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Determination of the total polyphenol content and antioxidant activity in banana and oranges waste☆

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Abstract:
The banana and orange processing industry generates a large number of by-products, mainly consisting of peel, which can be a good source of bioactive polyphenols. The total phenolic content (TPC), total flavonoid content (TFC), DPPH and ABTS scavenging activity were determined by spectrophotometric analysis of banana and orange peels. The TPC, TFC, DPPH and ABTS values of banana peels were 48.75 mgGAE/g, 82 mgQE/g, 28.7%, 4.9 μmolTE/g and orange peel were 9.40 mgGAE/g, 4.20 mgQE/g, 3.95%and 7.4 μmolTE/g.

Keywords: polyphenols, banana and orange peel, antioxidant activity

1. INTRODUCTION

Fresh fruit and vegetables consumption has experienced a significant increase in the population, generating a large amount of waste (seeds, peels, pods, etc.) with a direct impact on the environment.

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Agriculture is one of the sectors that produces large amounts of food waste and residues (40-50% of root crops, fruits and vegetables) [1] which are used as animal feed, biofuel, soil improvement materials, etc. [2] and sources of bioactive compounds (carotenoids, saponins, tannins, alkaloids, sterols, steroids, triterpenes, peptides and carbohydrates, etc.) [3].

Fruit waste and fresh vegetables in households in the European Union (EU) exceeds 17 billion kg annually or 35.3 kg per person, of which 14.2 kg can be avoided. The average quantity of fresh wasted products purchased by families (EU) is 29% [4].

Fruit peel waste represents between 15 and 60% of the different types of fruit waste which usually are thrown away. For many fruits, such as mango (30-50%), orange (30-50%), pineapple (40-50%) and banana (20%), a significantly quantity is often wasted. Fruits as mango, banana, orange, watermelon and lemon, represents between 25 and 57 million tons of waste produced annually [4].

Preliminary studies have shown that several types of freshly cut fruits produced variable amounts of by-products, even exceeding the amount of finished product, thus increasing the amount of waste [5]. When recovering these bioactive compounds contained in a selected waste it is necessary to establish a methodology which offers a recovery yield of different compounds, the use of ecological solvents, application of advanced ecological and traditional techniques with low production costs [6].

Techniques used to recover bioactive compound from waste are presented in Fig. 1.

By recovering these compounds extracted from fruit and vegetable waste, they can be reused in other food products as functional ingredients capable of conferring certain characteristics and quality criteria, while at the same time exerting benefits for human health.

2. MATERIALS AND METHODS

2.1. Materials

Chemicals

All chemicals and reagents were of analytical grade and were purchased from Sigma Chemical Co., Aldrich Chemical Co. Merck.

Gallic acid 2,2-diphenyl-1-picrylhydrazyl (DPPH), Folin–Ciocalteu reagent, sodium carbonate, sodium nitritrite, Trolox, aluminum chloride and sodium hydroxide.

Fruit peel

Fresh orange and banana peels were collected in 2024. The fruits were purchased from a local supermarket in Craiova-Romania. The fruits were fully developed in size and ready for immediate consumption.

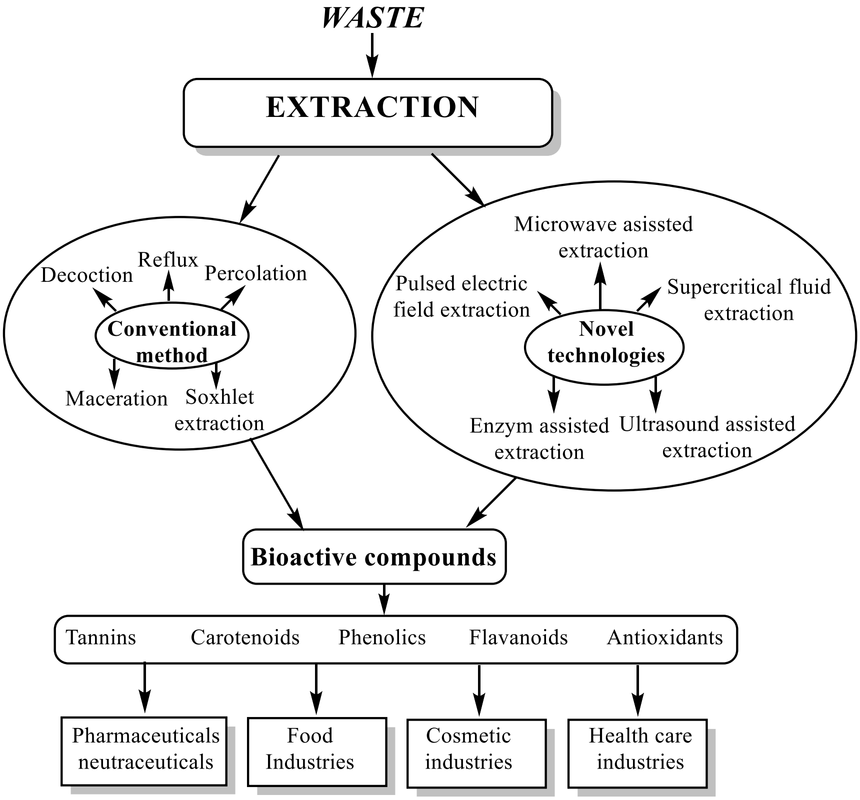

Figure 1. Traditional and advanced waste processing techniques.

