integrity Research Journals

Research Journal of Food Science and Nutrition
Volume 7(2), pages 59-67, April 2022
Article Number: 094E07F24
ISSN: 2536-7080
https://doi.org/10.31248/RJFSN2022.142
https://integrityresjournals.org/journal/RJFSN

Full Length Research

Functional and pasting properties of wheat and cooking banana flour blends and their utilization in cookies production

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Received 2nd April 2022; Accepted 28th April 2022

ABSTRACT: The main objective of this study was to investigate the functional and pasting properties of wheat and cooking banana flour blends and their utilization in cookie production. Wheat and cooking banana composite flour were mixed in the ratios of 100:0, 0:100, 95:5, 90:10, 85:15, and 80:20, coded as samples AKCA, AKCB, AKCC, AKCD, AKCE, and AKCF respectively and used to produce cookies. The cookies were subjected to proximate and sensory evaluation while the flour blends were analyzed for their functional and pasting properties. Proximate analysis of the cookies revealed a significant ($p<0.05$) increase in moisture (5.81 to 7.80%), ash (4.00 to 5.25%), and crude fibre (2.07 to 3.10%) with a corresponding decrease in protein (8.40 to 7.69%), fat (25.84 to 23.95%) and carbohydrate (53.87 to 52.21%). Results for functional properties revealed a significant ($p<0.05$) increase in the water absorption capacity (0.75 to 2.28 g/ml) while bulk density and oil absorption capacity ranged from 0.82 to 0.88 g/g and 1.08 to 1.31 g/g, respectively with least gelation concentration of 2%. Results for pasting properties revealed a significant ($p<0.05$) increase in the peak viscosity (191.25 to 669.10 RVU), trough viscosity (104.70 to 380.54 RVU), breakdown viscosity (85.96 to 288.63 RVU), final viscosity (191.25 to 669.17 RVU), and setback viscosity (94.05 to 139.34 RVU). On the other hand, a decrease in the peak time (6.07 to 4.93 minutes) and pasting temperature (94.80 to 83.33°C) was observed. Sensory evaluation of the cookies showed that the control sample (100% wheat cookies) was the most preferred for colour, texture, taste and overall acceptability. Based on the overall scores, the control sample did not differ significantly ($p<0.05$) from the cookie samples substituted with cooking banana flour. This, therefore, shows that cooking bananas can be substituted with wheat flour at levels of 0 to 20% for the production of acceptable cookies of nutritional quality. The flour blends may also be utilized in households for the production of other functional bakery products such as bread, biscuits, and cakes thereby reducing the dependency on wheat flour.

Keywords: Cookies, flour, functional, pasting, proximate, sensory, wheat.

INTRODUCTION

Cookies are a type of confectionery product that is widely used as a snack food by children, and adults, and on a big scale in underdeveloped nations where protein and caloric deficiencies are common (Chinma *et al*., 2012). They are popular baked goods because of their low manufacturing costs, ease of use, and long shelf life (Onwurafor *et al*., 2019). If easily available to the populace, they can act as a vehicle for the delivery of vital nutrients (China *et al*., 2020a). Wheat flour is the primary ingredient used in the manufacturing of cookies. Wheat flour (*Triticum aestivum*), a byproduct of wheat grain, is deficient in protein, vitamins, and minerals (Emelike and Ujong, 2020). As a result, fortifying wheat flour with other nutrient-dense plants for the development of healthy food products will boost the nutritional content of wheat-based products.

The demand for wheat flour for the creation of baked goods and other food products has expanded dramatically as a result of the gradual growth in consumption of these food products and increasing utilization of wheat flour by Nigerian households (China *et al*., 2020a). This has forced research into partially substituting wheat flour with alternative grains for food production. Several studies have been conducted in an attempt to achieve this. Eke-Ejiofor and Deedam (2015) produced confectionaries such as cake and biscuits from blends of tiger nut and wheat flour. China *et al*. (2019) also produced stiff porridge from wheat and cooking banana flour while China *et al*. (2020b) utilized blends of wheat and fluted pumpkin flour for the production of biscuits and cake.

