

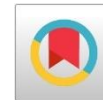


Chemical and Nutritional Evaluation of Banana Peels and Their Potential Use in Improving The Egyptian Balady Bread

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ABSTRACT: Banana (*Musa Sapientum*) is the largest herbaceous plant in the world and is among the ten most important crops. However, A large portion of their production is waste mainly peels, causing environmental pollution. In the present study, 60 kg of bananas grown in Egypt were divided into three maturation stages namely unripe (green), ripe (yellow) and after the ripe stage (AR) were peeled washed, dried and packed in glass containers for further and analysis. Results of the proximate chemical analysis revealed that the unripe stage (green) contained the highest moisture and crude fiber, whereas, the ripe(yellow) stage contained, the highest protein and ash.The AR stage, exhibited the highest significant content of total phenolic and flavonoids of 31.31 mg GAE/g and 25.63 g QE /100g, respectively. Also, the AR stage exhibited the highest antioxidant activity as measured by DPPH inhibition and FRAP (89.60% and 48.15 mg Te/g) as compared to the other stages. Sensory evaluation of Balady bread showed that the 15% substitution by AR stage powder was highly accepted by panelists. The accepted level of bread was further subjected to proximate chemical analysis against control to reveal its effect on the nutritional and health benefits. Results revealed a significant rise in all chemical parameters (protein, ash and fat) except for moisture and carbohydrate, while the total phenolics revealed a higher significant increase value than the control (139. 35mg GAE/100g). This study showed that banana peel incorporated in bread can provide nutritional and health added value product.

Keywords: Banana peels, proximate analysis, Total phenolic and flavonoids, Antioxidant activity, Sensory evaluation.

INTRODUCTION

Food production is increasingly seeking nutritious foods with health benefits (Coltro and Karaski, 2019). Fruit and vegetable peels are the main by-product of processing and are an excellent source of phytochemicals that have many beneficial effects on human health(Lario *et al.*, 2004).

Bananas are the second most produced fruit after citrus, accounting for 16% to 17% of total world production(Alzate *et al.*, 2021). Banana, *Musa* genus, is one of the major fruit crops with high global economic value and ranks fifth in world trade (Wardhan *et al.*, 2022). Bananas are economically rentable, but their consumption generates more than 26 million tons of dry matter residue annually worldwide, mainly due to the disposal of their peels(Ahmad and Danish, 2018; Coltro and Karaski, 2019 and Gomes *et al.*, 2022).

In 1987, efforts were initiated in Egypt to enhance banana production by introducing new banana germplasm varieties, specifically Grand Nain (*Macusa cavendishii*) and Williams hybrid (*Mucosa accuminata*).The results indicated that

both species exhibited high yields and produced good-quality fruit (Abo-EL-Ez, 2017).According to the report by Sabin Nature (2022), banana production in Egypt reached 1.29 million tonnes. This represents a significant increase from 108,000 tonnes in 1972, with an average annual growth rate of 5.49%.

However, one study has shown that the peel contains high levels of polyphenols, carotenoids, and other bioactive components that are beneficial to health(Zhang *et al.*, 2005). However, one study has shown that the peel contains high levels of polyphenols, carotenoids, and other bioactive components that are beneficial to health(Gomes *et al.*, 2022). This may be due to a lack of understanding of the benefits of business use.

In addition to its excellent nutritional value, banana peels have a variety of health benefits, treating enteritis, diarrhea, dysentery, ulcerative colitis, nephritis, gout, heart disease, hypertension, and diabetes. Banana peels are also rich in phenolic compounds,with high antioxidant activity that prevent heart disease and cancer.

Banana peels are rich in fiber, protein, crude fat, lipids, pectin, essential amino acids, polyunsaturated fatty acids, and micronutrients (Oguntoyinbo *et al.*, 2021). Banana peel extracts contain more antioxidants, suggesting intensive peel use in foods and nutraceuticals. However, the chemical composition and physicochemical and functional qualities of banana peels determine their potential use (Zaini *et al.*, 2022).

Banana peel flour, like pulp flour, could be employed in new products with standardized compositions for a variety of industrial and household applications (Chen *et al.*, 2020). Despite being an important source of numerous functionally essential bioactive chemicals, little scientific effort has yet been made to identify their usefulness in terms of food and nutraceutical applications. This biomaterial has the potential to provide novel products with standardized compositions for a variety of industrial and residential applications (Singh *et al.*, 2016). Therefore, new economic strategies to reduce waste and post-harvest losses and increase the added value of this food crop should be evaluated (Petsakos *et al.*, 2019).

