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ORIGINAL ARTICLE

Physico-Chemical and Sensory Properties of Cookies Produced from Composite Flours of Wheat and Banana Peel Flours

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Abstract

Banana peels have various health benefits to excellent nutritional status, and it treats the intestinal lesion, diarrhoea, dysentery, ulcerative colitis, nephritis, gout, cardiac disease, hypertension, and diabetes. This study aimed to utilize flour from banana peel to develop functional cookies. Banana peel flour was substituted in wheat flour at 11, 13 and 15 %, then used to produce cookies. Composite cookies produced were evaluated for proximate composition, mineral composition and heavy metals content as well as anti-nutritional content. Result of proximate composition of the cookies indicated that increase in addition of banana peel flour resulted in increase in the fat, ash and crude fibre of the composite cookies. The fat, ash and crude fibre varied between (12.00 – 12.20%), (2.26 – 2.73%) and (1.03 – 1.33%) respectively. From the result of mineral analysis, it was observed that calcium, potassium, magnesium, iron, manganese, zinc, potassium and sodium of the cookies ranged between 70.00-150.00 mg/100g, 6.66–40.00 mg/100g, 23.33–55.00 mg/100g, 1.36–4.76 mg/100g, 0.01–0.23 mg/100g, 0.16–0.40 mg/100g, 93.33–140.00 mg/100g and 233.33–340.00 mg/100g respectively. Cookies supplemented with flours of banana peel had higher contents of all these minerals but zinc than those produced from wheat flour alone. Cookies supplemented with banana peel flour had higher anti-nutritional values than the control in terms of (phytates, phenols, flavonoids, saponin and tannin) examined. Heavy metals content of the cookies shows that there were little or no traces and it is within the standard limit control of recommended daily allowance. It was concluded that the use of flours from banana peels as composites of wheat had good potential for production of nutritionally superior cookies compared to the use of wheat alone. This study may be an economically viable approach towards promoting utilization of food wastes for production of value added products in developing countries such as Nigeria, where food security has been a major challenge.

Practical application

The knowledge of nutritional and bioactive component as well as the antioxidant activity of banana peels can help in development of cookies in order to reduce waste generation, environmental pollution and reduce cost in waste disposal. Inclusion of banana peel in cookies production can serve as a potential source of functional food ingredients in its production to prevent damages caused by free radicals in the body.

Keywords: Cookies, composite flour, banana peels, heavy metals, anti-nutrients.

1. Introduction

With the constant increase in the consumption of bread and other baked products such as cookies in many developing countries, coupled with ever-growing urban populations, the composite flour technology in the making of baked food products could be very useful (Olaoye & Ade-Omowaye, 2011). Consumers' awareness on the need to eat healthy and functional foods is increasing worldwide and health conscious consumers prefer food that furnishes extra health benefits beyond the basic nutritional requirements (Baba *et al.*, 2015). Therefore, there is a trend to produce functional foods such as cookies and noodles made from wheat flour and health promoting compounds from non-wheat flours known as functional ingredients (Dewettinck *et al.*, 2008).

Banana (*Musa spp*.) is among the leading fruit crops in the economic value in the world. It is ranked the fifth in the world trade (Guylene *et al.*, 2008). Banana peels have various health benefits to excellent nutritional status, and it treats the intestinal lesion, diarrhoea, dysentery, ulcerative colitis, nephritis, gout, cardiac disease, hypertension, and diabetes (Imam and Akter, 2011). Banana peels are rich in phenolic compounds as they are a good source of antioxidants, which protect against heart disease and cancer (Someya *et al.*, 2002). Banana peel wastes from industrial processes represent about 40% of fresh bananas (Anhwange *et al.*, 2009). These wastes pose an environmental problem for their generation of large quantities of organic waste. Researchers have shown that noodles flour from banana peels lowers glycemic index and reduces the duration of digestion due to the high content of resistant starch (Li *et al.*, 2006; Ramli *et al.*, 2009).

Recently, the food industry is dealing with high rate of food waste which is produced by fruit processing of different products such as juices, wines, jams, purees, etc (Bertagnolli *et al.*, 2014). Re use of banana processing waste, such as peel, could improve the yield of raw materials and subsequently minimise the large waste disposal problems faced by the food industry (Mahloko *et al.*, 2019). Therefore, the economic and technological feasible alternative will be to produce flours from banana peels to make new products such as noodles or to partially incorporate these flours in wheat flour in order to improve the nutritive value of confectionaries such as cookies.

This by-product constitutes an environmental problem because it contains large quantities of nitrogen and phosphorus and its high water content makes it susceptible to modification by microorganisms (Arun *et al.*, 2015). The banana fruits are consumed at different stages of maturity and the amount of peels is expected to increase with the development of processing industries that utilise the green and ripe banana. Banana peel flour potentially offer new products with standardised compositions for various industrial and domestic uses (Emaga *et al.*, 2007). Various studies have been conducted to investigate possible value addition to banana peel including the production and evaluation of banana peel flour (Shayma & Alaa, 2020), production of cookies from wheat and banana/avocado peels (Olaoye *et al.* 2019), the effects of ripeness stage on the dietary fibre components and pectin of banana peels (Emaga *et al.*, 2008), production of biscuits from banana and prickly peel flours (Mahloko *et al.*, 2019; Hernawati *et al.*, 2017), Utilizing banana peels in the production of balady flat bread (Nareman, 2016). The objective of this study therefore was to determine the nutrient composition, physical and sensory properties of cookies produced from composite flours of wheat and banana peels.

2. Materials and Methods

2.1. Materials

2.1.1. Source of raw materials and flours preparation

Wheat (white) flour, sugar, salt, fat, sodium bicarbonate (baking powder) and whole milk powder were purchased from Oja Oba market, Akure, Ondo State, Nigeria. All reagents used were of good analytical grade.