Cooking banana (*Musa acuminate*) is a banana species endemic to South East Asia, with the largest diversity in Malaysia and Indonesia (Harith *et al*., 2007). This species is a cross between wild and cultivated bananas known scientifically as *M. acuminate* Colla (AAA group) 'Dwarf Cavendish' (China *et al*., 2020a). They are typically grown as houseplants and can be consumed uncooked. The fruits are 8 to 13 cm long and 2.5 to 5.5 cm in diameter, and are short, stubby, and very angular (Ogbonna *et al*., 2016). They can be eaten ripe or unripe, are starchy, and are commonly known as plantains or green bananas. Cooking bananas varied in flavour from sweet to savoury, in shape from bent to straight, and in colour from green to yellow, pink, silver, stripped, or speckled. They are high in vitamin A and C, as well as minerals including potassium, calcium, and phosphorus (China *et al*., 2020a). The unripe cooking banana flour is reported to contain 5.69 to 6.47% protein, 0.41 to 0.70% fat, 2.58 to 3.16% ash and 89.66 to 91.30% carbohydrate (Ogbonna *et al*., 2016). In Nigeria, there is a low inclination for cooking banana, which necessitates its use in a composite with wheat flour for cookie making. To ensure sustainable food consumption at the household level, it is critical to promote the use of underutilized food crops such as cooking bananas. The study's focus is that cooking bananas are underutilized during this time of food crisis, and their availability in Nigeria is a privilege for households to defend against food insecurity. The study will show households how to properly and efficiently enjoy cooking bananas by employing its flour in the making of cookies.

For composite flours such as wheat and cooking banana flour blends to be applied in the production of food systems apart from stiff porridge, a foreknowledge of their performance is required (Iwe *et al*., 2017) as improper knowledge of these functionalities may result in products with varying consumer acceptability. Functional properties are fundamental physicochemical properties which reflect how food ingredients behave during preparation and cooking and they include water and oil absorption capacity, bulk density, solubility, swelling power, etc (Orisa and Udofia, 2020). Therefore, for efficient utilization and acceptance of wheat and cooking banana flour composite flour, studies on its desirable functional and pasting properties are important as their application for the production of food products is primarily governed by these properties. The objective of this study was to provide information on the functional and pasting properties of wheat and cooking banana flour blends with a view to establishing the full industrial potential of the flour blends for utilization in cookie production.

MATERIALS AND METHODS

Sources of materials

Freshly harvested unripe cooking banana and wheat flour were purchased from Mile 3 market in Port Harcourt Local Government Area of Rivers State. All reagents used for all analysis were obtained from the Analytical Laboratory, Department of Food Science and Technology, Rivers State University, Port Harcourt and were of analytical grade.

Processing of cooking banana flour

The processing of the cooking banana into flour was carried out using the method of China *et al*. (2020a) (Figure 1). Unripe cooking banana was washed in tap water and peeled using hand pressure to obtain the pulp. The pulp was sliced and blanched for fifteen minutes. The blanched cooking banana was dried at 60°C for 24 hours in a hot-air fan oven, ground and sieved. The flour obtained was stored in an air-tight plastic container at room temperature (37°C) until used.

Sample and recipe formulation

Wheat and cooking banana flour blends were formulated at different ratios of 95:5, 90:10, 85:15, and 80:20 while 100% wheat flour and 100% cooking banana flour were used as control (Table 1). The flour blends were mixed using a Nutri-Blender for 10 minutes in order to achieve uniform blending.

Production of cookies

The butter and sugar were measured into a mixing bowl and creamed until fluffy. The egg and vanilla were stirred into the mixture. All dry ingredients were mixed in a separate bowl and added to the batter which was mixed homogeneously and placed in the refrigerator for one hour. After one hour, the dough was taken out of the fridge, rolled into a log and cut into 1 cm slices. The cut dough was transferred to a greased baking tray and allowed to cook in a preheated oven of about 200°C (392°F) for 10 minutes. When cooked, the cookies were allowed to cool and stored in an airtight container.