The fruits were washed with tap water and peeled by hand. To prepare the laboratory samples, each fruit peel was cut into small pieces and dried in a vacuum oven type VO-Memmert at a temperature of 50 °C for 10 hours. Subsequently, the peels were ground in a grinder.

2.2. Analysis methods

Extraction of Polyphenols

To extract total phenolic compounds, 10 g of orange and banana peel powder was placed in an Erlenmeyer flask containing 500 mL of 90% ethanol. The extraction was performed for 1 h by stirring at 250 rpm at 50 °C. The mixture was further centrifuged at 5000 × g for 10 min, and the supernatant was stored at 4 °C until further use. The total phenolic content of the sample was analyzed using the Folin–Ciocalteu method, as described previously Dumitru, 2024 [7]. The results were expressed as mg (GAE)/g using the following equation based on the calibration curve:

$$y = 0.0134x + 0.0171,\ R^2 = 0.9981$$

Total flavonoids content (TFC)

The total flavonoid content (TFC) was determined based on the published article of Rakibul with some modifications. In brief, 1 mL of extracts was mixed with 4 mL of distilled water and 0.3 mL of 5% $NaNO_2$ solution in a falcon tube. After 5 min of rest, 0.3 mL of 10% $AlCl_3$ was added and allowed to stand for 1 min. Finally, 2 mL of 1 M NaOH and 2.4 mL of distilled water were added and mixed care fully. The mixture was centrifuged at 4000 × g for 10 min and left in a dark place for 15 min. Thereafter, the absorbance was read at 510 nm and the TFC (mg QE/g DM) was calculated based on the quercetin (0–100 μM) calibration curve ($R^2 = 0.993$) [8].

Antioxidant activity by DPPH method (2,2-diphenyl-1-picrylhydrazyl) was analyzed using the method as described previously Dumitru, 2024 [7]. The inhibition percentage of the samples was calculated using the equation:

$$\% \text{ inhibition} = [(Abs_{control} - Abs_{sample}\ Abs_{control}] \times 100$$

where $Abs_{control}$ is the absorbance of DPPH radical + methanol; Abs_{sample} is the absorbance of DPPH radical + sample extract [7].

Antioxidant activity by ABTS

The ABTS (2,2-Azinobis(3-Ethylbenzothiazoline-6-Sulfonic Acid) assay was carried out according to the method described by Miller and Rice-Evans, 1997 [9] with some modifications. Briefly, 160 μL of the diluted sample was mixed with 2 mL of 1% ABTS•+, and after 1 min, the absorbance was measured at 734 nm. For the blank test, 96% ethanol was used.

A calibration curve for Trolox was created using working standard solutions, and results were expressed in mmol TE/100 g of dry banana peel.

3. RESULTS AND DISCUSSION

In human health, phenolic compounds are renowned for their antioxidant properties, which help neutralize harmful free radicals, potentially reducing the risk of chronic diseases such as cardiovascular disease, diabetes, and certain cancers [10]. A typical characteristic of phenolic compounds is an aromatic ring that contains one or more hydroxyl groups as shown in Fig. 3 [11].

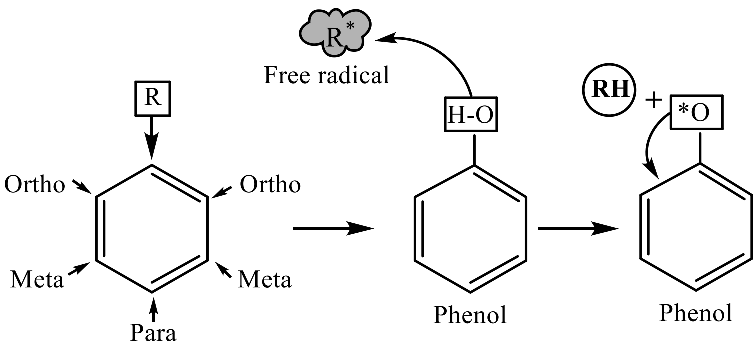

Figure 2. Structure of phenolic compound [11].

The antioxidant effect of phenolic compounds is believed to limit the generation of reactive oxygen species (ROS), scavenge ROS directly, and induce antioxidant enzymes [12]. Total phenol value of the peel of banana peel in this research is 48.75 mg GAE/g sample what ranges within the limits found by Someya et al. (2002) 9.53 mg GAE/g - 67.4 mg GAE/g sample. According to Someya et al. (2002) [13] phenolic compounds are more abundant in peel than in pulp, because they accumulate in dermal tissues of the plant body due to their role as protection against ultraviolet radiation.

