Effect of Banana Peel Addition on the Chemical, Functional and Organoleptic Properties of Cookies

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Abstract
The effect of banana peel addition on the functional, proximate, antioxidant properties of cookies and sensory attributes of cookies was investigated. Banana peels was added at 5, 10 and 15% to wheat flour. Bulk density decreased significantly (P<0.05) from 0.88 – 0.83g/ml, Dispersibility (75 – 72%), with increase in water absorption capacity (0.77 – 1.20g/g), oil absorption capacity (0.82 – 0.90g/g). Swelling power (5.21 – 6.22g), solubility (9.70 – 12.80%). There was significant (P<0.05) decrease in moisture content (5.7 – 4.19%) protein (10.77 – 10.46%), carbohydrate (60.51 – 53.78%) and increase in the Ash content (1.28 – 2.03%), fat (15.61 – 18.79%) and crude fibre (7.47 – 10.76%). Total phenol and flavonoid content increased significantly (P<0.05) from 2.20 – 4.10mg/100g for Total phenol and 18.13 – 23.31% for flavonoid. The physical properties of the cookies showed an increase in the spread ratio from 7 – 7.80. The cookies samples showed varying degrees of likeness for all the attributes with the control sample having the highest preference for overall acceptability. This investigation showed acceptable functional cookies can be produced with Banana peel addition.

Key Words: *Banana Peels, Bioactive Compounds, Functional Foods, Cookies.*

1. INTRODUCTION

Banana peels are part of the agricultural waste which are generally discarded as trash or used as animal feed. Results of previous studies show that banana peels flour are functional food ingredient containing high fiber (Steel and Torrie, 1993).

Banana peels are beneficial to health as it contains good therapeutic and nutritional values, they are a good source of dietary fibre and antioxidants (Chakraborty *et al.*, 2017). it should be noted that both unripe banana flour (whole and with peel) have a high nutritional value (high fiber, mineral, and resistant starch content) (Alkarkhi *et al.*, 2011; Almeida *et al.*, 2020).

A large number of by-products such as hulls brans husks peels, pomaces are generated by food processing industry (Owuno *et al.*, 2021). The possibility of Utilization of by-products of the food processing industry as sources of dietary fibre, functional or novel fibre in human food formulations created the possibility of waste reduction and income generation. (Joshni and Sharma, 2011).

There also exists currently a preference for food products which contain bioactive compounds that provides additional benefits beyond basic nutrition (Owuno and Achinewhu, 2021).

Oladotun *et al.* (2021) reported that cookies produced from wheat-banana peels composite flours had a positive effect on wheat-banana peel cookies (Suresh *et al.,* 2014).

Cookies are small, flat dessert treats, commonly formed into a circular shape. They constitute an important component of the diet (Joshni and Sharma, 2011). Cookies represent the largest category of snack items among baked foods all over the world. It contains less moisture content. Different verities of cookies are used as one of the fast and nutritious snacks. Cookies are popular as convenient food (Owuno and Achinewhu, 2021).

Cookies with the addition of banana peels flour is a product that needs to be developed and the potential to meet their food needs. Therefore, this present study was aimed at utilizing banana peels for preparing functional cookies with high nutritional contents, high dietary fiber and improved sensory properties.

2. MATERIALS AND METHODS

2.1. Preparation of Banana Peel Flour

The method of Suresh *et al.* (Suresh *et al.,* 2014) was adopted with slight modification for the preparation of banana peel flour. The banana fruit was sorted, washed and separated into peel. Peels were dipped in 0.5 % w/v citric acid solution for 3hours at 4ºC, drained and dried in hot air oven at 60^0C for 8 hours. Dried peels were grinded and sieved to obtain banana peel flour. Banana peel flour was stored in airtight plastic packs in cold storage (15±2°C) for further analysis.