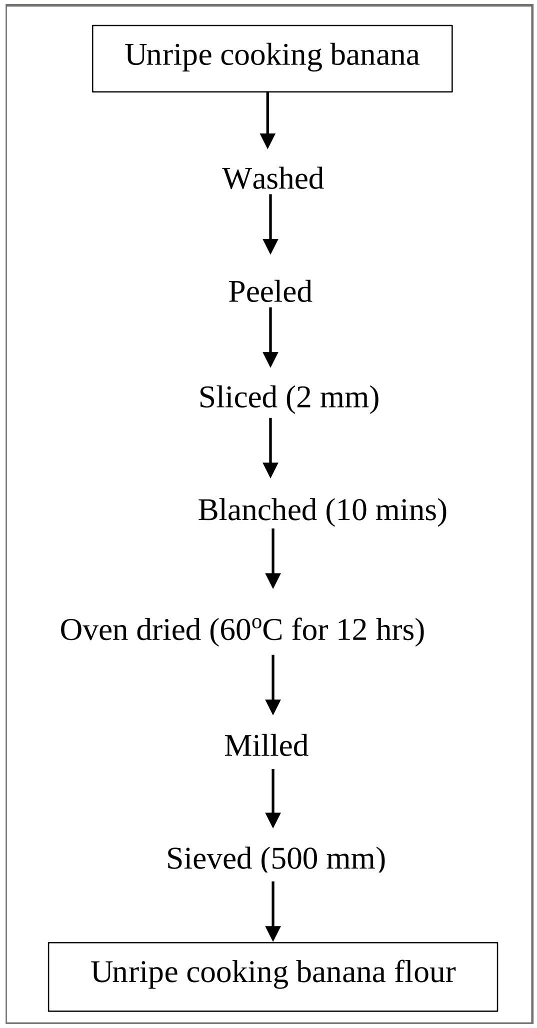

Figure 1. Production of flour from unripe cooking banana (Source: China *et al*., 2020a).

Table 1. Recipe for production of cookies.

Ingredients	A	B	C	D	E	F
WF (g)	100	-	95	90	85	80
CBF (g)	-	100	5	10	15	20
Margarine (g)	225	225	225	225	225	225
Sugar (g)	200	200	200	200	200	200
Salt (teaspoon)	¼	¼	¼	¼	¼	¼
Egg (whole)	1	1	1	1	1	1
Vanilla essence (teaspoon)	2	2	2	2	2	2

Key: WF= Wheat flour; CBF= Cooking banana flour.

Proximate analysis

Proximate analysis (moisture, ash, protein, fat and crude fibre) of the cookies was determined using the method of the Association of Official Analytical Chemists (AOAC, 2006) while total available carbohydrate was calculated by difference using the formula:

100% - (% Moisture + % Ash + % Crude protein + % Fat + % Crude fibre)

Functional properties of the flour blends

The oil and water absorption capacity of the flour blends was determined as described by Onwuka (2005). Relative bulk density and least gelation concentration were determined by the method described by Narayana and Narasinya (1984).

Pasting properties of the flour blends

The pasting properties of the samples were determined using the Rapid Visco Analyzer (RVA) also known as amylograph according to Newport Scientific, Narrabeen Australia as described by Ikegwu *et al*. (2010). Thirty grams (30 g) of the flour samples and 50 ml of distilled water were mixed in a paddle. The paddle was placed into a canister containing the samples and water. The samples were then inserted into the rapid viscous analyser. The analysis was carried out at a programmed heating and cooling cycle where the samples were held at 50ºC for 1 minute, heated at 95ºC for 3 to 8 minutes and held at 50ºC for 1 to 4 minutes. The pasting performance of the samples was automatically recorded on the graduated sheet of the instrument.

Sensory analysis

The samples were subjected to sensory evaluation 30 minutes after preparation. This was carried out using 20 panellists made up of students of the Department of Home Science/Food Science, Rivers State University, Port Harcourt. The following attributes namely: colour, texture, taste, aroma and overall acceptability were assessed on a 5-point hedonic scale. The assessment ranged from 5 (like extremely) to 1 (dislike extremely) as described by Iwe (2007). The criterion for the selection of panellists was based on their knowledge of the products to be evaluated. The panellists were asked to sit on the laboratory stools with spaces apart and with a coded paper given to each of them according to the samples to be evaluated. The panellists were instructed to rinse their mouths with water before and after tasting the samples.