Fresh matured banana (at stage 5 of ripening: yellow) was obtained from a market in Oja Oba, Akure, Ondo State, Nigeria. The samples were selected and separated into pulps and peels. To reduce enzymatic browning, the banana peels (stage 5 of ripening) were dipped in 0.5% (w/v) citric acid solution for 10 minutes. The peels were drained and dried in cabinet oven at 50°C until constant weight obtained. The dried peels were milled in a Retsch mill laboratory (RetschAS200, Ham, Germany) to pass through 40 mesh screens of aperture of 0.25 m size to obtain banana peel flour. Flour was stored in airtight plastic packs in cold storage (15±2°C) for further studies.

2.1.2. Formulation and optimization of wheat-banana peel flours

The flour blends combination of wheat and banana peel flour in percentage was determined using Optimal Mixture Design of Response Surface Methodology (Design Expert 9.0). Thirteen formulations were generated by the software and were analysed for nutritional contents as the dependent variables (Table 2). The desirability function approach (DFA) was used to simultaneously optimize the responses. Three optimum blends were selected for the wheat – banana peel cookies production and 100% wheat flour was used as control (Table 3).

2.1.3. Preparation of wheat – banana peel cookies

The four optimum blends were used in the preparation of *cookies*. The basic formulations used for preparation of cookies are outlined in Table 1. Cookies were produced using a modified method of Kiin-Kabari & Eke-Ejiofor (2013). 50g of vegetable shortening was added to the flour or blend and mixed until a sandy texture was obtained. The other ingredients were added, followed by already whisked egg and mixed thoroughly to obtain dough. The dough was placed on a clean table, rolled and cut out into required shapes, baked in an oven at 180°C for 30 minutes.

2.2. Analysis

2.2.1. Functional properties

Water and oil absorption capacities were determined using the method described by Adebowale *et al.* (2012), bulk densities of the various composite flour and control samples were determined using the method described by Ashraf *et al.* (2012) with slight modifications.

Swelling capacity was studied using the method described by Hirsch (2002). One gram of sample was poured into pre-weighed graduated centrifuge tube appropriately labelled. Then, 10 ml of distilled water was added to the weighed sample in the centrifuge tube and the solution was stirred and placed in a water bath heated at different temperature range (55, 65, 75, 85, 95^{0}C) for 1 h while shaking the sample gently to ensure that the starch granules remained in suspension until gelatinization occurs. The samples were cooled to room temperature under running water and centrifuged for 15 min at 3000 rpm. After centrifuging, the supernatant was decanted from the sediment into a pre-weighed petri-dish; the supernatant in the petri-dish was weighed and dried at 105 °C for 1 h. The sediment in the tube was weighed and the reading recorded. The swelling power was determined according to the equations below;

$$\textit{Swelling power} = \frac{\textit{weight of swollen sediment}}{\textit{weight of dry starch}}$$

Table 1. Basic formulation of wheat – banana peel cookies

Ingredients	Cookies formulation			
	100%WF	**11%BPF**	**13%BPF**	**15%BPF**
Wheat flour (g)	100	89	87	85
Banana peel flour (g)	0	11	13	15
Sugar (g)	40	40	40	40
Fat (g)	35	35	35	35
Salt (g)	0.5	0.5	0.5	0.5
Milk powder (g)	2	2	2	2
Water (ml)	15	15	15	15
Ammonium bicarbonate (g)	1.5	1.5	1.5	1.5

Table 2. Response Surface Optimization of wheat-banana peel flour blends with respect to some chemical parameters

Runs	Wheat Flour (%)	Banana peel flour (%)
1	92.5	7.5
2	91	9
3	98	2
4	85	15
5	85	15
6	100	-
7	96	4
8	87	13
9	85	15
10	89	11
11	100	-
12	100	-
13	92.50	7.5

Table 3. Optimum flour blends for production of wheat-banana peel based noodles and cookies

Runs	Wheat flour	Banana peel flour
Control	100	-
4	89	11
8	87	13
10	85	15

Least gelation concentration was studied according to the method of AOAC (2006) with slight modifications. In every case for triplicate samples, 5 cm^3 of 2-20% (w/v) suspended samples were in test tubes and heated for 1 h in a boiling water bath followed by rapid cooling under running cold tap water. The test tubes were further cooled for 2 h at 4°C and the gelation capacity was the least gelation concentration determined as the concentration when the sample from the inverted test tube did not fall or slip.

2.2.2. Pasting properties

Pasting properties of the flour blends were characterized using the Rapid Visco Analyzer (RVA Model 3c, Newport Scientific PTY Ltd, Sydney) as described by Sanni *et al.* (2006). Five (5) grams of samples were accurately weighed into a weighing vessel and 25ml of distilled water was dispersed into a new test canister. Samples were transferred onto the water surface of the canister after which the paddle was placed into the canister. The blade was vigorously joggled up and down through the sample ten times or more until no flour lumps remained either on the water surface or the paddle. The paddle was properly centred into the canister and the measurement cycle initiated. Peak viscosity (RVA), Peak time (min), Peak temperature (°C), Trough (RVU), pasting temperature (°C) and final viscosity (RVU) were read on the instrument while breakdown and setback viscosities (RVU) were calculated.

2.2.3. Determination of Physical properties of the cookies samples

The physical properties of cookies was determined with slight modifications following the method of Chinma & Gernah (2007). Diameter (D) and height (H) was determined using Vernier calliper and it was used to calculate spread ratio. Six cookies were laid edge to edge and the overall diameter of the cookies was measured. The cookies were rearranged six times and the diameter recorded. Six cookies were stacked at top of each other and the height of the cookies was recorded using a Vernier calliper. The cookies were rearranged six times and height recorded. The averages obtained were given off as diameter and height of the cookies. Values obtained were used to calculate spread ratio as ratio of diameter of cookies and height of cookies.

$$Spread\ ratio = \frac{Diameter}{Thickness}$$

2.2.4. Determination of Proximate and Mineral Contents of the noodles and cookies samples

Moisture, fat, ash, protein, crude fibre and carbohydrate contents of the cookies prepared from different mixtures of wheat and banana peel flours were determined using standard analytical methods described by AOAC (2010) procedure. Moisture content was determined by drying the samples in an oven at 103^0C to constant weight.