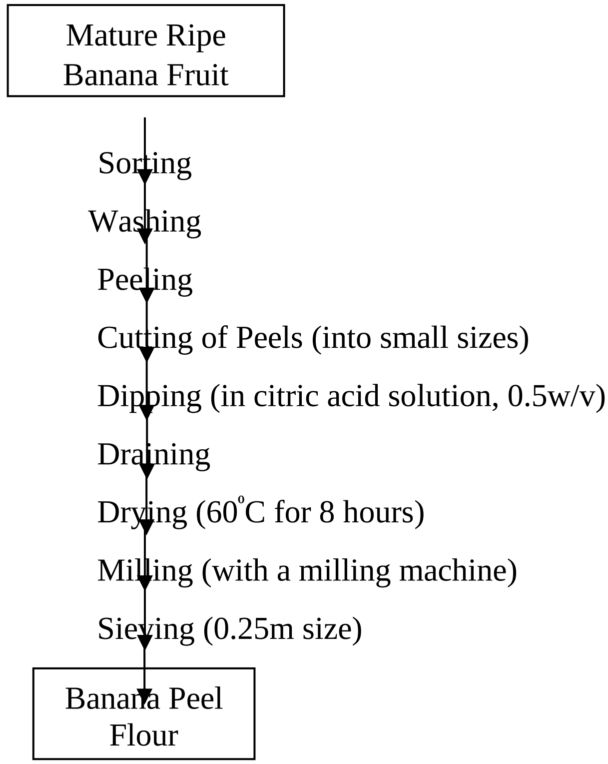

Fig. 3.1: Flow diagram for Banana Peel Flour

2.2. Formulation of Composite Blends.

Table 1: Flour Composition Blend for Cookies

Sample	Wheat Flour	Banana Flour
A	100	-
B	95	5
C	90	10
D	85	15

KEYS:
A: 100% Wheat flour
B: 95% Wheat flour : 5% Banana Peel flour
C: 90% Wheat flour : 10% Banana Peel flour
D: 85% Wheat flour : 15% Banana Peel flour

Table 2: Recipe for Cookies

Ingredients	A	B	C	D
Wheat Flour (%)	100	95	90	85
Ripe Banana Peel Flour (%)	-	5	10	15
Sugar (g)	35	35	35	35
Margarine (g)	35	35	35	35
Milk Powder (g)	2	2	2	2
Egg (g)	25	25	25	25
Ammonium Bicarbonate (g)	1.5	1.5	1.5	1.5
Milk Flavour (g)	0.5	0.5	0.5	0.5

Source: Kiin-Kabari & Eke-Ejiofor (2013)

KEYS:
A: 100% Wheat flour
B: 95% Wheat flour : 5% Banana Peel flour
C: 90% Wheat flour : 10% Banana Peel flour
D: 85% Wheat flour : 15% Banana Peel flour

2.3. Recipe for Cookies Production

The method of Kiin-Kabari and Eke-Ejiofor, (2013) was adapted with slight modification for the preparation of cookies. 35g of shortening was added to the flour or blend and mixed until a sandy texture was obtained. The other dry ingredients were added 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^{o}C for 20 minutes. Baked cookies were allowed to cool and packed in airtight Ziploc bags for further evaluation.

2.4. Functional Analysis of Composite Flour Blends

Water and Oil Absorption Capacities were determined by the method of Beuchat (1977), bulk density by the method described by Wang and Kinsella (1977). Swelling power and solubility were carried out using the method of Takashi and Sieb (1988). Dispersibility was determined by the method described by Kulkarni *et al.*, (1991).

2.5. Chemical Analysis of Wheat/Banana Peel Cookies

The proximate and the antioxidant properties of the cookies were determined. Proximate compositions were determined according to the methods of the Association of Official Analytical

Chemist (AOAC, 2012). Total phenol was determined by the method described by Jaffe (2013) and the flavonoid was determined using the method described by Boham and Kocipal (1994).

2.6. Physical Properties

The procedure as described by AACC (2000) was used to determine the physical properties (weight, diameter, height (thickness), and spread ratio) of the cookies.

2.7. Sensory Evaluation

Twenty untrained panelist from the University community were used. They were staffs and students of the Department of Food Science and Technology, Rivers State University, who are consumers of various kinds of bakery products including cookies. The cookies were evaluated for the attributes of aroma, appearance, taste, flavour, texture and overall acceptability using a 9-point hedonic scale where 1 was designated dislike extremely, 5 neither like nor dislike and 9 designated liked extremely.

2.8. Statistical Analysis

All the analyses were carried out in triplicate. Data obtained were subjected to Analysis of Variance (ANOVA); differences between means were evaluated using Turkey's Multiple Comparison Test with 95 % confidence level. The Statistical Package in Minitab Software version 16 was used.

