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ORIGINAL ARTICLE

Chemical Composition, Dietary fiber and Antioxidant Activity of Fermented Ripe Banana Peel Flour

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Abstract

Banana (*Musa acuminata*), is grown worldwide and normally consumed as ripe fruit. Their peels are considered as a waste and contribute to environmental problem due to their high nitrogen and phosphorus content. Banana peels contain natural bioactive compounds such as polyphenols, carotenoid and dietary fiber which offer health benefits including protection against cardiovascular diseases, cancer and other degenerative diseases. Banana of fifth stage of ripening was selected, separated into pulp and peel. The ripe peels were divided into two portions, A and B. One portion was allowed to ferment for 24 hours while the other portion did not undergo fermentation process. Protein, fat and crude fibre contents varied between 6.16-6.92%, 0.37-0.68% and 2.70-3.20% respectively. Total phenolic content and total flavonoid varied between 26.96-34.03 GAE/g and 291.66-428 mg/100g of dry matter respectively. Ripe fermented "Omini" banana (RFO) peel flour contained higher total phenolic content (34.03 GAE/g) and total flavonoid content (428 mg/100g) when compared with other varieties. Radical scavenging activities (inhibition of DPPH/IC_{50}) of the extracts ranged between 2.89 to 4.35%, RFO peel which had the highest polyphenols and carotenoid could be incorporated into value-added foods and can serve as a functional food.

Practical Applications

The knowledge of nutritional and bioactive component as well as the antioxidant activity of banana peels can help in food formulation and supplementation in order to reduce wastage generation, environmental pollution and reduced cost in waste disposal. Banana peel can serve as a potential source of functional food ingredients in processed food products to prevent damages caused by free radicals in the body.

Keywords: Banana Peel, Fermentation, Proximate composition, Total phenolic content, Total flavonoid content, DPPH Scavenging activities.

1. Introduction

Banana belongs to the family Musaceae one of the most important tropical fruits in the world market. Significant quantities of banana peels, equivalent to 40% of total weight of fresh banana are generated as a waste product in industries producing banana based products (Ramli *et al.*,2009). These products are not being used for any other purpose and are mostly dumped as solid waste at large expense. It is thus significant and even essential to find application for these peels as they can contribute a real environmental problem (Mohapatra *et al.*, 2010). Fruit processing results in large amounts of waste as by products such as peels and seeds. Thus, by-products and its further utilization in the production of functional foods or supplements with high nutritional value have aroused great interest since they are high-value products. Banana peels has shown beneficial effects in the prevention of several diseases, such as cardiovascular diseases, diverticulosis, constipation, irritable colon, colon cancer, and diabetes (Rodriguez *et al.*, 2006 ; Djilas *et al.*, 2009). The main drawback of using synthetic antioxidant is their potential of causing health hazards. Previous result of banana peel containing natural antioxidative compounds varied between 0.90 and 3 g/mg dry weight (Bhaskar *et al.*, 2012). Banana peel is a rich source of starch (3%) , crude protein (6-9%), crude fat (3.8-11%) and total dietary fibre (43.2-49.7%) (Sulaiman *et al.*, 2011 & Mohapatra *et al*,. 2010). From the total dietary fibre (TDF) around 5-13% is soluble dietary fibre (SDF) and 7-36% insoluble dietary fibre (IDF). Davey *et al.* (2009); and Awedem *et al.* (2015) found in their study that micronutrient such as iron, zinc were found in higher concentration in banana peel compared to pulp. Fermentation is generally considered as a safe and acceptable preservation technology to improvethe hygienic quality and safety of foods. Fermentation leads to a reduction in phytic acid and thus improves bioavailability of minerals and nutritional quality in food (Afify *et al.*, 2011). Therefore, this study was conducted to seek information about nutritional qualities and antioxidant activities of three varieties of banana (*Musa acuminata*) grown in Southern Nigeria namely "Paranta", "Omini" and "Saro" with the aim of exploiting the potential and possible utilization of peels.

2. Material and Methods

2.1. Preparation of the banana peel flour

Three of the most popular banana varieties of *Musa acuminata* species namely "omini', 'paranta' and 'saro' were obtained from a market in Oja Oba, Akure, Ondo State, Nigeria. Samples were ripe banana peels (at stage 5 of ripening: yellow) of the three banana species (Aurore *et al.*, 2009). The samples were selected and separated into pulp and peel. Each of the three varieties of the ripe banana peels were divided into portions A and B. One portion was allowed to ferment for 24 hours while the other portion did not undergo fermentation process.

To reduce enzymatic browning, banana peels of stage 5 of ripening were dipped in 0.5% (w/v) citric acid solution for 10 minutes. The peel was drained and dried in cabinet oven at 50°C until constant weight obtained. The dried peels were milled in a Retsch mill laboratory (Retsch AS200, 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 (as shown in Figure 1).

2.2. Determination of Proximate and Mineral Contents of the Flour

Moisture, fat, ash, protein, crude fibre and carbohydrate content of the ripe banana peels were determined using standard anslytical methods described by AOAC (2010) procedure. Moisture content was determined by drying the peels in an oven at 103^{o}C to constant weight. Ash content was determined incineration of the peels at 550^{o}C for 1 hour. 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 difference 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.

