives, Unité de Biochimie et de Biologie Moléculaire, Faculté des Sciences et Techniques, Universtité d'Abomey-Calavi, Bénin
[3]Programme Technologies Agricole et Alimentaire, Centre de Recherches Agricoles d'Agonkanmey, Institut National des Recherches Agricoles du Bénin, Bénin

Abstract
Background and Objective: Raw material for bread and pastry products, one of the world's most consumed foods, may become scarce and more expensive in coming decades, because of climate change and urbanization and a steadily growing population. Consumption of bread and other baked aerated wheat flour products has spread in developing countries such as Benin. The objective of the present study was to further characterize the effects of partial replacement of wheat flour by cassava flour on dough and bread properties. **Materials and Methods:** Wheat flour was replaced with 5-30% cassava flour prepared from solar and oven dried slices of cassava flesh variety (BEN 86 052) and the physical properties of the flour, dough and bread were studied. **Results:** Physicochemical analysis showed that substitution of wheat flour with 5-30% cassava flour yielded acceptable doughs and bread with a fine and uniform granulometry, close to that of wheat flour (<160 µm). A fiber content, ash content and moisture content were less than 1, 0.7 and 10%, respectively. Also, results demonstrated that no significant difference (p>0.05) was observed in lightness (L* around 88) of wheat flour in comparison to composite flour until 30% of partial replacement. The statistical analysis of the data showed there were no significant differences (p>0.05) for the quality attribute evaluated the 10% cassava flour substituted bread with 100% wheat flour bread. **Conclusion:** This research shows that cassava flour could be used in composite bread production at 20% level of substitution and beyond this level bread characteristics may be affected. Replacement of wheat flour by cassava flour at 10% in bread making is economically important in Benin as it could save $ 9 586 549 per year. Moreover, this would reduce the expenditure of foreign exchange, post-harvest losses, unemployment and poverty also reduce the celiac disease risk. Therefore, this could increase cassava production and increased income for farmers and local industries.

Key words: Bread, cassava, fortified food, sensory evaluation, wheat flour

Received: December 05, 2018 Accepted: February 16, 2019 Published: May 15, 2019

Citation: Camel Lagnika, Paul A. F. Houssou, Valère Dansou, Abel B. Hotegni, Abdou Madjid O. AMOUSSA, Flora Y. Kpotouhedo, Sanni A. Doko and Latifou Lagnika, 2019. Physico-functional and sensory properties of flour and bread made from composite wheat-cassava. Pak. J. Nutr., 18: 538-547.

Corre sponding Author: Camel Lagnika, Ecole des Sciences et Techniques de Conservation et de Transformation des Produits Agricoles de Sakété, Université Nationale d'Agriculture, Bénin
Laboratoire de Biochimie et des Substances Naturelles Bioactives, Unité de Biochimie et de Biologie Moléculaire, Faculté des Sciences et Techniques, Universtité d'Abomey-Calavi, Bénin

Competing Interest: The authors have declared that no competing interest exists.

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

INTRODUCTION

In coming decades, the rise in global temperatures owing to climate change may hinder the production of wheat in many temperate regions where the crop is grown today. The raw material for bread, one of the world's most consumed foods, may become scarce and more expensive as a result of increasing demand for such products[1].

Urbanization and a steadily growing population in developing countries create a rise of middle class that changes the consumption habits and adopt bakery and pastry products[2]. Those products become a staple food for most of the African population. In most cases, the wheat or wheat flour needed for making bread, rolls and pastry goods had to be imported, since the climatic conditions and soil did not permit wheat to be grown locally.

Wheat and its flours imports represent a major burden on the economy of importing countries including trade imbalance, overdependence on foreign foods, loss of foreign exchange, food insecurity, as well as displacement of local food, with detrimental effects on the agricultural and technological development of these regions[3]. In Benin and other developing countries, the imports of wheat had an increasingly adverse effect on the balance of trade[4]. The amount of money spent on wheat importation annually constitutes a very big drain in Benin's foreign exchange earnings and reserve. According to INSAE[5], Benin imported 204 622 metric tonnes of wheat (grain and flour) in 2017 that cost about $ 95 865 485. These imports are paid for with scarce foreign currency. Thus, huge amount of foreign exchange is used every year for import of wheat. Bread and other baked products are however relatively expensive, as they are produced from wheat[6]. For these reasons Food and Agriculture Organization (FAO) have encouraged the use of composite flours and blends of wheatless flours or meals to increase the nutritional quality and bioactive contents of aerated products such as bread, biscuit, cake, doughnut, etc.[7].

Measures to promote the use of cassava flour in tropical countries, particularly wheat importing countries, remain active however its implementation has not been consolidated[8]. Numerous authors were interested in the possibility of the total or partial replacement of wheat flour with flours from other cereals, oilseeds, legumes or tubers to produce bakery and confectionary products, noodles and breakfast cereals[9-13]. Despite these different researches, there is unavailability of composite flour ready for use on the Beninese market, which represents one of the bottlenecks in the use of composite flour. In addition, the presence of glutein and glutenin confers wheat with unique baking properties, unfortunately these metabolites are sometimes responsible for celiac disease[14-16]. In order to reduce the importation and make the bread and composite flour affordable by low-income earners who constitute the larger population of consumers, there is the need to use novel sources of crops such as cassava as flour substitute for the wheat.

