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Physico-chemical and Sensory Properties of Banana Flour-Sesame Paste Blends

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Abstract- This study was conducted to evaluate the physico-chemical and sensory properties of banana flour-sesame paste blends. The experiment consisted of ripe banana flour + sesame paste proportions: 55 +45% (B_fBR_1), 45 +55% (B_fBR_2) and 35 +65% (B_fBR_3), respectively. Sesame paste made from 50% sugar syrup was used as a control. Banana flour-sesame pastes showed a significant ($p<0.05$) increase in moisture (wb), fiber, ash, fat, protein from 3.33, 3.12, 3.28, 23.27, 11.76 (%) in the control to 5.24-6.42, 3.71-4.73, 4.94-5.12, 23.42-33.56, 11.96-15.89 (%) in the different blends respectively. Similarly Ca, Zn, Fe (db) were increased from 522.94, 2.09, 5.17 mg/100g in the control to 531.75-767.98, 2.27-2.83, 5.37-7.30 mg/100g in the blends respectively. But the carbohydrate content was reduced from the control value of 50.44% to 34.07-49.05% in the various blended pastes. The total phenolic content (mgGAE/g), ferric ion reducing power (FRP) (µmol/g) and phytic acid (mg/100g) contents (at B_fBR_2 and B_fBR_3) were increased from control value of 11.16, 15.68 and 164.96 to 11.99-16.19, 16.22-21.88 and 144.41-208.01 in the blended pastes, respectively. Sensory evaluation revealed that the most acceptable paste product for its flavor was obtained from 55% sesame paste higher than the control value. Descriptive sensory analysis revealed that all products had light brown and light yellow color, roasted nutty flavor and sweet taste. Therefore, ripe banana flour-sesame paste blending was found to produce acceptable pastes enriched by protein, ash, fiber, minerals, antioxidant power and phenolics.

Index Terms- Banana flour-sesame paste blends; Phyisco-chemical properties; and Sensory evaluations

I. INTRODUCTION

Sesame paste is produced from unhulled/hulled, ground, dry roasted sesame seeds. It is usually consumed straight, by blending with sugar syrups, honey, concentrated date fruit and sugar beet molasses with bread at breakfast (Isa, 2001; Razavi, 2007; Lake et al. 2010; Olagunju1 and Ifesan, 2013). Sesame seed is rich in lipids (54-65%), proteins (17-27%), carbohydrates (6.4-21.0%) and dietary fiber (9.3%) (Abu-Jdayil et al. 2002) and contains important minerals and vitamins such as Ca (429 mg/100g), P (732-840 mg/100g), Fe (9 mg/100g), niacin (4.5-5.5 mg/100g), and thiamin (1.1 mg/100g) (Abu-Jdayil et al. 2002;USDA, 2003; Arslan et al. 2005). It has also some potential of nutraceutical compounds such as liginan type phenolics and tocopherols with antioxidant activity that have significant effect on reducing blood pressure, lipid profile and degeneration of vessels thereby can impact in reducing chronic diseases (Jannat et al. 2010; Rehman, 2012). Zebib et al. (2015) studied on physico-chemical properties of sesame varieties and reported that sesame seeds should be processed in different products and blended with concentrated fruits to utilize as functional food for human nutrition.

Ripe banana is very perishable and subject to fast deterioration after harvesting (Devlet and Mahir, 2003), more susceptible to mechanical injuries and increasing the losses further due to spoilage (Wills et al. 1998). Dried banana flour prepared from ripe banana is suitable for incorporation into food products as sweetener, solubility, high energy contents (Singh et al. 2004; Zhang et al. 2005; Aurorea et al. 2009), sugar-rich and easily digested (Aurorea et al. 2009), enriched with minerals such as K and P (Hardisson et al. 2001; Leterme et al. 2006; Wall, 2006) and recognized for its desirable flavor (Bates et al. 2001). It also contains various antioxidants, for instance vitamins (pro-vitamin A β–carotene, B, C and E) and phenolic compounds such as catechin, epicatechin, lignin and anthocyanins (Someya et al. 2002; Wall, 2006; Lim et al. 2007). Abbas et al. (2009) recommended that incorporation studies of ripe banana flour into strategic food products should be attempted.