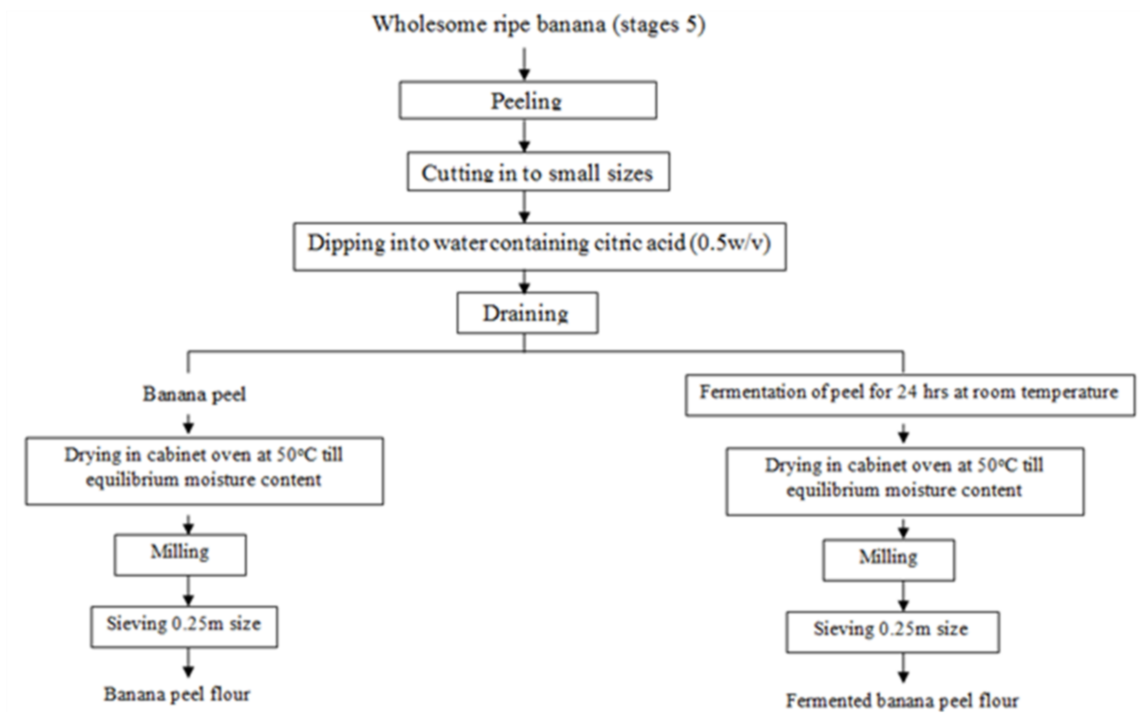

Figure 1: The Flow Chart for Production of Banana Peel Flour

The energy value was calculated using the energy conversion factor:

$$(4 \times \% \text{ of } carbohydrate + 4 \times \% \text{ of } protein + 9 \times \% \text{ of } fat).$$

Mineral content were determined by flame photometry using flame photometer as described by AOAC (2012) methods. Phosphorus was determined by molybdovanadate method (AOAC, 2010). Calcium and magnesium were determined using atomic absorption spectrophotometer (AOAC, 2010).

2.3. Determination of Dietary Fibre of the Flour

The dietary fibre analysis was carried out as described in “McCleary Method (AOAC, 2010). The dietary fiber content in the sample was measured in the laboratory by an enzymatic-gravimetric method. The sample was defatted by weighing 2.0 g of the sample into the pre-cleaned 250 mL capacity borosilicate beaker and the sample was extracted with 30 mL of the petroleum spirit for three consecutive times with soxhlet extractor equipped with thimble. The defatted sample was treated with enzymes that mimic the digestive process in the human small intestine. The pancreatic α-amylase enzyme was used and conditions much closer to physiological (pH 6, 37°C) for the enzymatic incubation step. Digestible carbohydrates were broken down into simple sugars and were removed from the sample by precipitation and filtration. The non-digestible precipitate contains the dietary fiber, protein and inorganic material. The protein and inorganic content were determined in the raw sample and removed from the non-digestible precipitate to get the dietary fiber.

2.4. Total phenolic content

The total phenolic (TP) content in banana peel extracts were spectrophotometrically determined by Folin Ciocalteu reagent assay using garlic acid as standard (Alothman *et al.*, 2009). The absorbance was determined at 750 nm using spectrophotometer (Unicum UV 300). The total phenolic content in the samples was expressed as mg garlic acid equivalents (GAE/g) dry weight sample. All samples were analyzed in triplicates.

2.5. Total flavonoid content

Total flavonoid (TF) of banana peel extracts were spectrophotometrically determined by the aluminum chloride method using quercetin (Zhishen *et al.*,1999). The absorbance was measured against blank at 510 nm by using spectrophotometer (Unicum UV 300). Total flavonoids in sample were expressed as mg quercetin equivalents (QE)/g dry weight. All samples were analyzed in triplicates.

2.6. Measurement of antioxidant activity by DPPH Radical-Scavenging Assay

DPPH scavenging activity was measured using the spectrophotometric method with slight modifications (Brand-Williams *et al*., 1995). The absorbance of DPPH diluted in methanol was considered as control. The decrease in absorbance was measured at 517 nm. The antioxidant capacity to scavenge the DPPH radical was calculated by the following equation:

Scavenging effect (%) = (1 - absorbance of sample)/(absorbance of control) x 100

Results were expressed as Mean ± SD of three experiments made by triplicate. The half-inhibition concentration IC50 (implies concentration required to obtain 50% antioxidant effect) (Omoba *et al.*, 2015). The IC50 was determined using linear regression analysis for the antioxidant assay (Omoba *et al.*,2015)

2.7. Metal chelating activity

Metal chelating effects on ferrous ions was carried out calorimetrically according to (Hsu *et al.*, 2003). The absorbance was measured at 562 nm. Mixture without extract was used as the control. A lower absorbance indicates a higher ferrous ion chelating capacity. The percentage of ferrous ion chelating ability was calculated using the following equation:

Iron chelating activity (Inhibition %) = (Ac - As)/As x 100

Where: Ac is the absorbance of the control reaction and As the absorbance in the presence of the plant extracts.