Cassava (*Manihot esculenta* Crantz) is the third most important source of calories in the tropics after rice and maize and sustains an estimated 800 million throughout Africa, Asia and Latin America[17]. Cassava generates billions of income both for families and government and then contributes a lot to food security at several levels[18]. This crop has great social value and cultural identity. Therefore, in Benin, cassava plays an important role in food security and nutrition being a source of income for producers, processors and trades contributing substantially to poverty alleviation. The main cassava food found in Benin are gari, tapioca, attieke, flour, starch, futu, fermented flours, ragout, ground fresh tuber, chips, lafun, etc. The cassava production increased during this decade to reach 4 317 642 t in 2016[19]. However, fresh cassava roots are highly perishable and difficult to store due to its high moisture and nutrients. Postharvest loss may cause both economical and environmental problems. Therefore, processing of fresh cassava into flour will reduce food losses and transportation cost and increase versatility and utilization in food formulations. Cassava flour is one of derivatives from cassava roots whose processing technology is cheaper and easier than cassava starch production besides require less consumption of water and energy and produce smaller quantity of by products and waste[20]. Successful production of bread supplemented with cassava flour will not only encourage improved cultivation of this crop but will also enhance the economic value of the crop. Therefore the objective of the present research was to study the effect of partial replacement of wheat flour by cassava flour on dough and bread properties.

MATERIALS AND METHODS

Cassava flour preparation: Fresh cassava, variety BEN 86 052, was obtained at harvest from a grower in Akassato, Calavi, Benin. They were washed with tap water, peeled by hand using stainless steel knives, secondarily washed and cut into 10 mm in thick slices. The slices were dried (solar and oven dried slices at 65°C). The dried cassava was milled into flour. The flour was sealed in polyethylene bag and stored at room temperature (25°C) until needed for further analysis.

Formulation of flour composites: Wheat flour was obtained from Benin flour mills (Grands Moulins du Bénin: GMB). Flour composites of wheat and cassava were formulated and presented in Table 1.

Proximate composition: The proximate composition (moisture, protein, fiber, fat, ash, carbohydrate) was analysed according to the method of James[21].

Water absorption capacity (WAC) and oil absorption capacity (OAC): WAC and OAC were determined according to the methods of Niba *et al.*[22]. One gram of each flour sample was dispersed in 5 mL of distilled water in a graduated centrifuge tube. The slurry was shaken for 1 min at room temperature and centrifuged (Thermo Scientific Heraeus Megafuge 16 R, Germany) at 3000 rpm for 20 min. The supernatant was decanted and discarded. The adhering drops of water were removed and reweighed. WAC and OAC were expressed as the weight of sediment (M_s) over initial weight of flour sample (M_f) (g g^{-1})[22].

$$\text{WAC or OAC} = \frac{M_s}{M_f}$$

Swelling power (SP): Swelling power of each flour sample was determined by heating a flour-water slurry (0.30 g flour in 10 mL of distilled water) in a water bath at 60°C for 30 min, with constant stirring[23]. After cooling to room temperature, the samples were centrifuged (Thermo Scientific Heraeus Megafuge 16 R, Germany) at 3000 rpm for 20 min. Swelling power was obtained by weighing the residue after centrifugation and dividing by original weight of flour on dry weight basis.

Bulk density (BD): Bulk density of the flour samples was determined by the gravimetric method[24]. A weighed sample (10 g) was put in a calibrated 25 mL measuring cylinder and the volume was recorded as the loose volume. The bottom of the cylinder was tapped repeatedly on a rm pad on a laboratory bench until a constant volume was observed. The packed volume was recorded. The loose bulk density (LBD) and packed bulk densities (PBD) were calculated as the ratio of the sample weight to the volume occupied by the sample before and after tapping.

Table 1: Formulation of cassava in wheat flour blends

Samples	Wheat/cassava flour blends
A	Wheat flour/Cassava flour. WF/CF (100:0%)
B	Wheat flour/Cassava flour. WF/CF (95:5%)
C	Wheat flour/Cassava flour. WF/CF (90:10%)
D	Wheat flour/Cassava flour. WF/CF (80:20%)
E	Wheat flour/Cassava flour. WF/CF (70:30%)
F	Wheat flour/Cassava flour. WF/CF (0:100%)

WF: Wheat flour, CF: Cassava flour. A: WF/CF (100:0%), B: WF/CF (95:5%), C: WF/CF (90:10%), D: WF/CF (80:20%), E: WF/CF (70:30%), F: WF/CF (0:100%)

Weight loss (WL) and Expansion ratio (ER) of bread: Bread making characteristics were studied using the following formulation: flour 100 g, compressed yeast: 1.0 g, salt: 1.0 g, sugar: 6.0 g and water: 50 mL (adjusted according to the flour water absorption). Weight loss was determined by weighing of each dough sample before bake (M_0) and weighing of bread samples after suf cient cooling (M_f) using a digital balance[25].

$$\text{Weight loss (\%)} = \frac{M_0 - M_f}{M_0} \times 100$$

The volume of bread was determined by the solid displacement method using millet.

The volume was measured before and after the end of the baking process. An expansion ratio (ER) is defined as[26]:

$$\text{ER} = \frac{V_f}{V_i}$$

where, V_i and V_f are the initial and final volume of dough and bread, respectively.

Color determination: Surface color of flours were determined by a spectrophotometer (CR-410, Konica Minolta Sensing, Tokyo, Japan) with CIE color parameters L* (light/dark), a* (red/green) and b*(yellow/blue). Color changes (E) were observed in 3 replicates using a previously described equation[27].

$$\Delta E = [(L_t^*\text{-}L_i^*)2+(a_t^*\text{-}a_i^*)^2+(b_t^*\text{-}b_i^*)^2]^{1/2}$$

where, ΔE indicates the degree of overall color change in comparison to color values of white plate (Li*: 91.33; ai*: -0.53; bi*: 4.09). Li*, ai* and bi* represents the white plate parameter and Lt*, at* and bt* refers to the individual readings of flours samples.