Many researchers have worked on sesame paste based product to enhance quality and consumer sensory acceptance to satisfy human nutrition. For example, Alpaslan and Hayta (2002) studied on rheological and sensory properties of pekmez (grape molasses)/tahin (sesame paste) blends, Mohammad and Alaei (2006) have studied on rheological properties of date syrup/sesame paste blend, Steve et al.(2009) on chemical, functional and sensory properties of roasted groundnut and cooking banana weaning diet and Gharehyakheh and Tavakolipour (2013) on rheological properties of sesame paste (Ardeh) with different concentration of honey, in different sesame growing areas. In Ethiopia there are a limited sesame based products even if there is high production of sesame varieties and no research has been done on sesame variety for sesame paste applications. The physico-chemical and sensory properties information of banana flour-sesame paste blends are important from stand point of nutrition, production industry and maximum utilization. Sesame paste supplemented with ripe banana flour might offer a promising nutritious and healthy alternative to consumers due to the high protein and dietary fiber content of sesame paste and high minerals and vitamins in ripe banana. In addition blending of banana flour in this product also reduces the postharvest loss of ripe banana since is consumed in such product before spoilage. So processing sesame locally into different forms adds value for sesame and banana. The objective of this study was to investigate physico-chemical and sensory properties of banana flour-sesame paste blends.

II. MATERIALS AND METHODS

Experimental Site

The experiment on proximate, mineral, anti-nutritional, antioxidant and sensory properties were conducted at the Department of Food Science and Postharvest Technology laboratory of Haramaya University, Ethiopia from October 2011 to June 2012.

Sample collection and preparation

T-85 sesame variety (*Sesamum indicum* L.*)* was collected from Humera Agricultural Research Center (HuARC), Ethiopia in November 2011. The seeds were cleaned, sorted out and stored in plastic bags at 4°C till used for the experiment. Whole, cleaned sesame seeds were dry roasted at 95°C for 3 minutes (Sawaya et al. 1985). Then roasted sesame seed was cooled at room temperature for few minutes and then ground into thick paste using grinding mill (A-11 Guangzhou P.R. CHINA) and stored in a jar with a tight fitting lid (IFT, 1997).

Matured cooking banana fruit (Dwarf Cavendish) was collected from Werer Agricultural Research Center (WARC), Ethiopia and sealed in wooden box for transportation. Fruits were ripened for 5-7 days at 25±2°C and 90-95 relative humidity (RH) until they reach ripening stage 7 according to standard peel color index (CSIRO, 1972). The ripeness stage 7 (full ripe, yellow color and perfect flavor for eating) was selected since this stage corresponds to various uses in industrial transformation and culinary preparations (Emaga et al. 2008). The ripe banana fruit was peeled and cut into transverse slices of about 1/8 inch thickness. Slices were then dipped in lemon juice solution for 10 min by mixing 240 g of lemon juice and 240 g of cold water (Kendall and Sofos, 2003). The treated slices were then drained and dried in an oven at 60°C for 18 hrs. The dried samples were ground to pass through 60 mesh screen to obtain ripe banana flour. The flour was stored in airtight plastic bag in cold storage (15±2°C) until required for the experiment (Abbas et al, 2009).

Banana flour-sesame paste blends

In order to work with standard samples, soluble solid content of ripe dried banana flour was adjusted by adding distilled water to 70 °Brix using the hand refractometer (Alpaslan. and Hayta, 2002). Then it was added to sesame paste and mixing evenly with spatula. The prepared pastes were stored at room temperature for further analysis.

Sugar syrup-sesame paste blends (control)

Sugar syrup (50%) i.e. made from table sugar (40%) was dissolved in water (10%). Then the solution was heated to 120°C and stirred until it turns white pale brown. This was then added into sesame paste (50%) while mixing evenly with spatula and then stored at room temperature for further analysis (Lake et al. 2010).

Chemical analysis

Moisture content (%)-was analyzed by drying a sample (about 3.0 g) at 100°C for 6 h in an air draught oven (Model: 101-1A, Tianjin Taisite Instrument Co., I td) (AOAC, 1995).

Crude protein content (%)-sample (about 0.3 g) was analyzed by *micro-Kjeldahl* method (digester: F30100184, SN: 111051, VELP Scientifica; distiller: F30100191, SN: 111526, Europe) (AOAC, 1995) using urea as control. Protein (%) = N (%) X 6.25.

Crude fat content (%) - was determined by Soxhlet extraction (Model: EV 16, SN: 4002824, Germany) of sample (about 2.0g) using petroleum ether as a solvent (AOAC, 1995).