2.8. FRAP (Ferric Reducing Antioxidant Power)

The reducing property of the extract was determined as described by Pulido *et al.* (2000). An aliquot of 0.25 mL of the extract was mixed with 0.25 mL of 200 mM of sodium phosphate buffer pH 6.6 and 0.25 mL of 1% Potassium Ferrocyanate (KFC). The mixture was incubated at 50°C for 20 min followed by the addition of 0.25 mL of 10% Tricarboxylic acid (TCA). The mixture was centrifuged at 2,000 ×g for 10 min and 1 mL of the supernatant was mixed with equal volume of distilled water and 0.1% of iron (III) chloride (FeCl3) and the absorbance was measured at 700 nm using a JENWAY UV–visible spectrophotometer. FRAP values were obtained by comparing the absorption change in the test mixture with those obtained from increasing concentrations of Fe^{2+} and expressed as mmol of Fe^{2+} equivalents per gram of the sample.

2.9. Statistical analysis

The data was analysed for mean and standard deviation. ANOVA was used to determine significant differences in polyphenols, flavonoids, proximate composition and antioxidant activity in ripe banana peel of different varieties using a statistical package SPSS 20.0

3. Results and Discussion

3.1. Proximate Composition

The proximate composition of different varieties of banana peel flour is shown in Table 1.

Table 1: Proximate composition of different varieties of fermented Ripe Banana Peel flour

Sample	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Crude Fibre (%)	Carbohydrate (%)	Energy (Kcal)
RFO	8.26 ± 0.15 ab	6.92 ± 0.20 a	0.63 ± 0.06 a	7.36 ± 0.15 ab	2.70 ± 0.10 b	74.1 ± 0.51 ab	329.75 ± 0.01a
RFP	8.00 ± 0.10 b	6.7 ± 0.10 a	0.47 ± 0.15 ab	7.46 ± 0.15 a	2.83 ± 0.15 b	74.5 ± 0.20 ab	329.03 ± 0.01a
RFS	8.36 ± 0.15 a	6.90 ± 0.10 a	0.58 ± 0.15 ab	7.37 ± 0.057 ab	2.80 ± 0.10 b	74.03 ± 0.32 ab	328.94 ± 0.01a
RUO	8.17 ± 0.15 ab	6.16 ± 0.15 c	0.40 ± 0.10 b	6.96 ± 0.57 c	2.80 ± 0.10 b	74.00 ± 0.32 ab	324.24 ± 0.01b
RUP	8.17 ± 0.15 ab	6.17 ± 0.15 c	0.40 ± 0.10 b	6.97 ± 0.57 c	3.16 ± 0.15 a	75.13 ± 0.15 a	328.80 ± 0.01a
RUS	8.10 ± 0.10 ab	6.47 ± 0.06 b	0.37 ± 0.06 b	7.13 ± 0.15 bc	3.20 ± 0.10 a	74.70 ± 0.10 ab	328.01 ± 0.01a

Mean ± Standard deviation triplicate determination. Mean with the same alphabet in a column are not significantly different ($p \geq 0.05$).
RFO = Ripe Fermented "Omini", RFP = Ripe Fermented "Paranta", RFS = Ripe Fermented "Saro", RUO = Ripe Unfermented "Omini", RUP = Ripe Unfermented "Paranta", RUS = Ripe Unfermented "Saro"

Moisture content is an important factor in food, making it possible to determine the life span and mode of preservation (Awedem *et al.*, 2015; Ahmed *et al.*, 2016). This ranged from 8.00-8.36% with sample RFP (Ripe Fermented Paranta) peel powder having the minimum value while sample RFS (Ripe Fermented Saro) had the maximum value. There was no significant difference (p≥0.05) among the samples except RFP and RFS. According to Bhaskar *et al.* (2012), Musa spp fruit peels moisture varies with cultivar, stage of ripening, soil and climatic conditions under which fruit were cultivated. The amount of moisture content obtained in this study, was significantly higher than that reported by Anhwange *et al.* (2009) and Shyamala & Jamuna (2011) who respectively obtained 6.7% and 1.45-1.71%.

Protein is also an important nutrient for adequate supply of essential amino acid for both human beings and animals (Ahmed *et al.*, 2016).

The protein content ranged from 6.16-6.92% with sample RFO (ripe fermented omini) having the highest value while sample RUO (ripe fermented omini) had the lowest value. The values obtained are comparable to 6%, 4.6-7.7%, 9.44-7.11% and 7.57% reported by Sheng *et al.* (2010); Shyamala *et al.* (2011); and Ahmed *et al.* (2016) but significantly lower than 8.89-10.35% and 12.5% reported by Awedem *et al.* (2015) and Bhaskar *et al.* (2012), yet higher than 0.9% and 2.3% reported by Anhwange *et al.* (2009) who worked on substitution of wheat flour with cassava flour using soybean as an improver. The result showed that the ripe banana peel powder had appreciable amount of protein needed in the body system. The nutritional value of Musa SPP fruit varies between cultivar, stage of ripeness, soil and climatic conditions under which the fruits were cultivated Bhaskar *et al.* (2012). The proteins in the banana peel are enzymes involved in the maturation of the fruit (Zhang *et al.*, 2012).