3. RESULTS

3.1. Functional Properties

Table 3.1 shows the functional properties of the flour blends. Bulk density ranged from 0.83g/g in sample D to 0.88g/g in sample A. WAC ranged from 0.77g/g in sample A to 1.20g/g in sample D. OAC ranged from 0.80g/g for sample B and C to 0.90g/g in sample D. Dispersibility ranged from 70.00% in sample D to 75.00% in sample A. Swelling power ranged from 5.21 in sample A to 6.22g in sample D. Percentage solubility ranged from 9.70% in sample A to 12.80% in sample D.

Table 3 Functional Properties of Flour Blends

Sample	Bulk density (g/ml)	Water absorption (g/g)	Oil absorption (g/g)	Dispersibility (%)	Swelling power (g)	Solubility (%)
A	$0.88^{a}\pm0.00$	$0.77^{c}\pm0.07$	$0.82^{a}\pm0.00$	$75.00^{a}\pm0.00$	$5.21^{c}\pm0.01$	$9.70^{b}\pm0.42$
B	$0.86^{a}\pm0.00$	$0.92^{bc}\pm0.00$	$0.80^{a}\pm0.14$	$74.00^{b}\pm0.00$	$5.92^{b}\pm0.00$	$10.80^{b}\pm0.00$
C	$0.84^{a}\pm0.00$	$1.02^{ab}\pm0.00$	$0.80^{a}\pm0.00$	$72.00^{c}\pm0.00$	$5.96^{b}\pm0.00$	$11.40^{ab}\pm0.85$
D	$0.83^{b}\pm0.00$	$1.20^{a}\pm0.06$	$0.90^{a}\pm0.00$	$70.00^{d}\pm0.00$	$6.22^{a}\pm0.00$	$12.80^{a}\pm0.00$

Mean values are of duplicate determination. Mean values within a column with different superscripts are significantly different at ($p < 0.05$).

KEY:
A: 100% wheat Flour
B: 95% Wheat Flour : 5% Banana Peel Flour
C: 90% Wheat Flour : 10% Banana Peel Flour
D: 85% Wheat Flour : 15% Banana Peel Flour

3.2. Proximate Composition of the Wheat/Banana Peel Cookies

Table 3.2 shows the proximate composition of the wheat/banana peel flour cookies. Moisture content (%) ranged from 4.19 in sample D to 5.0 in Sample. Ash (%) ranged from 1.28 in sample A to 2.03 in sample D. Protein (%) ranged from 10.46 in sample D to 10.77 in sample A. Fat (%) values ranged from 15.61 in sample D to 18.79 in sample D. Crude fibre (%) ranged from 7.47 in sample A to 10.76 in sample D. Carbohydrate content (%) ranged from 53.78 in sample D to 60.51 in sample A.

Table 4 Proximate Composition of the Cookies

Sample	Moisture Content (%)	Ash (%)	Protein (%)	Fat (%)	Crude Fibre (%)	Carbohydrate (%)
A	$5.07^{a}\pm0.00$	$1.28^{c}\pm0.03$	$10.77^{a}\pm0.03$	$15.61^{b}\pm0.15$	$7.47^{c}\pm0.11$	$60.51^{a}\pm0.01$
B	$4.37^{b}\pm0.04$	$1.60^{b}\pm0.00$	$10.74^{a}\pm0.01$	$16.22^{b}\pm0.03$	$8.14^{bc}\pm0.59$	$57.97^{b}\pm0.60$
C	$4.29^{b}\pm0.06$	$1.80^{ab}\pm0.07$	$10.70^{a}\pm0.03$	$18.00^{a}\pm0.00$	$9.34^{ab}\pm0.25$	$55.64^{c}\pm0.61$
D	$4.19^{b}\pm0.07$	$2.03^{a}\pm0.11$	$10.46^{b}\pm0.00$	$18.79^{a}\pm0.37$	$10.76^{a}\pm0.57$	$53.78^{d}\pm0.02$

Mean values are of duplicate determination. Mean values within a column with different superscripts are significantly different at ($p < 0.05$).

KEY:

A: 100% wheat Flour Cookies
B: 95% Wheat Flour : 5% Banana Peel Flour Cookies
C: 90% Wheat Flour : 10% Banana Peel Flour Cookies
D: 85% Wheat Flour: 15% Banana Peel Flour Cookies

3.3 Antioxidant Properties of the Cookies

Table 3.3 shows the effects of banana peel inclusion on the antioxidant properties of the cookies. The phenol ranged from 2.20mg/100g in sample A to 4.10mg/100g in sample D. Flavonoid (%) ranged from 18.13 in sample A to 23.21 in sample D.

