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Substituting Wheat Flour with Banana Flour: Effects on the Quality Attributes of Doughnut and Cookies

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ABSTRACT

This study investigated the possibility of incorporating Cardaba banana flour as a functional replacement ingredient for wheat flour in the production of cookies and doughnut. Cookies and doughnut were prepared by partially replacing wheat flour with Cardaba flour from 0-30% and investigated for their quality attributes. Supplementation significantly ($p \geq 0.05$) affected the nutritive values of the products; crude fibre, total ash and carbohydrate increased, while crude protein (15.37%-26.73% and 7.47-20.97% for doughnut and biscuit) and fat decreased. Caloric value reduced in doughnut but increased in biscuit. Dough properties were affected; volume and density increased, while height decreased. Functional and visco-elastic properties of the flour mixes showed that water absorption, peak, breakdown and final viscosities increased on substitution, oil absorption reduced while bulk density and setback varied. Sensory evaluation revealed that composite doughnut and biscuit with 10% and 20% Cardaba flour respectively were rated highest. Although substitution with Cardaba flour beyond 10% and 20% in doughnut and biscuit were less preferred as compared to the conventional products; higher ash and crude fibre and reduced caloric values may have more nutritional and functional benefits. Therefore, Cardaba banana flour has high potential as value added ingredient in doughnut and biscuit and its incorporation into baked foods will promote enhanced utilization and reduce dependence on wheat flour.

Keywords: Baked foods; Caloric value; Cardaba; Dietary fibre; Functional benefits; Wheat substitutes

INTRODUCTION

The demand for wheat flour has significantly increased due to increase in its utilization by food and allied industries in Africa, especially Nigeria. However, a major challenge to meeting this increasing demand has necessitated sourcing for local substitutes. Although some other cereal grains and tubers have been successfully used for this purpose, there is an increasing interest in fruits rich in dietary fibre which has been associated with health-promoting abilities. Consumption of foods with high dietary fibre has been reported in prevention and management of chronic diseases such as cardiovascular diseases, diabetes and colon cancer (Chen and Anderson, 1986).

Banana constitutes a major staple food crop for millions of people in developing countries and is extensively grown in the tropical and sub-tropical regions. Several reports have shown the successful use of green banana flour in preparation of various innovative products such as high-fibre bread, slowly digestible cookies, edible films and pasta with increased indigestible fraction (Juarez-Garcia *et al.*, 2006; Aparicio-Saguilan *et al.*, 2007; Rungsinee and Natcharee, 2007; Ovando-Martinez *et al.*, 2009). This is owing to its high starch content (73.4%), dietary fibre (~ 14.5%) and resistant starch (17.5%), all of which are much more abundant in starchy cooking bananas such as Cardaba. Usually, a certain percentage is incorporated into wheat flour since it lacks gluten and high gluten content of wheat flour is an essential property of most baked foods. However, wheat flour alternatives are gaining more popularity because they lack gluten which is a major source of concern in baked goods from wheat and its relatives, especially for people suffering from gluten intolerance and celiac disease. Ngalani and Crouzet (1995) have reported the use of flour from partially ripe plantain for biscuit and instant flour production, while the use of green dessert banana flour has been reported in cake and doughnut production (Adeniyi and Empere, 2001; Chong and Noor Aziah, 2008).

The incorporation of whole flour from new plantain and banana hybrids such as Cardaba into foods is anticipated to improve levels of nutrients, especially minerals, since these varieties have been reported to contain higher levels of minerals (Izonfuo and Omuaru, 1988). This will consequently reduce postharvest losses and enhance utilization of underutilized locally-grown crops (Ayo-Omogie *et al.*, 2010).