Ash content was determined by incineration of the samples at 550^0C for 3 hours. Nitrogen (N) content was determined using the micro-Kjedahl method according to AOAC procedures. The protein content was calculated as N (Protein Nitrogen) x 6.25. Lipid content was determined using soxhlet apparatus following AOAC methodology. The total percentage carbohydrate content was determined by the AOAC (2010) method. This method involves adding the total value of food protein, crude fat, moisture and ash constituents of the sample and subtracting it from 100. All the samples were analysed in triplicates.

Mineral content were determined by flame photometry using flame photometer as described by AOAC (2010) methods. Phosphorus was determined by molybdovanadate method (AOAC, 2010). Calcium and magnesium were determined using atomic absorption spectrophotometer (AOAC, 2010).

2.2.5. Heavy metals composition of the cookies samples

1g of each cookie sample was digested with concentrated nitric acid and perchloric acid in a ratio of 3:1 on a hot plate. At the end of complete digestion it was filtered using a Whatman filter paper No. 1 into a 50 mL volumetric flask and made up to mark with distilled water. Metals concentrations were determined by Atomic Absorption Spectrophotometer (Shimadzu AA-6800) with graphite furnace and background correction (SR-BDG). The flame conditions were optimized for maximum absorbency and linear response while aspirating known standards. The standards were prepared from individual 1000 ppm stock solution of the respective metals initially prepared from their respective salts.

2.2.6. Anti-nutritional composition of the noodles and cookies samples

Phytate content was determined as described by Ayele *et al.* (2017) after extraction of sample with 2.4% HCl for 1 h. The absorbance of sample was measured at 500 nm wavelength using a UV-vis Spectrophotometer (DU-64 spectrophotometer, Beckman, USA). The value obtained was subtracted from the blank absorbance value and the phytate content (mg/100 g sample) was estimated from the phytic acid standard calibration curve (5-36 mg/kg).

The method of Krishnaiah *et al.* (2009) was used to determine the flavonoids content. 1 g of the sample was weighed and repeatedly extracted with 100 cm^3 of 80% methanol at room temperature. The mixture was then filtered through filter paper into a 250 cm^3 beaker and the filtrate was transferred into a water bath and allowed to evaporate to dryness and weighed. The % flavonoid was calculated using the formula:

$$x = \frac{w2 - w1}{w3} \times 100$$

Where x = percentage flavonoids, W_1 = weight of empty beaker, W_2 = weight of empty beaker + flavonoid and W_3 = weight of sample.

Also, the method of Krishnaiah *et al.* (2009) was used to determine the saponin content. 0.5 g of the sample was added to 20 cm^3 of 1M HCl and was boiled for 4 h. After cooling, it was filtered and 50 cm^3 of petroleum ether was added to the filtrate and the ether layer evaporated to dryness. 5 cm^3 of acetone/ethanol mixture was added to the residue. 0.4 cm^3 of each was taken into 3 different test tubes. 6 cm^3 of ferrous sulphate reagent was added into them followed by 2 cm^3 of concentrated H_2SO_4. It was thoroughly mixed and after 10 min the absorbance was taken at 490 nm. Standard saponin was used to establish the calibration curve.

Tannin content was determined using a modified vanillin-hydrochloric acid method (Ayele *et al.*, 2017). Sample (about 1 g) was extracted with 10 mL of 1% HCl for 24 h. Extract (1 mL) was reacted with 5 mL vanillin HCl reagent (8% concentrated HCl in methanol and 4% vanillin in methanol, 50:50, v/v). The absorbance of colour developed was measured after 20 min at 500 nm wavelength using a UV-vis Spectrophotometer (DU-64 spectrophotometer, Beckman, USA). Catechin calibration curve was used to determine the tannin contents as mg of catechin/g of sample.

2.2.7. Sensory evaluation

Sensory attributes of the enriched and control *cookies* samples were evaluated with 50 semi-trained panellists who are members of the Department of Food Science and Technology with basic knowledge of food sensory assessment. Nine-point hedonic scale (1= dislike extremely to 9 = like extremely) was used to rank preferential scores. The panellists were served the *cookies* samples randomly and sensory assessments were done with respect to aroma, appearance, taste, texture, finger feel, after taste and overall acceptability.

2.2.8. Statistical Analysis

All analyses were carried out in triplicate and data generated were subjected to One-Way Analysis of Variance (ANOVA) using Statistical Package for Social Sciences (SPSS) version 20.0. The means were separated using Duncan's Multiple Range Test at 95% confidence level ($p < 0.05$).

3. Results and Discussion

3.1. Functional properties of the wheat – banana peel flour

Table 4 presents the functional properties of the wheat-banana peel flour samples. The functional properties of the flours showed that while water absorption consistently increase from 155.00% to 178.33% as banana peel flour substitution increases, oil absorption also varied between 131.66% to 151.00%.. This result is close to those of Suresh *et al.* (2014) who reported an increase in the water and oil absorption capacity of wheat flour with addition of banana peels. This high water absorption capacity values could be associated with the dietary fibre fraction contained in the peels which have been shown to be also closely related to oil holding capacity.

Table 4. Functional properties of the wheat-banana peel flour

Runs	WAC (%)	OAC (%)	Swelling capacity (%)	Loose Bulk density (g/ml)	Packed Bulk density (g/ml)	Least gelation concentration (%)
Control	155.00 ± 5.00^{c}	131.66 ± 2.88^{b}	1.86 ± 0.05^{a}	0.28 ± 0.01^{c}	0.28 ± 0.01^{d}	2.00 ± 0.00^{c}
10	167.00 ± 5.00^{b}	140.00 ± 5.00^{ab}	1.65 ± 0.05^{b}	0.37 ± 0.00^{b}	0.54 ± 0.00^{c}	4.00 ± 0.00^{b}
8	178.00 ± 3.33^{ab}	145.00 ± 5.20^{a}	1.53 ± 0.05^{c}	0.37 ± 6.00^{b}	0.59 ± 0.00^{b}	4.00 ± 0.00^{b}
4	178.33 ± 7.63^{a}	151.00 ± 5.00^{a}	1.50 ± 0.05^{c}	0.38 ± 0.00^{a}	0.63 ± 0.00^{a}	6.00 ± 0.00^{a}