Low fat content of plantain peel flours prevents the encouragement of rancid flavor during storage. The fat content varied between 0.37 and 0.63% with sample RFO having the highest value while sample RUS had the lowest value. The value obtained showed that banana peel powder is rich and has good sources of minerals (Mirconi *et al.*, 1997 & Olaoye *et al.*, 2006). The values obtained was significantly lower than 0.90%, 1.70%, 10.44%, 6.80-9.38% and 4.8% asreported by Okareh *et al.* (2015), Anhwange *et al.* (2009), Ahmed *et al.* (2016); and Akubor & Ishiwu (2013) respectively but are comparable to the values 0.6% and 0.4% obtained by Sheng *et al.* (2010).

The ash content varied between 6.96-7.46% with sample RFP having the highest values while sample RUO had the lowest value. The values obtained were significantly higher than 1.93-4.29%, as reported by Nwosu (2010) but significanly lower than 8.9-12.96%, 13.42%, 9.88-12.25% and 8.50% reported by Shyamala & Jamuna (2011); Ahmed *et al.* (2016); Awedem *et al.* (2015) and Anhwange *et al.* (2009). The crude fibre varied between 2.70-3.2% with sample RUS having the highest value while sample RFO had the lowest. There was no significant difference between sample RUO, RUP and RUS; RFO, RFP and RFS. 9.8-41.9% reported by Anhwange *et al.* (2009); Ahmed *et al.* (2016) & Shyamala *et al.* (2011) respectively.

3.2. Mineral Content

The mineral content of the different varieties of banana peel powder is presented in Table 2. The calcium varied between 173.33-188.33 mg/100g with sample RFO having the highest value while sample RUO had the lowest values. The values obtained were significantly lower than 482-687 mg/100g, and 166.54-244.68 reported by Awedem *et al.* (2015) and Shyamala & Jamuna (2011) but higher than the values 19.20 mg/100g as reported by Anhwange *et al.* (2009).

The appreciable amount of potassium in banana peel will help in the regulation of body fluids, maintaining normal blood pressure, controlling kidney failure, heart disease and irregular respiration (Anhwange *et al.*, 2009). The potassium varied between 75.00 and 85.50 mg/100g with sample RFS having the highest value while samples RUO and RUP had the lowest value. No significant difference ($P > 0.05$) among all the samples. The values obtained agree with 78.10 mg/100g reported by Anhwange *et al.* (2009) but lower compared to 5016.6-6480.00 mg/100g as reported by Awedem *et al.* (2015). This is because nutrients vary with varieties and goegraphical locations. Although the value is low compared with daily recommended dietary allowances (mg/day) reported by Aberoumand (2010) who worked on *Asparagus officinatis* stem and *Momordica dioica* fruit.

The magnesium varied between 38.33-48.33 (mg/100g) with sample RFP having the highest value while sample RUP had the lowest value. The values obtained were significantly lower

Table 2: Mineral Composition of different varieties of fermented ripe Banana Peel flour

Sample	Calcium mg/100g)	Potassium (mg/100g)	Magnesium (%mg/100g)	Iron (mg/100g)	Manganese (mg/100g)	Zinc (mg/100g)	Copper (mg/100g)	Sodium (mg/100g)
RFO	188.33 ± 7.64^{a}	78.33 ± 10.41^{a}	45.00 ± 5.00^{ab}	12.13 ± 0.15^{a}	0.05 ± 0.01^{a}	0.53 ± 0.06^{a}	0.40 ± 0.10^{a}	260.00 ± 5.00^{a}
RFP	186.67 ± 2.89^{ab}	80.00 ± 5.00^{a}	48.33 ± 2.89^{a}	12.43 ± 0.15^{a}	0.05 ± 0.01^{a}	0.50 ± 0.10^{a}	0.36 ± 0.05^{a}	258.33 ± 7.64^{a}
RFS	186.67 ± 7.64^{ab}	85.50 ± 5.00^{a}	45.00 ± 5.00^{ab}	12.23 ± 0.15^{a}	0.05 ± 0.01^{a}	0.57 ± 0.06^{a}	0.37 ± 0.06^{a}	255.00 ± 10.00^{a}
RUO	173.33 ± 7.64^{c}	75.00 ± 5.00^{a}	43.33 ± 2.89^{ab}	11.57 ± 0.25^{b}	0.05 ± 0.01^{a}	0.47 ± 0.06^{a}	0.33 ± 0.06^{a}	250.00 ± 5.00^{a}
RUP	178.33 ± 2.89^{c}	76.67 ± 2.89^{a}	38.33 ± 2.89^{c}	11.75 ± 0.15^{b}	0.04 ± 0.01^{a}	0.53 ± 0.06^{a}	0.37 ± 0.06^{a}	248.33 ± 7.64^{a}
RUS	176.67 ± 2.89^{bc}	75.00 ± 5.00^{a}	43.33 ± 2.89^{ab}	11.67 ± 0.25^{b}	0.05 ± 0.01^{a}	0.50 ± 0.10^{a}	0.33 ± 0.06^{a}	250.00 ± 5.00^{a}

Mean ± Standard deviation triplicate determination. Mean with the same alphabet in a column are not significantly different ($p \geq 0.05$).
RFO = Ripe Fermented "Omini", RFP = Ripe Fermented "Paranta", RFS = Ripe Fermented "Saro", RUO = Ripe Unfermented "Omini", RUP = Ripe Unfermented "Paranta", RUS = Ripe Unfermented "Saro"

than 211.3 - 273.0 as reported by Awedem et al. (2015) and other previous reports by Wickamarachchi & Ranamukharachchi (2005) and Sheng *et al.* (2010).