Granulometry of flour: Flour particle size distribution test was determined by sifting 200 g of sample for 5 min using the sieves with opening of 200, 160 and 112 μm.

Sensory evaluation: Sensory evaluation of the bread was performed with a forty-two (42) consumer panel. The quality attributes tested on a 9 point hedonic scale included taste, flavor, texture, appearance and crack formation, where 9 = Liked extremely, 8 = Liked very much, 7 = Liked moderately, 6 = Liked slightly, 5 = Liked (limit of acceptable), 4 = Disliked slightly, 3 = Disliked moderately, 2 = Disliked much and 1 = Disliked extremely.

Economic and social impact of use cassava flour in bread and pastry products: In order to study the socio-economic impact and availability of cassava flour for incorporation into bakery products, we collected some data on wheat imports and cassava production to calculate some parameters such as the available cassava flour (AF) and required cassava flour (NF) for substitution. Available cassava flour (AF) and required cassava flour (NF) were determined according to the formula, respectively:

$$AF = P\times 20\%$$
$$NF = WI\times \%S$$

where, P indicate the total production of cassava in Benin (4 317 642 t in 2016), 20% is the yield of flour obtained from the raw material (preliminary experiment), WI is the wheat import in Benin and %S is percentage substitution of wheat flour with cassava flour.

Statistical analysis: Statistical data analysis was performed using SPSS software (version 17.0 for Windows, SPSS Inc., Chicago, USA) using one-way analysis of variance followed by Duncan's multiple range tests. Differences of $p<0.05$ were considered statistically significant.

RESULTS AND DISCUSSION

Proximate composition: The proximate composition values of different formulation of cassava in wheat flour blends samples are shown in Table 2. Moisture content, protein, fiber, fat and ash of flours samples were 9.98±0.03, 10.93±0.62, 1.03±0.01, 2.38±0.10 and 0.67±0.03 for WF and 8.12±0.02, 0.87±0.00, 0.83±0.01, 0.19±0.10 and 0.53±0.01 for CF, respectively. The high protein content in WF could be due to the level of gluten in wheat. The moisture content, protein, fiber, fat and ash of the composite flours decreased with increasing level of substitution. This result agrees with a previous study conducted by Oladunmoye *et al.*[28]. This is attributed to the higher value of these parameters in wheat flour compared to cassava flour. Otherwise, carbohydrate content increased with increasing level of substitution. Similar observations were reported by Oladunmoye *et al.*[28] and Eleazu *et al.*[29].

For the protein, no significant ($p>0.05$) difference was observed in WF and composite flours. The moisture, protein, fiber, fat and ash content was lower than the previously reported for cassava flour by Samad *et al.*[30] and Bankole *et al.*[31]. This could be due to the variety, the conditions in which the crop was cultivated, maturity and storage. In terms of energy, there is no significant difference ($p>0.05$) between wheat, cassava and mixed flour at 5 and 10% of substitution. Beyond 10% of substitution, the energy increases proportionally with increasing the substitution percentage. Composite flour from wheat-cassava flour could be used to manage cases of protein malnutrition and energy which is prevalent in most developing countries of the world.

Functional properties: The results of the functional properties (WAC, OAC, SP, BD and WL) of the samples are shown in Table 3.

Water absorption capacity (WAC) and oil absorption capacity (OAC): WAC and OAC of the composite flour samples varied from 1.71±0.05 to 1.81±0.04 g g^{-1} and 1.14±0.09 to 1.18±0.12 g g^{-1} ($p>0.05$), respectively. Increasing the portion of cassava in the composite flour caused WAC and OAC to increase. The highest WAC and AOC values were

Table 2: Proximate composition of different formulation of cassava in wheat flour blends

Samples	Moisture (%)	Protein (%)	Fiber (%)	Fat (%)	Ash (%)	Carbohydrate (%)	Energy (kcal/100 g)
A	9.98 ± 0.03^{b}	10.93 ± 0.62^{b}	1.03 ± 0.01^{c}	2.38 ± 0.10^{d}	0.67 ± 0.03^{c}	66.42 ± 1.05^{a}	330.82 ± 0.08^{a}
B	9.97 ± 0.03^{b}	10.46 ± 1.25^{b}	0.98 ± 0.05^{c}	2.25 ± 0.07^{c}	0.66 ± 0.02^{bc}	67.53 ± 0.92^{a}	332.21 ± 0.01^{a}
C	9.73 ± 0.01^{b}	10.47 ± 0.03^{b}	0.97 ± 0.00^{c}	2.12 ± 0.04^{bc}	0.63 ± 0.00^{b}	68.32 ± 0.75^{ab}	334.24 ± 0.03^{a}
D	9.38 ± 0.01^{b}	9.61 ± 0.00^{b}	0.97 ± 0.01^{c}	1.86 ± 0.08^{b}	0.61 ± 0.02^{b}	70.61 ± 1.25^{b}	337.62 ± 0.07^{b}
E	9.10 ± 0.01^{b}	10.90 ± 0.63^{b}	0.94 ± 0.00^{b}	1.77 ± 0.03^{b}	0.60 ± 0.01^{b}	73.30 ± 0.54^{c}	352.73 ± 0.11^{c}
F	8.12 ± 0.02^{a}	0.87 ± 0.00^{a}	0.83 ± 0.01^{a}	0.19 ± 0.10^{a}	0.53 ± 0.01^{a}	80.46 ± 1.19^{d}	327.03 ± 0.05^{a}