Musa ABB Cardaba banana is one of these hybrids. It is a starchy, vigorous, very cold-hardy, fast growing, disease-resistant banana that may be eaten raw but is usually cooked. Its hardiness, abundance in Nigeria and year-round availability make it relatively cheaper than dessert banana and plantain (Ayo-Omogie, 2012). The high starch content and functional properties of green Cardaba banana flour qualify it as a source of dietary starch and a possible source of flour for baked foods (Ayo-Omogie *et al.*, 2010; Ayo-Omogie and Oyewole, 2011). Despite these attributes, it is still grossly under-utilized; being restricted to local production of fried chips and flour. Hence, high postharvest losses contributed by its rapid metabolic activities, high moisture content and inadequate utilization of the fruits do occur in this banana. Curbing these losses will therefore require enhanced utilization of this banana as a functional ingredient in various food products. This study has therefore investigated the possibility of partially replacing wheat flour with Cardaba banana flour (CBF) on the quality attributes of doughnut and biscuit.

MATERIALS AND METHODS

Acquisition of materials and processing of banana flour

Mature green Cardaba banana obtained from the Teaching and Research Farm of the Federal University of Technology Akure, Nigeria; was processed into flour using the method of Perezsira (1997) with slight modification for prevention of enzymatic browning. Wheat flour, vegetable oil, baking powder, sugar, butter, salt and dry yeast were purchased at the Akure main market, Akure, Ondo state, Nigeria. All chemicals used were of analytical grade.

Formulation of flour blends and production of doughnut and cookies

Composite Flour blends were formulated by substituting wheat flour with Cardaba banana flour (CBF) at levels of 10% (WBF$_1$), 20% (WBF$_2$) and 30% (WBF$_3$), while 100% each of wheat flour (WF) and CBF served as controls. Doughnuts were prepared by the straight-dough method according to modified formulation (Braden, 1976). Ingredients (Table 1) were mixed using a Kenwood electronic mixer (Model KM 200, Kenwood Ltd, Britain) for 1 minute at speed 2 with exception of shortening which was added later and mixed for another 10 min at speed 6. Mixing was further continued for 5 minutes at speed 8. The mixed dough was allowed to ferment for 45 min at ambient temperature, divided to 12 mm thickness, kneaded and cut with a doughnut cutter then placed on a greased tray, covered with a damp cloth to proof for 15-20 min. The doughnuts were then deep-fried in soya oil at 185^{o}C ± 5 on each side for 3 min. Cookies were prepared using the method of Akpapunam and Darbe (1994). The formulation (Table 1) was mixed using the Kenwood electronic mixer, kneaded, cut using a biscuit cutter and baked at 160^{o}C for 15-20 min. Doughnuts and cookies were allowed to cool at ambient temperatures, packaged in plastic bags and sealed for further analyses.

Table 1: Recipe for Wheat-Banana flour doughnut and cookies

Ingredients	Weights (%)	
	Doughnut[a]	Cookies[b]
Flour	100	100
Yeast	1.12	-
Milk	6	
Egg	10	25
Salt	1	2
Sugar	6	50
Baking powder	1.4	3
Margarine	18	18
Water	36	22

[a] Braden (1976); [b]Mepba *et al.* (2007)

Analysis of flour blends, doughnut and cookies

Physical measurement

Three samples each of doughnut and cookies were randomly selected for physical measurements. Volume of dough was determined using the water displacement method (Osundahunsi *et al.*, 2010). Weight of the cookies was determined by randomly picking three cooled biscuits and taking their weights. Density of the cookies was thereafter calculated by dividing weight by volume. Measurements were done in triplicate. Height of dough for doughnut sample was measured after fermentation using a calibrated ruler.

Proximate analysis and caloric value

Proximate analysis was determined according to AOAC (1990) methods for moisture (14.004), crude fat (14.081), crude fibre (7.0006), ash (14.006) and crude protein (47.021) in which nitrogen to protein conversion factor of 6.25 was used. Carbohydrate was calculated by difference. All analyses were done in triplicate. Caloric values for all samples were determined by calculation. Percentages for protein, crude fat and carbohydrate were multiplied with their respective factors as follows:

Caloric value (kcal/100g) = (% protein x 4) + (% crude fat x 9) + (% carbohydrate x 4).