Table 5 Antioxidant Properties of the Cookies

Sample	Total Phenol (mg/100g)	Flavonoid (%)
A	$2.20^{c}\pm0.021$	$18.13^{b}\pm0.025$
B	$2.70^{bc}\pm0.021$	$20.50^{ab}\pm0.134$
C	$3.30^{b}\pm0.000$	$21.36^{a}\pm0.021$
D	$4.10^{a}\pm0.014$	$23.21^{a}\pm1.004$

Mean values are of triplicate determinations. Mean values within a column with different superscripts are significantly different at (p <0.05).

KEY:
A: 100% wheat Flour Cookies
B: 95% Wheat Flour : 5% Banana Peel Flour Cookies
C: 90% Wheat Flour : 10% Banana Peel Flour Cookies
D: 85% Wheat Flour : 15% Banana Peel Flour Cookies

3.4. Change in the Physical Properties of the Cookies

The physical properties are presented in Table 3.4. The height of the cookies ranged from 0.43cm in sample D to 0.50cm in sample A. Diameter ranged from 3.50cm in sample A to 3.87cm in sample D. The weight ranged from 4.72cm in sample A to 6.67cm in sample C. The spread ratio of the cookies showed values ranging from 7.00 in sample A to 7.80 in sample D.

Table 6 Physical Properties of the Cookies

Sample	Height (cm)	Diameter (cm)	Weight (g)	Spread Ratio
A	$0.50^{a}\pm0.000$	$3.50^{b}\pm0.000$	$4.72^{c}\pm0.203$	$7.00^{d}\pm0.000$
B	$0.50^{a}\pm0.000$	$3.60^{b}\pm0.000$	$5.99^{b}\pm0.201$	$7.20^{c}\pm0.000$
C	$0.50^{a}\pm0.000$	$3.80^{a}\pm0.100$	$6.67^{a}\pm0.110$	$7.53^{b}\pm0.116$
D	$0.43^{a}\pm0.000$	$3.87^{a}\pm0.058$	$5.92^{b}\pm0.006$	$7.80^{a}\pm0.000$

Mean values are of triplicate determinations. Mean values within a column with different superscripts are significantly different at (p <0.05).

KEY:

A: 100% wheat Flour Cookies
B: 95% Wheat Flour : 5% Banana Peel Flour Cookies
C: 90% Wheat Flour : 10% Banana Peel Flour Cookies
D: 85% Wheat Flour : 15% Banana Peel Flour Cookies

3.5. Sensory Scores of Wheat/Banana Peel Cookies

The acceptability of the cookies are presented in Table 3.5. Colour ranged from 5.75 in sample B to 8.10 in sample A. Aroma ranged from 5.20 in sample B to 8.20 in sample A. Texture ranged from 6.25 in sample B to 7.20 in sample C. Taste ranged from 5.30 in sample B to 8.30 in sample A. Overall Acceptability of the cookies, ranged from 5.63 in sample B to 7.88 in sample A.

Table 7 Sensory Scores of the Wheat/Banana Peel Cookies

Sample	Colour	Aroma	Texture	Taste	Overall Acceptability
A	$8.10^{a}\pm1.165$	$8.20^{a}\pm1.005$	$6.90^{a}\pm2.174$	$8.30^{a}\pm1.129$	$7.88^{a}\pm1.131$
B	$5.75^{b}\pm2.197$	$5.20^{b}\pm2.215$	$6.25^{b}\pm1.682$	$5.30^{b}\pm2.515$	$5.63^{b}\pm1.802$
C	$6.50^{ab}\pm1.606$	$5.70^{b}\pm2.029$	$7.20^{a}\pm1.399$	$6.15^{b}\pm2.207$	$6.39^{b}\pm1.492$
D	$6.25^{b}\pm2.468$	$5.75^{b}\pm1.713$	$7.00^{a}\pm1.451$	$6.10^{b}\pm1.651$	$6.28^{b}\pm1.325$

Mean values are of duplicate determinations. Mean values within a column with different superscripts are significantly different at ($p < 0.05$).