Values are Mean±standard deviation (n = 3). Data in same column with different letters are significantly different ($p<0.05$), WF: Wheat flour, CF: Cassava flour. A: WF/CF (100:0%), B: WF/CF (95:5%), C: WF/CF (90:10%), D: WF/CF (80:20%), E: WF/CF (70:30%), F: WF/CF (0:100%)

Table 3: Functional properties of different formulation of cassava in wheat flour blends

Samples	Water absorption capacity (g g^{-1})	Oil absorption capacity (g g^{-1})	Swelling power (g g^{-1})	Bulk density Loose and packed (g mL^{-1})		Weight loss of bread (%)
				LBD	PBD	
A	1.68±0.03^{a}	1.06±0.14^{a}	13.45±0.21^{d}	0.48±0.07^{b}	0.71±0.01^{b}	33.25±0.22^{a}
B	1.71±0.05^{a}	1.14±0.09^{a}	12.43±0.92^{c}	0.48±0.01^{b}	0.70±0.07^{b}	33.36±0.10^{a}
C	1.72±0.01^{a}	1.16±0.14^{a}	11.79±0.09^{bc}	0.47±0.06^{b}	0.70±0.07^{b}	34.07±0.28^{ab}
D	1.72±0.01^{a}	1.19±0.22^{a}	11.28±0.17^{bc}	0.47±0.01^{b}	0.69±0.05^{b}	35.01±0.11^{ab}
E	1.81±0.04^{a}	1.18±0.12^{a}	10.47±0.15^{b}	0.47±0.06^{b}	0.68±0.09^{b}	36.81±0.23^{b}
F	2.21±0.02^{b}	1.25±0.05^{b}	8.75±0.37^{a}	0.45±0.07^{a}	0.66±0.10^{a}	42.80±0.15^{c}

Values are mean ± standard deviation (n =3). Data in same column with different letters are significantly different (p<0.05), WF: Wheat flour, CF: Cassava flour. A: WF/CF (100:0%), B: WF/CF (95:5%), C: WF/CF (90:10%), D: WF/CF (80:20%), E: WF/CF (70:30%), F: WF/CF (0:100%)

obtained with CF. The same behavior was observed by Agunbiade *et al.*[32]. This result may be related to the high amount of starch in cassava flour. The water absorption data reflects that a larger amount of water is needed in the preparation of doughs with cassava flour. Similar findings have been reported by Oladunmoye *et al.*[28]. WAC is important in bulking and consistency of product as well as baking applications[22]. Several researchers Ajatta *et al.*[33], Lee *et al.*[34] and Morita *et al.*[35] have reported increased water absorption in composite flours compared to wheat flour alone. The increase in the water absorption capacity of the composite and cassava flours might be attributed to the ability of the cassava starch to absorb water[36]. This effect might be due to the loose association of amylose and amylopectin in the native starch granules and the weak binding forces that maintains the starch granules structure in cassava flour[33-38].

The oil absorption capacity is the flavor retaining capacity of flour which is very important in food formulations and gives soft texture and good flavor to food[39]. Therefore absorption of oil by food products improves mouth feel and flavor retention.

Swelling power (SP): SP of the samples ranged from 10.47±0.15 to 12.43±0.92 g g^{-1} among the blends and decreased proportionately with increase in cassava flour in the formulation. WF had the highest swelling power while CF had the least. The high SP observed with WF could be explained by its higher gluten content. When flour is mixed with water, the gluten swells to form a continuous network of fine strands. High swelling capacity has been reported as part of the criteria for a good quality product[40]. The lower swelling power of cassava flour implies greater degree of associative forces in the granules. This phenomenon can also be due to the high particle size of CF.

Bulk density (BD): Bulk density gives an indication of the relative volume of packaging material required. LBD and PBD swas 0.48±0.07 g mL^{-1} and 0.71±0.01 g mL^{-1} for WF and 0.45±0.07 g mL^{-1} and 0.66±0.10 g mL^{-1} for CF, respectively. Significant difference (p<0.05) was recorded between WF and CF bulk densities. The bulk densities of wheat and all composites flours investigated were not significantly different from each other (p>0.05). The CF group showed a lower values of bulk densities different from other samples. This could be attributed to the relatively high particle size distribution and lower protein and fat contents of cassava flour. Bulk density is influenced by particle size[41] and starch polymers structure[42]. Loose structure of the starch polymers could result in low bulk density. This observation is in good agreement with that reported by Oladunmoye *et al.*[43]. Bulk density of the flour samples is higher than the 0.29 and 0.39 g mL^{-1} reported for cassava and wheat flours[31-39], respectively. In contrast, WF bulk density is higher and may be caused the particles stick to each other due to the presence of water, thereby allowing more particles to agglomerate. Bulk density is a measure of low bulk densities desirable in flour blends because it contributes to reduce dietary bulkiness. Also, it serves as a good physical attribute when determining transportation and storage properties[44,45]. Furthermore, higher bulk density is desirable for greater ease of dispersibility and reduction of paste thickness[46].

Weight loss (WL) and Expansion ratio (ER) of bread: The WL and ER of bread from different formulation are presented in Table 3 and Fig. 1, respectively. The WL decreased proportionately with increase in cassava flour in the formulation. The behavior recorded by the composite bread samples is attributed to low gluten content which has a direct contribution to obtain a heavy bread. These results correlated with the ER of the bread.

