

Waste to Worth: Characterization of Apple Pomace Powder and its Incorporation into a Sustainable Snack

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Introduction

The **by-products of the food industry**, which are produced during the process of food manufacturing, are often regarded as waste, despite the fact that these by-products may contain **valuable compounds** with beneficial biological activity. For instance, the fruit and vegetable industry is responsible for the production of a wide range of by-products, including **pulp, peel, seeds, skin, pomace, husks, pods and stems**. Collectively, these by-products constitute the majority of agri-food by-products (Reguengo et al., 2022). The production of these substances in large quantities renders them a valuable resource, which is rich in **dietary fibre** and **bioactive compounds**. These include polyphenols, carotenoids and glucosinolates, amongst others. Consequently, it may be advantageous for the food sector to valorise these by-products in the development of **high-nutritional-value ingredients** that align with **sustainability** and the **circular economy principles** (Rațu et al., 2023; Mateos-Aparicio & Matias, 2019).

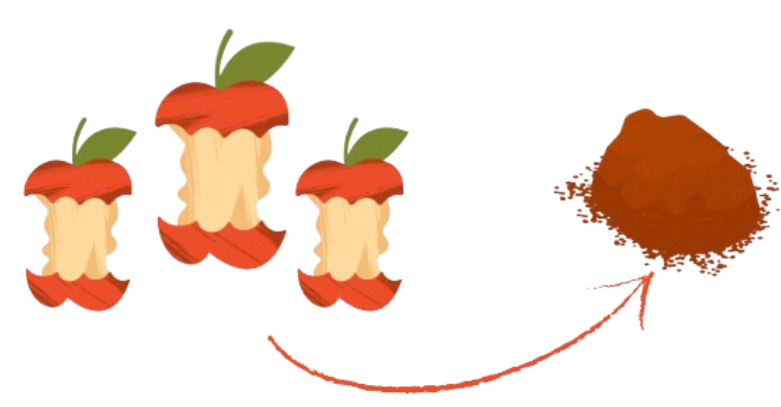
Objectives

The primary objective of this study was to analyse apple pomace powder in terms of proximate composition, prebiotic potential, antioxidant capacity and antidiabetic activity. The second objective of this study was to develop a snack using apple pomace powder, with a focus on its nutritional composition, physicochemical properties, and bioactive potential, as a sustainable strategy for reducing waste in the food industry and concomitantly adding value to food.



Methods

Production of Apple Pomace Powder



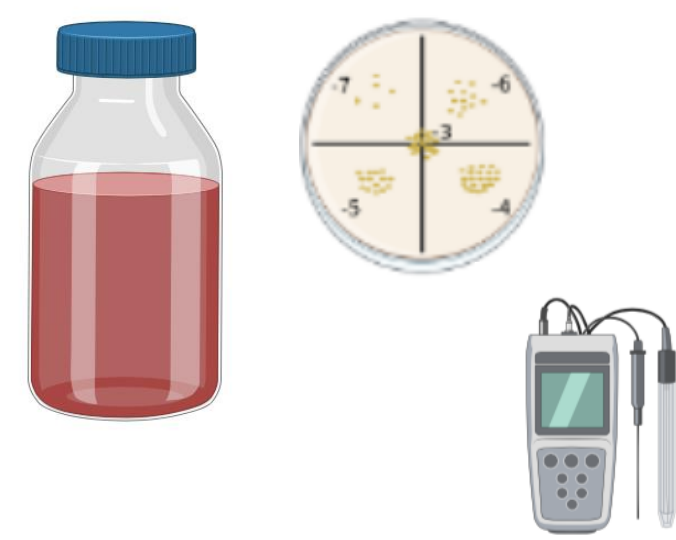
Grinding of Apple Pomace and Subsequent Drying

Proximate Composition Analysis



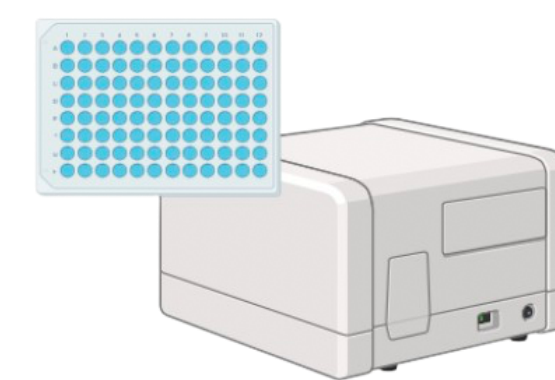
Determination of moisture, total protein, total fat, ash, total carbohydrates and dietary fibre) using AOAC methods (AOAC Official Methods of Analysis, 2000)

Prebiotic Potential Assay



Evaluation of prebiotic potential of apple pomace powder on different *Lactobacillus* strains according to Sousa et al. (2015).