*Values are means of three replicates. Mean values ± standard deviation followed by different superscripts across columns are significantly different ($p \leq 0.05$). WAC = Water absorption capacity, OAC = Oil absorption capacity; Control = 100% Wheat flour, Run 10 = 89% Wheat flour + 11% Banana peel flour, Run 8 = 87% Wheat flour + 13% Banana peel flour, Run 4 = 85% Wheat flour + 15% Banana peel flour

According to Sharoba *et al.* (2013) oil absorption capacity of the fibre source samples might also depend on the total content of protein present. Also, Kiin-Kabari *et al.* (2015) had reported that the ability of food materials to absorb water is sometimes attributed to the protein content. This suggests that increase in water absorption in the blends can be useful in bakery products such as bread, cakes, cookies that requires hydration to improve dough handling characteristics. Ferreira *et al.* (2013) reported that both water and oil absorption capacity correlate with food quality because they are important functional properties.

Table 5. Pasting properties of the wheat-banana peel flour

Runs	Peak (RVU)	Trough1 (RVU)	Breakdown (RVU)	Final Viscosity (RVU)	Setback (RVU)	Peak Time (min)	Pasting Temperature (^{0}C)
Control	1781 ± 1.00^a	1024 ± 1.00^a	657 ± 1.00^b	1914 ± 0.01^a	990 ± 0.01^a	5.73 ± 0.00^b	77.25 ± 0.01^c
10	1630 ± 1.00^b	980 ± 1.00^{ab}	700 ± 1.00^{ab}	1858 ± 0.00^b	928 ± 0.00^b	5.87 ± 0.00^{ab}	82.25 ± 0.01^b
8	1515 ± 1.00^c	972 ± 1.00^{ab}	723 ± 1.00^a	1761 ± 6.00^c	919 ± 0.00^b	6.20 ± 0.00^{ab}	88.00 ± 0.01^a
4	1091 ± 1.00^d	624 ± 1.00^b	467 ± 1.00^c	1496 ± 0.00^d	872 ± 0.00^{bc}	6.60 ± 0.00^a	90.45 ± 0.01^a

*Values are means of three replicates. Mean values ± standard deviation followed by different superscripts across columns are significantly different ($p\leq0.05$). Control = 100% Wheat flour, Run 10 = 89% Wheat flour + 11% Banana peel flour, Run 8 = 87% Wheat flour + 13% Banana peel flour, Run 4 = 85% Wheat flour + 15% Banana peel flour

Swelling capacity decreased initially from 1.86% to 1.50% in flour with up to 15% banana peel flour addition. There was significant difference ($p < 0.05$) in swelling power between control and composite flours. Addition of banana peel flour improved the hydration capacity of the composite flour blends.

The loose and packed bulk density of the different flour blends ranged from 0.28 to 0.38g/ml and 0.28 to 0.63g/ml respectively, with the control (100% wheat flour) having the lowest value and flour with 15% banana peel flour addition having the highest value as shown in Table 3. The higher the bulk density, the denser the flour, suggesting that 15% banana peel flour is heavier than other substituted samples. Information on bulk density may be useful in packaging. Increase in bulk density may be as a result of the porosity of banana peel 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. Significant difference was recorded between most of the composite flours and the control (100% wheat flour), indicating noticeable influence of flours from banana peels. The implication of this is that using flours from peels of banana as composite of wheat may result in varieties of composite flour technology which could be useful in bakery technology and other food formulations. It has been noted that functional properties are intrinsic physico-chemical characteristics of food (especially flours) which affect the behaviour of properties in food systems during processing, manufacturing, storage and preparation (Olaoye & Obidegwe, 2018).

3.2. *Pasting properties of the wheat – banana peel flour*

Table 5 presents the pasting properties of the wheat-banana peel flour samples. The pasting properties of the flours considered include the peak viscosity, trough, breakdown viscosity, final viscosity, setback, peak time and pasting temperature. A peak viscosity of 1781 RVU which was significantly different from other flour blends was observed in the control, while the least peak viscosity of 1091 RVU was recorded in the flour blends containing 15% banana peel flour as shown in Table 4. However, peak viscosity of the samples decreased with increase in banana peel flour addition. Peak viscosity which is the maximum viscosity developed during or soon after the heating portion of the pasting test was higher than the values reported for wheat flour and blended plantain flour by Arisa *et al.* (2013). This difference may be attributed to differences in analytical procedures and experimental conditions used. Peak viscosity is often correlated with the final product quality and also provides an indication of the viscous loads likely to be encountered during mixing (Maziya-Dixon *et al.*, 2004). The hold period (Trough) sometimes referred to as shear thinning, holding strength or hot paste viscosity is a period when the samples were subjected to a period of constant temperature and mechanical shear stress. It ranged from 624 RVU in flour blend containing 15% banana peel flour to 1024 RVU in the control. This result indicates higher trough than that reported by Arisa *et al.* (2013) who reported a trough viscosity value of 259.25 RVU for blended unripe plantain flour, and 186.75 RVU for plantain flour treated with sodium metabisulphite. The break down viscosities of the wheat-banana peel flour samples ranged from 467 RVU found in flour blend containing 15% banana peel flour to 723 RVU found in flour blend containing 11% banana peel flour. It is an indication of breakdown or stability of the starch gel during cooking (Ragace *et al.*, 2006). The breakdown is regarded as a measure of paste stability. Arisa *et al.* (2013) reported lower breakdown viscosities between 34.67 to 46.92 RVU for blanched unripe plantain flour. However, Daramola & Osanyinlusi (2005) reported much higher values of breakdown viscosity (115.42-487.9 RVU) in six different varieties of banana in Ekiti State, Nigeria. A final viscosity range of 1496 RVU in flour blends containing 15% banana peel flour to 1914 RVU in the control observed in this study are far lower when compared to the report of Okafor & Ugwu (2013) who observed final viscosity values of 284.50 RVU for French plantain and soy residue flour blends and 270.25 RVU for false horn plantain and soy residue flour blend. Lower setback viscosity indicates higher potential for retrogradation in food products and gives an idea about retrogradation tendency of starch (Oduro *et al.*, 2000). It shows the viscosity of cooked paste after cooling to 50°C. Higher setback value is associated with cohesiveness. This study showed a setback viscosity range of 872 to 990 RVU. Flour blends containing banana peel flour having setback viscosities of 872 - 928 RVU compared favourably with the control (990 RVU). Arisa *et al.* (2013) reported a setback value of plantain flour treated with sodium metabisulphite to be 35.83 RVU which is lower than the values reported in this study. The peak time is a measure of the cooking time (Adebowale *et al.*, 2005). Peak time increased from 5.73 minutes in the control to 6.60 min in flour blends containing 15% banana peel flour. Peak time increased with increase in the level of banana peel flour in the flour blends as shown also in Table 4. The pasting temperature of the wheat-banana peel flour blends varied between 77.25 to 90.45°C. The control had the lowest pasting temperature (77.25°C) in while banana peel flour addition up to 15% had the highest pasting temperature (90.45°C) . Since pasting temperature is a measure of the minimum temperature required to cook a given food sample, flour blends with higher pasting temperature may not be recommended for certain products due to high cost of energy. Similarly, a pasting temperature of 89.2 ℃ was observed for plantain flour and increased to 92.40℃ with increase in soy substitution (Abioye *et al.*, 2011).