Statistical analysis

Data obtained from the analysis were subjected to analysis of variance (ANOVA) using the Statistical Package for the Social Sciences (SPSS) version 23.0. Duncan's Multiple Range Test (DMRT) was used to determine the significant differences in mean values with significant differences considered at the level of $p<0.05$.

RESULTS AND DISCUSSION

Proximate composition of cookies produced from wheat and cooking banana flour blends

Table 2 shows the proximate composition of cookies produced from wheat (WF) and cooking banana flour (CBF) blends. The results showed a significant difference in the moisture content of the products. Moisture content for cookies ranged from 5.81 to 7.80% with sample AKCA (100% wheat flour) having the lowest moisture content (5.81%) and sample AKCF (80% wheat flour: 20% cooking banana flour) having the highest moisture content (7.80%). The moisture content of the cookies increased with the increase in the ratio of cooking banana flour added. This increase was reported by Ayo-Omogie and Odekunle (2015) for wheat-cardaba banana flour blend cookies. They reported that the moisture increases in the composite products resulting from Cardaba banana flour substitution might be due to the higher moisture content of the dough. Ho *et al*. (2013) further added that the dietary fibre of banana flour has high water absorption capacities than wheat flour. Bakery products with moisture of less than 13% are stable from moisture-dependent deterioration (Ayo-Omogie and Odekunle, 2015). The moisture content of all the cookies produced was below this specified moisture content.

There was an increase in the ash content of the cookies with values ranging from 4.0% in sample AKCA to 5.25% in sample AKCF. Significant ($p<0.05$) differences existed in the ash content of the cookies. Ash content of any food material is an indication of the non-organic compound containing mineral content of the food. The cookies produced from 80% WF and 20% CBF had the highest ash content implying that when used as composite flour, it will improve the mineral content of the product. This finding is in correlation with that of Ayo-Omogie and Odekunle (2015) who also reported an increase in ash content of cookies produced from wheat-cardaba banana flour blends 0.52 to 1.20% as the substitution with Cardaba banana increased.

The fat content of the cookies ranged from 21.14% in cookies made with 100% CBF to 25.84% in cookies made with 100% WF. There was a decrease in the fat content of the cookies as a substitution for wheat flour with CBF increased. This trend was also observed by Edima-Nyah and Ukwo (2016) who reported a decrease in fat content of banana-cocoyam composite flour blend biscuits (10.90-7.37%) as the substitution with banana flour increased. Fat plays a significant role in predicting the shelf-life of food products and as such high fat content could be undesirable in baked food products as it promotes rancidity leading to the development of unpleasant and odorous compounds (China *et al*., 2020a).

The protein content of the cookies decreased as the substitution for wheat flour with cooking banana flour

Table 2. Proximate composition (%) of cookies produced from wheat and cooking banana flour blends.

Samples	Moisture	Ash	Fat	Protein	Crude fibre	Carbohydrate
AKCA	$5.81^{d}\pm0.11$	$4.00^{c}\pm0.11$	$25.84^{a}\pm0.73$	$8.40^{a}\pm0.01$	$2.07^{e}\pm0.05$	$53.87^{bc}\pm0.33$
AKCB	$7.18^{c}\pm0.07$	$4.08^{c}\pm0.20$	$21.14^{d}\pm0.65$	$4.38^{e}\pm0.03$	$4.79^{a}\pm0.04$	$58.43^{a}\pm0.78$
AKCC	$6.62^{b}\pm0.19$	$4.38^{bc}\pm0.78$	$25.45^{ab}\pm0.07$	$8.37^{a}\pm0.01$	$2.22^{e}\pm0.04$	$52.97^{bc}\pm0.23$
AKCD	$7.25^{b}\pm0.00$	$4.51^{abc}\pm0.35$	$25.12^{abc}\pm0.18$	$8.22^{b}\pm0.01$	$2.50^{d}\pm0.04$	$52.30^{bc}\pm0.11$
AKCE	$7.53^{ab}\pm0.07$	$4.89^{ab}\pm0.42$	$24.33^{bc}\pm0.18$	$7.88^{c}\pm0.01$	$2.81^{c}\pm0.03$	$52.56^{bc}\pm0.35$
AKCF	$7.80^{a}\pm0.07$	$5.25^{a}\pm0.26$	$23.95^{c}\pm0.21$	$7.69^{d}\pm0.01$	$3.10^{b}\pm0.06$	$52.21^{c}\pm0.22$