Crude fiber content (%) - was determined by taking about 3.0 g sample as portion of carbohydrate that resisted sulfuric acid (1.25%) and NaOH (1.25%) digestion followed by sieving (75 µm), washing, drying and ignition to subtract ash from fiber (AOAC, 1995).

Total ash (%)-was determined by ashing about 3.0 g sample in a muffle furnace (Model: MF120, SN: 04-1524, Ankara Turkey) at 550°C until ashing complete (over 12 hrs) (AOAC, 1995).

Total carbohydrates (%)-was determined by difference: 100- (% Moisture content + % Crude protein +% Crude fat +% Crude fiber +%Total ash).

Iron (mg/100g)- was determined after digestion of sample (about 2.0 g) by measuring absorbance of Fe^{2+} -1, 10-phenanthroline red complex color at 510 nm using UV-VIS spectrophotometer (AACC, 2000). The iron level was estimated from standard calibration curve (0.0-10.0 µg Fe/mL) prepared from analytical grade iron wire.

Calcium (mg/100g) - was determined after digestion of sample (about 2.0 g) by Atomic Absorption spectrophotometer (AAS) at 422.7 nm using air-acetylene as a source of energy for atomization by adding enough 1% lanthanum (1mL La solution/5mL) to suppress interferences. Calcium level was then estimated from standard calibration curve (5.0-25.0 µg Ca/mL) prepared from analytical grade calcium carbonate ($CaCO_3$) (AACC, 2000).

Zinc (mg/100g) - was determined after digestion of sample (about 2.0 g) by Atomic Absorption Spectrophotometer (AAS) at 213.8 nm using air-acetylene as a source of energy for atomization (AACC, 2000). Zinc level was then estimated from standard calibration curve (0.5-3.0 µg Zn/mL) prepared from ZnO (AACC, 2000).

Phytic acid:-was determined through phytate phosphorus (Ph-P) analysis (Wheeler and Ferrel, 1971). Sample (about 0.25 g) was extracted with 12.5 mL of 3% Trichloroacetic acid (TCA) for 45 min in a water bath (GLS 400 water bath, England) with vortex mixing (REAX top, Germany) at ambient temperature (23°C) and centrifuged (4000 rpm10 min) (Centrurion Scientific Model 1020 DE, United Kingdom). About 4 mL of $FeCl_{3}.6H_2O$ was mixed to 10 mL of the sample solution and the precipitate ferric phytate formed digested and was analyzed for phytate phosphorus as phosphomolybdate blue absorbance at 822 nm using UV-Vis spectrophotometer (Model 6505, Genway LTD, U.K) (Morrison, 1964). The absorbance for sample was subtracted from the blank and phosphorus level was estimated from the calibration curve (0.0-1.2 mg/mL) prepared from KH_2PO_4. Then the phytic acid content was estimated by multiplying the amount of phytate-phosphorus by the factor 3.55 based on the empirical formula $C_6P_6O_{24}H_{18}$ 660 g and phytic phosphorus (P_6) 186 g (i.e., phytate = P × 3.55) and the results were expressed as phytic acids in mg per 100 g (db).

Total phenolic content (TPC)-was determined colorimetrically using Folin-Ciocalteau reagent, as described by Singleton and Rossi (1965). Sample (about 0.4 g) was extracted with 20 mL of acidified methanol (1% HCl in methanol) for 1 h at 25°C, with vortex mixing at 5 min intervals. Samples were centrifuged (Model 1020 D.E, U.K.) for 10 min at 1,200 x g. Three replicate sample extract supernatants (0.5 mL) was mixed with 2.5 mL of Folin-Cicalteau reagent and allowed to stand at 25°C for 8 min. Then 7.5 mL of 20% sodium bicarbonate solution was added to the mixture. After 2 h at 25°C, absorbance was measured at 760 nm using a UV-visible spectrophotometer. A standard curve was prepared using various concentration of gallic acid and the results were reported as mg gallic acid equivalents/g of sample (db).