3.3. Physical properties of the wheat – banana peel cookies

The effect of incorporation of banana peel flour on the physical properties of cookies such as diameter, thickness and spread ratio are presented in Table 6. The diameter of the cookies ranged within 38.00-39.00 mm. There was no significant difference in the diameter of control and the banana peel enriched cookies. On the other hand, the thickness of the cookies differ significantly, where, average thickness of control cookies was 5.79 mm and that for the cookies with 11, 13 and 15 % of banana peel flour was 6.37, 6.70 and 7.12 mm respectively. This difference in the thickness is reflected in spread ratio of control as well as cookies with banana peel flour. As it can be seen, spread ratio of cookies with banana peel flour is significantly lower as compared to the control cookies. Since the water content was kept constant for the dough preparation for all the formulations in the present study, there is an increase in the number of hydrophilic sites in the dough with banana peel flour due to increase in fibre content for the limited water available in the cookie dough as the fibre hold more water. This leads to the partitioning of free water and higher concentration of sugar in the available water phase, resulting in more viscous dough. Since the dough with banana peel flour was already in an elastic solid form and more viscous due to reduced water content, its spreading during baking would have been reduced, resulting in cookies with an increased thickness and thus reduced spread ratio. It is reported that spread ratio of cookies is affected by the viscosity of the dough (Zucco *et al.*, 2011). Tangkanakul *et al.* (1996) showed that the spread ratio decreases with increase in fibre content in cookies. A study conducted by Kawai *et al.* (2013) also reported that lower water activity resulted in lower spread ratio of the cookies.

Table 6. Physical properties of cookies produced from wheat-banana peel flour blends

Sample	Diameter (mm)	Thickness (mm)	Spread ratio
CA1	38.00 ± 0.20^a	5.79 ± 0.11^d	6.56 ± 0.09^a
CB2	38.39 ± 0.41^a	6.37 ± 0.09^c	6.03 ± 0.02^b
CC3	38.70 ± 0.73^a	6.70 ± 0.13^b	5.78 ± 0.01^c
CD4	39.00 ± 0.13^a	7.12 ± 0.07^a	5.48 ± 0.03^d

*Values are means of three replicates. Mean values ± standard deviation followed by different superscripts across columns are significantly different ($p \leq 0.05$). CA1 = 100% Wheat flour, CB2 = 89% Wheat flour + 11% Banana peel flour, CC3 = 87% Wheat flour + 13% Banana peel flour, CD4 = 85% Wheat flour + 15% Banana peel flour

3.4. Proximate composition of the wheat – banana peel cookies

The proximate composition of cookies produced from wheat flour and banana peel flour are presented in Table 7. The moisture content ranged from 4.93 to 5.63%. High moisture content has been associated with short shelf life of products as they encourage microbial spoilage of products (Ayo *et al.*, 2007).

Table 7. Proximate Composition of Wheat-Banana Peel Cookies

Sample	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Crude fibre (%)	Carbohydrate (%)
CA1	5.36 ± 0.15^{ab}	8.73 ± 0.15^{a}	11.83 ± 0.20^{b}	1.56 ± 0.15^{c}	11.66 ± 2.88^{c}	72.10 ± 0.20^{a}
CB2	5.63 ± 0.15^{a}	8.70 ± 0.20^{a}	12.00 ± 0.20^{ab}	2.26 ± 0.15^{b}	31.66 ± 2.88^{b}	70.36 ± 0.55^{b}
CC3	5.13 ± 0.15^{bc}	8.50 ± 0.10^{b}	12.20 ± 0.10^{a}	2.56 ± 0.15^{a}	38.33 ± 2.88^{ab}	70.43 ± 0.32^{b}
CD4	4.93 ± 0.15^{c}	8.16 ± 0.15^{c}	12.13 ± 0.15^{ab}	2.73 ± 0.15^{a}	45.00 ± 5.00^{a}	70.70 ± 0.44^{b}

*Values are means of three replicates. Mean values ± standard deviation followed by different superscripts across columns are significantly different ($p \leq 0.05$).CA1 = 100% Wheat flour, CB2 = 89% Wheat flour + 11% Banana peel flour, CC3 = 87% Wheat flour + 13% Banana peel flour, CD4 = 85% Wheat flour + 15% Banana peel flour

The highest was found in cookies produced from wheat flour supplemented with 11% banana peel flour while the lowest was observed in cookies produced from wheat flour supplemented with 15% banana peel flour. There was statistically significant ($p<0.05$) decrease in moisture content with increase in banana peel addition except for cookies from wheat flour supplemented with 11% banana peel flour which had a higher moisture content than the control. Significant difference was recorded between moisture values of cookies produced from wheat flour supplemented with 15% banana peel flour in comparison with others ($p < 0.05$). The moisture contents recorded in this study were similar to those reported in by Arun *et al.* (2015) for cookies produced from Plantain cultivar 'Nendran' Peel Flour. However, Mahloko *et al.* (2019) reported increase in moisture of biscuits with 4% banana peel flour.