Mean values are of duplicate determinations. Mean values within a column with different superscripts are significantly different at p<0.05. **Keys:** AKCA: 100% wheat flour, AKCB: 100% cooking banana flour, AKCC: 95% wheat flour and 5% cooking banana flour, AKCD: 90% wheat flour and 10% cooking banana flour, AKCE: 85% wheat flour and 15% cooking banana flour, AKCF: 80% wheat flour and 20% cooking banana flour.

increased. The protein content of the cookies ranged from 8.40% in cookies made with 100% wheat flour to 4.38% in cookies made with 100% cooking banana flour. This decrease was also reported by Edima-Nyah and Ukwo (2016) who reported that the decrease in the crude protein of cookies was a result of increase in banana proportion. Ayo-Omogie and Odekunle (2015) also reported a decrease in wheat-cardaba flour blend cookies from 20.97 to 12.97% due to increase in the substitution of cardaba banana flour. Protein plays a part in the organoleptic properties of the cookies in addition to being a source of amino acids (Usman *et al*., 2015).

The crude fibre content of the cookies increased significantly from 2.07% in cookies made with 100% WF to 4.79% in cookies made with 100% CBF. This is in line with the findings of Loza *et al*. (2017) that the addition of banana flour increased the crude fibre content of wheat flour cookies. Onyekwelu and Ogbu (2017) also reported an increase in fibre content of wheat, unripe plantain and morning leaf blend cookies from 0.50 to 2.00% as the substitution with the unripe plantain flour increased. China *et al*. (2020a) also reported an increase from 1.06 to 2.81%. An increase in fibre content of the cookies suggests that these products will aid digestion thereby preventing constipation (Elleuch *et al.,* 2011).

There was a decrease in the carbohydrate content of the cookies from 58.43% in cookies made with 100% CBF to 52.21% in cookies made with 80% WF and 20% CBF. Cookies made from 100% WF have been reported to contain a high amount of carbohydrates due to the higher amount of carbohydrates in wheat flour (Hawa *et al*., 2018). The reduced carbohydrate content in wheat/cooking banana flour blend cookies may not favour better production of energy in meeting daily activities. Ijeh *et al*. (2010) reported that high carbohydrate is important as it provides the energy needed to do work; however, low carbohydrate content in diets is also of advantage for diabetic patients that need very low carbohydrate contents in their diets.

Functional properties of flour blends formulated from wheat and cooking banana

Table 3 shows the functional properties of flour blends formulated from wheat and cooking banana. The results revealed that the water absorption capacity (WAC) of the flours ranged from 0.75 to 2.28g/g. The WAC was observed lowest in sample AKCA (100% wheat flour) 0.75 g/g and highest in sample AKCB (100% cooking banana flour) 2.28 g/g. Samples AKCD, AKCE and AKCF showed no significant difference (p>0.05) in their water absorption capacity. The incorporation of cooking banana flour resulted in an increase in the WAC of the flour blends. Water absorption is the water-binding capacity of the flour. Water absorption capacity (WAC) is the ability of flour particles to entrap large amount of water such that exudation is prevented. Eke-Ejiofor and Owuno (2012) described water absorption as an important processing parameter that has implications for viscosity and is also important in bulking and consistency. The result showed that water absorption capacity was highest in sample AKCB and increased as the ratio of cooking banana flour added increased. This may be attributed to the low protein and high carbohydrate contents and particle size of the cooking banana flour. This result is in line with the report of Ohizua *et al*. (2017) that carbohydrates greatly influence the water absorption capacity of foods. However, the results for all the samples showed positive water absorption capacity thus making them suitable raw materials in the development of baked food products.

