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(RESEARCH ARTICLE)

Chick'n fiber: Development of breading mix using banana (*Musa sapientum* var. *lacatan*) peel as a good source of dietary fiber

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Abstract

Banana is one of the fruit crops that is mainly consumed and produced in the Philippines. As a result, banana peels (BPs) are neglected as waste. Furthermore, numerous studies have investigated and stated that BPs are a good source of dietary fiber (DF). The aim of the study was to develop a breading mix (BM), determine the most acceptable formulation of BM with BPs, and evaluate its nutrient and microbiological content. One (1) control commercial BM and three (3) BMs with different formulations, including the substitution of all-purpose flour (APF) with partially fine-dried banana peel (PFDBP) for 25%, 30%, and 35% in the production of the BM formulation, were tested in terms of nutrient and microbiological content. For sensory evaluation, Quantitative Descriptive Analysis was conducted by eleven (11) trained panelists and the Consumer Acceptability Test was facilitated by fifty (50) untrained panelists using the 9-point hedonic scale, utilizing chicken breast fillet as a carrier. The statistical treatments used were weighted mean and one-factor repeated measures analysis of variance. The BM formulations produced were all found to be high in total dietary fiber (TDF), except for the control. Hence, it was proven that BPs are a suitable dietary source for BM formulations. Furthermore, the BM with DF had a lower fat content than the control due to its low oil-holding capacity, which is beneficial with fried foods. Apart from color, all the BM samples tested on pan-fried chicken breast fillets were comparable to the control's sensory characteristics. Therefore, the most favorable sample was BM A, which contains a 25% substitution of APF with PFDBP, as it has shown an impressive result regarding TDF, fat and microbiological analysis, and evaluation in terms of its sensory attributes.

Keywords: Dietary fiber; Breading mix; Banana peel; Sensory evaluation; Dehydration; Product development

1. Introduction

The Philippines is one of the leading producers of bananas globally and there is high consumption of bananas among all the regions in the country as reported by the Philippine Statistics Authority [1]. However, BPs are thrown away and neglected as waste. According to Ali et al. [2], for every ten tons of bananas, approximately one ton of waste is produced. Today, one-third of all the food produced in the world ends up as waste before it even reaches the table and there are environmental consequences after disposal [3].

In a study by Angeles-Agdeppa & Custodio [4], it was found that the fiber intake of Filipino working adults was only 7.97 grams (g) which is contrasting with the recommended nutrient intake (RNI) of 20 to 25g per day. Furthermore, there is a rise in fast-food consumption problems among adults. As evidenced by a study conducted by researchers from the University of the Philippines, young Filipino adults have an increased prevalence of developing non-communicable diseases as a result of fast food consumption. In addition to this, a lower intake of fiber from fast-food consumption was

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proven by the Department of Science and Technology-Food and Nutrition Research Institute (DOST-FNRI) among young adults who have an excessive intake of energy-dense foods [5].

The edibility of BP and its nutritive benefits have been investigated by numerous studies in the past. However, there is insufficient study regarding the topic revolving around its potential use in the food industry, specifically in BM. Therefore, the researchers have been able to gather sufficient information in making food technological advancements concerning the potentiality of utilizing BP as a fiber ingredient source for BM.

The research aimed to develop an acceptable BM containing sources of DF for adults. The study also highlighted the following specific objectives: (1) to develop a BM containing a good source of DF; (2) to determine the most acceptable formulation of BM with BP in terms of the hedonic test; and (3) to evaluate the developed BM using chemical (i.e., TDF and FA), and microbiological analysis (i.e., SPC and YMC). According to the PPAN Research Agenda, one of the included priorities for 2019 to 2022 nutrition research is food product and technology development. The researchers wanted to develop solution/s to existing and constantly evolving nutrition problems, especially on the health of adults aged 19 to 59 years old, and other concerns through innovative strategies.

2. Material and methods

2.1. Study Design

The study utilized a quantitative approach that included the process of collecting, analyzing, and interpreting data. The researchers collected the quantitative data from the numerical equivalent of the attributes of the QDA of the utilized BM by the trained food panelists. Simultaneously, the sensory evaluation was conducted with untrained food panelists aged 21-59 years old, and a 9-point hedonic test was used to determine the degree of acceptability of the developed product. Moreover, the results from the differences in the formulations' microbiological and nutrient tests were analyzed quantitatively.