Volume is an important quality characteristic of bread and that is negatively affected when wheat is replaced by cassava. However, increasing the cassava ratio decreased

Table 4: Color parameters of different flours

Samples	L*	a*	b*	ΔE
A	88.03±0.02[a]	-0.30±0.03[a]	9.63±0.03[a]	6.45±0.03[a]
B	88.07±0.09[a]	-0.31±0.03[a]	9.71±0.03[a]	6.50±0.03[a]
C	88.13±0.10[a]	-0.31±0.03[a]	9.64±0.03[a]	6.41±0.03[a]
D	88.59±0.07[a]	-0.29±0.03[a]	9.53±0.03[a]	6.09±0.03[a]
E	88.89±0.11[a]	-0.28±0.03[a]	9.50±0.03[a]	5.94±0.03[a]
F	90.71±0.06[b]	-0.11±0.03[b]	9.16±0.03[a]	5.12±0.03[a]
White plate	91.33±0.00[c]	-0.53±0.00[c]	4.09±0.01[b]	-

Values are Mean±standard deviation (n = 3). Data in same column with different letters are significantly different (p<0.05). WF: Wheat flour, CF: Cassava flour. A: WF/CF (100:0%), B: WF/CF (95:5%), C: WF/CF (90:10%), D: WF/CF (80:20%), E: WF/CF (70:30%), F: WF/CF (0:100%)

Table 5: Particle size distribution of different flour

	Granulometry (%)			
	≥200 µm	160 µm	≤112 µm	<160 µm
A	25.0±7.35[a]	25.0±9.33[a]	50.0±9.90[c]	75.0±6.01[b]
B	26.8±6.79[a]	24.3±3.68[a]	48.9±3.11[c]	73.2±2.51[b]
C	29.6±2.82[a]	30.3±2.83[b]	40.1±5.66[b]	70.4±3.72[b]
D	29.1±4.81[a]	28.6±5.94[b]	42.3±10.74[b]	70.9±4.8[b]
E	27.8±9.62[a]	29.6±4.61[b]	42.6±4.81[b]	72.2±3.11[b]
F	36.0±0.56[b]	33.4±0.85[c]	30.6±8.20[a]	64.0±4.091[a]

Values are Mean±standard deviation (n =3). Data in same column with different letters are significantly different (p < 0.05). WF: Wheat flour, CF: Cassava flour. A: WF/CF (100:0%), B: WF/CF (95:5%), C: WF/CF (90:10%), D: WF/CF (80:20%), E: WF/CF (70:30%), F: WF/CF (0:100%)

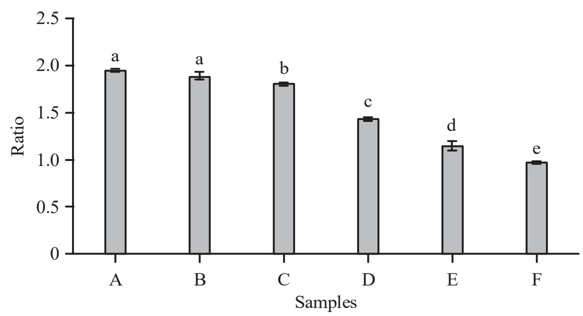

Fig. 1: Effects of different flour on expansion ratio (ER) of bread
WF: Wheat flour, CF: Cassava flour. A: WF/CF (100:0%), B: WF/CF (95:5%), C: WF/CF (90:10%), D: WF/CF (80:20%), E: WF/CF (70:30%), F: WF/CF (0:100%)

the volume of the bread. No significant difference (p>0.05) was found between A and B samples. The overall effect of a reduced bread volume with cassava flour in the flour mixture can be explained by reduced flour strength and a lower ability of the gluten network to enclose the carbon dioxide produced during fermentation. Similar findings on loaf volume of composite flours were reported by Navickis[47], Almazan[48] and Khalil *et al.*[49]. Bread made from 100% CF has a low porous structure with small gas cells and is prone a compact structure during cooling. Cassava flour do not have gluten, moreover, it cannot provide a stabilizing network for retention of gas during baking.

Color determination: The chromatic parameters of different formulation of flour are presented in Table 4. The L* value, which represents the lightness value, was higher for the cassava flour. The wheat and composite flours showed no significant difference (p>0.05) in chromatic parameters. In comparison to the white plate as reference (L*: 91.33; a*: -0.53; b*: 4.09), the color changes of all samples were not reveal significant difference (p>0.05) suggesting that the mixing of the flour did not affect the color of the samples. This could be due to the variety of the cassava. No difference in the color characteristics of the flours could be due to the botanical origin, variety of the cassava or composition of the flour.

Granulometry of flour: As shown in Table 5, wheat used in this study had a finer particle size distribution (75%) at sieves with opening <160 µm compared to cassava flour (64%). Cassava contains fibers, which to some extent are difficult to fine mill. Consequently, the cassava flour was not as fine as the wheat flour[43]. The wheat and composite flours did not vary significantly within the mass fraction found to be <160 µm. Particle size distribution of flours affects the rate of hydration during processing, as very fine (<180 µm) particle-sized flours have greater tendency of absorbing more water during hydration[50]. Tian *et al.*[51] suggested that small granules have higher solubility and hence enhanced water absorption capacity, which have positive implications for functionality of

Table 6: Effect of cassava flour on the sensory properties of bread

	Taste	Flavor	Texture	Appearance	Crack formation
A	8.12±1.35[c]	8.06±1.64[c]	8.23±1.02[c]	8.31±1.99[d]	No crack
B	7.99±1.01[c]	8.24±1.62[c]	7.79±1.92[c]	7.63±1.43[d]	No crack
C	7.62±0.91[c]	7.39±3.11[c]	7.23±0.63[c]	7.07±2.03[d]	No crack
D	5.54±2.92[bc]	6.73±1.00[c]	5.32±2.17[bc]	5.76±1.03[c]	Small cracks
E	4.21±3.03[b]	4.63±0.93[b]	4.01±1.83[b]	4.73±1.02[b]	Large cracks
F	1.72±1.34[a]	2.40±2.05[a]	1.23±0.39[a]	2.43±1.23[a]	Large cracks