The oil absorption capacity of the flour blends ranged from 1.31 g/g in sample AKCA to 1.08 g/g in sample AKCF. There was no significant (p>0.05) difference in the oil absorption capacity of the flour samples. The result shows that wheat flour has a higher oil absorption capacity as a result of the hydrophobic property of the protein in the flour. The presence of protein in wheat flour exposes more amino acids to the fat and enhances hydrophobicity as a result of which the flour absorbs more oil than other samples. This result is in agreement with Jitngarmkusol *et al*. (2008) who reported that the major chemical component affecting oil absorption capacity is the protein which is composed of both hydrophilic and hydrophobic parts. The different flour blends showed good oil absorption capacity and according to Oluwalana *et al*. (2011), good oil absorption capacity of flours suggests that they may be useful in food preparations that involve oil mixing like bakery products where oil is an important ingredient.

Table 3. Functional properties of flour blends formulated from wheat and cooking banana.

Samples	Water absorption capacity (g/ml)	Bulk density (g/g)	Oil absorption Capacity (g/g)	Least gelation concentration (%)
AKCA	$0.75^{d}\pm0.06$	$0.86^{a}\pm0.01$	$1.31^{a}\pm0.02$	$2.00^{a}\pm0.00$
AKCB	$2.28^{a}\pm0.04$	$0.86^{a}\pm0.01$	$1.19^{a}\pm0.04$	$2.00^{a}\pm0.00$
AKCC	$0.79^{cd}\pm0.02$	$0.82^{a}\pm0.04$	$1.17^{a}\pm0.06$	$2.00^{a}\pm0.00$
AKCD	$0.87^{bc}\pm0.00$	$0.85^{a}\pm0.02$	$1.15^{a}\pm0.11$	$2.00^{a}\pm0.00$
AKCE	$0.90^{bc}\pm0.01$	$0.87^{a}\pm0.02$	$1.14^{a}\pm0.06$	$2.00^{a}\pm0.00$
AKCF	$0.92^{bc}\pm0.00$	$0.88^{a}\pm0.03$	$1.08^{a}\pm0.29$	$2.00^{a}\pm0.00$

Mean values are of duplicate determinations. Mean values within a column with different superscripts are significantly different at $p<0.05$.**Keys:** AKCA: 100% wheat flour, AKCB: 100% cooking banana flour, AKCC: 95% wheat flour and 5% cooking banana flour, AKCD: 90% wheat flour and 10% cooking banana flour, AKCE: 85% wheat flour and 15% cooking banana flour, AKCF: 80% wheat flour and 20% cooking banana flour.

The bulk density of the flour samples was represented as packed bulk density and loose bulk density. The packed bulk density of the flour samples ranged from 0.85 g/cm^3 in sample AKCD (85% wheat flour and 15% cooking banana flour) to 0.88g/g in sample AKCF (80% wheat flour and 20% cooking banana flour). The flour samples showed no significant difference ($p<0.05$) in the values of the packed bulk density. Bulk density is important in determining the packaging requirement, material handling and application in wet processing in the food industry (Orisa and Udofia, 2020). Generally, higher bulk density is desirable for greater ease of dispersibility and reduction of paste thickness (Amandikwa *et al*., 2015). Amandikwa *et al*. (2015) further reported that low bulk densities of flour are good physical attributes when determining transportation and storability since the products could be easily transported and distributed to required locations. The result of this research shows no significant difference in the bulk densities of the flour blends and should be recommended where such attributes are of great importance.

There was no significant difference ($p<0.05$) in the least gelation concentration of the flour blends. The value for the least gelation concentration was 2.00 for all samples. The least gelation concentration (LGC) measures the minimum amount of flour needed to form a gel in a measured volume of water (China *et al*., 2019). The authors further reported that the higher the LGC, the higher the quantity of flour needed to form a gel and the lower the LGC the better the gelling ability of the flour. The low least gelation concentration of the flour blends shows that little quantity of flour will be needed for gel in a volume of water.

Pasting properties of flour blends formulated from wheat and cooking banana

The pasting properties of the flour blends are shown in Table 4. Peak viscosity of the flour blends ranged from 191.25 to 669.17 RVU with the lowest value in sample AKCD (191.25 RVU) and the highest in sample AKCB (669.17 RVU) which differed significantly ($p>0.05$) from other samples. Peak viscosity is an indicator of the strength of pastes which are formed from gelatinization during processing in food applications. It also reflects the extent of granule swelling (Eke-Ejiofor and Owuno, 2017). Sanni *et al.* (2004) also reported that peak viscosity is the ability of starches to swell freely before their physical breakdown and it indicates the strength of the pastes formed during gelatinization. According to an earlier report by Osungbaro (1990), it was revealed that higher starch content of flour and higher water-binding capacity resulted to higher peak viscosity. This trend is also seen in this research as the cooking banana flour had the highest water absorption capacity and also shows the highest value for peak viscosity. This result shows that the starch content of cooking banana flour is higher than that of wheat flour and can be used in composite with non-starchy or low starchy foods to increase their starch content.