2.2. Study Setting and Population

The preparation and production of the BM were carried out in a residential area in Paco, Manila City. The sensory evaluation was conducted at DOST-FNRI-Sensory Evaluation Laboratory (DOST-FNRI-SEL), whereas the chemical and microbiological analyses were completed at Intertek Testing Services Philippines, Inc.

The study population for QDA testing consisted of 11 trained panelists. The selected panelists included four (4) nutritionist-dietitians, two (2) licensed chemists, two (2) food technologists, one (1) science aide, one (1) clerk, and one (1) statistician. Regarding hedonic testing, 50 consumers who were adults aged 21-59 years old participated in the study.

2.3. Inclusion and Exclusion Criteria

The DOST-FNRI has taken charge of the laboratory activities including the selection process and orientation of sensory panelists; and the actual conduct of sensory evaluation tests for the product samples. The duration of the pre-testing was ten (10) days, which included 11 trained panelists, while the final testing consisted of 50 consumer participants. The following criteria were established for the participants to be part of the study: a.) aged 19 to 59 years old; b.) female and/or male; c.) consumer of BM and other breading products; d.) consumer of breaded fried foods; e.) with no allergies to gluten, egg, and chicken; f.) not lactating or pregnant; and g.) healthy individuals.

On the other hand, the exclusion criteria were as follows: a.) aged 18 years old and below and aged 60 years old and above; b.) not a consumer of BM and other breading products; c.) not a consumer of fried foods that are breaded; d.) with allergies specifically to gluten, egg, or chicken; e.) lactating or pregnant; and f.) with health concerns (i.e., hypertension, diabetes, cardiovascular disease).

2.4. Materials

A cluster of banana lacatan was procured from a local dry market. Other dry ingredients for the BM base such as APF, salt, black pepper, cornstarch, garlic, and onion powder were purchased from a local supermarket. Additionally, ingredients used for cooking the applied BM formulations such as chicken breast, egg, and cooking oil were also procured from a local supermarket. Moreover, aluminum non-stick pans were used as a medium to pan-fry the chicken breast.

The equipment utilized in the production of the developed BM were: (1) a knife for cutting the BPs into uniform sizes; (2) a food dehydrator and electric grinder for making the partially fine-dried BPs; (3) calibrated digital weighing scale used in weighing the ingredients; (4) flour sifter, measuring cups and spoons used in measuring the dry ingredients; and (5) food grade containers were used for the storage of the developed BM.

2.4.1. Partially Fine Dried Banana Peel

The bananas were separated into peels and pulp. RBPs were cut into smaller pieces with uniform sizes. Afterward, the peels were washed with running water. The BPs were soaked with diluted citric acid powder (6 teaspoons citric acid powder: 1 quart water) for ten (10) minutes in cold water to prevent enzymatic browning by lowering the pH value [6] and due to the reason that this was known to be an effective treatment for removing pesticide residue [7]. Next, the peels were drained. Then, the peels were subjected to Severin 4-layer food dehydrator at 70°C for five (5) to nine (9) hours until no more sap can be seen when tearing the sample apart. Lastly, the peels were blended using a grinder and were flour sifted with a sieve or mesh size of 0.25 mm or 60 mesh [8].

2.4.2. Formulation of Breading Mix (BM)

Four (4) samples of the breading mix were produced: BM Control or Brand C, was used as the control, with no added PFDBP to the BM formulation (0%), while BM A, BM B, and BM C substituted APF with 25%, 30%, and 35% PFDBP in the breading mix formulation, respectively. On the other hand, the three (3) samples were prepared by following a standardized recipe of the BM while utilizing the other ingredients such as salt, ground black pepper, garlic powder, onion powder, and cornstarch.

2.5. Data Collection

TDF content was determined using the enzymatic, gravimetric method and Association of Official Analytical Chemists (AOAC), Official Methods of Analysis, 20th Ed., 2016, in-house procedure. Meanwhile, total fat content was determined using the acid hydrolysis method, AOAC 920.85, 20th edition, 2016; and procedure SPC and YMC were determined using the AOAC, Official Methods of Analysis, 20th Ed., 2016 by petrifilm.