Data in same column with different letters are significantly different ($p<0.05$). WF: Wheat flour, CF: Cassava flour. A: WF/CF (100:0%), B: WF/CF (95:5%), C: WF/CF (90:10%), D: WF/CF (80:20%), E: WF/CF (70:30%), F: WF/CF (0:100%)

Table 7: Wheat import, cassava production and need of cassava flour at 10% of substitution

	Wheat import		Cassava production	
	WI	P	AF	NF
Quantity (Tons)	204 622*	4 317 642**	863 528	20 462
Cost ($)	95 865 485	-	-	-
WI limitation cost at 10%S ($)	-	-	-	9 586 549

*2017; **2016, WI: Wheat import, P: Cassava production, AF: Available cassava flour, NF: Need cassava flour at 10% substitution

flour during processing, often create more cohesion in most baking systems. Large granules, on the other hand, would be insufficiently hydrated. The particle size of the flours used in this study was below 300 µm and was therefore easily hydrated as observed also by Oladunmoye *et al.*[28]. As noted above, the high water absorption capacity of cassava flour observed, despite its bigger particle size distribution could be due to its high starch content.

Sensory evaluation: The quality of a product and its appearance are important factors to consumers. Quality and appearance can be described by color, flavor and taste in addition to physical attributes such as texture. The mean sensory scores for each quality attribute evaluated (taste, flavor, texture, appearance and crack formation) of the bread samples prepared from the composites flours are presented in Table 6. The statistical analysis of the data showed there were no significant differences ($p>0.05$) for the quality attribute evaluated of the 10% cassava flour substituted breads with the 100% wheat bread. The mean score of the bread samples decreased as cassava flour increased in the formulation. At 20% cassava flour substituted the scores were above average (5) with small cracks. Beyond 20%, the scores became low, less than 5, indicated that bread baked from cassava flour substituted more than 20% was less acceptable also presented the large cracks. The result obtained from this present study is not in good agreement with that reported by Jensen *et al.*[10] and Defloor *et al.*[52] that successfully obtain good quality bread with up to 30% of cassava flour in composite flour from wheat-cassava. The difference of results might be attributed to the type of variety, maturity of cassava, agro-climatic conditions and the process of making flour. Otherwise, a number of studies have been conducted to use cassava flour in bread making and revealed that wheat flour can be replaced by 5-10% cassava flour without significant effects on processing and the quality of bread[13,53]. One hundred percent cassava bread gave the worst product that was unacceptable to the consumers. The result of this research shows that cassava flour could be used in composite bread production at 20% level of substitution and beyond this level, bread characteristics may be affected.

Economic and social impact of use cassava flour in bread and pastry products: To consider incorporating cassava flour into pastry and bakery products, it is imperative to ensure the availability of the raw material. For this purpose, available cassava flour (AF) and need cassava flour (NF) were determined and the results are recorded in Table 7. The result showed that 863 528 t of cassava flour is available and 20 462 t (at 10% of substitution) of cassava flour is being utilized.

NF represents 42% of AF, which justifies the availability of the raw material and the incorporation of cassava flour in bakery products will not cause any problem of availability of raw material. Otherwise, replacement of wheat flour by cassava flour at 10% in bread making is economically important in Benin as it could save $ 9 586 549 per year. Moreover, this would reduce expenditure of foreign exchange, post-harvest losses, unemployment and poverty also reduce the celiac disease risk. Therefore, this could increase cassava production and increased income for farmers and local industries.

Composite flour from wheat-cassava flour showed physicochemical and nutritional interesting properties in bread making. Thus, production of composite flour on an industrial scale should consider. This research was limited only to the functional chemical nature of cassava flour from variety (BEN 86 052), so further research is required to look at the physical-chemical properties of other varieties of cassava and starches. The application of cassava flour in bread making is highly dependent on the physical-chemical properties of starch.

CONCLUSION

To reduce wheat imports in Benin and/or to improve nutritive value of bakery products, studies have been conducted on the use of composite flours, which consist of blending wheat flour with flour from cassava. The result of this research shows that cassava flour could be used in composite bread production at 20% level of substitution and beyond this level, bread characteristics may be affected. The use of cassava flour in bread making is a convenient alternative for promoting the use of a local crop as well as reducing imports of wheat flour, promoting the production of high quality cassava flour, offering a gluten-free product and developing fortified foods. Also helps to create jobs and contribute to household food security.

SIGNIFICANCE STATEMENT

This study discovers the physical-functional and sensory properties of composite wheat-cassava flour that can be beneficial for bread production at 20% level of substitution. This study will help researchers uncover critical research areas of composite wheat-cassava flour that many researchers have not been able to explore. This research can add knowledge about the advantages of cassava flour used in bread making that may not be found in other areas.

ACKNOWLEDGMENT

The author's thanks French embassy for the financial support (FSP n° 2015-23 ACUPRO); also thanks APP/SP Bénin and Grands Moulins du Bénin (GMB) for technical assistance.