Banana peel powder is a good source of iron needed for daily intake. Iron is an important element that carries oxygen to the cells, aid production of energy, proper functioning of the immune system and the synthesis of collagen (Anhwange *et al.*, 2009). The iron varied between 11.57 and 12.43 mg/100g with sample RFP having the highest value while sample RUO had the lowest value. The values obtained were significantly higher than 0.01 mg/100g and 0.61 as reported by Cheng *et al.* (2010) and Anhwange *et al.* (2009). Although the values obtained agree with the standard recommended dietary allowances (mg/day), 10-15 g/100 reported by Aberoumand (2010) who worked on fruit of *Momordica dioica* and *Asparagus officinalis* stem.

Lack of manganese could affect normal reproductive, skeletal and cartilage formation and glucose tolerance (Smith *et al.*, 1996) but its presence aids the formation of skeletal and cartilage (Anhwange *et al.*, 2009). The manganese varied from 0.04-0.05 mg/100g with samples RFO, RFP, RFS and RFO having the highest values while samples RUP and RUS had the lowest values. The values obtained were significantly lower than 76.20 mg/100g, 32.46-46.60 mg/100g reported by Anhwange *et al.* (2009) and Awedem *et al.* (2015). This implies that banana peel powder when taken could help the body system.

The zinc varied between 0.47-0.57 mg/100g with sample RFS having the highest value while samples RUO had the lowestvalue. The values obtained were significantly lower than 1.34 and

2.60; and 17.20- 22.53 mg/100 as reported by Aberoumand (2010) and Awedem *et al.* (2015).

The copper varied between 0.33-0.40 mg/100g with sample RFO having the highest value while samples RUS and RUO had the lowest values. The values obtained were significantly lower than 3.07-5.43 mg/100g and 0.01 mg/100g as reported by Awedem *et al.* (2015) and Sheng *et al.* (2010).

The sodium varied between 248.33 and 260.00 mg/100g with sample RFO having the highest value while sample RUP had the lowest value. The values obtained were significantly higher than that reported by Aberoumand (2010); Awedem *et al.* (2015) and Anhwange *et al.* (2009), who respectively obtained sodium content of 1.84 and 1.51 mg/100g, 4.7-6.4 mg/100g and 24.30 mg /100g.

3.3. Mineral ratio of different varieties of Banana peel powder

The mineral ratio of different varieties of ripe banana peel powder is presented in Table 3. The Na/k ratio varied between 1.37-1.44 with sampled RUO having the highest value while sample RFS had the lowest value. There is no significant difference ($P > 0.05$) between the fermented samples RFO, RFP and RFS while there was a significant difference ($P < 0.05$) between the unfermented samples RUO, RUP and RUS. The value obtained was significantly lower than 1.51-8.25 reported by Aberoumand (2010). This indicates that the varieties of banana peel powder had a very low ratio of Na/k.

The Ca/P ratio varied between 1.26-1.39 with sample RFO having the highest value while sample RFS had the lowest value. No significant difference ($P > 0.05$) wae recorded between RFO and RFP while there were significant differences ($P < 0.05$) among other samples. The values obtained are lower compared to the ideal ratio 4.20 and 9.17 (Morley, 2014). The Fe/Zn ratio varied between 21.46-24.86 with sample RFP having the highest value while sample RFS had the lowest value.

Table 3: Mineral ratio of different varieties of fermented ripe banana peel flour

Sample	Na/k ratio	Ca/P ratio	Fe/Zn ratio
RFO	1.38^{c}	1.31^{b}	22.89^{d}
RFP	1.38^{c}	1.32^{b}	24.86^{a}
RFS	1.37^{c}	1.29^{c}	21.46^{f}
RUO	1.44^{a}	1.24^{e}	24.59^{b}
RUP	1.43^{ab}	1.26^{d}	22.13^{e}
RUS	1.42^{b}	1.39^{a}	23.34^{c}

Mean in triplicate determination; Mean with the same alphabet in a column are not significantly different (p >0.05); RFO = Ripe Fermented "Omini", RFP = Ripe Fermented "Paranta", RFS = Ripe Fermented "Saro", RUO = Ripe Unfermented "Omini", RUP = Ripe Unfermented "Paranta", RUS = Ripe Unfermented "Saro"

3.4. Molar Ratio

The molar ratio between phytate and mineral of the different varieties of banana peel powder is presented in Table 4. The phytate: Ca molar ratio ranged from 0.06-0.08 with samples RFS and RUP having the highest values while samples RFO, RFP and RUS had the lowest values. The values obtained in this work were significantly lower than 0.44, 0.35 and 0.36 as reported by Aberoumand (2010), Norhaizan & Faizadatul (2009) and also lower than the recommended value (0.24). The phytate Zn molar ratio varied between 34.36-43.75 with sample RFS having the highest value while sample RFO had the lowest. There were significant difference (P< 0.05) among all the samples. The value obtained in this work was significantly higher than 5.65-30.32 and 7.68-31.98 reported by Saha *et al.* (1994) and Lopez *et al.* (1998) but acceptable for the daily recommended allowances (>15).