2.5.1. Data Analysis

The data from Microsoft Excel were imported and analyzed using Stata MP 14. The following statistical tools used were weighted mean, One-Factor Repeated Measures ANOVA, and Bonferroni Test.

2.6. Ethical Consideration

The study protocol entitled, Chick'n Fiber: Development of Breading Mix Using Banana (*Musa sapientum* var. *lacatan*) Peel As A Good Source of Dietary Fiber; with a protocol code of USTCON-2022-OR19, has been reviewed by the University of Santo Tomas College of Nursing Ethics Review Board and has been approved for implementation. Necessary study-related documents were also obtained, reviewed, and approved for use in the study such as study protocol, ethical considerations, data collection forms, curriculum vitae of investigators, informed consent form, and certificate of completion of good clinical practice.

3. Results

Table 1 Total Dietary Fiber of Four Breading Mix Formulations per 100 g sample

Food Composition	Control	BM A	BM B	BM C
TDF (g/per 100g sample)	0	9.44	11.02	12.82

Table 2 Total Fat Percentage of Three Breading Mix Formulations as Applied on Pan-fried Chicken Breast Fillet

Food Composition	Control	BM A	BM C
Total Fat Percentage (%) (per 100g sample)	11.35	6.06	10.1

Table 1 shows the TDF of four BM formulations per 100g sample. BM control had no DF content, while the remaining BM formulations had increasing amounts of DF. As seen in the table, BM C had the highest amount of TDF (12.82g/100g BM), followed by BM B with 11.02g/100g BM, and BM A with 9.44g/100g BM.

Table 2 shows the percentage of total fat per 100g of pan-fried chicken breast fillet coated with BM formulations (BM A, BM B, and BM C). Among the three BM formulations, BM A had the lowest percentage of total fat, while BM Control had the highest.

Table 3 Microbiological Characteristics of Three Breading Mix Formulations

Microbiological Test	**Maximum acceptable level of organisms***	**BM A**	**BM B**	**BM C**
Yeasts and Molds Count (CFU/g)	100	<10	<10	<10
Standard Plate Count (CFU/g)	1×10^4	4.3×10^3	1.2×10^4	1.1×10^3

*For one sample tested

Table 3 presents the microbiological characteristics of each BM formulation through the YMC and SPC tests. For the YMC test, all the BMs had less than 10 CFU/g, which shows that BM A, BM B, and BM C had acceptable levels of microorganisms. However, for the SPC test, only BM A and BM C had acceptable levels of microorganisms (less than 10,000 CFU/g). The second BM formula, BM B, had a higher number of microorganisms (12,000 CFU/g) than the acceptable level. Therefore, only BM A and BM C were used for the sensory evaluation.

Table 4 Total Dietary Fiber and Percent Recommended Intake of Four Breading Mix Formulations per 25g serving size

	Control	**BM A**	**BM B**	**BM C**
Actual TDF (per 25g serving)	0	2.36	2.76	3.21
%RNI (%)*	0	9.4-11.8	11.0-13.8	12.8-16.1

*Percent RNIs are based on the FNRI reference of the RNI for adults (19 to 59 years old).

Table 4 shows the amount of TDF for a serving of 25g of each BM formulation. Among the four BM formulations, only BM Control had no TDF content. On the other hand, there was an increasing amount of TDF among BM A (2.36g), BM B (2.76g), and BM C (3.21g). This shows the percentage of TDF for a serving of 25g of each BM formulation. Among the four BM formulations, BM control had no %RNI, whereas the other three BM formulations were considered good sources of DF.

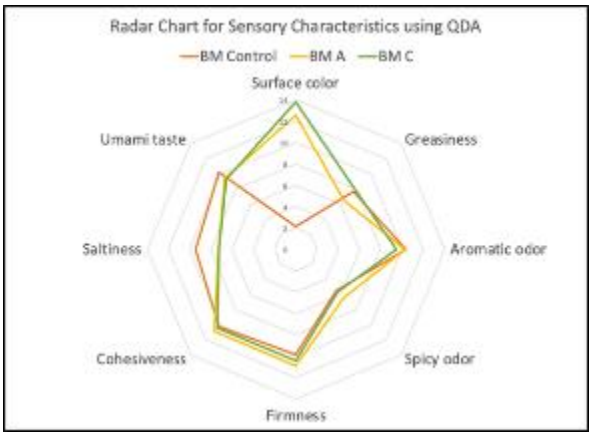

Figure 1 Chart for Sensory Characteristics from QDA

Figure 1 presents the sensory characteristics of each BM formulation through a radar chart. Among the three BM formulations, most of the sensory characteristics scores were close to each other, except for the surface color, where BM Control significantly had the lowest score. On the other hand, BM Control had the highest score for aromatic odor,

saltiness, and umami taste. BM A had the highest score for spicy odor (smell of spices), firmness, and cohesiveness. Lastly, BM C had the highest score for surface color and greasiness.