KEY:
A: 100% wheat Flour Cookies
B: 95% Wheat Flour : 5% Banana Peel Flour Cookies
C: 90% Wheat Flour : 10% Banana Peel Flour Cookies
D: 85% Wheat Flour : 15% Banana Peel Flour Cookies

4. DISCUSSION

Table 3 presents the various functional characteristics of the flour blends. Functional characteristics of flour plays a major role in the accomplishment of ready to eat food products and high water absorption capacity may facilitate in the cohesiveness of the product (Shobha *et al.*, 2014). The bulk densities have values ranging from 0.83g/g in sample D to 0.88g/g in sample A. Bulk density plays a major role in analyzing the packaging requirement and material handling in the food industry (Cheng and Bhat, 2016). Marak *et al.*, (2019) reported similar values in flour blends incorporated with foxtail millet and ginger powder.

An increasing trend in water absorption capacity was observed with increase in banana peel with values ranging from 0.77g/g in sample A to 1.20g/g in sample D. The variance may be due to the difference in particle size, shape and also the presence of different hydrophilic carbohydrates, lipids and proteins (Kaur *et al.,* 2015) (Singh *et al.,* 2003). Niba *et al*. (2001) stated that WAC is important in bulking and consistency of product as well as baking applications. Suruya *et al*. (2017) reported values of WAC ranging from 2.65 – 5.74% for flour blends of wheat and *Amorphophallus paeoniifolius*.

Oil absorption capacity of flour plays a significant role in improvement of shelf life and palatability especially in bakery product where fat absorption is desirable. OAC also reflects in flavor retention and enhanced mouth feel (Aremu *et al.,* 2007). The oil absorption capacity ranged from 0.82g/g in sample D to 0.90g/g sample A. The results from this study are slightly lower than Amandikwa *et al*., (2015) that recorded values of OAC ranging from 0.88 – 2.10ml/g in wheat-yam composite flour.

The value of dispersibility which is an index of the ease of reconstitution of flour or composite flour in water (Adebowale *et al.,* 2012) ranged from 70.00% in sample D as the least, to 75.00% in sample A as highest. A significant ($p<0.05$) reduction was observed in the dispersibility of flour blends with increasing substitution level, which means that increased levels banana peel flour substitution, will not easily reconstitute to give a fine consistency dough during mixing. This result is in agreement with Adebowale *et al*. (2012) that reported a decrease in the dispersibility of sorghum-wheat composite flour blends with values ranging from 73.5% to 76.5%.

Swelling power of a sample is the ability of the sample to imbibe water and expand (Rickard *et al.,* 1997). The swelling power ranged from 5.21g in sample A to 6.22g in sample D. Swelling power is related to the water absorption index of the starch – based flour during heating (Loos *et al.,* 1981). Zouari *et al*. (2016) reported increase in swelling power for wheat flour blended with sesame peels flour.

Solubility Index is a measure of the dextrinisation of starch (Suntharalingam and Ravindran, 1993). The solubility index increased from 9.70% in sample A to 12.80% in the sample D. This increase may be attributed to the high content of lipids in banana peel flour. Abdul-Rasaq *et al.* (2012) reported values of solubility index ranging from 9.87 – 10.34% in Sorghum-wheat flour blends.

The results for the proximate composition of the cookies are shown in table 4 Moisture content is an important factor in food, making it possible to determine the life span and mode of preservation (Awedem *et al.,* 2015) (Ahmad *et al.,* 2016). This ranged from 4.19 in sample D to 5.07% in sample A. The values recorded in this study are comparable to those reported by Oladotun *et al.* (2021) for cookies produced from composite flour blends wheat and banana peel flour.

The ash content ranged from 1.28% in sample A to 2.03% in sample D. An increase was observed in the ash contents of all cookies with increasing level of banana peel flour substitution. This result therefore indicates that the composite flours utilized were of nutritional significance, since ash is generally indicative of the mineral contents of foods (Oladotun *et al.*, 2021). This result is within the findings of Syarifah *et al.* (2018) for biscuits incorporated with banana peel flour and also comparable to Olaoye *et al*., (2019) that reported an increase in ash content of composite flours with addition of up to 10% banana peel flour.

The protein content showed a decreasing trend as the quantity of banana peel flour increases. This decrease may be due to the reduced quantity of wheat flour used in making the cookies as wheat flour has high gluten protein content. This study is similar to the findings of Nimesha *et al.* (2021) for cookies incorporated with different varieties of banana flour.

