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Use of agricultural wastes to design natural products for the prevention of cardiovascular diseases †

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Abstract: Cardiovascular diseases (CVD) 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, 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 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 (CVD). 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. 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 since the population primarily consume 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, banana is the primary production on Madeira Island, but its peel, like other agricultural by-products, is usually rejected [3]. However, the banana peel has been consumed as food and medicine in some regions of the world, so possibly it can be transformed into functional food. Furthermore, it has been reported that banana peel presents a broad

range of bioactive chemical constituents and biological activities, which seems to support the proposed use of banana peel 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 in 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 disease, colon cancer, and obesity. In addition, prospective cohort studies show that high fibre intakes are linked to less probability of developing cardiovascular disease. 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 made 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

Bananas da Madeira were acquired in 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), then cooked in boiling water for 15 min. Finally, the whole fruit was reduced to puree, mixed with powdered cocoa, and moulded as small spheres.

Chocolate commercial sweets were bought in the supermarket for comparison purposes.

2.2. Proximate analysis

Several nutritional parameters of the sweets were analyzed, such as total lipids, total sugars, and fibres, using sample triplicates for each analysis.

According to Maia et al. [4], the determination of total lipid content was performed by the Folch method. The total sugar content was assayed through the phenol-sulfuric method described by Soares et al. [5], and the total fibre content according to Obregón-Cano et al. [6]. The analysis 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 analyzed in a microplate reader (BioTek Synergy HTX Multimode Reader, Winooski, Vermont, EUA) reported by Soares et al. [7]. All analysis were performed in triplicate.

2.4. Statistical analysis

Statistical analysis was performed using the software program IBMS SPSS for Windows, version 26 (IBM Corp., Armonk, N.Y., USA). The data normality was evaluated by Kolmogorov–Smirnov and Shapiro–Wilk tests. The parameters values were presented in % represented as mean ± standard deviation (SD), and comparisons between groups were made 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 contents analysis in mass percentage on a dry basis are shown in Table 1.

Table1. 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 by different letters ($p<0.05$).

The results show that using banana puree and peels as a substitute for butter and sugar when preparing cocoa-based sweets increases the nutritional value of the sweets by decreasing the total lipid and total sugar content. The increase in fibre content is mainly due to banana puree and peels. Banana flour is usually obtained after drying and milling the pulp from defect-containing fruits, containing an important fraction of dietary fibre (up to 15% in some varieties). It 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 the 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 is a slight increase in the TPC of the banana sweets compared with commercial ones.

Table 2. TPC comparison between the banana sweets prepared 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 can 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 (by Folin–Ciocalteu method)) [9].

4. Conclusions

The results show that the final product's dietary fibre and phenolic content increased while 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.

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

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