Table 5 Mean Scores for Consumer's Sensory Evaluation of Breading Mix Formulations as Applied on Pan-Fried Chicken Breast Fillet

	Mean Scores		
Sensory Characteristics	**BM Control**	**BM A**	**BM C**
Aroma 1,2,3	7.84	7.24	6.7
Flavor 1,2	7.56	6.92	6.76
Texture 1	7.66	6.94	7.30
Color 1,2	7.70	5.40	5.34
Appearance 1,2	7.88	5.72	5.64
Overall acceptability 1,2,3	7.74	6.48	6.10
Interpretation	Like very much	Like slightly	Like slightly

Note: Significant at α=0.05 for the pairwise comparison: 1-BM Control vs. BM A; 2-BM Control vs. BM C; 3- BM A vs. BM C

(A) (B) (C)

Figure 4 Breading Mix Formulations: (A) Breading Mix A consisted of 25% substitution of AFP with PFDBP; (B) Breading Mix B consisted of 30% substitution of AFP with PFDBP; (C) Breading Mix C consisted of 35% substitution of AFP with PFDBP

(A) (B) (C)

Figure 5 Breading Mix as Applied on Pan-fried Chicken Breast: (A) Applied Breading Mix A consisted of 25% substitution of AFP with PFDBP; (B) Applied Breading Mix B consisted of 30% substitution of AFP with PFDBP; (C) Applied Breading Mix C consisted of 35% substitution of AFP with PFDBP

Table 5 presents the mean scores of BM Control, BM A, and BM C from the sensory evaluation among 50 untrained food panelists or consumers. All the sensory characteristics showed significant p-values (less than 0.05) using one-factor repeated measures ANOVA. Therefore, at least one breading mix formulation was different in aroma (p-value=0.0001), flavor (0.0003), texture (0.0012), color (0.0001), appearance (0.0001), and overall acceptability (p-value=0.0001). In terms of the **aroma**, BM Control had a significantly higher mean score compared to BM A (p-value=0.005) and BM C (p-value=0.001). On the other hand, BM A had a significantly higher mean score compared to BM C (p-value=0.011). For the **flavor**, BM Control had a significantly higher mean score compared to BM A (p-value=0.002) and BM C (p-value=0.001). For the **texture**, BM Control had a significantly higher mean score compared to BM A (p-value=0.001). Lastly, for the **color**, BM Control had a significantly higher mean score compared to BM A (p-value=0.001) and BM C (p-value=0.001).

4. Discussion

4.1. Microbiological Analysis

BM A, BM B, and BM C were within the acceptable level for YMC (100 CFU/g) for dry mixes for soup and sauces [9]. This denotes that the three BM formulations were safe for human consumption. For SPC, only BM A and BM C were within the acceptable level of microorganisms. Microorganisms need water in an available form to grow in food products [10]. One possibility that might affect the growth of microorganisms in BPs is the retained moisture content and there is a possibility that the microorganism grows even if the BPs were dehydrated.

4.2. Nutrient Analysis

There is an increasing amount of TDF per 25g of BM A, BM B, and BM C, and this is mainly due to the inclusion of 25%, 30%, and 35% PFDBP, respectively. Hence, the addition of banana peel powder (BPP) enhances the nutritive value of the BM, particularly the DF content [11]. As cited by Jambhale and Gohatre [8] and Hashem Gouda [12], BP is a good source of DF. Thus, based on the Philippine Dietary Reference Intakes (PDRI) recommendation of 20 to 25g of DF per day, all BM formulations were considered good sources, wherein the %RNI of BM A, BM B, and BM C were respectively 9.4 to 11.8%, 11.0 to 13.8%, and 12.8 to 16.1%. Therefore, as there is an increasing amount of BPP present in foods, so does the DF content [11].