Table 4: Molar ratio between phytate and mineral of different varieties of Fermented Ripe Banana peel flour

Sample	Phytate (mg/100g)	Phytate: Ca Molar ratio	Phytate: Zn Molar ratio	Phytate x Ca/Zn
RFO	186.70^{e}	0.06^{b}	34.36^{f}	161.80^{e}
RFP	200.00^{c}	0.06^{b}	39.47^{d}	184.34^{b}
RFS	231.66^{a}	0.08^{a}	43.75^{a}	204.89^{a}
RUO	188.33^{d}	0.07^{ab}	39.58^{c}	171.39^{d}
RUP	218.33^{b}	0.08^{a}	41.25^{b}	176.41^{c}
RUS	185.00^{f}	0.08^{a}	36.41^{e}	160.20^{f}
Control limit	5600	0.24	>15	>200

Mean is triplicate determination; Mean with the same alphabet in a column are not significantly different (p≥ 0.05); RFO = Ripe Fermented "Omini", , RFP = Ripe Fermented "Paranta", , RFS = Ripe Fermented "Saro", RUO = Ripe Unfermented "Omini", , RUP = Ripe Unfermented "Paranta", RUS = Ripe Unfermented "Saro"

The phytate x Ca/Zn molar ratio ranged from 160.20-204.89 with sample RFS having the highest value while sample RUS had the lowest value. There were significant difference ($P < 0.05$) among all the samples. The values obtained were significantly higher than 0.88-81.09 reported by Aberoumand (2010) but within the range (>200) recommended for daily allowances (WHO, 2002).

3.5. Heavy Metals

The heavy metals of the different varieties of Ripe Banana peel powder are presented in Table 5 below. The Pb (lead) varied between 0.07-0.11 mg/100g with samples RUS and RUO having the highest values while sample RFP had the lowest. No significant difference ($p \geq 0.05$) existed between sample RUO, RUP and RUS; RFO, RFP and RFS respectively. The value obtained is compared favourably well with the ideal recommended daily allowance. The Hg^{++} (mercury) was not detected in the different varieties of banana peel powder. The Cr^{++} (chromium) varied between 0.02-0.04 mg/100g with sample RUO, RFO and RUS having the highest values while sample RFS had the lowest value. Significance difference (p<0.05) existed between the samples except RFO, RUO and RUS, while sample RFP and UUO had no significant difference (P≥0.05). The values obtained are within the ideal recommended daily allowance (0.05). The Co^{++} (cobalt) varied between 0.02-0.04 mg/100g with sample RUO and RUS having the highest values while sample RFO and RFS had the lowest values. Significant difference (p<0.05) existed among the samples except RFO and RFS; RUP and RFP ; RUO and RUS which had no significant difference (p≥0.05). The Cd^{++} (cadmium) varied between 0.01-0.02 mg/100g with samples RUO and RUS having the highest values while all other samples had the least values. The values obtained are within the ideal recommended daily allowances by WHO/FAO, (2007).

Nickel varied between 0.02-0.04 mg/100g with sample RUO and RUP having the highest values and RFS has the lowest. No significant difference ($p \geq 0.05$) was noted between RFO, RFP and RUS; RUO and RUP, while significant difference ($p \leq 0.05$) existed with RFS.

sample RUS had the lowest value. The total phenolic varied between 26.96 and 34.03 mg GAE/g, RFO with highest value while sample RFS has the lowest value. The values obtained were significantly higher than 9.89-17.89 mg as reported by Ahmed *et al.* (2016). Total phenolics are more abundant in peel than in pulp (Someya *et al.*, 2002; Shyamala & Jarmina, 2011). The flavonoid varied between 291.66-428.3 mg/100g with sample RFO having the highest value while

Table 5: Heavy Metals of different varieties of fermented ripe banana peel flour

Sample	Pb^{++} (Lead) mg/100g	Hg^{++} (Mercury) mg/100g	Cr^{++} (Chromium) mg/100g	Co^{++} (Colbalt) mg/100g	Cd^{++} (Cadmium) mg/100g	Ni^{++} (Nickel) mg/100g
RFO	0.08 ± 0.01^{b}	ND	0.04 ± 0.01^{a}	0.02 ± 0.01^{b}	0.01 ± 0.01^{a}	0.03 ± 0.01^{ab}
RFP	0.07 ± 0.01^{b}	ND	0.03 ± 0.01^{ab}	0.03 ± 0.01^{ab}	0.01 ± 0.01^{a}	0.03 ± 0.01^{ab}
RFS	0.08 ± 0.01^{b}	ND	0.02 ± 0.01^{b}	0.02 ± 0.01^{b}	0.01 ± 0.01^{a}	0.02 ± 0.01^{b}
RUO	0.11 ± 0.01^{a}	ND	0.05 ± 0.01^{a}	0.04 ± 0.01^{a}	0.02 ± 0.01^{a}	0.04 ± 0.01^{a}
RUP	0.10 ± 0.01^{a}	ND	0.04 ± 0.01^{a}	0.03 ± 0.01^{ab}	0.01 ± 0.01^{a}	0.04 ± 0.01^{a}
RUS	0.11 ± 0.01^{a}	ND	0.04 ± 0.01^{a}	0.04 ± 0.01^{a}	0.02 ± 0.01^{a}	0.03 ± 0.01^{ab}
WHO/FAO Standard mg/day	0.214		0.05-0.2		0.060	1.4