Therefore, the objective of this study is to evaluate the chemical and bioactive components of banana peels (*Musa sapientum*) grown in Egypt during three ripening stages and to apply the sensory evaluation of a flat Egyptian bread formulation designed to produce value-added nutritious and functional products and reduce disease risk.

MATERIALS AND METHODS

MATERIALS:

Sixty Kg of Bananas (*Musa sapientum*) were collected from a distribution market in Alexandria-Egypt and were divided into 3 stages of ripening: Unripe (green), ripe (yellow) and after-ripening (AR).

Other ingredients used in the preparation of bread were flour (72% extraction), sugar, and leavening from the local market.

Chemical and reagents:

Chemicals and reagents were obtained from El-Gomhouria company, Alexandria, Egypt and Sigma Aldrich (Steinheim, Germany). All chemicals are analytical grade.

Preparation of banana peel powder:

The samples were thoroughly cleaned and the pulp and peel were separated. Peels were washed with distilled water and dried at 60°C for 48 h. in an air oven. The dry peels were ground to obtain a powder, packed in glass containers and frozen and stored at -18°C until further analysis.

METHODS:

Proximate chemical analysis:

Initial moisture content, cured protein, crude Lipid, ash, and crude fiber were determined in banana peels at different stages of maturity following the methods described in the Association of Official Analytical Chemists (AOAC, 2005). The Nitrogen Free Extract was calculated according to the following formula;

$$\text{NFE}\% = [100 - (\text{CP}\% + \text{CL}\% + \text{CF}\% + \text{ASH}\%)]$$

Where: CP=Crude Protein, CL=Crude Lipid, CF=Crude Fiber.

Determination of total phenolics and flavonoid contents:

The total phenolics content of banana peels was determined using a modified Folin-Ciocalteu colorimetric method described by Sakanaka *et al.* (2005). The total phenolics content of the three stages was expressed as mg gallic acid equivalent per gram from the calibration curve of gallic acid. Total flavonoid content was determined using a modified method by Sakanaka *et al.* (2005). Briefly, the measurement was compared to a preset standard curve of prepared Quercetin standard solution and expressed as mg of Quercetin equivalents per 100 g of flour.

Determination of antioxidant activity:

Scavenging activity of DPPH radical:

The determination of DPPH free radical scavenging activity of peel extract was determined as described by Ahmad, A. *et al.* (2015) based on a reaction with stable 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical dissolved in absolute ethanol. The capacity to scavenge the DPPH radical was calculated using the following equation:

$$\text{DPPH-scavenging effect (Inhibition\%)} = 100 \times \frac{A_{\text{blank}} - A_{\text{sample}}}{A_{\text{blank}}}$$

Where A=Absorption.

Ferric reducing antioxidant power (FRAP) assay:

The reducing power of ethanolic extracts was determined according to the method cited by (Oyaizu, 1986), which involves the presence of antioxidants in extracts to reduce the ferricyanide complex to the ferrous form. Absorbance measurements were taken at 700 nm. Triplicate tubes were prepared for each extract increased absorbance of the reaction mixture indicated increased reducing power.

Determination of total carotenoids:

Total amount of carotenoids determined according to (Rangana, 1979) 15 g of peel powders plus 3g celite 454 (Tedia, Ohio, USA) were weighed. Successive extractions with 25mL

acetone were done to obtain a paste which was transferred into a sintered funnel (5µm) coupled to a 250 mL Buchner flask and filtered under vacuum. The procedure was repeated several times until a colourless sample was obtained. The extract is then transferred to a 500 separatory funnel containing 40 ml petroleum ether. The aqueous phase was discarded. The extract was then transferred through a funnel to a 50mL volumetric flask containing 15g of anhydrous sodium sulfate. The volume was made up of petroleum ether and the samples was examined at 450 nm

The total carotenoid content was calculated using the following formula

$$\text{Carotenoid content } (\mu\text{g/g}) = \frac{A \times V \text{ (ml)} \times 10^4}{P \text{ (g)} \times A_{1\text{cm}}^{1\%}}$$

where A = Absorbance

Total extract volume = V

P = sample weight

$A_{1\text{cm}}^{1\%} = 2592$ (B-carotene extinction coefficient in petroleum ether)

Preparation of bread using peel powder:

Baladi bread was prepared according to the method described by (Segura-Badilla *et al.*, 2022). Flatbread (72% extraction) with some of the flour replaced with banana peel flour (5%, 10%, 15%) (Eshak, 2016). The mixture consisted of 95,90,85 g flour, 2% compressed yeast dissolved in warm water (40°C), 3.5 g corn oil, 2 g salt, and 50-72 ml water. The flour and other ingredients were mixed and left at room temperature for 40 minutes to complete fermentation. The dough was cut into loaves and baked in an electric oven at 250°C for 3 minutes. It was then air cooled and packed in polyethylene bags until used for the required analysis and measurements.