On the other hand, BM Control had the highest percentage of total fat per 100g. In line with a study by Wachirasiri et al. [13], one of the characteristics of BP is the low oil binding capacity. Additionally, others have shown that this characteristic of BPP is essential in the reduction of oil absorption during frying [14]. With this, the results have demonstrated that pan-fried chicken breast coated with BM A and BM C had a lower fat content as compared to BM Control. This is an essential finding in the understanding of the potential of the BM with DF when applied to chicken breast fillet in lowering oil absorption during frying, thus resulting in a product with low-fat content.

4.3. Sensory Evaluation

4.3.1. QDA

QDA is an objective method of sensory evaluation, it examines and measures the intensity of sensory properties (i.e., texture, taste, appearance) using unstructured line scales [15]. This was used in the study to obtain information about the differences in the target qualities or attributes of food products that were being developed, which is known to be beneficial in modifying, changing, or reformulating a product recipe. The BM formula was analyzed by trained panelists with the following attributes: a.) surface color; b.) greasiness; c.) aromatic odor; d.) spicy odor; e.) firmness; f.) cohesiveness; g.) saltiness; and h.) umami taste.

Surface color is described as the increasing intensity of orange to dark brown. In terms of this attribute, BM control had a significant difference compared to BM A and BM C. As the percentage of the PFDBP increases in the formulation of BM A and BM C, the brown color of the BM in the pan-fried chicken breast becomes more prominent. This shows an increasing trend between the color and BM samples. The difference in color between BM A and BM C may be due to an enzymatic browning reaction between the presence of oxygen, polyphenols, and a phenolic compound, affecting a variety of foods like fruits and vegetables [16]. However, since BM control does not contain PFDBP, the color was not affected.

Additionally, cooking, specifically frying, enables the Maillard reaction between sugar and protein that results in caramelization or the development of golden to brown hues on the food item [16,17]. On the other hand, the granulation

of breading affects the surface color of the BM samples, a fine breading formulation absorbs oil and moisture quickly, which results in the darkening of the surface during the frying process [18].

The appearance was evaluated through greasiness, which is defined as the oily appearance on the surface of the food item. BM A scored lower and had a significant difference compared to BM control and BM C. This elucidates the low oil-holding capacity of the PFDBP, resulting in a less greasy appearance.

Regarding the taste, specific parameters such as umami taste and saltiness were evaluated. Umami taste is stated as the intensity of the savory taste of spices and meat. There were no significant differences among the BM A and BM C samples compared to BM Control regarding the umami taste. In line with this, both BM A and BM C samples had varying formulations, particularly among the RBP and APF. As compared to BM C, BM A had a lower amount of RBP and a higher amount of APF, thus it obtained a higher rating for the umami taste. From this result, as the RBP content of the BM increases, the umami taste of the BM may diminish. Moreover, the inclusion of spices facilitated the visual perception of the consumers, it is proven to make foods more palatable and attractive, therefore spices were added to the formula [19].

Additionally, in terms of saltiness, BM control had a significant difference compared to BM A and BM C. BM control obtained the highest rating of being salty or strongly salty. Salty taste is a key component in consumer acceptance of foods [20], but excessive saltiness is deemed unfavorable. With this, BM A and BM C had an adequate amount of salt in their ingredient list, resulting in a moderate score for saltiness.

Moreover, the odor was evaluated with parameters such as aromatic and spicy. Aromatic odor is described as the intensity of the savory smell of onion and garlic [21], while the spicy odor is the characteristic smell of spices, specifically black pepper [22]. There were no significant differences among the BM A and BM C samples compared to BM Control, but BM A had the highest intensity rating for spicy odor and aromatic odor compared to BM C. Furthermore, BM C had a higher intensity rating for spicy odor compared to BM Control, which may be due to the inclusion of spices in the BM formulations.

The texture was evaluated through firmness and cohesiveness. Firmness is defined as the force to cut the sample between teeth during the first bite, while cohesiveness is described as the coating that sticks firmly and does not break, crack, or crumble during the first bite. There were no significant differences among the BM A and BM C samples compared to BM Control, but BM A had the highest intensity rating for firmness and cohesiveness compared to BM C and BM Control. This may be due to the granulation of the BM samples, as this determines their texture. Finer particles can pack closely on the surface of the coating which results in great pick-up and coverage; thus, it creates a more firm and cohesive breading compared to coarser formulations [23].