The trough viscosity of the flour samples ranged from 104.7 RVU in sample AKCE to 380.54 RVU in sample AKCB. Similarly, the cooking banana flour had the highest trough viscosity differing significantly ($p<0.05$) from other flour blend samples. Trough is the minimum viscosity which measures the ability of paste to withstand breakdown during cooling. High trough viscosity for 100% cooking banana flour indicates that the flour can withstand high heat treatments during processing; hence the addition of cooking banana flour to products can increase their hold period (trough).

The breakdown viscosity of the flour blends ranged from 85.96 RVU in sample AKCD to 288.63 RVU in sample AKCB. A significant ($p<0.05$) decrease in the breakdown viscosity was observed in the other flour blend samples. The breakdown is essentially a measure of the degree of paste stability or starch granules disintegration during heating (Oluwalana *et al*., 2012). The samples containing more wheat flour had reduced breakdown viscosities implying that these samples will form a more stable paste during heating than sample AKCB (100% cooking banana flour) which had higher breakdown viscosity.

Set back viscosity of the flour blends ranged from 94.05

Table 4. Pasting properties (RVU) of flour blends formulated from wheat and cooking banana

Samples	Peak viscosity (RVU)	Trough viscosity (RVU)	Breakdown viscosity (RVU)	Setback viscosity (RVU)	Peak Time (min)	Pasting Temperature (°C)
AKCA	$206.75^b±2.23$	$113.55^b±4.42$	$93.21^b±6.66$	$99.96^b±0.65$	$6.07^a±0.19$	$94.73^a±0.25$
AKCB	$669.10^a±14.62$	$380.54^a±0.06$	$288.63^a±14.67$	$139.34^a±6.24$	$4.93^b±0.00$	$83.33^b±0.11$
AKCC	$201.42^b±17.68$	$106.17^b±7.54$	$95.25^b±10.14$	$98.29^b±2.18$	$5.84^a±0.05$	$94.75^a±0.28$
AKCD	$191.25^b±16.26$	$105.29^b±11.37$	$85.96^b±4.89$	$94.05^b±5.83$	$5.90^a±0.04$	$94.70^a±0.35$
AKCE	$225.6^b±15.56$	$104.7^b±12.02$	$96.71^b±6.67$	$99.57^b±6.51$	$5.78^a±0.06$	$94.80^a±0.49$
AKCF	$219.00^b±13.44$	$111.06^b±13.11$	$102.52^b±8.00$	$100.94^b±6.81$	$5.82^a±0.03$	$93.85^a±0.28$

Mean values are of duplicate determinations. Mean values within a column with different superscripts are significantly different at $p<0.05$. **Keys:** AKCA: 100% wheat flour, AKCB: 100% cooking banana flour, AKCC: 95% wheat flour and 5% cooking banana flour, AKCD: 90% wheat flour and 10% cooking banana flour, AKCE: 85% wheat flour and 15% cooking banana flour, AKCF: 80% wheat flour and 20% cooking banana flour.

Table 5. Mean sensory scores of composite cookies produced from wheat and cooking banana flour.

Samples	Colour	Texture	Aroma	Taste	Overall acceptability
AKCA	$4.45^a±0.89$	$4.10^a±1.07$	$3.95^a±0.89$	$4.45^a±0.76$	$4.24^a±0.77$
AKCB	$2.40^b±0.75$	$2.90^b±1.07$	$3.35^a±1.18$	$3.40^b±1.19$	$3.01^b±0.73$
AKCC	$3.95^a±1.00$	$3.75^{ab}±1.07$	$3.75^a±0.64$	$4.15^{ab}±0.75$	$3.86^a±0.60$
AKCD	$4.25^a±0.64$	$3.55^{ab}±2.00$	$3.80^a±0.89$	$4.10^{ab}±0.79$	$3.93^a±0.65$
AKCE	$3.70^a±0.98$	$3.40^{ab}±0.82$	$4.05^a±0.69$	$4.25^a±0.79$	$3.85^a±0.59$
AKCF	$3.90^a±0.72$	$3.55^{ab}±0.94$	$3.70^a±0.57$	$4.08^{ab}±0.93$	$3.83^a±0.53$