Determination of functional and visco-elastic properties of flour blends

Water and fat absorption capacities were determined as described by Beuchat (1977) and expressed as percentage of oil or water absorbed by the flour. Pasting properties of the flour blends were characterized using Rapid Visco Analyzer (Model: RVA – 4, Newport Scientific Pty. Ltd., Sydney, Australia). 5 g of flour was added into water to obtain a ratio 1:2 (w/v). This was heated from 28 to 150^{o} C at 4^{o} C/min. The RVE-3d was operated with 250 g of 9.9% treated starch in water suspension. The temperature profile included a 2 min isothermal step at 50^{o} C, linear temperature increases to 95^{o} C in 7 min, a holding step (8 min at 95^{o} C), a cooling step (7 min) with linear temperature decrease to 50^{o} C and a final isothermal step at 50^{o} C (Delcour *et al.*, 2000). Bulk density of the flours was determined using the method of Sathe *et al*. (1982).

Sensory evaluation of doughnut and biscuit

Sensory evaluation was performed 5 h after preparation of doughnuts and cookies. Attributes evaluated were crust and crumb colour, taste, aroma, crispness (for biscuit), hardness, texture, shape, appearance and overall acceptability. Forty panelists (twenty each for doughnut and biscuit familiar with quality attributes of the products) were randomly selected from students and staff of the Department of Food Science and Technology, Federal University of Technology, Akure, to perform the evaluation. Panelists evaluated the samples on a 9 point hedonic scale quality analysis with 9 = extremely like, 8 = like very much, 7 = like, 6 = mildly like, 5 = neither like nor dislike, 4 = mildly dislike, 3 = dislike, 2 = dislike very much and 1 = extremely dislike.

Statistical analysis

Triplicate data obtained were analyzed statistically using analysis of variance (ANOVA) and means separated using Duncan's Multiple Range Test (DMRT). The experimental design used was Randomized Complete Block Design (RCBD). Values were considered significant at $p \leq 0.05$.

Table 2: Physical properties of dough samples for wheat-banana doughnut and cookies

	Doughnut			Cookies		
Wheat:Cardaba banana flour	Sample codes	Height of dough (cm)	Volume of dough (cm^3)	Sample codes	Volume of dough (cm^3)	Density (g/dm^3)
100:0	WD	0.81^c	24.7^a	WC	5.07^a	0.72^a
90:10	WBD_1	0.80^c	29.3^c	WBC_1	5.13^a	1.31^b
80:20	WBD_2	0.60^b	30.7^d	WBC_2	5.00^a	1.54^b
70:30	WBD_3	0.59^b	25.3^b	WBC_3	5.73^b	1.11^b
0:100	BD	0.42^a	40.0^e	BC	9.93^c	1.11^b

Values are means of three replicates. Mean Values followed by different superscripts across rows are significantly different ($p \geq 0.05$).

RESULTS

Physical properties of wheat-banana dough for doughnut and cookies are presented in Table 2. Dough volume (24.7 – 40.0 cm^3 and 5.0 - 9.93cm^3 for doughnut and biscuit) increased as banana flour supplementation level increased, except in 80:20 cookies and 70:30 doughnut, while height of dough reduced consistently from 0.81cm to 0.59cm.

Results obtained for proximate composition (Table 3) indicated that moisture content (ranging from 8.83–19.9% and 4.07–6.2% for doughnut and cookies) significantly increased on CBF inclusion. 100% banana doughnut (BD) had the lowest value (8.83%), and 70:30 composite doughnuts (WBD_3) the highest (19.9%); while for cookies, 100% wheat cookies (WC) had the lowest value (4.07%) and 100% banana cookies (BC) the highest (6.2%). Significant reductions were observed in the protein contents of composite doughnuts and cookies as compared to WD (100% wheat doughnut) and WC (100% wheat cookies). Fat content also reduced in the doughnuts, but increased in the cookies. However, significant increases occurred in the carbohydrate (47.84 - 69.49% and 52.36 - 59.24%), crude fibre (0.06-1.03% and 0.07-1.07%) and ash (0.5-1.21% and 0.52-2.02%) contents of both doughnuts and biscuits. Caloric value of the biscuits (482.84-499.07 Kcal) was higher than those of the doughnut (340.29-418.61 Kcal).