Mean ± Standard deviation triplicate determination. Mean with the same alphabet in a column are not significantly different ($p \geq 0.05$).
RFO = Ripe Fermented “Omini”, RFP = Ripe Fermented “Paranta”, RFS = Ripe Fermented “Saro”, RUO = Ripe Unfermented “Omini", RUP = Ripe Unfermented “Paranta”, RUS = Ripe Unfermented “Saro”

3.6. Phytochemical

Phytochemicals are useful for medical purposes such as anticancer, antioxidant, antibacterial and anti-inflammatory (Ahmed *et al.*, 2016). The banana peel powder is an important phytochemical which when consumed will help fight against diseases. The phytochemical Composition of the different varieties of banana peel powder are presented in Table 6. The phytate varied between 185.00-231.66 mg with sample RFS having the highest value while sample RUS had the lowest value. The values obtained were significantly higher than 39.01-389.33 mg and 8.56-21.04 mg reported by Fatemeh *et al.* (2012) and Ahmed *et al.* (2016). The carotenoid varied between 301.66 and 341.66 g/100g with sample RFO having the highest value while sample RUO had the lowest. Significant difference existed among the samples except RUP, RUS and RUO that had no significant difference ($P > 0.05$).

3.7. Antioxidant properties

The antioxidant properties of different varieties of Banana peel powder is shown in Table 6 shows the IC_{50} of DPPH radical scavenging, hydroxyl scavenging (OH) and iron chelating activity. IC_{50} (implies concentration required to obtain a 50% antioxidant effect) is a typically used parameter to express the antioxidant capacity and to compare the activity of different compounds. A lower value of IC_{50} corresponds a higher antioxidant activity of the banana peel extracts. Free radical scavenging expressed as IC50 ranged from 2.89-4.35%. Ripe Unfermented Saro peel powder (RUS) had the highest free radical scavenging while ripe unfermented Omini (RUO) had the lowest free radical scavenging DPPH of 4.35. Ripe unfermented Saro peel powder (RUS) was the most effective. The values obtained varied between 26.55-52.66%, 67.03% which was significantly lower than that reported by Fatemah *et al.* (2012) and Choo & Azis (2010). The values were high as 29.13% when extracted with aqueous. They were 24.18% when extracted with methanol (80%), 21.71% when extracted with ethanol (80%) and 17.50% when extracted with acetone (80%) (Ahmed *et al.*, 2016).

74080-94803 Nmoles in water extract and 48577-66727 N moles in ethanol extract have higher activity of DPPH radical scavenging activity and this may be attributed to the presence of higher levels of total phenolic and flavonoids and different antioxidant components (Shyamala & Januna, 2011).

The hydroxyl radical (OH) varied between 0.45-0.90%, ripe fermented saro peel (RFS) 0.45% showed the highest scavenging activity against the hydroxyl radical while the lowestwas ripe unfermented paranta (RUP) 0.90%.

Table 6: Total Phenolic, Total flavonoid and Antioxidant Properties different varieties of Fermented Ripe Banana Peel flour

Sample	Total Phenolic (GAE/g)	Total flavonoid (mg/100g)	Carotenoid (µg/100g)	DPPH (%) Radical scavenger (IC_{50})	HYDROXYL (OH) (IC50)	Iron chelating (%) (IC50)	FRAP (mmol/AAE g)
RFO	34.03 ± 0.25 ^{a}	428.33 ± 10.4 ^{a}	341.66 ±10.40 ^{a}	3.72 ± 0.01 ^{c}	0.71 ± 0.01 ^{b}	0.91 ± 0.01 ^{d}	1.36 ± 0.01 ^{b}
RFP	29.13 ± 0.15 ^{c}	393.33 ± 12.58 ^{b}	328.33 ± 10.46 ^{ab}	3.63 ± 0.01 ^{e}	0.71 ± 0.01 ^{b}	0.91 ± 0.01 ^{d}	1.18 ± 0.01 ^{d}
RFS	23.46 ± 0.152 ^{e}	405 ± 5.00 ^{b}	318.33 ± 7.63 ^{bc}	3.84 ± 0.01 ^{b}	0.45 ± 0.01 ^{e}	0.86 ± 0.01 ^{e}	1.32 ± 0.01 ^{c}
RUO	26.96 ± 0.152 ^{d}	331.67 ± 7.64 ^{c}	0.96 ± 0.01 ^{i}	4.35 ± 0.01 ^{a}	0.57 ± 0.01 ^{c}	0.96 ± 0.01 ^{c}	0.18 ± 0.01 ^{e}
RUP	31.36 ± 0.152 ^{b}	306.66 ± 7.64 ^{d}	1.28 ± 0.01 ^{g}	3.65 ± 0.01 ^{d}	0.9o ± 0.01 ^{a}	1.28 ± 0.01 ^{a}	0.12 ± 0.01 ^{f}
RUS	31.26 ± 0.20 ^{b}	291.66 ± 7.63 ^{d}	1.07 ± 0.01 ^{h}	2.89 ± 0.01 ^{f}	0.55 ± 0.01 ^{d}	1.07 ± 0.15 ^{b}	3.99 ± 0.01 ^{a}

Mean ± Standard deviation triplicate determination; Mean with the same alphabet in a column are not significantly different ($p \geq 0.05$); RFO = Ripe Fermented "Omini", RFP = Ripe Fermented "Paranta", RFS = Ripe Fermented "Saro", RUO = Ripe Unfermented "Omini", RUP = Ripe Unfermented "Paranta", RUS = Ripe Unfermented "Saro"

Significant difference ($p<0.05$) among the samples, except RFO and RFP which had no significant difference ($p\geq0.05$). The Fe^{2+} iron chelating activity with IC50 value varied betweeen 0.86 - 1.28%. Ripe fermented saro peel (RFS) had the highest iron chelating ability of IC50 0.86% while the ripe unfermented paranta peel (RUP) had the lowestiron chelating ability of 1.28%. The values obtained are lower compared with 19.40% for ethanolic extract, 15.45% for aqueous extract, 12.20% for methanolic extract and 12.34% for acetone extract from banana peel reported by Ahmed *et al.* (2016).