The total flavonoid content among the extract were expressed in term of quercetin equivalent using the standard curve equation:

$$y = 0.0134x + 0.0171, R^2 = 0.9981.$$

The total flavonoid content in extract from banana peel is 82 mg QE/g, value that ranges between the values found by Fidrianny et al., 2014 de 55 –102.2 mg QE/g [14]. The total phenolic and total flavonoid contents of orange peel were 9.40 mg GAE/g and 4.20 mg QE/.

These values are within the limits of the values obtained by Humaira et al., 2015 [15] (1.75 mg GAE/g sample – 2.09 mg GAE/g sample and 0.72 mg GAE/g sample-0.8 mg GAE/g sample.

The antioxidant effect of phenolic compounds is believed to limit the generation of reactive oxygen species (ROS), scavenge ROS directly, and induce antioxidant enzymes [16]. Banana peel and orange extracts show strong DPPH radical scavenging activity, attributed to the hydroxyl groups on their phenolic compounds, which act as electron donors to terminate free radical reactions.

The DPPH (2,2-diphenyl-1-picrylhydrazyl) assay measures antioxidant capacity by assessing the ability of compounds to donate a hydrogen atom or electron, thereby reducing the stable DPPH radical to its non-radical form and changing its color. ABTS(+ radical bleaching occurs due to transfer of hydrogen atoms or transfer of electrons in order to stabilize this free radical. ABTS(+ values obtained for the different varieties are higher than those obtained using the DPPH(method because the molecule of ABTS(+ is a completely flat structure that, unlike DPPH radical, reacts readily with reducing agents [17].

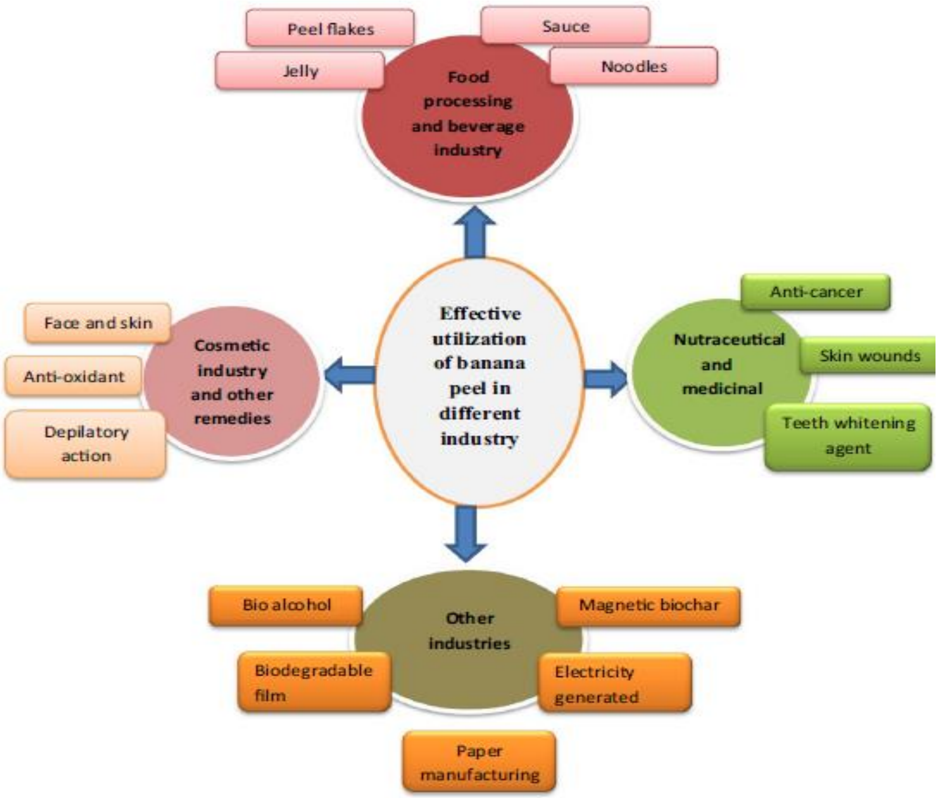

Figure 3. Utilization of banana peel in various industrial applications.

The obtained antioxidant activity values were 28.7.0% by DPPH method and 4.9 µmol TE/g by ABTS method for banana peels and 39.5% by DPPH method and 7.4 µmol TE/g by ABTS meyhod for oranges. These values are similar to those obtained by Humaira et al., 2024 [15] and Ahmed et al. 2016 [18]. The valorization of banana peel and orange bioactives presents a promising avenue for sustainable resource utilization and the development of value-added products across multiple industries. In fig. 3, Khalid, 2025 presents the use of banana peels in various industries described by Bhavani et., al 2023 [19].

4. CONCLUSION

The valorization of banana peel and orange bioactives presents a promising avenue for sustainable resource utilization and the development of value-added products across multiple industries. The banana peel and orange, once considered a waste product, harbors a treasure trove of bioactive compounds with significant health benefits and functional properties. Future research eforts should focus on addressing these challenges while exploring innovative strategies to maximize the valorization of banana peel bioactives, thereby contributing to waste reduction and environmental sustainability. In the future, extensive work in isolation and characterization of the active biomolecules in these fruit peels is required.

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