Table 3: Proximate composition and caloric value of wheat-banana doughnut and cookies

Wheat:Cardaba banana flour	Sample codes	Components						
		Moisture (%)	Crude protein (%)	Crude fat (%)	Crude fibre (%)	Total ash (%)	Carbohydrate (%)	Caloric value (kcal/100g)
Doughnut								
100:0	WD	11.50^{e}	26.73^{g}	13.37^{e}	0.06^{a}	0.50^{a}	47.84^{a}	418.61^{e}
90:10	WBD$_1$	12.33^{e}	26.61^{g}	9.93^{d}	0.16^{b}	0.65^{b}	50.32^{b}	397.09^{d}
80:20	WBD$_2$	17.67^{f}	19.50^{e}	7.97^{c}	0.45^{c}	0.71^{c}	53.70^{d}	364.53^{b}
70:30	WBD$_3$	19.90^{g}	16.90^{d}	5.57^{b}	0.90^{d}	1.09^{d}	55.64^{f}	340.29^{a}
0:100	BD	8.83^{d}	15.37^{c}	4.07^{a}	1.03^{e}	1.21^{e}	69.49^{h}	376.07^{c}
Cookies								
100:0	WC	4.07^{a}	20.97^{f}	21.83^{f}	0.07^{a}	0.52^{a}	52.54^{c}	490.51^{g}
90:10	WBC$_1$	4.10^{a}	16.73^{d}	23.53^{g}	0.16^{b}	0.75^{c}	54.73^{e}	492.81^{h}
80:20	WBC$_2$	5.67^{b}	15.53^{c}	24.97^{gh}	0.43^{c}	1. 04^{d}	52.36^{c}	496.49^{i}
70:30	WBC$_3$	5.50^{b}	12.97^{b}	25.87^{h}	0.87^{d}	1.20^{e}	53.59^{d}	499.07^{j}
0:100	BC	6.20^{c}	7.47^{a}	24.00^{g}	1.07^{e}	2.02^{f}	59.24^{g}	482.84^{f}

Values are means of three replicates. Mean Values followed by different superscripts across rows are significantly different ($p\geq0.05$).

The functional and pasting properties of the flours (Table 4) showed that while water absorption consistently increased from 190.00g/g to 300.00g/g as CBF substitution increased, oil absorption reduced from and 200.00g/g to 106.67g/g (Table 4). Bulk density increased initially from 0.76 g/cm^3 to 0.82 g/cm^3 (in WBF$_1$), but reduced thereafter to 0.75 g/cm^3. The increase in peak viscosity of the flours (ranging from 1.33 – 2.64 rvu) was insignificant; however, CBF had the significantly highest peak viscosity of 2.64 rvu (Table 4). Breakdown viscosity also increased on addition of CBF (from 58.04 rvu for WF to 67.13 rvu for WBF$_3$), although insignificantly; but CBF had the lowest value of 1.02 rvu. Setback viscosity of wheat flour varied significantly as on CBF inclusion. On addition of 10% CBF, setback increased from 95.79 rvu to 99.75 rvu but decreased thereafter from 94.38 rvu to 86.71 rvu with 20% and 30% CBF inclusion.

