

Enriched Low-Glycemic Ice Cream with Wild *Prunus spinosa* Fruit Powder as a Source of Polyphenols with Antidiabetic Potential

Alina Manuela ROTARU¹, Silviu MĂNTĂILĂ¹, Nicoleta BALAN¹, Mihaela COTĂRLEȚ¹, Dănuț Gabriel MOCANU¹, Oana Viorela NISTOR¹, Doina Georgeta ANDRONOIU^{1*}

¹"Dunărea de Jos" University of Galați, Faculty of Food Science and Engineering, 111 Domească Street, 800201, Galați, Romania

1 ABSTRACT

Diabetes currently affects approximately 10.5% of the adult population (ages 20–79), and estimates indicate an increase to 12.2% by 2045. The development of functional foods with antidiabetic and antioxidant potential, based on the use of wild fruits and low glycemic index sweeteners, may contribute to the prevention of this condition.

The present study aimed to characterize the polyphenolic profile of wild *Prunus spinosa* fruit powder, to evaluate its antidiabetic potential, and to incorporate it into an ice cream formulation.

The analysis revealed the presence of 17 phenolic compounds, with catechin ($122.38 \pm 0.53 \mu\text{g/mL}$), epicatechin ($6.59 \pm 0.32 \mu\text{g/mL}$), and chlorogenic acid ($11.12 \pm 0.90 \mu\text{g/mL}$) as the predominant constituents. α -amylase inhibitory activity was observed at a concentration of $6.59 \pm 0.01 \text{ mg extract/mL}$ (IC_{50}), while in silico analysis suggested a possible competitive inhibition mechanism.

Principal component analysis showed that the first two components explain 87.8% of the variation in the color parameters, polyphenolic profile, and antioxidant activity of the ice cream formulated using different proportions of powder (2% and 6%), cream (10% and 30%), and xylitol (3.5%).

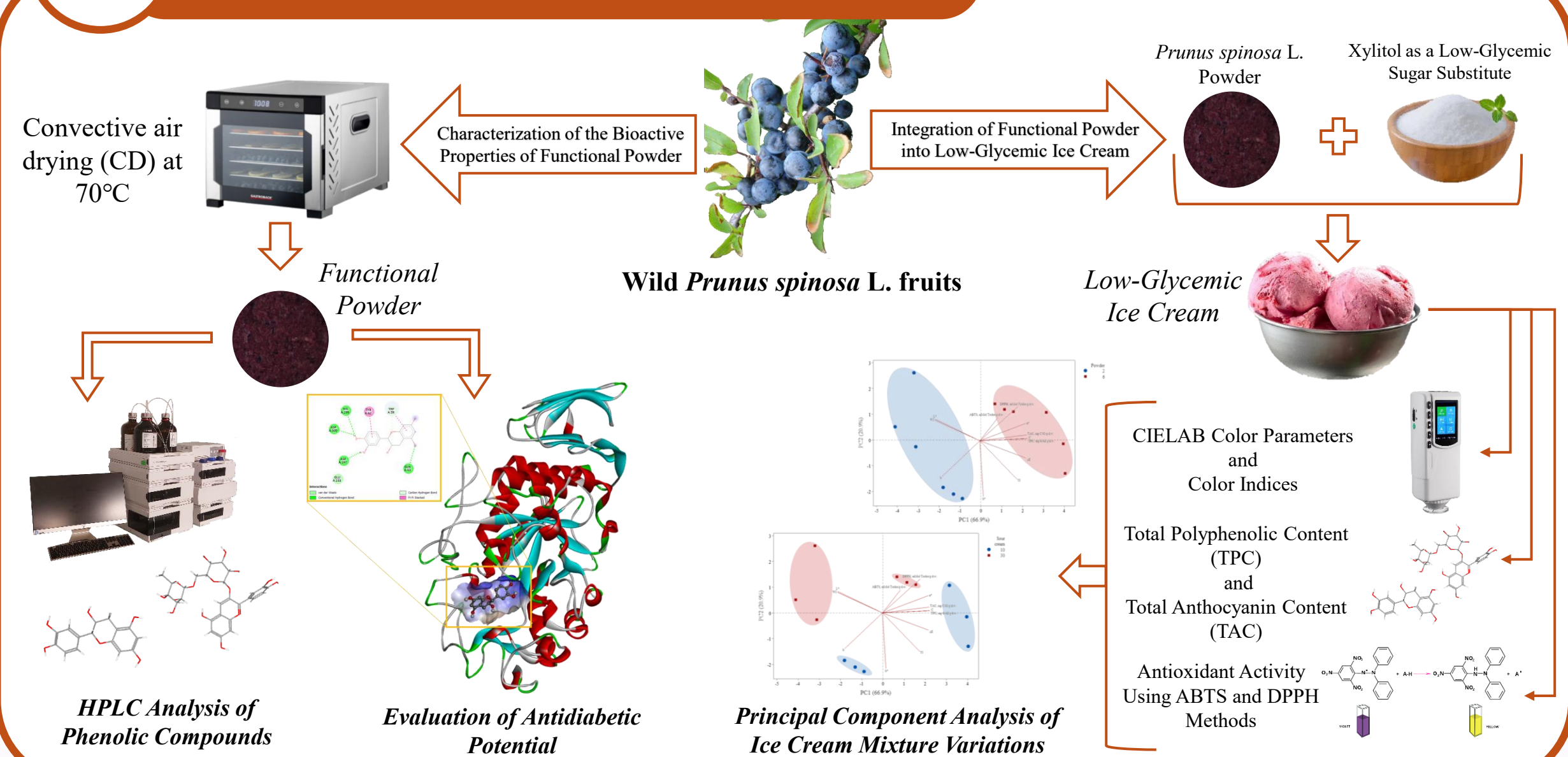
The results support the development of a functional ice cream using wild *Prunus spinosa* powder as a natural alternative to synthetic colorants, providing antioxidant properties and potential antidiabetic effects. Moreover, the substitution of sugar with xylitol represents a viable strategy for the formulation of products intended for people with diabetes.