4.3.2. Hedonic

The 9-point hedonic scale is the most commonly used scale for measuring food acceptability. The scale's verbal anchors were chosen so that the psychological distance between successive scale points is approximately equal. This equal-interval property contributes to the practice of analyzing responses by assigning successive integer values (1, 2, 3,... up to 9) to scale points and testing differences in average acceptability using parametric statistics [24]. Each integer has its corresponding range from 1 to 9 consecutively; dislike extremely, dislike very much, dislike moderately, dislike slightly, neither, like slightly, like moderately, live very much, and like extremely. The scale's reliability, validity, and discriminative ability were demonstrated in field and laboratory food acceptance tests with soldiers, as well as large-scale food preference surveys. The BM formula was analyzed by consumers with the following attributes: a.) aroma; b.) flavor; c.) texture; d.) color; e.) appearance; and f.) overall acceptability.

Aroma is one of the chemical senses stimulated by the chemical properties of odor molecules which makes smells detected by breathing air that carries odor molecules. The results for aroma showed that BM Control is preferred over BM A and BM C, but all samples were considered acceptable based on the 9-point hedonic rating. BM control has more aroma since it is commercialized. Commercialized food products, especially in powder form, undergo encapsulation. In the food industry, encapsulation is done to protect sensitive food components and prevent degradation during storage. Food aroma is very sensitive to processing and storage conditions [25]. From the 9-point scale, the control had a score of 8 (like very much) while BM A and BM C had a score of 7 (like moderately). Between the two, BM A had a significantly higher mean score than BM C.

Flavor is defined as the combination of taste, odor, and mouthfeel [16]. Using multiple comparisons test, the result shows that BM Control is preferred in flavor compared to BM A and BM C, but all samples were considered acceptable

based on the 9-point hedonic rating. The BM Control scored 8 (like very much) and this may be due to the formulation of BM Control as it contains spices and taste sectors which are referred to as edible chemicals and extracts that affect the flavor of this food product. Additionally, BM Control contains maltodextrin, which is a food additive applied in various food items to enhance their flavor, texture, and stability [26, 27]. Moreover, BM A and BM C also contain spices, specifically black pepper, garlic powder, and onion powder, but lack maltodextrin. Although the product lacks maltodextrin, BM A and BM C gained a score of 7 (like moderately) which is found to be acceptable in terms of flavor, by the consumers.

In terms of palatability, savory foods enriched in umami are associated with increased consumer acceptance, considering the function of umami in product development, as well as how it could eliminate added salt and enhance flavor in foods [28]. Moreover, consumer preferences are also defense mechanisms as they use flavor to determine whether something is acceptable.

In terms of texture, BM control had a significant difference compared to BM A, and it gained the highest mean acceptability rating compared to BM A and BM C. This is with the inclusion of maltodextrin in the product formula of BM Control, it is used as a food additive applied in various food items to make improvements in the product's texture, thus resulting in a crispier product [26, 27]. Moreover, starch is the first in the ingredients list of BM Control. When compared to amylopectin, high amylose-containing starch species provide more brittle and crisp coatings to fried products due to their linear molecular structure. The swelling of starch granules during the frying process releases the amylose fraction and creates a film barrier that prevents oil penetration into and moisture loss from the food material. Gelatinization and film formation are crucial in providing crispness and texture to the finished fried product. Previously, amylose content was found to be positively correlated with crispness [29].

In terms of color, BM control is preferred over BM A and BM C. The BM Control scored 8 (like very much), BM A and BM C gained a score of 5 (neither like nor dislike). For fried foods, golden brown has always been the most popular color. A trend in the coating industry is to blend colored particulates with breadings for visual attraction. The colored bits are usually made from specially stabilized spices or starch-based blends that do not blacken or brown at frying temperatures. Rapid color development can be achieved by appropriate levels of reducing sugars, as well as agents like paprika. Higher levels of reducing sugars such as lactose and dextrose add brown notes through increased Maillard reaction [19]. Moreover, there is an increasing trend between the color and BM samples, as the percentage of PFDBP increases in the formulation of BM A and BM C, the brown color of the BM in the pan-fried chicken breast becomes more distinct, thus affecting the color and appearance, whereas BM control did not contain PFDBP, as a result, the color and appearance were unaffected.