Table 4: Functional and visco-elastic properties of composite wheat-banana flours

Property	Wheat:Cardaba banana flour				
	100:0 (WF)	90:10 (WBF$_1$)	80:20 (WBF$_2$)	70:30 (WBF$_3$)	0:100 (CBF)
Bulk density (g/cm^3)	0.76^{b}	0.82^{c}	0.75^{b}	0.75^{b}	0.62^{a}
Water absorption capacity (g/g)	190.00^{a}	193.33^{a}	266.67^{b}	296.67^{c}	300.00^{c}
Oil absorption capacity (g/g)	153.33^{d}	200.00^{e}	120.00^{b}	106.67^{a}	131.67^{c}
Peak viscosity (rvu)	1.33^{a}	1.40^{a}	1.43^{a}	1.49^{a}	2.64^{b}
Trough (rvu)	75.13^{b}	77.79^{b}	80.33^{b}	82.00^{b}	1.62^{a}
Breakdown (rvu)	58.04^{b}	62.46^{b}	62.34^{b}	67.13^{b}	1.02^{a}
Final viscosity (rvu)	1.71^{a}	1.78^{a}	1.75^{a}	1.69^{a}	2.69^{b}
Setback (rvu)	95.79^{c}	99.75^{d}	94.38^{c}	86.71^{b}	1.06^{a}
Peak time (min)	5.88^{d}	5.61^{c}	5.43^{bc}	5.25^{b}	4.97^{a}
Pasting temp (° c)	49.01^{a}	48.96^{a}	48.21^{a}	48.81^{a}	48.51^{a}

Values are means of three replicates. Mean Values followed by different superscripts across rows are significantly different ($p\geq0.05$).

Results of sensory evaluation showed that both 100% wheat doughnut (WD) and cookies (WC) scored the highest, hence the most preferred; and while 100% banana doughnut (BD) and cookies (BC) the least preferred (Table 5). The 90:10 doughnut (WBD$_1$) was closely rated as high as 100% wheat doughnut (WD), but in the cookies, WC and WBC$_1$ did not differ significantly in taste, texture, crispiness and overall acceptability and up to 20% supplementation was rated as high as 100% wheat cookies in terms of hardness and overall acceptability. Significant difference ($p\geq0.05$) did not exist between the 80:20 (WBD$_2$) and 70:30 (WBD$_3$) composite doughnuts. However, significant differences ($p\geq0.05$) existed among the composite cookies where increasing inclusion of banana flour correlated negatively with consumers' preference. Also, 10% and 20% composite cookies did not differ significantly ($p\geq0.05$) in terms of taste, appearance, crispness and overall acceptability.

Table 5: Sensory properties of composite wheat-banana doughnut and cookies

	Wheat:Cardaba banana composite doughnut				
Parameter	100:0 (WD)	90:10 (WBD$_1$)	80:20 (WBD$_2$)	70:30 (WBD$_3$)	0:100 (BD)
Appearance	6.73^{d}	5.53^{c}	4.87^{b}	4.53^{b}	2.67^{a}
Taste	5.60^{d}	5.20^{bc}	4.93^{b}	5.00^{b}	3.13^{a}
Aroma	5.93^{d}	5.87^{c}	5.53^{b}	5.20^{a}	5.31^{a}
Colour	6.53^{d}	5.67^{c}	4.27^{b}	4.73^{b}	2.67^{a}
Crumb texture	6.20^{e}	5.27^{d}	4.80^{b}	5.07^{bc}	3.00^{a}
Crumb colour	6.47^{d}	5.27^{c}	4.27^{b}	4.27^{b}	2.80^{a}
Crust colour	6.67^{e}	5.60^{d}	4.67^{c}	3.87^{b}	2.60^{a}
Crust texture	6.20^{c}	5.93^{bc}	5.00^{b}	4.93^{b}	3.27^{a}
Overall acceptability	6.53^{d}	5.47^{c}	4.93^{b}	4.80^{b}	3.33^{a}