Sensory evaluation:

Ten trained penalties from staff and post-graduate students from Food Science Department. Fac. Agric-Saba Basha evaluated the bread color, flavor, texture and overall acceptability. A nine-point hedonic scale was used to rate the sensory properties where 9 is (Like extremely) and 1 (Dislike extremely). The ratings were then given numerical values (Amerine *et al.*, 1965).

Statistical Analysis :

All results were presented as means ± Standard deviation (SD). Data was subjected to one-way analysis of Variance (ANOVA) using (SPSS/PC+) Version-22 Soft Ware Package. Means were further differentiated using Duncan's Multiple Range Test at $p < 0.05$ (Steel and Torrie, 1997)

RESULTS AND DISCUSSION

Proximate chemical composition of banana peel at various stages of maturity

Table (1) presents the proximate chemical composition of the three stages of banana peel maturation. Results revealed significant changes in all tested parameters in the different stages.

The moisture content of both unripe (green) peels and ripe (yellow) peels exhibited the highest moisture content which was significantly different compared to AR peels, being 90.20, 89.34 and 87.17 %, respectively. As a matter of fact, the water content plays an important role in determining the shelf-life of the product, as it is dependent on the genetic content of varieties as well as climatic conditions. In our study, it was obvious that the peels in all stages carry much water. The high moisture peel contents observed suggest that the peels requiring carbohydrates are the chief source of energy to the body. It was reported by Hausmann *et al.* (2016) that products with lower water content generally are less subjected to degradation by microorganisms and chemical changes. But generally speaking the moisture content in this study was similar to other varieties of banana peels. The crude protein content showed a significantly higher content in ripe (yellow) peels (8.72) than in unripe and AR stage Table (1). It is important to remark that fruits values of crude protein are low because fruits generally are not potential sources of proteins (Marles, 2017). On the other hand, Zaini *et al.* (2022) reported that crude protein in banana varieties may range between 5.5 and 7.87 depending on diversity and genetic composition. Ahmed *et al.* (2016), reported that crude protein in yellow peels was 7.57%. Banana peel can be considered a good source of amino acids because most of the 18 amino acids (essential and non-essential amino acids) are present in banana peel at various levels of development (Khawan and Deka, 2016).

The crude fat of all three stages ranged between 7.50% for ripe peels to 8.35% for unripe. Both unripe (green) and ripe (yellow) stages exhibited the highest crude fat content with no significant differences between them being 8.35% and 8.22%, respectively and were significantly different than after the ripe stage (7.50%). Meanwhile, Ahmed *et al.* (2016) reported that crude fat in the powder peel of banana peel (yellow), was 10.44 which is higher than the recorded values in our study and lower than those of Anhwange *et al.* (2009). It was reported by Zaini *et al.* (2022). that crude fat in peels of different varieties ranges between 2.24% and 11.6%.

Ash is the inorganic residue remaining after water and organic matter have been removed

by heating. It was reported by **Emaga et al. (2007)** that the ash content in different banana peels varied from 6.4 to 12.8%. As can be seen, in Table (1) the highest ash content was observed in yellow dried peels at 17.79% which was significantly different from the green and ripe stages.

Unripe (green) peels showed the highest crude fiber content (37.12%) compared to both the ripe (yellow) and AR stage. Green banana peels contained the highest crude fiber content (37.12%) and were significantly different than the

yellow and ripe peels. On the other hand, **Pyar and Peh (2018)** reported that crude fiber banana peel may reach 19.2%. It was reported by **Arun et al. (2017)** that the soluble dietary fiber from *Musa paradisiaca* decreases cholesterol than the insoluble dietary fiber

Considering carbohydrates measured as NFE, both yellow and unripe peels had the Lowest NFE with no significant differences between them, whereas, the after ripe stage, recorded the highest NFE content (40.90%).

Table (1) Proximate chemical composition of banana peel at various stages of maturity.