Mean values are of duplicate determinations. Mean values within a column with different superscripts are significantly different at $p<0.05$. **Keys:** AKCA: 100% wheat flour, AKCB: 100% cooking banana flour, AKCC: 95% wheat flour and 5% cooking banana flour, AKCD: 90% wheat flour and 10% cooking banana flour, AKCE: 85% wheat flour and 15% cooking banana flour, AKCF: 80% wheat flour and 20% cooking banana flour.

RVU in sample AKCD to 139.34 RVU in sample AKCB. Similarly, the setback viscosity of the flour blends was highest in sample AKCB (100% cooking banana flour), there was no significant difference ($p>0.05$) in the setback viscosity of the other flour samples. A high setback viscosity is associated with a cohesive paste while a low value is an indication that the paste is not cohesive (Oduro *et al*., 2000). The reduction in setback viscosity in other samples is an indication of a low rate of starch degradation and syneresis of the gel. The lower setback viscosity of these samples also indicates its lowest rate of degradation and this will be useful in the prolonged shelf life of the flour.

The peak time of the flour blends ranged from 4.93 minutes in sample AKCB to 6.07 minutes in sample AKCA. There was a slight decrease in the peak time of the flour blends as the proportion of cooking banana flour increased. The peak time is usually regarded as an indication of the total time taken for each sample to attain its respective peak viscosity. Therefore, a complementary food sample with a lower peak time will cook faster than that with a higher peak time.

The pasting temperature of the flour blends ranged from 83.33°C in sample AKCB to 94.80°C in sample AKCE. The increased ratio of cooking flour resulted in a slight increase in the pasting temperature, however, there was no significant difference in the pasting temperature of the other flour blends indicating their ability to form gel at the same temperature range. Sample AKCB showed a significant difference ($p<0.05$) from the other flour samples. The pasting temperature provides an indication of the minimum temperature required to cook a given food sample which can also have implications on energy usage (Ragaee and Abdel-Aai, 2006). A high pasting temperature usually indicates that the flour has a high water absorption capacity.

Sensory evaluation of cookies produced from composite flours

Table 5 shows the mean sensory scores of cookies produced from wheat and cooking banana flour. The result indicates that sample AKCA (cookies made from 100% wheat flour) gave the highest sensory scores of 4.45 for colour, 4.10 for texture, 4.45 for taste and 4.24 for overall acceptability. Sample AKCE (cookies made with 85% WF and 15% CBF) gave the highest sensory scores for aroma. Sample AKCC (cookies made with 95% WF and 5% CBF) and sample AKCD (cookies made with 90% WF and 10% CBF) also showed good sensory scores for colour, texture, aroma, taste and overall acceptability which can be compared favourably to cookies made with 100% wheat flour. This trend was also reported by China *et al*. (2020a). Sample AKCB (cookies made 100% cooking banana flour) was significantly different (p<0.05) from other samples in colour, texture, taste and overall acceptability.

Conclusion

This study reveals that cooking banana flour can be used as a partial substitute for wheat flour in a range of 0 to 20% for the production of cookies. It was also observed that the inclusion of cooking banana flour improved the ash content of the products. There was also a significant decrease in the fat content of the products with a corresponding increase in cooking banana flour which will serve as a healthier substitute for those trying to cut down on their fat intake. The study also revealed that cooking banana flour possesses good pasting properties and thus will produce cooked and baked products of good quality. The result also indicated that blends of wheat and cooking banana flour bends could find applications in the confectionary and functional bakery products and also in food systems such as complementary food formulation. It is therefore recommended that cookies of acceptable quality could be produced by substituting wheat flour with cooking banana flour within the range of 5 to 20%.

CONFLICT OF INTEREST

The authors confirm that they have no conflict of interest.

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