	Wheat:Cardaba banana composite cookies				
	100:0 (WC)	90:10 (WBC$_1$)	80:20 (WBC$_2$)	70:30 (WBC$_3$)	0:100 (BC)
Appearance	6.33^{d}	5.20^{c}	4.80^{bc}	4.47^{b}	3.40^{a}
Taste	6.60^{d}	6.33^{cd}	6.07^{c}	5.40^{b}	3.80^{a}
Aroma	6.20^{d}	5.53^{c}	5.27^{b}	5.13^{b}	4.20^{a}
Colour	6.33^{e}	5.20^{d}	4.87^{c}	4.33^{b}	3.73^{a}
Texture	6.00^{d}	5.93^{d}	5.60^{c}	4.87^{b}	4.20^{a}
Hardness	6.00^{d}	5.87^{c}	5.93^{d}	5.33^{b}	4.93^{a}
Crispness	6.20^{d}	5.93^{d}	5.73^{c}	5.27^{b}	4.60^{a}
Overall acceptability	6.40^{cd}	5.93^{c}	5.47^{bc}	5.13^{b}	3.73^{a}

Values are means of three replicates. Mean Values followed by different superscripts across rows are significantly different ($p \geq 0.05$).

DISCUSSION

The increase in the dough volume resulting from banana flour supplementation may be attributed to the higher water absorption capacity of banana flour due to its high starch content, consequently resulting in higher swelling of the starch granules (Ayo-Omogie and Oyewole, 2011). However, the consistent reduction in the height of dough may be attributed to reduced gluten content in the flour blends since banana flour lacks gluten and consequently, the ability of the gluten network to trap gas and increase in height during fermentation, was reduced.

Moisture increase in the composite products resulting from CBF substitution may be attributed to the high moisture content of Cardaba banana (Ayo-Omogie *et al.*, 2010) which resulted in dough of higher moisture. Also, the hydrophilic chains in the dietary fibre of banana flour have higher water absorption capacities than wheat flour; therefore, it is necessary to increase the water level during composite flour mixing (Ho *et al.*, 2013). Except for the 80:20 and 70:30 doughnuts, other samples may be of good storability, since food products with moisture less than 13% are stable from moisture-dependent deterioration (Potter and Hotchkiss, 1995). The reduction in protein content may have resulted from dilution, since Cardaba flour is low in protein and predominantly a starchy food (Ayo-Omogie and Oyewole, 2011); hence resulting in increased carbohydrate content in the composite doughnuts and biscuits.

Reduced fat content of the doughnut with increase in CBF may be due to reduction of protein (gluten) since wheat has higher protein content. Noor Aziah *et al.* (2012) had earlier reported similarly in wheat-banana bread and this reduction has been attributed to the fact that protein and wheat gluten have more hydrophobic binding sites which are usually available for binding hydrophobic substances (Heywood *et al.*, 2002). However, the increase in fat with CBF increase observed in cookies may be related to the fat retention of the flours caused by differences in heat processing techniques used in preparation of the products which showed that on baking, fat content increased but reduced on frying. Heat processing has been reported to increase oil absorption of unripe plantain, sweet potato starch, precooked tannia and blanched Cardaba banana flours (Fagbemi, 1999; Osundahunsi and Fagbemi, 2003, Fagbemi and Olaofe, 2000; Ayo-Omogie, 2012 respectively). This has been attributed to denaturation and dissociation of protein during heat treatment which may be responsible for the higher oil absorption capacity of these heat-treated flours because the apolar amino acids of proteins unfold during heat treatment thereby encouraging hydrophobicity (Hutton and Campbell, 1981). According to Kinsella (1976), hydrophobic proteins show superior binding of lipids, implying that the non-polar amino acid side chains bind the paraffin side chains of fat. Apparently, baking could be said to have resulted in higher protein denaturation and consequently more hydrophobicity, thereby improving the fat retention in cookies as compared to deep frying used in preparation of the doughnut.

Increased crude fibre content is an indication of the possible increase in dietary fibre, thereby making Cardaba banana flour a functional food ingredient. Increased ash content may be attributed to the higher levels of some minerals in Cardaba banana (Ayo-Omogie *et al.*, 2010), hence improving the micronutrient content of the products. Higher caloric value of the cookies is traceable to differences in the fat contents of both samples (Table 3). The reduction in these values in doughnut and increase in cookies can be linked to reduced fat in doughnut and increase in cookies; hence indicating that fat contributes most to caloric value of foods as compared to carbohydrates or proteins. This can be corroborated with values obtained for carbohydrate contents of the samples which were although higher in doughnut but still did not result in higher caloric values of doughnuts (Table 3).