* Component %	Unripe banana peel (Green)	Ripe Banana Peel (Yellow)	Banana peel after ripe stage
Moisture	90.20±2.19 ^a	89.34±3.40 ^a	87.17±2.15 ^b
Crude protein	7.56±2.66 ^b	8.72±2.77 ^a	7.60±2.17 ^b
Crude fat	8.35±2.55 ^a	8.22±2.27 ^a	7.50±2.75 ^b
Total ash	17.39±3.95 ^b	17.79±2.17 ^a	15.50±1.15 ^c
Crude fiber	37.12±3.12 ^a	34.80±3.80 ^b	28.50±2.85 ^c
NFE	29.58±2.40 ^b	30.47±3.55 ^b	40.9±2.44 ^a

- The results are expressed as mean±standard deviation of triplicate analysis.
- Means within the same row of different letters are significantly different at (P < 0.05).

- *Calculated on a dry weight basis
- NFE= Nitrogen-free extract

Total phenolics, total flavonoids and carotenoids of banana peels at different stages of maturity

As can be seen, the significant increase in the content of TP and TF is observed as the process of ripening progresses, reaching its maximum at banana peel after the ripe stage being 31.31 mg GAE/g and 5.63 mg/100ml, respectively.

Phenols are important secondary metabolites and are present at higher levels in banana peels than in other fruits. Numerous phenolic compounds are present in banana peels, including gallic acid, catechins, epicatechins, tannins, and anthocyanins (**Sidu and Zafar, 2018**). It has also been reported that the gallic acid in banana peels is five times higher than in the pulp, proving that the peel is a treasure trove of antioxidants (**Someya et al., 2002**)

It was reported by **Vu et al. (2018)** that banana peels comprise more than 40 compounds

identified as individual phenolics with a total content of 47mg of gallic acid equivalent (GAE/g dry matter). The phenolic compounds, found in banana peel can be further categorized into four subgroups, namely flavonols, hydroxycinnamic acids flavan-3-ols and catecholamines (**Vu et al., 2018**).

Results also revealed in Table (2) that the highest stage contained carotenoids in ripe yellow banana peel being 13.93 µg leutin / 100g and was significantly different than the unripe green peel and peel after the ripe stage being 8.21 and 10.99 µg leutin / 100g, respectively. Carotenoids have many beneficial effects on human health, including being precursors of vitamin A, antioxidants, anti-cancer, anti-obesity, and anabolism of bone components, (**Vu et al., 2019**).

Table (2): Total phenolics and total Flavonoids and carotenoids of banana peels at different stages of maturity

Parameters	Unripe banana peel (Green)	Ripe Banana Peel (Yellow)	Banana peel after ripped stage
Total Phenol (mg GAE/100g)	15.40±1.15 ^c	24.63±2.14 ^b	31.31±3.14 ^a
Total flavonoid (mg QE*/100 g)	3.05±1.05 ^c	3.65±1.02 ^b	5.63±1.16 ^a
Carotenoids (µg leutin equivalents/100 g)	8.21±1.12 ^c	13.93±1.13 ^a	10.99±1.19 ^b

- The results are expressed as mean±standard deviation of triplicate analysis.
- Means within the same row of different letters are significantly different at (P < 0.05).
- *QE;Quercetin Equivalent

Antioxidant activity of banana peels at different stages of maturity

Table (3) represents the antioxidant activity of banana peels at the different stages as measured by DPPH% inhibition and FRAP.

Results revealed that as the ripening stage progresses the antioxidant activity significantly (P<0.05) increases reaching its maximum for banana peel after the ripe stage (89.66) compared to unripe (green) and ripe (yellow) stages (44.16 and 64.82%), respectively as measured by DPPH.

The FRAP assay also showed a significant activity as the maturation at the age of peels developed where the banana peels after the ripe stage showed high significant antioxidant activity (48.15 mg TE /g) as compared to both the unripe (green) and ripe (yellow) stage Table (3).

Antioxidant assays are used to evaluate the antioxidant capacity of banana peel extracts

and fractions. It is essential to measure the ability of the chemical components of banana peel extracts to scavenge free radicals and prevent the formation of reactive oxygen species (ROS). High levels of ROS can cause abnormal signaling to cells, resulting in cell damage(Winterbourn, 2008)

Multiple studies have linked (ROS) to chronic diseases such as neurodegeneration, cancer, diabetes, and inflammation(Mittal *et al.*, 2014; Świątek *et al.*, 2019). The phenolic compounds in banana peels are composed of a significant number of hydroxy groups, which may enhance their ability to scavenge reactive oxygen species(Świątek *et al.*, 2019) It is worth noting that the high FRAP activity in the peel is attributed to phenols and carotenoids(Kreft *et al.*, 2006).