The ferric reducing power varied between 0.18-3.99 mmol/AAE g, RUS having the highest value while sample RUO had thelowest. The values obtained was significantly lower than 774, 470, 487 and 399 at IC_{50}µg/ml in aqueous, methanolic, ethanolic and acetone extracts of *Musa paradaisica* peel reported by Ahmed *et al.* (2016) and Badejo *et al.* (2017) respectively. The reducing power of banana peel extracts may be due to the action of hydroxyl group of the phenolic compounds (Ahmed *et al.*, 2016), low viscosity of the solvent which has low density and high diffusivity (Amarouwicz & Shahidi, 1995) and the reducing power of bioactive compounds is associated with antioxidant activity (Agama-Acevedo *et al.*, 2016). However, the reducing power of a compound may serve as a significant indicator of its potential antioxidant activity (Gonzalez-Montelongo *et al.*, 2010; Badejo *et al.*, 2017).

3.8. Dietary Fibre

Dietary fibers derived from fruits and vegetables have a relatively high proportion of soluble dietary fiber (Onimawo and Akubor, 2012). This kind of fiber shows some functional properties such as water holding, oil holding, swelling capacity, viscosity or gel formation. These properties of fiber play an important role in the prevention and treatment of obesity, atherosclerosis, coronary heart diseases, colorectal cancer and diabetes (Cho *et al.*, 2013). The dietary fibre of different varieties of ripe banana peel powder is shown in Table 7.

Table 7: Dietary fibre of different varieties of fermented ripe banana peel flour

Sample	Total dietary fibre (%)	Insoluble dietary fibre (%)	Soluble dietary (%)	IDF: SDF
RFO	6.07 ± 0.01 ^{f}	4.82 ± 0.01 ^{f}	1.25 ± 0.01 ^{e}	4:1
RFP	6.82 ± 0.01 ^{d}	5.44 ± 0.01 ^{d}	1.38 ± 0.01 ^{d}	4:1
RFS	6.25 ± 0.01 ^{e}	5.15 ± 0.01 ^{e}	1.10 ± 0.01 ^{f}	5:1
RUO	7.12 ± 0.01 ^{c}	5.62 ± 0.01 ^{c}	1.50 ± 0.01 ^{c}	4:1
RUP	7.82 ± 0.01 ^{a}	6.26 ± 0.01 ^{a}	1.56 ± 0.00 ^{a}	4.:1
RUS	7.44 ± 0.01 ^{b}	5.91 ± 0.01 ^{b}	1.53 ± 0.00 ^{b}	4 :1

Mean in triplicate determination; Mean with the same alphabet in a column are not significantly different (p >0.05); RFO = Ripe Fermented “Omini”, RFP = Ripe Fermented “Paranta”, RFS = Ripe Fermented “Saro”, RUO = Ripe Unfermented “Omini", RUP = Ripe Unfermented “Paranta”, RUS = Ripe Unfermented “Saro”

The total dietary fibre varied between 6.07-7.82% with sample RUP having the highest value and sample RFO the lowest. The value obtained was significantly lower than 29.01-44.97%, 83.00-89.35%, 10.23-50.09% reported by Badejo *et al.* (2017); Wachirasiri *et al.* (2009); and Awedem *et al.* (2015) but significantly higher than 4.96% reported by Sheng *et al.* (2010). The insoluble dietary fibre varied between 4.82% and 6.26% with sample RUP having the highest value and sample RFO the lowest significant difference ($p<0.05$) existed among the samples. The values obtained was significantly lower than 28.09- 41.23%, 70.16-73.06 g/100g and 9.40-45.28% reported by Badejo *et al.* (2017); Wachirasiri *et al.* (2009) and Awedem *et al.* (2015). The soluble dietary fibre varied between 1.10-1.56% with sample RUP having the highest value while sample RFS had the lowest value. The values obtained were significantly lower than 12.84-17.84%, 0.82-4.80% and 0.92-3.74 % respectively as reported by Wachirasiri *et al.* (2009); Awedem *et al.* (2015) and Badejo *et al.* (2017).This indicates that food produced from the flour could be a very good food that will aid easy stooling (Badejo *et al.* (2017); and Wachirasiri *et al.* (2009). The peel is also rich in soluble dietary fiber (pectin) which has a hypocholesterolemic effect.

4. Conclusion

The nutritional composition analysis of ripe banana peel indicated that among the three varieties analysed Protein, calcium, potassium, zinc, sodium and antioxidants (polyphenols, flavonoid and carotenoid) were high in ripe fermented omini peel flour. The peels if used as a supplement can provide natural nutrients as health benefits in food products. These peel otherwise can be used as potentials source of antioxidants and bio-active components for industrial application in production of food products.

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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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