Antioxidant property analysis - was measured by ferric ion reducing power (FRP) method as described by Zhao *et al.* (2008). Sample (about 0.5 g) was extracted with 80% methanol (1 mL) on wrist action shaker for 2 h. Sample extracted supernatants was mixed with 2.5 mL of phosphate buffer (0.2 M, pH 6.6) and 2.5 mL potassium ferricyanide (1%) was mixed followed by incubation at 50 °C for 20 min. After then 2.5 mL of trichloroacetic acid solution (10%) was added to the mixture and was then centrifuged (Model 1020 D.E, U.K.) at 3000 g for 10 min. The upper layer solution (2.5 mL) was mixed with 2.5 mL distilled water and 0.5 mL ferric chloride (0.1%). The absorbance of the mixture was measured at 700 nm immediately and FRP was estimated from ascorbic acid standard curve as µmol ascorbic acid equivalents/g of sample (db).

Sensory evaluation

Sensory evaluation of banana flour-sesame paste blends were evaluated by 50 consumer panelists (36 males, 14 females of age between 20 and 50 years) selected from the staff members and graduating class students of Food Science and Postharvest Technology Department of Haramaya University. Sensory attributes were evaluated using acceptability and descriptive methods (David and Francis, 1957). The sensory acceptability taste (color, flavor, taste and overall acceptability) were evaluated using five point hedonic scale rated from 1 (extremely dislike), 3(neither like nor dislike) to 5 (extremely like). Samples were also analyzed by a descriptive method for taste (sweet, salty, sour, bitter and other), flavor (roasted, nutty, caramel and burnt) and color (gray white, creamy, light brown and light yellow). The samples were served to judges on white plates along with table spoons by using three digit sample code system in a random order (Resurreccion, 1998). Orientation was given to the judges on the procedure of sensory evaluation before the taste session.

Statistical analysis

Triplicate data were subjected to ANOVA (Gomez and Gomez, 1984) using Statistical Analysis System (SAS Institute and Cary NC) Version 9.0. Significant differences between means were determined with Duncan's multiple range tests at P< 0.05.

III. RESULTS AND DISCUSSIONS

Proximate composition of banana flour-sesame paste blends

The proximate compositions of the banana-sesame paste blend are shown in Tables 1. The blended product B_fBR_1 had the highest moisture content (6.42 %.) while least was in the control (3.33%) sample. The current study results are almost similar to the range 5.9-6.9% for banana-groundnut flour blends reported by Steve et al. (2009). Results showed that moisture content of all paste blends was higher than the control. This increase in the moisture content of blends is due to higher moisture content in the ripe banana flour and this happens due to break down of starches into sugar and migration of moisture from peel to pulp during ripening process (Marriott et al. 1981).

The highest crude fiber content was recorded in B_fBR_3 (4.73%) while lowest value was in B_fBR_1 (3.71%). These finding results are much higher than 1.48% by Yildiz (2013) for Turkish traditional mulberry product (pestil with hazelnuts) but lower than the range 5.66-6.14% by Rehman et al. (2012) for apricot-date bars containing skim milk powder, roasted gram flour and peanuts. In this study, it was also observed that fiber content of all paste products was significantly higher than the control (3.12%) value. This is due to high amount of fiber in sesame (Abu-Jdayil et al. 2002; Gharehyakheh and Tavakolipour, 2013) and some amount of fiber in ripe banana flour (Abbas et al. 2009) that contributed to high crude fiber contents in the blended products.

Results show that as % of sesame paste increases, the ash content of the blended pastes increases. The B_fBR_3 has contained highest ash value (5.12%) while B_fBR_1 contained the least ash value (4.94%). Steve et al. (2009) reported that ash contents of 2.3-3.4% for banana-groundnut flour paste and the range 4.06-4.20 for apricot-date bars by Rehman et al. (2012) which are much lower than this results. Ash content of all formulated paste was significantly higher than the control (3.28%) due to the contribution of ash content by the ripe banana flour (Abbas et al. 2009) to the blended products. There were no significant ($p>0.05$) differences on crude fat content of B_fBR_1 and the control sample. The highest crude fat content (33.56%) was obtained in B_fBR_3 while the lowest (23.42%) was in B_fBR_1 which were significantly higher than the control crude fat content (23.17%). The crude fat contents found in this work are higher than the values 16.08%, 13.78% and 13.24% for pestil with hazelnuts, pestil with walnuts and Kome mulberry products, respectively reported by Yildiz (2013).