Protein content ranged from 8.16 to 8.73%. The lowest was found in cookies produced from wheat flour supplemented with 15% banana peel flour while the high was observed in cookies produced from 100% wheat flour. Protein content of the cookies decreases as wheat flours was replaced with banana peel flour although not significantly. Wheat is known to have higher protein value than banana (Mahawan *et al.*, 2015; Castelo-Branco *et al.*, 2017); this may be responsible for the higher protein recorded in the control than others. It is noteworthy to state that the quality of protein in wheat has been reported to be superior to those of other vegetable flours, especially in terms of ability to form elastic networks responsible for trapping carbon dioxide (produced by yeast action) in dough. This quality index is of importance in baked food products such as bread, but may be less important in other baked products such as cookies and biscuit is where rising of dough (batter) through yeast action is of no significance.

The fat content ranged from 11.83 to 12.20%. The highest was found in cookies produced from wheat flour supplemented with 13% banana peel flour while the lowest was observed in cookies produced from 100% wheat flour. There was increase in fat content with increase in banana peel addition prompting the assumption that banana peel might contain more fat than wheat. Findings from the studies carried out by Turker *et al.* (2016) and Gomes *et al.* (2016) on banana peel flour substitution in wheat in the production of cake and bread respectively are supportive of this assumption; the authors recorded higher fat contents in banana peel flours than wheat. In related studies, Mahawan *et al.* (2015) and Nnaji & Okereke (2016) reported higher values of fat than normally found in wheat.

The Ash content ranged from 1.56 to 2.73%. The highest was found in cookies produced from wheat flour supplemented with 15% banana peel flour while the lowest was observed in cookies produced from 100% wheat flour. There was significant ($p<0.05$) increase in ash content with increase in banana peel addition. The result of the ash contents of the composite cookies therefore indicates that the composite flours utilized were of nutritional significance, since ash is generally indicative of the mineral contents of foods. In agreement with the present study, Olaoye *et al.* (2019) reported an increase in ash content of composite flours with addition of up to 10% banana peel flour. Cookies produced from this flour were also reported to have up to 62% increase in ash content with addition of banana peel flour (Olaoye *et al.*, 2019).

The crude fibre ranged from 0.36 to 1.33%. The highest was found in cookies produced from wheat flour supplemented with 15% banana peel flour while the lowest was observed in cookies produced from 100% wheat flour. There was significant ($p<0.05$) increase in crude fibre content with increase in banana peel addition. Increased crude fibre content is an indication of the possible rise in dietary fibre, thereby making banana peel flour a functional food ingredient with the produced cookies expected to be a food that can lower blood cholesterol levels in patients with hypercholesterolemia or can maintain the balance of lipid levels and blood sugar levels. Crude fibre is anti-diabetic (WHO, 2004). Similar findings was reported by Olaoye *et al.* (2019) and Arun *et al.* (2015) for increased crude fibre content with addition of banana peel flour.

Carbohydrate content ranged from 70.70 to 72.10%. The highest was found in cookies produced from 100% wheat flour while the lowest was observed in cookies produced from wheat flour supplemented with 11% banana peel flour. There was significant difference ($p<0.05$) between cookies from 100% wheat flour and those produced by banana peel flour substitution. However, Carbohydrate content decreased with banana peel addition. Olaoye *et al.* (2019) also reported a reduction in carbohydrate content of cookies as banana peel flour was added.

3.5. Mineral composition of the wheat – banana peel cookies

The mineral composition of cookies produced from wheat flour and banana peel flour are presented in Table 8. The calcium (Ca) content ranged from 70.00 to 150.00 mg/100g. The highest was found in cookies produced from wheat supplemented with 15% banana peel flour while the lowest was observed in cookies produced from 100% wheat flour. There was significant ($p<0.05$) increase in calcium content with banana peels concentration. Olaoye *et al.* (2019) reported far lower calcium content (30.48 to 65.26 mg/100g) for cookies produced from wheat, banana and avocado peel composite flours.

Table 8. Mineral composition of cookies produced from wheat-banana peel flour

Sample	Ca (mg/100g)	K (mg/100g)	Mg (mg/100g)	Fe (mg/100g)	Mn (mg/100g)	Zn (mg/100g)	P (mg/100g)	Na (mg/100g)
CA1	70.00±5.00^{c}	6.66±2.88^{c}	23.33±2.88^{c}	1.36±0.15^{d}	0.01±0.00^{c}	0.40±0.51^{a}	93.33±2.88^{c}	233.33±2.88^{d}
CB2	121.66±5.00^{b}	26.66±2.88^{b}	40.00±5.00^{b}	3.43±0.25^{c}	0.02±0.00^{bc}	0.16±0.05^{a}	120.0±5.00^{b}	306.66±7.63^{c}
CC3	140.00±5.00^{a}	31.66±2.88^{b}	51.66±2.88^{a}	4.26±0.15^{b}	0.23±0.00^{ab}	0.26±0.05^{a}	133.3±5.00^{a}	326.66±7.63^{b}
CD4	150.00±5.00^{a}	40.00±5.00^{a}	55.00±5.00^{a}	4.76±0.57^{a}	0.03±0.00^{a}	0.23±0.05^{a}	140.00±5.00^{a}	340.00±5.00^{a}

*Values are means of three replicates. Mean values ± standard deviation followed by different superscripts across columns are significantly different ($p \leq 0.05$). CA1 = 100% Wheat flour, CB2 = 89% Wheat flour + 11% Banana peel flour, CC3 = 87% Wheat flour + 13% Banana peel flour, CD4 = 85% Wheat flour + 15% Banana peel flour

The potassium (k) content ranged from 6.66 to 40.00 mg/100g. The highest was found in cookies produced from wheat supplemented with 15% banana peel flour while the lowest was observed in cookies produced from 100% wheat flour. There was a significant ($p<0.05$) increase in potassium content with increase in banana peel addition. Values for potassium content (412.47 to 460.82 mg/100g) of cookies from wheat, banana and avocado peel composite flours reported by Olaoye *et al.* (2019) were far higher than values reported in the present study. Although a similar trend was observed with the increase in this parameter as banana peel flour substitution increased.