REFERENCES

1. Alisson, E., 2017. Cassava flour can be a partial substitute for wheat flour in bread. Agencia FAPESP, October 18, 2017. http://agencia.fapesp.br/cassava-flour-can-be-a-partial-substitute-for-wheat-flour-in-bread/26423/.
2. Eggleston, G., P.E. Omoaka and D.O. Ihedioha, 1992. Development and evaluation of products from cassava flour as new alternatives to wheaten breads. J. Sci. Food Agric., 56: 377-385.
3. Ohimain, E.I., 2014. The prospects and challenges of cassava inclusion in wheat bread policy in Nigeria. Int. J. Sci. Technol. Soc., 2: 6-17.
4. Seibel, W., 2006. Composite Flours. In: Future of Flour: A Compendium of Flour Improvement, Popper, L., W. Schafer and W. Freund (Eds.). Verlag Agri Media, Hamburg, Germany, ISBN-13: 9783862630424, pp: 193-198.
5. INSAE., 2018. Statistiques economiques. Institut National de la Statistique et de l'Analyse Economique (INSAE), Cotonou, Benin. https://www.insae-bj.org/statistiques/statistiques-economiques.
6. Edema, M.O., L.O. Sanni and A.I. Sanni, 2005. Evaluation of maize-soybean flour blends for sour maize bread production in Nigeria. Afr. J. Biotechnol., 4: 911-918.
7. Nwanekezi, E.C., 2013. Composite flours for baked products and possible challenges-a review. Niger. Food J., 31: 8-17.
8. Aristizabal, J., J.A. Garcia and B. Ospina, 2017. Refined cassava flour in bread making: A review. Ingenieria Invest., 37: 25-33.
9. Ayele, H.H., G. Bultosa, T. Abera and T. Astatkie, 2017. Nutritional and sensory quality of wheat bread supplemented with cassava and soybean flours. Cogent Food Agric., Vol. 3, No. 1. 10.1080/23311932.2017.1331892
10. Jensen, S., L.H. Skibsted, U. Kidmose and A.K. Thybo, 2015. Addition of cassava flours in bread-making: Sensory and textural evaluation. LWT-Food Sci. Technol., 60: 292-299.
11. Noorfarahzilah, M., J.S. Lee, M.S. Sharifudin, A.B.M. Fadzelly and M. Hasmadi, 2014. Applications of composite flour in development of food products. Int. Food Res. J., 21: 2061-2074.
12. Masamba, K. and H. Jinazali, 2014. Effect of cassava flour processing methods and substitution level on proximate composition, sensory characteristics and overall acceptability of bread made from wheat-cassava flour blends. Afr. J. Food Agric. Nutr. Dev., 14: 2190-2203.
13. Eddy, N.O., P.G. Udofia and D. Eyo, 2007. Sensory evaluation of wheat/cassava composite bread and effect of label information on acceptance and preference. Afr. J. Biotechnol., 6: 2415-2418.
14. Tovoli, F., C. Masi, E. Guidetti, G. Negrini, P. Paterini and L. Bolondi, 2015. Clinical and diagnostic aspects of gluten related disorders. World J. Clin. Cases, 3: 275-284.
15. Penagini, F., D. Dilillo, F. Meneghin, C. Mameli, V. Fabiano and G. Zuccotti, 2013. Gluten-free diet in children: An approach to a nutritionally adequate and balanced diet. Nutrients, 5: 4553-4565.
16. Di Sabatino, A. and G.R. Corazza, 2009. Coeliac disease. Lancet, 373: 1480-1493.