Table (3): Antioxidant activity of banana peels at different stages of maturity

Parameters	Unripe banana peel (Green)	Ripe Banana Peel (Yellow)	Banana peel after ripped stage
DPPH (%)	44.16±2.16 ^c	64.82±3.13 ^b	89.66±3.17 ^a
FRAP(mg TE*/g)	19.71±1.17 ^c	32.97±2.14 ^b	48.15±1.15 ^a

- The results are expressed as mean±standard deviation of triplicate analysis.
- Means within the same row of different letters are significantly different at (P < 0.05).
- *TE: Trolox Equivalents

Sensory evaluation of Egyptian Balady bread substituted with different percentages of banana peel powder from the after ripe stage.

Table (4) shows the sensory evaluation of Egyptian Balady bread substituted with different percentages of banana peel powder from the AR stage.

Interestingly, it was found that the flavour as tested by panelists was still accepted up to 15% substitution with a score of (6.50). As a matter of fact, both texture and colour were less scored by panelists as the level of substitution increased but was not rejected (up to 15%). As a

matter of fact, the light brownish colour of the obtained powder did not affect the acceptability of colour by the panelists (Wohlt *et al.*, 2009) That is why in our present study we have chosen 15% substitution level which gained the highest score in overall acceptability by panelists as compared to the control for further proximate chemical analysis to examine how much this substitution level will enhance both nutritional value of bread Moreover, also a high concentration of banana peel in the formula from AR stage may increase the phytochemical and antioxidant potency of the product.

Table (4): Sensory evaluation of Egyptian Balady bread with different concentrations of banana peels

Sensory parameters	Banana peels			
	Control	5%	10%	15%
Color	7.13±1.22 ^d	7.50±1.21 ^c	8.20±1.41 ^b	8.22±1.12 ^a
Flavor	8.20±1.14 ^a	7.7±1.16 ^b	7.03±1.11 ^c	6.50±1.10 ^d
Texture	8.7±1.13 ^a	8.0±1.11 ^b	7.02±1.13 ^c	6.50±1.12 ^d
Overall acceptability	8.6±1.13 ^a	8.1±1.11 ^b	8.2±1.11 ^b	8.00±1.12 ^b

- The results are expressed as mean±standard deviation of triplicate analysis.

- Mean values in a row with different letters

Proximate chemical composition of bread with added 15% banana peel from after ripe stage

Table(5) demonstrate the proximate chemical composition of bread with 15% banana peel after the ripe stage as compared to control

Bread is a staple food eaten daily. Because bread is made primarily from refined flour, it contains small amounts of dietary fiber, vitamins, minerals, and other phytochemicals that help prevent various diseases (Capurso and Capurso, 2020).

As presented in our results a significant increase was observed in protein, fat and ash content of substituted bread with 15% added after ripening banana peel powder compared to control. However, a significant decrease was observed in moisture, and carbohydrate content of the substituted bread. These results were similar

Table (5): Proximate chemical composition of Balady bread with 15% substitution with banana peel after the ripe stage.

*sample type%	Moisture	Protein	Fat	Ash	Carbohydrate	Total phenolics (mg GAE/100 g)
Bread Control	27.05±0.56 ^a	8.62±0.99 ^b	3.16±0.28 ^b	1.35±0.13 ^b	58.62±0.58 ^a	19.05±0.55 ^b
Bread 15%	22.04±0.98 ^b	9.29±0.61 ^a	9.29±0.61 ^a	1.87±0.10 ^a	56.87±0.19 ^b	139.35±0.57 ^a

- The results are expressed as mean±standard deviation of triplicate analysis.

are significantly different at $p < 0.05$

to those of Eshak, (2016) when substituting Balady flatbread with 5 and 10% banana peel. Similar to our study, a decrease in carbohydrate content was observed. Several studies have shown that carbohydrate restriction improves glycemic control, insulin resistance, and obesity (Yancy *et al.*, 2005).

Interestingly, a hugely significant increase was observed in total phenolic content revealing a huge impact on health promoting compounds reaching 139.75mg GAE/100g compared to 19.67 mg GAE/ 100g for control bread.

Thus it was stated by Agama *et al.* (2016) Banana peels have significantly higher amounts of ash, protein, fat, and fiber than pulp, making banana peel foods with excellent functional properties possible.

- Means within the same row of different letters are significantly different at ($P < 0.05$).

