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Proceeding Paper

Use of Agricultural Wastes to Design Natural Products for the Prevention of Cardiovascular Diseases †

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Abstract: Cardiovascular diseases (CVDs), or risk factors for CVD, such as diabetes, hypertension and hypercholesterolemia, are the leading cause of death worldwide. Therefore, the use of agricultural by-products as a source of functional ingredients, particularly those from crop plants, has received significant interest. For example, the banana (*Musa* spp.) is a common food crop worldwide and is the primary production on Madeira Island in Portugal. In this work, banana peels and puree were incorporated into sweet food products as butter and sugar substitutes, enhancing the nutritional content. The results show that the final product's dietary fibre and phenolic content increased, while the lipidic and total sugar content decreased. The obtained results show that banana peels have a great potential to be developed into beneficial functional foods and nutraceuticals.

Keywords: banana of Madeira; cardiovascular diseases; chemical characterization; functional foods; sustainability

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1. Introduction

The leading cause of death worldwide is cardiovascular diseases (CVDs). These diseases can also be associated with several risk factors, such as diabetes, hypertension and hypercholesterolemia [1]. The use of agricultural by-products as a source of functional ingredients that present cardioprotective properties, particularly those from crop plants, has received significant interest. The banana (*Musa acuminata* L.) is a prevalent fruit in the world market in terms of its importance as a food crop. It is grown in over 130 countries: mainly in tropical and subtropical areas [2]. Almost one-third of all bananas gathered is lost due to the population primarily consuming ripe bananas. Ripe bananas are prone to mechanical damage and are perishable during maturation, making their storage and transport difficult. Almost 20% of banana production is not commercialized due to size and appearance flaws, increasing their loss [2]. Therefore, fruit processing emerged, aiming to solve problems such as the weak infrastructure, inadequate transportation and perishable nature of the product; therefore, the grower sustains substantial losses. In Portugal, the banana is the primary production on Madeira Island, but its peel, such as other agricultural by-products, is usually rejected [3]. However, banana peels are consumed as food and medicine in some regions of the world, so, possibly, they could be transformed into a functional food. Furthermore, it has been reported that banana peels present a broad range of bioactive chemical constituents and biological activities, which seems to support the proposed use of banana peels in several food industries [3].

Using bananas as an ingredient in different food products exerts a beneficial effect on human health. The incorporation of bananas in the recipes of many food products improves the total diet content of fibre, resistant starch, total starch and some essential minerals (phosphorus, magnesium, potassium and calcium). Dietary fibre protects against the development of Western diseases, including diabetes, cardiovascular diseases, colon cancer and obesity. In addition, prospective cohort studies have shown that high-fibre intakes are linked to a lower probability of developing cardiovascular diseases. The banana is a staple food in many countries and, due to its high nutritive value, has a positive effect on the health and well-being of many people. Several researchers have also evidenced that bananas contain important health-promoting phytochemicals [2,3].

Therefore, this study aimed to design a functional food created from the variety Dwarf Cavendish from the Autonomous Region of Madeira (Portugal) as a sustainable product. In this work, banana peels and puree were incorporated into sweet food products as butter and sugar substitutes, enhancing the nutritional content.

2. Materials and Methods

2.1. Samples

Madeira island bananas were acquired from local supermarkets and were chosen with different maturation degrees. First, the bananas were dehydrated at 41 °C for 72 h in a food dehydrator (Excalibur 9 Tray Dehydrator, Model 4926 T, USA) and then cooked in boiling water for 15 min. Finally, the whole fruit was reduced to a puree, mixed with powdered cocoa, and moulded as small spheres.

Commercial chocolate sweets were bought in the supermarket for comparison purposes.

2.2. Proximate Analysis

Several nutritional parameters of the sweets were analysed, such as total lipids, sugars and fibres, using triplicate samples for each analysis.

According to Maia et al. [4], the determination of the total lipid content was performed with the Folch method. The total sugar content was assayed using the phenol-sulfuric method described by Soares et al. [5], and the total fibre content according to Obregón-Cano et al. [6]. The analyses were performed in triplicate.

2.3. Total Phenolic Content (TPC)

The sweets' extract for this analysis was prepared using a solution of ethanol (80%) at 85 °C for 15 min. The TPC assays were performed in 96-well plates and analysed in a microplate reader (BioTek Synergy HTX Multimode Reader, Winooski, VT, USA), as reported by Soares et al. [7]. All analyses were performed in triplicate.

2.4. Statistical Analysis

A statistical analysis was performed using the software program IBMS SPSS for Windows, version 26 (IBM Corp., Armonk, NY, USA). The data normality was evaluated using the Kolmogorov–Smirnov and Shapiro–Wilk tests. The parameter values were presented in %, represented as the mean ± standard deviation (SD), and comparisons between groups were determined using the Mann–Whitney test, at a significance level of $p < 0.05$.

3. Results and Discussion

3.1. Chemical Composition

The values obtained for the total lipids, total sugars and fibre content analysis in mass percentages on a dry basis are shown in Table 1.

Table 1. Banana and commercial cocoa sweets' chemical composition (%) as mean ± SD (n = 3). The values are presented as a percentage on a dry basis (%).

Parameters	Banana Sweets	Commercial Sweets
Total lipids (%)	2.61 ± 0.09 [a]	34.4 ± 5.5 [b]
Total sugars (%)	17.1 ± 0.6 [a]	35.3 ± 2.7 [b]
Fibres (%)	5.87 ± 2.47 [a]	1.53 ± 0.72 [b]

Within lines, significant differences between measurements are shown with different letters ($p < 0.05$).

The results showed that using banana puree and peels as a substitute for butter and sugar when preparing cocoa-based sweets increased the nutritional value of the sweets by decreasing the total lipid and total sugar contents. The increase in fibre content was mainly due to the banana puree and peels. Banana flour is usually obtained after drying and milling the pulp of defect-containing fruits, containing an important fraction of dietary fibre (up to 15% in some varieties). This consists primarily of pectin (soluble fraction) and cellulose, lignin and hemicellulose (insoluble fraction) [8]. The peels present even higher amounts of fibre, mainly cellulose [8]. The fibre content increase can significantly impact gut health and microbiome population, impacting the immune system and preventing CVD risk factors [8].

3.2. Total Phenolic Content (TPC)

Regarding the TPC values of the products presented in Table 2, there was a slight increase in the TPC of the banana sweets compared with the commercial ones.

Table 2. TPC comparison between the prepared banana sweets and the commercial ones. The values are presented as mg of gallic acid equivalents per 100 g of fresh sample (mg GAE/100 g FW).

Parameters	Banana Sweets	Commercial Sweets
Total phenolic compounds (mg GAE/100 g)	290 ± 23	278 ± 11

This increase could be related to the presence of the banana puree and peels that were reported to present a high number of phenolic compounds (reported value for a commercial banana of 475 mg GAE/100 g FW (using the Folin–Ciocalteu method)) [9].

4. Conclusions

The results showed that the final product's dietary fibre and phenolic content increased, while the lipidic and total sugar content decreased. The obtained results showed that banana peels have great potential to be developed into beneficial functional foods and nutraceuticals.

As future work, the intention is to perform further analyses of the chemical composition of the products, such as the content of minerals and proteins, among others, and to study their biological characterization to assess their potential value as a functional food. Despite the nutrients offered by banana peels, assessing the antinutrient content, such as, is also necessary.

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