Furthermore, color is the most significant aspect of any food's appearance, especially when it is linked to other food-quality characteristics. BM control is preferred compared to BM A and BM C in terms of appearance. From the 9-point scale, BM control scored 8 (like very much), while BM A and BM C gained a rating of 6 (like slightly). Despite the variation in appearance, all the samples were deemed acceptable to the consumer's liking.

In the BM samples, the appearance may be influenced by the following factors: PFDBP content, for the reason that the banana peel is naturally brown when dehydrated and BM A and BM C samples had increasing amounts of PFDBP in their ingredients list. The difference between the BM control to the BM A and BM C in terms of appearance may be due to the enzymatic browning. It was stated that polyphenol oxidases contributed to the gradual change of color quality of fruit products from brown to dark brown (Moon et al., 2020), thus influencing the sensory quality. Hence, since BM control had no PDFBP content, the color was not affected. Next, the Maillard reaction contributed to the addition of golden brown notes through the presence of protein, reducing sugars, and heat [16]. Apart from this, the inclusion of spices may also facilitate the development of tones and hues on the breaded food item [19]. Lastly, granulation of breading, fine-textured breading, quickly absorbs oil and moisture compared to the coarser formulations, therefore producing a browning or darkening effect during the cooking process [18].

Moreover, the appearance can also be influenced by the color quality of the illumination in terms of intensity, color temperature, and fidelity, as well as the characteristics of the product's structure [30]. The prominence of the color affects the impression of the product. Expectations are driven by appearance properties, which control responses throughout the evaluation of food products. The color and appearance of food as well as that of the food environment both drive and are intimately linked through the information transfer process with expectations [31].

Lastly, for the overall sensory evaluation, BM Control was the most preferred formulation in terms of sensory qualities. On the other hand, according to consumers' ratings, BM A and BM C were still found to be acceptable and appetizing.

Abbreviations

- %RNI - Percent Recommended Nutrient Intake
- ANOVA - Analysis of Variance
- AOAC - Association of Official Analytical Chemists
- APF - All-Purpose Flour
- BM/s - Breading Mix/es
- BP/s - Banana peel/s
- BPP - Banana peel powder
- DF- Dietary Fiber
- DOST - Department of Science and Technology
- FDA - Food and Drug Administration
- FNRI - Food and Nutrition Research Institute
- g – Grams
- PDRI - Philippine Dietary Reference Intakes
- PFDBP- Partially Fine Dried Banana Peel
- PPAN - Philippine Plan of Action for Nutrition
- PSA - Philippine Statistics Authority
- QDA - Qualitative Data Analysis
- RBP - Ripe Banana Peel
- RNI - Recommended Nutrient Intake

5. Conclusion

In summary, the substituted APF with PFDBP among BM A, BM B, and BM C yielded a significant amount of dietary fiber, with 9.4-11.8%, 11.0-13.8%, and 12.8-16.1% respectively, thus resulting in a BM that is a good source of the mentioned nutrient. These findings are consistent with previous research showing that BP contributes to the improvement of nutrient content, particularly DF, among various food products. About the fat analysis, the present finding provides further knowledge regarding the oil-holding capacity of the BM. It was found that the coated chicken breast fillet with the BM with DF had a lower fat content as compared to BM Control. This result provides evidence for the ability of the BM to absorb less oil during frying. In terms of microbiological analysis of SPC, only BM B had several microorganisms that are beyond the acceptable level, and this is mainly due to the moisture that is still present in the dehydrated BP. Regarding the sensory evaluation, pretesting of the three BM formulations was done through QDA. Afterward, the results from the hedonic testing revealed that BM A was the most preferred BM formulation as it received the highest score among the following attributes: aroma, flavor, color, appearance, and overall acceptability, compared to BM C. These findings indicate that the most suitable formulation is BM A for adults aged 19 to 59 years old, as it contains a good source of DF and reduces oil absorption during frying. Based on the results, it is suggested to further extend the research on the use of BM with 25% PFDBP substitution to broaden its application as a functional food ingredient, particularly on various dish applications such as applying it on pork, beef, and fish cutlets.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare no conflict of interest.

Statement of ethical approval

The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Ethics Review Committee of University of Santo Tomas (2022-OR19, April 12, 2022).

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