- *Calculated on a dry weight basis

CONCLUSION

Banana peels showed an enhanced nutritional value and functional properties which can provide a new perspective for producers with regard to developing value added products. In our present study the incorporation of banana peel in Balady bread significantly improved their nutritional value and provided essential antioxidant compounds for disease prevention.

REFERENCES

Abo-EL-Ez, A. T., Abdalla, B. H., Gad, EL Kareem, M.R. and Essa, A. E. (2017). Evaluation of some banana cultivars under south Egypt conditions. *J. Sohag Agriscience (JSAS)*, 2:1-13.

Agama-Acevedo, E., Sañudo-Barajas, J., Vélez De La Rocha, R., González-Aguilar, G., and Bello-Perez, L.A. (2016). Potential of plantain peels flour (*musa paradisiaca l.*) as a source of dietary fiber and antioxidant compound. *CyTA- Journal of Food*, 14(1), 117-123.

Ahmad, A., Sattar, M., Rathore, H.A., Hussain, A.I., Khan, S.A., Fatima, T., Johns, E.J. (2015). Antioxidant activity and free radical scavenging capacity of l-arginine and NaHS: A comparative in vitro study. *Acta Pol Pharm*, 72(2), 245-252.

Ahmad, T., and Danish, M. (2018). Prospects of banana waste utilization in wastewater treatment: A review. *Journal of Environmental Management*, 206, 330-348.

Ahmed, J., Mulla, M.Z., and Arfat, Y.A. (2016). Thermo-mechanical, structural characterization and antibacterial performance of solvent casted polylactide/cinnamon oil composite films. *Food Control*, 69, 196-204.

Alzate Acevedo, S., Díaz Carrillo, Á.J., Flórez-López, E., and Grande-Tovar, C.D. (2021). Recovery of banana waste-loss from production and processing: A contribution to a circular economy. *Molecules*, 26(17), 5282.

Amerine, M., Pangborn, R., and Roessler, E. (1965). Laboratory studies: Types and principles. *Principles of Sensory Evaluation of Food; Academic Press: New York, NY, USA*, 275-314.

Anhwange, B. A., Ugye, T. J., and Nyiaatagher, T. D. (2009). Chemical composition of *Musa sapientum* (banana) peels. *Electronic Journal of Environmental, Agricultural and Food Chemistry*, 8(6), 437-442.

AOAC (2005). Official methods of analysis of the association official analytical chemists, 17th ed., Vol. 1. Washington, DC, USA.