The protein content had varied significantly ($p<0.05$) among banana-sesame paste products (Table 1). With increasing of sesame paste ratios, protein content in the blended products was increased from 11.96% in B_fBR_1 to 15.89% in the B_fBR_3. The results obtained are significantly higher than the range 6.7-13.8% reported by Steve et al. (2009) for banana-groundnut flour blends and the value 7.42% for pestil with hazelnuts mulberry product reported by Yildiz (2013). The protein content of two paste blends was significantly higher than control (11.76%) however with no significant ($p>0.05$) differences between B_fBR_1. This is due to the high amount of crude protein in sesame paste (Orrun and Morgan, 2005; El-Khier et al. 2008) and partly also contribution from the protein content of dried ripe banana flours (Emag et al. 2007; Abbas et al. 2009) than in the control which was processed by addition of table sugar syrups. The highest carbohydrate content (49.05%) was obtained in B_fBR_1 and the lowest (34.03%) was in B_fBR_3. The total carbohydrates found in this work are significantly lower than the range 68.9-77.8% reported for banana-bambara groundnut paste by Steve et al. (2009) and 52.28-55.67% for apricot-date bars by Rehman et al. (2012). The carbohydrate content of control (50.44%) was significantly higher than all blended pastes. This may be due to only sugar addition in the control that contributed to high total carbohydrate contents.

Mineral composition of banana flour-sesame paste blends

The mineral composition of the banana flour-sesame paste blends are presented in Table 2. Significant ($p<0.05$) differences in mineral composition of blended products were observed. The blended products B_fBR_3 contained highest amounts of Ca (767.98 mg/100g), Zn (2.83 mg/100g) and Fe (7.30 mg/100g) contents while B_fBR_1 has the lowest amount of Ca (531.75 mg/100g), Zn (2.27 mg/100g) and Fe (5.37 mg/100g) contents. The Ca, Zn and Fe contents of the control sample were 522.94, 2.09 and 5.17 mg/100g respectively. The Ca contents of banana flour-sesame paste blends were much higher than 166.3 mg/100g for date bars containing almonds, sesame, oat and skim milk powder reported by Al-Hooti et al. (1997) and the range 197.9-459.5 mg/100g reported by Steve et al. (2009) for banana-groundnut flour blends. Similarly, Rehman et al. (2012) found lowest Ca values (101.02-102.59 mg/100g) for apricot-date bars. Al-Hooti et al. (1997) and Rehman et al. (2012) obtained 4.30 and 4.85-5.05 mg/100g Fe contents respectively which are lower than the iron content of banana flour-sesame paste blends of this work. The Zn contents (mg/100g) of banana flour-sesame paste (2.27-2.83) were similar with the range 2.68-2.75 for apricot-date bars reported by Rehman et al. (2012) but lower than 2.97 reported for date bars by Al-Hooti et al. (1997). The result showed that there were a significant improvements in Ca, Zn and Fe contents in the banana flour-sesame paste blends as compared to the control due to high mineral composition of banana flour than in the control which was processed from sugar syrups. Hardisson et al. (2001), Leterme et al. (2006) and Wall (2006) reported that ripe banana is notably enriched with minerals.

Anti-nutritional and antioxidants contents of banana flour-sesame paste blends

The anti-nutritional and antioxidants of banana-sesame paste blends are shown in Table 3. Phytic acid content had varied significantly ($p<0.05$) among the blends. The highest phytic acid content (208.01 mg/100g) was recorded in B_fBR_3 while lowest (144.41 mg/100g) was in B_fBR_1. Steve et al. (2009) reported the lowest phytic acid content (7-27.5 mg/100g) for banana-groundnut flours at different blends than the contents found in banana-sesame paste blends of this work. The concentration of phytic acid in the blended products have increased as the % of sesame increased in the paste because sesame seeds bears anti-nutritional factors such as phytic acid, trypsin inhibitors, alpha -amylase inhibitors, lectins and tannins (Leiner, 1994; Adegunwa et al. 2012).

The blended product B_fBR_3 contained the highest amount of total phenolic content (16.19 mg GAE/g) and antioxidant power value (21.88 μmol/g) while B_fBR_1 contained the lowest total phenolic content (11.99 mg GAE/g) and antioxidant power value (16.22 μmol/g). The total phenolic contents were higher than the range 25.32-32.24 mg GAE/g by Yildiz (2013) for traditional Turkish mulberry products. Rehman et al. (2012) reported a significantly higher total phenolic contents ranging from 22.52 to 26.38 mg/g as compared to the contents found in banana-sesame paste blends of this work. The antioxidant power of banana-sesame paste blends was higher than the range 8.12-9.23 μmol/g found by Yildiz (2013) for traditional Turkish mulberry products. The total phenolic content and the antioxidant power value of banana-sesame paste blends were significantly increased as compared to the control sample. Kanazawa and Sakakibara (2000); Wall (2006) and Lim et al. (2007) reported that fruits contain various antioxidants, such as vitamin C, phenolics, vitamin E, and β-carotene and some of these are contributor to the total phenolic contents. The antioxidant capacity of the bananas may be attributed to the gallocatechin content and should be considered to be a good source of natural antioxidants for foods (Someya et al. 2002).