Increased water absorption may be attributed to the higher starch content of the flours contributed by the Cardaba banana which is majorly a starchy food as indicated by the relative increase of carbohydrate (Table 3). Water absorption could be related to the physical state of starch, dietary fibre and protein in flour; thus flours with higher starch content have higher water absorption capacity (Waliszewski *et al.*, 2003). The higher number of hydroxyl groups found in fibre structure, which tends to allow more water interactions through hydrogen bonding has been reported to be responsible for high water absorption capacity of fibre-rich flours (Noor Aziah *et al*., 2012). Hence, the blends could be useful in bakery products where hydration to improve handling is desired. Reduction in oil absorption may, however, be attributed to the higher protein content in WF which is a hydrophobic material that could result in more available hydrophobic binding sites available for oil holding by the protein (Heywood *et al*., 2002). Despite this, the high oil absorption of the flours may be useful for stabilizing emulsions of food system, as well as being a good source of dietary fibre and in ground meat, doughnuts, and pancakes where oil absorption property is of prime importance. Increase in bulk density may be as a result of the porosity of banana flour (i.e. small pore space) which enables it to be more compressed when stacked. Product density influences the amount and strength of packaging material.

Peak viscosity, which is the maximum viscosity, developed during or soon after the heating portion of the pasting test, may be attributed to different rates of water absorption and swelling of the starch granules (Ragaee and Abdel-Aal, 2006). Thus, CBF which had the highest value could be said to have the highest water-binding potential, while WF with the lowest value has the lowest water-binding potential. This is corroborated with results of water absorption capacity earlier reported and may be attributed to the possible increase in starch content as CBF substitution increased. Higher swelling index is indicative of higher peak viscosity and this may be responsible for the increase in dough volume as earlier reported. The least breakdown viscosity obtained for 100% CBF implies it was more resistant to heat and shear force during heating and that there was less starch granule rupture which could therefore guarantee a more stable cooked paste (Farhat *et al.*, 1999) since breakdown viscosity has been reported as a measure of the degree of disintegration of starch granules or paste stability during heating (Dengate, 1984). Increased inclusion of CBF may therefore not necessarily affect the paste stability of the products. The decrease in setback may indicate increased stability of the flours against retrogradation since setback viscosity has been reported to be an indication of the stability of cooked paste against retrogradation and as such can also be used to predict the storage life of a product prepared from the flour (Zaidul *et al.*, 2007). Hence samples baked with WBF_3 (70:30) composite flour will have the least tendency to retrogradation as compared to WF (100% wheat) or WBF_1 (90:10) composite flours.

Consumer’s preference for the 90:10 doughnut and cookies (WBD_1 and WBC_1) is an indication that substitution of banana flour up to 10% would give good quality acceptable products comparable to 100% wheat. However, the insignificant difference in sensory rating between the 90:10 and 80:20 composite cookies implies that up to 20% CBF inclusion is permissible for production of acceptable cookies. Also, comparing 100% Cardaba cookies to 100% Cardaba doughnut, the former was rated higher than the latter, thus further implying that for cookies production, higher amount of CBF substitution may not seriously affect consumers’ acceptance of the product.

CONCLUSION

The reduced fat content and caloric value in doughnut as Cardaba flour substitution increased may make for healthy eating, while increased crude fibre (which is an indication of possible increase in dietary fibre) and ash in both products makes Cardaba banana flour a functional food ingredient and hence a good substitute for wheat-less baked foods. However, composite doughnuts and cookies of acceptable quality can be produced by substituting wheat flour with Cardaba banana flour at levels not exceeding 10% and 20% respectively. Thus, Cardaba banana flour has high potential as value added ingredient that can be incorporated in doughnut and cookies.

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