- Arun, K. B., Thomas, S., Reshmitha, T. R., Akhil, G. C., and Nisha, P. (2017).** Dietary fibre and phenolic-rich extracts from *Musa paradisiaca* inflorescence ameliorates type 2 diabetes and associated cardiovascular risks. *Journal of Functional Foods*, 31, 198-207.
- Capurso, A., and Capurso, C. (2020).** The mediterranean way: Why elderly people should eat wholewheat sourdough bread—a little known component of the mediterranean diet and healthy food for elderly adults. In (Vol. 32, pp. 1-5): Springer.
- Chen, L.-H., Sun, M.-H., Wang, Z., Yang, W., Xie, Z., and Su, B.-L. (2020).** Hierarchically structured zeolites: From design to application. *Chemical Reviews*, 120(20), 11194-11294.
- Coltro, L., and Karaski, T.U. (2019).** Environmental indicators of banana production in Brazil: Cavendish and Prata varieties. *Journal of Cleaner Production*, 207, 363-378.
- Emaga, T.H., Andrianaivo, R.H., Wathélet, B., Tchango, J.T., and Paquot, M. (2007).** Effects of the stage of maturation and varieties on the chemical composition of banana and plantain peels. *Food Chemistry*, 103(2), 590-600.
- Eshak, N.S. (2016).** Sensory evaluation and nutritional value of balady flat bread supplemented with banana peels as a natural source of dietary fiber. *Annals of Agricultural Sciences*, 61(2), 229-235.
- Gomes, S., Vieira, B., Barbosa, C., and Pinheiro, R. (2022).** Evaluation of mature banana peel flour on physical, chemical, and texture properties of a gluten-free rissol. *Journal of Food Processing and Preservation*, 46(8), e14441.
- Hausmann, B., Knorr, K.-H., Schreck, K., Tringe, S.G., Glavina del Rio, T., Loy, A., and Pester, M. (2016).** Consortia of low-abundance bacteria drive sulfate reduction-dependent degradation of fermentation products in peat soil microcosms. *The ISME Journal*, 10(10), 2365-2375.
- Khawas, P., and Deka, S. C. (2016).** Comparative nutritional, functional, morphological, and diffractogram study on culinary banana (*Musa ABB*) peel at various stages of development. *International Journal of Food Properties*, 19(12), 2832-2853.
- Kreft, I., Fabjan, N., and Yasumoto, K. (2006).** Rutin content in buckwheat (*Fagopyrum esculentum* moench) food materials and products. *Food Chemistry*, 98(3), 508-512.
- Lario, Y., Sendra, E., Garcia-Pérez, J., Fuentes, C., Sayas-Barberá, E., Fernández-López, J., and Perez-Alvarez, J. (2004).** Preparation of high dietary fiber powder from lemon juice by-products. *Innovative Food Science & Emerging Technologies*, 5(1), 113-117.
- Marles, R.J. (2017).** Mineral nutrient composition of vegetables, fruits and grains: The context of reports of apparent historical declines. *Journal of Food Composition and Analysis*, 56, 93-103.
- Mittal, M., Siddiqui, M.R., Tran, K., Reddy, S.P., and Malik, A.B. (2014).** Reactive oxygen species in inflammation and tissue injury. *Antioxidants & redox signaling*, 20(7), 1126-1167.
- Oguntoyinbo, O.O., Olumurewa, J.A.V., and Omoba, S. (2021).** Physico-chemical and sensory properties of cookies produced from composite flours of wheat and banana peel flours. *J. Food Stab*, 4(3), 1-21.
- Oyaizu, M. (1986).** Studies on products of browning reaction antioxidative activities of products of browning reaction prepared from glucosamine. *The Japanese journal of nutrition and dietetics*, 44(6), 307-315.
- Petersen, R. G. (1977).** Use and misuse of multiple comparison procedures 1. *Agronomy Journal*, 69(2), 205-208.
- Pyar, H., and Peh, K. (2018).** Chemical compositions of banana peels (*Musa sapientum*) fruits cultivated in Malaysia using proximate analysis. *Res. J. Chem. Environ*, 22(2), 108-111.
- Rangana, S. (1979).** *Manual of analysis of fruit and vegetable products*: Tata McGraw-Hill.
- Rebello, L. P. G., Ramos, A. M., Pertuzatti, P. B., Barcia, M. T., Castillo-Muñoz, N., and Hermosín-Gutiérrez, I. (2014).** Flour of banana (*Musa AAA*) peel as a source of antioxidant phenolic compounds. *Food Research International*, 55, 397-403.
- Sakanaka, S., Tachibana, Y., and Okada, Y. (2005).** Preparation and antioxidant properties of extracts of Japanese persimmon leaf tea (*kakinoha-cha*). *Food Chemistry*, 89(4), 569-575.
- Segura-Badilla, O., Kammar-García, A., Mosso-Vázquez, J., Sánchez, R.Á.-S., Ochoa-Velasco, C., Hernández-Carranza, P., and Navarro-Cruz, A.R. (2022).** Potential use of banana peel (*Musa cavendish*) as ingredient for pasta and bakery products. *Heliyon*, 8(10).
- Sidu, J. S., and Zafar, T. A. (2018).** Bioactive compounds in banana fruits and their health benefits. *Food Quality and Safety*, 2(4), 183-188.
- Singh, J.S., Koushal, S., Kumar, A., Vimal, S.R., and Gupta, V.K. (2016).** Book review: Microbial inoculants in sustainable agricultural