Sensory acceptability taste of banana flour-sesame paste blends

Table 4. shows the sensory acceptability taste result of banana flour-sesame paste blends. Color acceptance score of B_fBR_2 (4.21) showed no significant ($p>0.05$) difference as compared to the control (4.22). However it was significantly higher than the other formulated samples. All the scores, being between 3.76 and 4.22 in a scale of 5, and the products are moderately accepted by panelists. The flavor acceptance value had a significant ($p<0.05$) effect in flavor of banana-sesame paste. The highest value of paste flavor (4.37) was recorded in B_fBR_2 (like very much) and lowest (3.90) was recorded in the control. In general all banana-sesame pastes had obtained higher flavor scores than the control showing acceptable levels of close to and above "like moderately". Bates et al. (2001) reported that banana has been recognized for its desirable flavor. In the texture evaluation, the control did obtain significantly ($p<0.05$) higher score (4.33) than the two banana flour-sesame paste blends with no significant ($p>0.05$) differences with the product B_fBR_2 (4.29). The texture evaluation scores of all products were above 4 on the 5 point scale showing the acceptability of the products.

The overall acceptability score of the control (4.25) score was significantly ($p<0.05$) higher than banana flour-sesame paste blends. The next significantly ($p<0.05$) high overall acceptability was obtained in B_fBR_2 (4.11). Results show that all the scores obtained in the overall acceptability scores were varied from 3.92 to 4.25. This indicates that all the products, despite their differences in the values, are in the range of "like moderately" and "like extremely", thus shows the positive contribution of ripe banana flour subtle weak points to the products.

Sensory descriptive taste of banana flour-sesame paste blends

Sensory descriptive taste of banana flour-sesame paste blends are shown in Table 5. The blended products had light yellow and light brown colors. Blended product B_fBR_3 had 96% light brown and 4% light yellow color where as B_fBR_1 have light yellow color (98%) due to the domination of light yellow color of ripe banana flour at increased proportions. Control had 100% light brown color. The blended product B_fBR_3 had 60% roasted flavor and 40% nutty flavor while B_fBR_2 had 62% roasted flavor and 38% nutty flavor. Control had roasted (54%), nutty (40) and caramel (6%) flavors. All the banana flour-sesame paste blends have sweet taste (100%) similar to the control sweetness.

IV. CONCLUSIONS

Banana flour-sesame paste blends had significantly improved the nutrient density, antioxidants and sensory acceptability (flavor) as compared to the control which is processed from sesame and sugar syrup only. Generally the present result suggested B_fBR_2 (45% banana flour + 55% sesame paste proportions) showed quite good physico-chemical and sensory properties as compared to the other blends. Storage conditions on sensory quality and microbial activity of banana flour-sesame paste product need to be studied.

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Table 1. Proximate composition of banana-sesame paste blends

Nutrients (%)	B_f	RS	B_fBR_1	B_fBR_2	B_fBR_3	C
Moisture	9.18±0.11	3.96±0.15	6.42±0.10^a	6.00±0.09^b	5.24±0.13^c	3.33±0.14^d
Crude fiber	1.32±0.02	6.09±0.08	3.71±0.07^c	4.08±0.04^b	4.73±0.13^a	3.12±0.05^d
Total ash	4.22±0.09	6.19±0.07	4.94±0.05^c	4.98±0.04^b	5.12±0.13^a	3.28±0.12^d
Crude fat	0.74±0.12	51.18±0.22	23.42±0.75^c	28.30±0.30^b	33.56±0.24^a	23.27±0.17^c
Crude protein	3.95±0.10	24.27±0.38	11.96±0.08^c	13.78±0.14^b	15.89±0.15^a	11.76±0.19^c
Carbohydrate	80.15±0.15	8.31±0.25	49.05±0.41^b	42.22±0.51^c	34.07±0.08^d	50.44±0.53^a