The Magnesium (Mg) content ranged from 23.33 to 55.00 mg/100g. The highest was found in cookies produced from wheat supplemented with 15% banana peel flour while the lowest was observed in cookies produced from 100% wheat flour. There was a significant ($p<0.05$) increase in magnesium content with banana peels addition. Similar results (31.21 to 42.65 mg/100g) were reported by Olaoye *et al.* (2019) for magnesium content of cookies produced from wheat, banana and avocado peel composite flour.

The Iron (Fe) content ranged from 1.36 to 4.76 mg/100g. The highest was found in cookies produced from wheat supplemented with 15% banana peel flour while the lowest was observed in cookies produced from 100% wheat flour. There was a significant ($p<0.05$) increase in iron content with increase in banana peel. Olaoye *et al.* (2019) reported relatively close values (2.10-3.19 mg/100g) for iron content found in cookies from wheat, banana and avocado peel composite flour.

The Manganese (Mn) content ranged from 0.01 to 0.23 mg/100g. The highest was found in cookies produced from wheat supplemented with 15% banana peel flour while the lowest was observed in cookies produced from 100% wheat flour. There was a significant ($p<0.05$) increase in manganese content with banana peels addition.

The Zinc (Zn) content ranged from 0.16 to 0.40 mg/100g. The highest was found in cookies produced from 100% wheat flour while the lowest was observed in noodles produced from wheat flour supplemented with 11% banana peel flour. There was no significant difference ($p>0.05$) between cookies from 100% wheat flour and those produced by banana peel flour substitution. However, Zinc content increased with banana peel addition. Zinc content were observed to be lower (2.74-4.38 mg/100g) in cookies produced from wheat, banana and avocado peel composite flours (Olaoye *et al.*, 2019).

The Phosphorus (P) content ranged from 93.33 to 140.00 mg/100g. The highest was found in cookies produced from wheat supplemented with 15% banana peel flour while the lowest was observed in cookies produced from 100% wheat flour. There was a significant ($p<0.05$) increase in phosphorus content with increase in banana peel addition. Phosphorus content were observed to be higher (12.5 to 54.62 mg/100g) in biscuit produced from mushroom -wheat composite flour (Bello *et al.*, 2017).

The Sodium (Na) content varied between 233.33 to 340.00 mg/100g. increase in sodium contents of cookies with increase in the level of banana flour addition is an indication that banana peel is a good source of minerals, sodium content was significant ($p<0.05$) higher than values reported by Olaoye *et al.* (2019) (1.89-8.56 mg/100g) for sodium content of cookies from wheat, banana and avocado peel composite flours. Although, far lesser values were reported.

It was found that sodium is the most abundant mineral in the formulated cookies followed by calcium, phosphorus, magnesium, potassium, iron, zinc and manganese in the descending order. The higher contents of minerals in the cookies made from the banana peel flours than in wheat flour alone have been noted (Olaoye & Ade-Omowaye, 2011). In a research investigation, Olaoye *et al.* (2007) reported higher contents in the ash of biscuits made from composite flours of breadfruit and wheat compared with those from wheat flour alone. Gomes *et al.* (2016) also observed a value of ash in bread made from banana peel flour/wheat higher than those in their counterparts from wheat flour.

3.6. Heavy Metal content of the wheat – banana peel cookies

The heavy metals content of cookies produced from wheat flour and banana peel flour are presented in Table 9. The Lead (Pb) content ranged from 0.01 to 0.02 mg/100g. level of lead (pb)investigated are generally below the maximum permissible level (0.214) mg/day set by World Health Organisation (WHO,2002).All the cookies produced show no presence of Mercury (Hg). Chromium (Cr), Cobalt (Co) and Cadmium (Cd) .The Nickel (Ni) content ranged from 0.01 to 0.02 mg/100g. The highest was found in cookies produced from wheat supplemented with 13% and 15% banana peel flour while the lowest was observed in cookies produced from 100% wheat flour. Values obtained are within the permissible tolerance limit (1.4 mg/day) according to WHO and FAO standard (WHO/FAO, 2007). All the results obtained were within the critical limit control of the standard.

Table 9. The heavy metal content of wheat-banana peel cookies

Sample	Phytates (mg/100g)	Phenol (GAE/g)	Flavonoids (mg/100g)	Saponin (mg/100g)	Tannins (mg/100g)
CA1	20.00±5.00^{b}	9.43±0.20^{d}	15.00±5.00^{c}	5.00±0.00^{b}	6.66±2.88^{b}
CB2	33.33±2.88^{a}	16.1±0.15^{c}	41.66±2.88^{b}	11.66±2.88^{a}	15.00±5.00^{ab}
CC3	35.00±5.00^{a}	18.67±0.20^{b}	56.67±2.88^{a}	13.33±2.88^{a}	20.00±5.00^{a}
CD4	36.66±2.88^{a}	22.20±0.26^{a}	60.00±5.00^{a}	15.00±11.25^{a}	20.00±5.00^{a}

*Values are means of three replicates. Mean values ± standard deviation followed by different superscripts across columns are significantly different (p≤0.05). CA1 = 100% Wheat flour, CB2 = 89% Wheat flour + 11% Banana peel flour, CC3 = 87% Wheat flour + 13% Banana peel flour, CD4 = 85% Wheat flour + 15% Banana peel flour

3.7. Anti-nutritional composition of the wheat – banana peel cookies

The anti-nutritional composition of cookies produced from wheat flour and banana peel flour blends are presented in Table 10. The phytates content ranged from 20.00 to 36.66 mg/100g. The highest was found in cookies produced from wheat flour supplemented with 15% banana peel flour while the lowest was observed in cookies produced from wheat flour supplemented with 11% banana peel flour. There was a significant ($p<0.05$) increase in phytates content with the increase in banana peel addition as cookies produced from 100% wheat flour showed significant difference($p<0.05$) from the rest of the cookies produced.