17. Food Safety Network, 2014. Cassava nutritional network. University of Guelph, Canada, March 14, 2014, pp: 1-2.
18. FAO., 2012. Food outlook global market analysis. Global Information and Early Warning System (GIEWS), FAO, Rome, Italy, November 2012, pp: 1-129.
19. INSAE., 2017. Statistiques economiques. Institut National de la Statistique et de l'Analyse Economique (INSAE), Cotonou, Benin.
20. Abass, A., A.O. Onabolu and M. Bokanga, 1998. Impact of the high quality cassava flour technology in Nigeria. Proceedings of the 7th Triennial Symposium of the International Society for Tropical Root Crops-African Branch, October 11-17, 1998, Cotonou, Benin.
21. James, C.S., 1995. Analytical Chemistry of Foods. 1st Edn., Chapman and Hall, New York, ISBN: 978-1-4613-5905-0, Pages: 178.
22. Niba, L.L., M.M. Bokanga, F.L. Jackson, D.S. Schlimme and B.W. Li, 2002. Physicochemical properties and starch granular characteristics of flour from various *Manihot esculenta* (Cassava) genotypes. J. Food Sci., 67: 1701-1705.
23. Crosbie, G.B., 1991. The relationship between starch swelling properties, paste viscosity and boiled noodle quality in wheat flours. J. Cereal Sci., 13: 145-150.
24. Okezie, B.O. and A.B. Bello, 1988. Physicochemical and functional properties of winged bean flour and isolate compared with soy isolate. J. Food Sci., 53: 450-454.
25. Vanin, F.M., D. Grenier, C. Doursat, D. Flick, G. Trystram and T. Lucas, 2017. Water loss and crust formation during bread baking, Part II: Technological insights from a sensitivity analysis of a numerical model of baking. Drying Technol., 35: 1518-1529.
26. Tabtiang, S., S. Prachayawarakon and S. Soponronnarit, 2012. Effects of osmotic treatment and superheated steam puffing temperature on drying characteristics and texture properties of banana slices. Drying Technol., 30: 20-28.
27. Wang, H., G. Cui, M.R. Luo and H. Xu, 2012. Evaluation of colour-difference formulae for different colour-difference magnitudes. Color Res. Applic., 37: 316-325.
28. Oladunmoye, O.O., O.C. Aworh, B. Maziya-Dixon, O.L. Erukainure and G.N. Elemo, 2014. Chemical and functional properties of cassava starch, durum wheat semolina flour and their blends. Food Sci. Nutr., 2: 132-138.
29. Eleazu, C., K. Eleazu, C. Aniedu, J. Amajor, A. Ikpeama and I. Ebenzer, 2014. Effect of partial replacement of wheat flour with high quality cassava flour on the chemical composition, antioxidant activity, sensory quality and microbial quality of bread. Prev. Nutr. Food Sci., 19: 115-123.
30. Samad, S., H. Rasulu, Hasbullah and S. Hasan, 2018. Chemical properties of High-Quality Cassava Flour (HQCF) from several varieties of cassava. Pak. J. Nutr., 17: 615-621.
31. Bankole, Y.O., A.O. Tanimola, R.O. Odunukan and D.O. Samuel, 2013. Functional and nutritional characteristics of cassava flour (lafun) fortified with soybeans. J. Educ. Social Res., 3: 163-170.
32. Agunbiade, S.O., O.J. Ojezele and A.M. Eze, 2017. Maximizing the incorporation of cassava flour as an adjunct in bread baking in Nigeria. Chem. Int., 3: 92-96.
33. Ajatta, M.A., S.A. Akinola and O.F. Osundahunsi, 2016. Proximate, functional and pasting properties of composite flours made from wheat, breadfruit and cassava starch. Applied Trop. Agric., 21: 158-165.
34. Lee, M.R., B.G. Swanson and B.K. Baik, 2001. Influence of amylose content on properties of wheat starch and breadmaking quality of starch and gluten blends. Cereal Chem., 78: 701-706.
35. Morita, N., T. Maeda, M. Miyazaki, M. Yamamori, H. Miura and I. Ohtsuka, 2002. Dough and baking properties of high-amylose and waxy wheat flours. Cereal Chem., 79: 491-495.
36. Kaur, M. and N. Singh, 2005. Studies on functional, thermal and pasting properties of flours from different chickpea (*Cicer arietinum* L.) cultivars. Food Chem., 91: 403-411.
37. Sanni, O.L., A.A. Adebowale, T.A. Filani, O.B. Oyewole and A. Westby, 2006. Quality of flash and rotary dried fufu flour. J. Food Agric. Environ., 4: 74-78.
38. Lorenz, P.K., 1990. Quinoa (*Chenopodium quinoa*) starch-physico-chemical properties and functional characteristics. Starch-Starke, 42: 81-86.
39. Amandikwa, C., M.O. Iwe, A. Uzomah and A.I. Olawuni, 2015. Physico-chemical properties of wheat-yam flour composite bread. Niger. Food J., 33: 12-17.
40. Achinewhu, S.C., L.I. Barber and I.O. Ijeoma, 1998. Physicochemical properties and garification (gari yield) of selected cassava cultivars in Rivers State, Nigeria. Plant Foods Hum. Nutr., 52: 133-140.
41. Kulkarni, K.D., N. Govinden and D. Kulkarni, 1996. Production and use of raw potato flour in Mauritian traditional foods. Food Nutr. Bull., 17: 1-8.
42. Plaami, S., 1997. Myoinositol phosphates: Analysis, content in foods and effects in nutrition. LWT-Food Sci. Technol., 30: 633-647.
43. Oladunmoye, O.O., R. Akinoso and A.A. Olapade, 2010. Evaluation of some physical-chemical properties of wheat, cassava, maize and cowpea flours for bread making. J. Food Qual., 33: 693-708.
44. Aluge, O.O., S.A. Akinola and O.F. Osundahunsi, 2016. Effect of malted sorghum on quality characteristics of wheat-sorghum-soybean flour for potential use in confectionaries. Food Nutr. Sci., 7: 1241-1252.
45. Agunbiade, S.O. and M.O. Sanni, 2001. The effect of ambient storage of cassava tubers on starch quality. Proceedings of the 8th Triennial Symposium of the International Society for Tropical Root Crops-African Branch, November 12-16, 2001, Ibadan, Nigeria, pp: 189-194.

46. Udensi, A. and O. Eke, 2000. Proximate composition and functional properties of flour produced from *Mucuna cochinensis* and *Mucuna utles*. Proceedings of the 1st Annual Conference of the College of Agriculture and Veterinary Medicine, September 10-13, 2000, Abia State University, Nigeria, pp: 170-174.
47. Navickis, L.L., 1987. Corn flour addition to wheat flour doughs-effect on rheological properties. Cereal Chem., 64: 307-310.
48. Almazan, A.M., 1990. Effect of cassava flour variety and concentration on bread loaf quality. Cereal Chem., 67: 97-99.
49. Khalil, A.H., E.H. Mansour and F.M. Dawoud, 2000. Influence of malt on rheological and baking properties of wheat-cassava composite flours. LWT-Food Sci. Technol., 33: 159-164.
50. Hatcher, D.W., G.G. Bellido and M.J. Anderson, 2009. Flour particle size, starch damage and alkali reagent: Impact on uniaxial stress relaxation parameters of yellow alkaline noodles. Cereal Chem., 86: 361-368.
51. Tian, Q., M. Streuli, H. Saito, S.F. Schlossman and P. Anderson, 1991. A polyadenylate binding protein localized to the granules of cytolytic lymphocytes induces DNA fragmentation in target cells. Cell, 67: 629-639.
52. Defloor, I., M. Nys and J.A. Delcour, 1993. Wheat starch, cassava starch and cassava flour impairment of the breadmaking potential of wheat flour. Cereal Chem., 70: 526-526.
53. Defloor, I., R. Leijskens, M. Bokanga and J.A. Delcour, 1995. Impact of genotype, crop age and planting season on the breadmaking and gelatinisation properties of cassava (*Manihot esculenta* Crantz) flour. J. Sci. Food Agric., 68: 167-174.