All values are mean ± standard deviation of triplicate analyses (db) except moisture (wb). Values in a row with the same letter are not significantly different ($p<0.05$). B_f= Banana flour; RS=Raw sesame; B_fBR_1 =Banana flour +sesame paste (55:45); B_fBR_2 = Banana flour +sesame paste (45:55); B_fBR_3 = Banana flour +sesame paste (35:65) and Control(C) = Sugar syrup + sesame paste

Table 2. Mineral composition of banana flour-sesame paste blends

Minerals (mg/100g)	B_f	RS	B_fBR_1	B_fBR_2	B_fBR_3	C
Ca	18.38±0.42	1225.71±7.76	531.75±1.36^c	647.17±0.66^b	767.98±1.04^a	522.94±1.01^d
Zn	0.62±0.03	4.45±0.01	2.27±0.05^c	2.46±0.05^b	2.83±0.06^a	2.09±0.04^d
Fe	0.62±0.03	10.75±0.06	5.37±0.05^c	6.35±0.05^b	7.30±0.08^a	5.17±0.05^d

All values are mean ± standard deviation of triplicate analyses (db). Values in a raw with the same letter are not significantly different ($p<0.05$). B_f= Banana flour; RS=Raw sesame; B_fBR_1 =Banana flour +sesame paste (55:45); B_fBR_2 = Banana flour +sesame paste (45:55); B_fBR_3 = Banana flour +sesame paste (35:65) and Control(C) = Sugar syrup + sesame paste

Table 3. Anti-nutritional and antioxidants of banana flour-sesame paste blends

Components	B_f	RS	B_fBR_1	B_fBR_2	B_fBR_3	C
Phytic acid (mg/100g)	ND	324.91±1.73	144.41±1.80^d	176.79±1.78^b	208.01±2.14^a	164.96±1.78^c
TPC (mg GAE/g)	3.63±0.11	25.69±0.85	11.99±0.43^c	13.72±0.40^b	16.19±0.44^a	11.16±0.53^d
FRP (μmol/g)	3.53±0.10	34.53±0.32	16.22±0.02^c	19.74±0.03^b	21.88±0.04^a	15.68±0.15^d

All values are mean ± standard deviation of triplicate analyses (db). Values in a row with the same letter are not significantly different ($p<0.05$). Note: ND=not determined; TPC=total phenolic content; FRP=ferric ion reducing power; B_f= Banana flour, RS=Raw sesame; B_fBR_1 =Banana flour +sesame paste (55:45); B_fBR_2 = Banana flour +sesame paste (45:55); B_fBR_3 = Banana flour +sesame paste (35:65) and Control(C) = Sugar syrup + sesame paste

Table 4. Sensory acceptability taste of banana flour-sesame paste blends

Products	Color	Flavor	Texture	Overall acceptability
B_fBR_1	3.92±1.12^c	3.99±0.98^b	4.15±1.27^b	3.99±0.93^c
B_fBR_2	4.21±0.98^b	4.37±1.10^a	4.29±1.11^a	4.11±1.08^b
B_fBR_3	3.76±1.04^d	3.94±1.04^c	4.03±0.81^c	3.92±1.06^d
C	4.22±1.07^a	3.90±1.02^c	4.33±1.04^a	4.25±1.17^a

Values in a column with the same letter are not significantly different ($p<0.05$). B_fBR_1 =Banana flour +sesame paste (55:45); B_fBR_2 = Banana flour +sesame paste (45:55); B_fBR_3 = Banana flour +sesame paste (35:65) and Control(C) = Sugar syrup + sesame paste

Table 5. Sensory descriptive taste of banana flour-sesame paste blends

	Color				Flavor					Taste				
Products	Gray white	Creamy	Light yellow	Light brown	Roasted	Floury	Nutty	Caramel	Burnt	Sweet	Salty	Sour	Bitter	Other
B_fBR_1	_		98%	2%	64%	_	36%	_	_	100%	_	_	_	_
B_fBR_2	_	_	25%	75%	62%	_	38%	_	_	100%	_	_	_	_
B_fBR_3	_	_	4%	96%	60%	_	40%	_	_	100%	_	_	_	_
C	_	_	_	100%	54%	_	40%	6%	_	100%	_	_	_	_

B_fBR_1 =Banana flour +sesame paste (55:45); B_fBR_2 = Banana flour +sesame paste (45:55); B_fBR_3 = Banana flour +sesame paste (35:65) and Control(C) = Sugar syrup + sesame paste