Antioxidant and Antidiabetic Activities



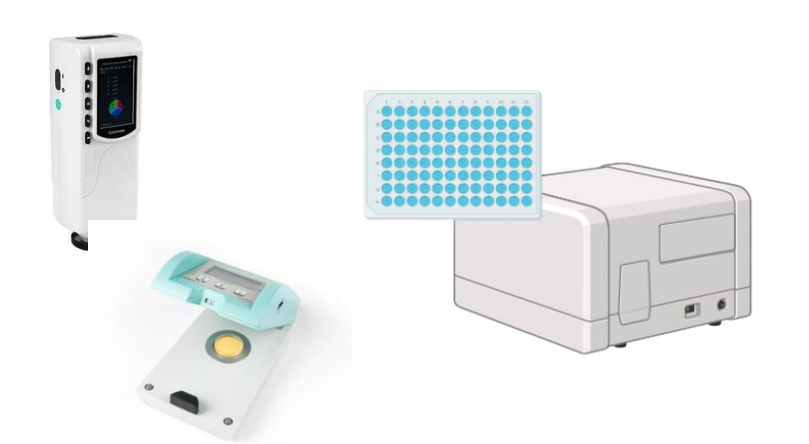
Determination of Total Phenolic Content using Folin-Ciocalteu Method (Coscueta et al., 2018), Antioxidant Activity through ABTS Assay (Gonçalves et al., 2009) and Antidiabetic Activity through the inhibition of α -glucosidase (Kwon et al., 2008)

Production of Apple Based Snack and Characterization



Mixing of 4 ingredients: Apple Puree, Apple Pomace Powder, Egg and Baking Powder Baking at 200 °C for 10 min, followed by 10 min at 140 °C

Characterization of the Apple Pomace Snack



Determination of physicochemical parameters (water activity, texture, and colour) and bioactive potential according to previously described methods

Results

Characterization of the Apple Pomace

Table 1 – Proximal Composition of Apple Pomace Powder

Parameter	g/ 100 g
Fat	1.1
Total Carbohydrates	48.8
Total Dietary Fibre	32.3
Total Protein	2.9
Moisture	8.6 g
Ash	1.4

Apple pomace powder is rich in total dietary fibre, while having a low fat content

Table 2 – Bioactive Potential of Apple Pomace Powder

Total Phenolic Content (mg of GAE/g of sample)	Antioxidant Activity (μ mol of Trolox equivalent/g of sample)	Antidiabetic activity (α -glucosidase inhibition (%))
1.491 \pm 0.129	7.528 \pm 0.193	72.47 \pm 7.951

The apple pomace powder exhibited a low-moderate level of total phenolic content, with a proportionally moderate antioxidant activity and high antidiabetic activity.

Table 3 – Fold change in CFU/g of the Prebiotic Potential Assay after 24h in log CFU/g

Condition	<i>L. rhamnosus</i> GG	<i>L. rhamnosus</i> R11	<i>L. casei</i> 01
Positive Control	0.699	0.859	0.403
Negative Control	0.190	0.064	0.189
Pomace Powder 2%	1.679	1.712	0.659
Pomace Powder 6%	3.278	3.065	1.609

Apple pomace powder shows prebiotic potential for all three *Lactobacillus* strains evaluated evidenced by an increase in CFU (similar or higher than positive control) and a decline in pH, reflecting metabolic activity over a 24-hour period.

Characterization of the Apple Pomace Snack



The proposed recipe yielded a product with characteristics reminiscent of grissino, thus designated 'Apple Chewies'.

The product exhibited:

- a reddish hue accompanied by a golden tint.
- a crispy exterior that is indicative of a well-formed chewie texture on the interior.

Table 4 – Bioactive Potential of Apple Pomace Snack

Total Phenolic Content (mg of GAE/g of sample)	Antioxidant Activity (μ mol of Trolox equivalent/g of sample)
2.954 \pm 0.384	15.682 \pm 2.164

The final product exhibited a low-moderate level of total phenolic content, with a proportionally moderate antioxidant activity.

Conclusions

Apple pomace powder is a nutritionally valuable, eco-friendly, and multifaceted ingredient that has significant potential for use in the development of functional foods.

Its incorporation into snack products, such as apple chewies, was shown to enhance the bioactive value of the product, while providing an effective example of the process of upcycling agro-industrial by-products into value-added products.

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