- productivity-vol. II: Functional application. In: Frontiers Media SA.
- Someya, S., Yoshiki, Y., and Okubo, K. (2002).** Antioxidant compounds from bananas (*Musa cavendish*). *Food Chemistry*, 79(3), 351-354.
- Sabin Nature (2022).** Egypt Topics, groups production. December 29, 2022
- Steel, R. G. D., and Torrie, J. H. DA Dic ey (1997).** *Principles and procedures of Statistics. A biometrical approach. McGraw-Hill Boo Company In Company. Toronto (Canada).* 481.
- Świątek, M., Lu, Y.-C., Konefal, R., Ferreira, L.P., Cruz, M.M., Ma, Y.-H., and Horák, D. (2019).** Scavenging of reactive oxygen species by phenolic compound-modified maghemite nanoparticles. *Beilstein journal of nanotechnology*, 10(1), 1073-1088.
- Vu, H.T., Scarlett, C.J., and Vuong, Q.V. (2018).** Phenolic compounds within banana peel and their potential uses: A review. *Journal of Functional Foods*, 40, 238-248.
- Vu, H.T., Scarlett, C.J., and Vuong, Q.V. (2019).** Changes of phytochemicals and antioxidant capacity of banana peel during the ripening process; with and without ethylene treatment. *Scientia Horticulturae*, 253, 255-262.
- Wardhan, H., Das, S., and Gulati, A. (2022).** Banana and mango value chains. *Agricultural Value Chains in India: Ensuring Competitiveness, Inclusiveness, Sustainability, Scalability, and Improved Finance*, 99-143.
- Winterbourn, C.C. (2008).** Reconciling the chemistry and biology of reactive oxygen species. *Nature Chemical Biology*, 4(5), 278-286.
- Wohlt, P.D., Zheng, L., Gunderson, S., Balzar, S.A., Johnson, B.D., and Fish, J.T. (2009).** Recommendations for the use of medications with continuous enteral nutrition. *American Journal of Health-System Pharmacy*, 66(16), 1458-1467.
- Yancy, W.S., Foy, M., Chalecki, A.M., Vernon, M.C., and Westman, E.C. (2005).** A low-carbohydrate, ketogenic diet to treat type 2 diabetes. *Nutrition & metabolism*, 2(1), 1-7.
- Zaini, H.M., Roslan, J., Saallah, S., Munsu, E., Sulaiman, N.S., and Pindi, W. (2022).** Banana peels as a bioactive ingredient and its potential application in the food industry. *Journal of Functional Foods*, 92, 1050-1054.
- Zhang, Y., Tan, Y.-W., Stormer, H.L., and Kim, P. (2005).** Experimental observation of the quantum hall effect and berry's phase in graphene. *nature*, 438(7065), 201-204 .

الملخص العربي

تقييم كيميائي وتغذوي لقشور الموز ومقدرة استخدامه لتحسين العيش البلدي المصري

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يعتبر الموز من أضخم النباتات العشبية وبين أهم عشر محاصيل مزرعة في العالم. ومع ذلك، يتم فقد 40% من إنتاجها على شكل قشور، مما يتسبب في التلوث البيئي. وفي هذه الدراسة، تم تقسيم 60 كجم من الموز المزروع في مصر (*Musa sapientum*) إلى ثلاث مراحل من النضج وهي المرحلة غير الناضجة (أخضر) والناضجة (صفراء) ومرحلة ما بعد النضج. تم غسل القشور وتجفيفها في فرن هوائي على درجة حرارة 60 درجة مئوية لمدة 48 ساعة، ومن ثم تعبئتها في عبوات زجاجية لحين إجراء الاختبارات المعملية عليها. أظهرت نتائج التحليل الكيميائي التقريبي أن المرحلة غير الناضجة (الخضراء) تحتوي على أعلى نسبة رطوبة وألياف خام، بينما تحتوي المرحلة الناضجة (الصفراء) على أعلى نسبة من البروتين والرماد كما أظهرت مرحلة ما بعد النضج ارتفاع في إجمالي محتوى المركبات الفينولية والفلافونويدات الكلية بواقع 31.31 ملجم GAE / جرام و 25.63 جم 100 QE / جرام على التوالي. كما اشارت الدراسة ان مرحلة ما بعد النضج اظهرت أعلى نشاط مضاد للأكسدة وتم قياسه بواسطة تثبيط DPPH و FRAP (89.60% و 48.15 ملجم Te / جرام) مقارنة بالمرحل الأخرى. أظهر التقييم الحسي للخبز البلدي أن استبدال 15% من مسحوق القشور مرحلة ما بعد النضج بالدقيق لاقى استحسان كبير لدي المحكمين. تمت مقارنة التحليل الكيميائي التقريبي للخبز المقبول مقارنة بالكونترول لمعرفة مدى تأثيره على الفوائد التغذوية والصحية. أظهرت النتائج أيضا ارتفاعا ملحوظا في جميع المكونات (البروتين والرماد والدهن) باستثناء الرطوبة والكاربوهيدرات، في حين أظهرت الفينولات الكلية ارتفاعا ملحوظا أعلى من الكونترول بواقع (139.35 ملجم جالنيك /100جم). ومن هنا ندرك أهمية هذه الدراسة بأن مسحوق قشور الموز المضافة إلى الخبز يمكن أن توفر قيمة غذائية وصحية.

الكلمات الرئيسية: قشور الموز، التحليل الكيميائي التقريبي، الفينولات الكلية، الفلافونويدات الكلية، النشاط المضاد للأكسدة، التقييم الحسي.