The fat contents ranged from 15.61% in sample A to 18.79% in sample D. It increased as the level of banana peel flour increased. This may due to the high content of fat in banana peel flour. According to Wachirasiri *et al.* (2009), banana peel has greater fat content compared to sweet orange peel and lemon peel (2.6g/100g and 2.5g/100g). The values obtained are comparable to 15.00 – 15.60% reported by Nimeshe *et al*. (2021) but significantly lower than 22.99 - 23.16% as reported by Arun *et al*. (2016) for cookies substituted with plantain flour and higher than 11.83 – 12.20% values for wheat/banana peel flour cookies reported by Oladotun *et al.* (2021).

The crude fibre ranged from 7.47 – 10.76%. The highest was found in sample D, while the lowest was observed in sample A. 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 (WHO, 2004). Similar findings were reported by Olaoye *et al*. (2019) and Arun *et al*. for increased crude fibre content with addition of banana peel flour (Arun *et al.,* 2016).

Carbohydrate content ranged from 53.78% in sample D to 60.51% in sample A. Carbohydrate content decreased with banana peel addition. This result is within the findings of Olaoye *et al*. that also reported a reduction in carbohydrate content of cookies with banana peel flour inclusion (Olaoye *et al.,* 2019).

The incorporation of banana peel flour gradually increased the phenolic content in the cookies. Previous reports suggest that replacement of wheat flour with other sources rich in dietary fibre improve the phenolic content of cookies (Sharma and Gujral, 2014). This result is similar to the findings of Arun *et al.*, showing increase with increasing plantain peel flour substitution (Arun *et al.,* 2016).

Flavonoid content ranged from 18.13% in sample A to 23.21% in sample D. Pasqualone *et al*. (2015) observed increase 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. Oladotun *et al*, (2021) recorded increasing values for wheat-banana peel cookies.

The effect of incorporation of banana peel flour on the physical properties of cookies are presented in Table 6 The height of cookies have values ranging from 0.43cm - 0.50cm. The heights recorded in this result is in agreement with Ebere *et al*., that reported heights of 0.42cm to 0.52cm for cookies with added levels of cashew-apple fibre (Ebere *et al.*, 2015).

The diameter of the cookies ranged within 3.50 – 3.87cm, showing increase in the diameter of the banana peel enriched cookies. This result is in agreement with Oladotun *et al*. (2021) that reported increasing values ranging from 3.80 – 3.90cm in cookies enriched with banana peel cookie. Also Ebere *et al*., (2015) reported values of diameter ranging from 2.92 – 3.13cm for cookies enriched with added levels of cashew-apple fibre.

The weight of the cookies also differs significantly, where average weight of control cookies (sample A) is 4.92g having the least and that for the cookies with 10% of banana peel flour is 6.67g

having the highest weight. Supplementation with banana peel flour resulted in cookies with significantly greater weight compared to control. This result is similar to the findings of Azuan *et al.*, that recorded an increase in the weight of cookies supplemented with different levels of spent coffee ground extract (Azuan *et al.,* 2020).
Spread ratio is a measure of cookie quality. For better cookies, higher spread ratio is desirable (Barak *et al.,* 2013). Results shows that the spread ratio of the composite cookies displayed an increasing trend along with the increasing substitution level of banana peel flour. This result is slightly similar to Ebere *et al*., and Chauhan *et al*., for cookies produced with added levels of cashew-apple fibre and wheat–amaranth flour blend respectively (Ebere *et al.*, 2015) (Chauhan *et al.,* 2016).

The mean sensory scores are presented in table 7. It was observed that sample A was more preferred in terms of colour, aroma, taste and overall acceptability compared to other samples with banana peel flour inclusion, except for texture that had sample C as the most preferred. The colour of the cookies with banana peel flour influenced the colour of the cookie.

5. CONCLUSION

This study revealed that incorporation of banana peel flour improved the functional (bioactive) and physical properties of the cookies. The ash, fat, crude fibre and antioxidant content were significantly ($p<0.05$) higher than cookies produced from 100% Wheat flour.
Therefore, the utilization of banana peels for the preparation of cookies will promote the utilization of food waste for the production of value added products which will result to functional cookies, thereby improving health benefits.

The banana peels, if used as a supplement can provide health benefits in food products. These peels otherwise can be used as potential source of antioxidants and bio-active components for industrial application in food products.

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