Table 10. Anti-nutritional content of cookies produced from wheat-banana peel flour blends

Sample	Pb^{2+} (mg/100g)	Hg^{2+} (mg/100g)	Cr^{2+} (mg/100g)	Co^{2+} (mg/100g)	Cd^{2+} (mg/100g)	Ni^{2+} (mg/100g)
CA1	ND	ND	ND	ND	ND	0.01
CB2	ND	ND	ND	ND	ND	0.01
CC3	0.01	ND	ND	ND	ND	0.02
CD4	0.02	ND	ND	ND	ND	0.02

*Values are means of three replicates. Mean values ± standard deviation followed by different superscripts across columns are significantly different (p≤0.05). CA1 = 100% Wheat flour, CB2 = 89% Wheat flour + 11% Banana peel flour, CC3 = 87% Wheat flour + 13% Banana peel flour, CD4 = 85% Wheat flour + 15% Banana peel flour

Phenol content ranged from 9.43 to 22.20 mg/100g. The highest was found in cookies produced from wheat flour supplemented with 15% banana peel flour while the lowest was observed in cookies produced from 100% wheat flour. There was significant ($p<0.05$) increase in phenol content with increase in banana peel addition and this could be attributed to 87.41% mg/100 g of ascorbic acid concentration in fruit peels per dry weight as stated by Anwar & Sallam (2016). According to Rebello *et al.* (2014), banana fruits contain phenolic compounds such as catecholamines, phenolic acids and flavonoids. For banana, the availability as well as the quantity of these health beneficial nutrients is influenced by various factors such as ripening stages of the fruit, location, climatic factor, agricultural and cultural practices (Anyasi *et al.*, 2017).

Table 11. Sensory properties of cookies produced from wheat-banana peel flour blends

Sample	Taste	Crispness	Aroma	Appearance	General Acceptability
CA1	7.78±0.84^{a}	7.22 ±1.34^{a}	7.46±1.27^{a}	7.30±1.09^{a}	7.60±1.09^{a}
CB2	6.94±1.20^{b}	7.19 ±1.12^{a}	6.80±1.21^{b}	6.80±1.02^{b}	7.21±1.02^{b}
CC3	6.81±1.44^{b}	7.11±1.44^{a}	6.79±1.30^{b}	6.90±1.01^{b}	6.74±1.01^{c}
CD4	6.54±1.04^{b}	6.97±1.35^{a}	6.73±1.41^{b}	7.53±1.03^{b}	6.70±1.03^{c}

*Values are means of three replicates. Mean values ± standard deviation followed by different superscripts across columns are significantly different ($p \leq 0.05$). CA1 = 100% Wheat flour, CB2 = 89% Wheat flour + 11% Banana peel flour, CC3 = 87% Wheat flour + 13% Banana peel flour, CD4 = 85% Wheat flour + 15% Banana peel flour

Flavonoid content ranged from 15.00 to 60.00 mg/100g. The highest was found in cookies produced from wheat flour supplemented with 15% banana peel flour while the lowest was observed in cookies produced from 100% wheat flour. There was a significant ($p<0.05$) increase in flavonoid content with increase in banana peel addition. Moreover, Pasqualone *et al.* (2015) observed significant increase ($p < 0.05$) of flavonoids in biscuits and indicated that the increase was due to the contribution of semolina and shortening as well as incorporation of plant by-products such as banana peels which imparts their volatile compounds.

The saponin content ranged from 5.00 to 15.00 mg/100g. The highest was found in cookies produced from wheat flour supplemented with 15% banana peel flour while the lowest was observed in cookies produced from 100% wheat flour. There was a significant ($p<0.05$) increase in saponin content with increase in banana peel addition. The value observed in this present study is slightly higher than that reported by Yamunadevi (2018).

The tannin content ranged from 6.66 to 20.00 mg/100g. The highest was found in cookies produced from wheat flour supplemented with 13% and 15% banana peel flour while the lowest was observed in cookies produced from 100% wheat flour. There was a significant ($p<0.05$) increase in tannin content with increase in banana peel addition. The tannin content of the formulated cookies from this study is generally high when juxtaposing with the lethal dose of 0.7 to 0.9 mg/100g suggested by Pikuda & Ilelaboye (2013). However despite the detrimental effects of anti-nutritional factors, they have also been found to contain anti-cancer and anti-microbial properties but this is in variation with the amounts consumed (Pikuda & Ilelaboye, 2013).

3.8. Sensory evaluation of the wheat-banana peel cookies

The mean sensory scores recorded for the different cookies samples are shown in Table 11. It was observed that cookies from 11% banana peel addition are well accepted in terms of taste, crispiness, aroma when compare to control .Higher mean scores were observed for cookies samples made from 100% wheat flour than others in the attributes of taste and general acceptability. Cookies from 11% banana peel addition also compared favourably well with the control in terms of general acceptability .Incorporation of banana peel flour had significant influence on the surface colour characteristic of the cookies.

4.0. Conclusion

This study revealed that incorporation of Banana peel flour improved the nutritional quality of the cookies. Application of experimental design approach by mixture design surface methodology was used to determine the effect of variation in levels of wheat flour and banana peel flour on nutritional composition of four cookies formulations. The optimum composite flour blends for cookies production consisted of 100%,89%,87% and 85% of wheat flour and 0%,11%,13% and 15% Banana peel flour respectively. The formulated cookies serve source of nutrients when compare with wheat cookies (100% refined wheat flour) .The addition of banana peel flour gave an excellent nutritional effect on the cookies. Result from sensory characteristics revealed that banana peel can be incorporated into cookies up to 15% since it had no adverse effect on the nutritional composition of the cookies and values obtained were within safe daily dietary limit control standard owing to the level of addition. The cookies produced from composite wheat and banana peel flours were of nutritional advantage than 100% wheat flour in term of ash, crude fibre and mineral content, the value of adding Banana peel flour in the form of functional food ingredients in food products can bring remarkable economical change which will help to resolve the problem of food insecurity that is widespread in many countries in the world.

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Conflict of interest

The authors declare that there are not conflicts of interest.

Ethics

This Study does not involve Human or Animal Testing.

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