2 INTRODUCTION

The food industry is increasingly oriented toward the development of functional products, driven by the incorporation of natural ingredients derived from wild forest resources. At the same time, there is growing interest in identifying alternative sweeteners to reduce sugar intake.

In this context, the present study investigates the incorporation of wild *Prunus spinosa* fruits and xylitol in the development of a low glycemic index ice cream, aiming to position the product within the category of value-added functional foods.

3 MATERIALS AND METHODS



4 RESULTS AND DISCUSSION

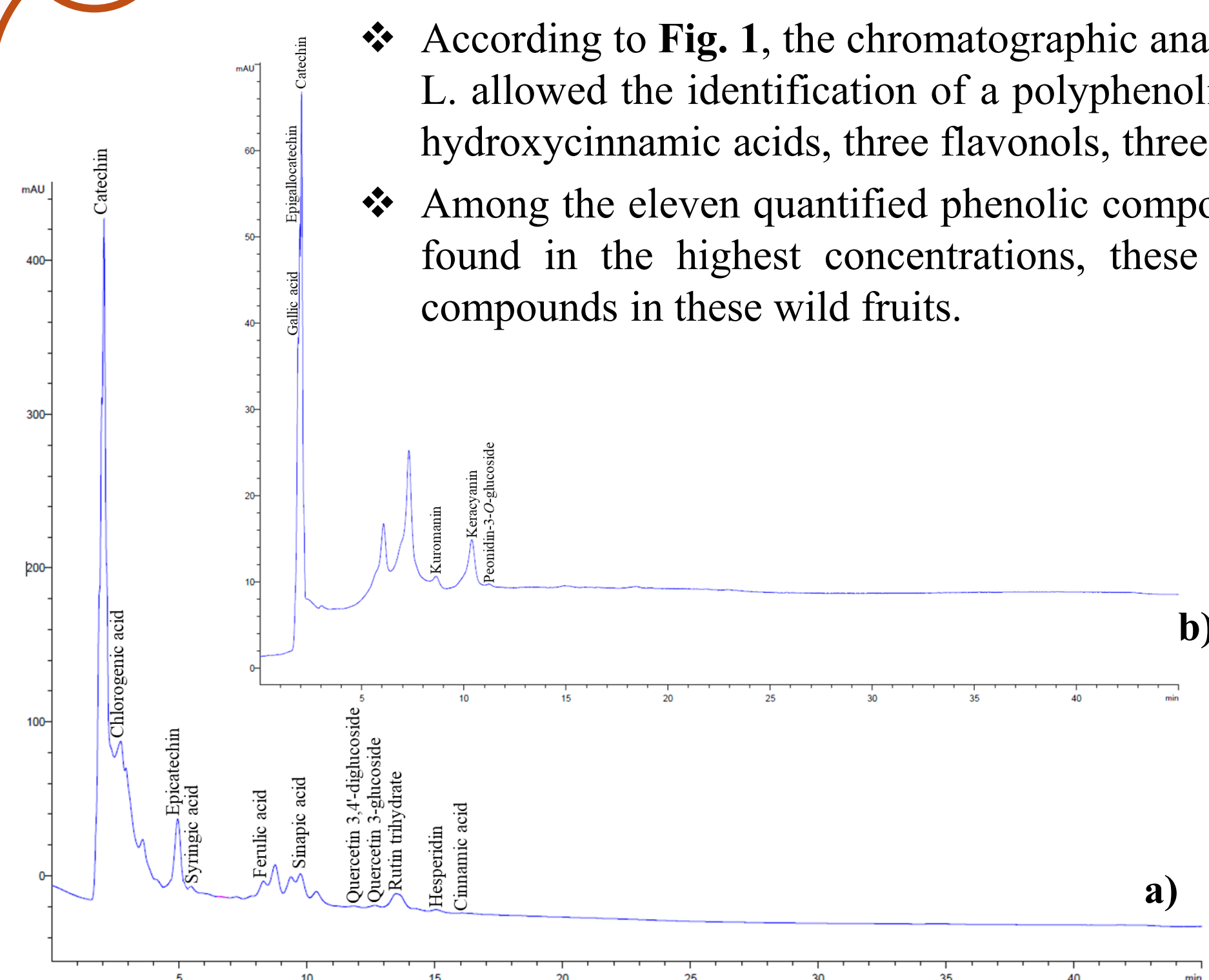


Figure 1. Polyphenolic compounds quantified at 320 nm (a) and 520 nm (b) in *Prunus spinosa* L. concentrated extract.

- According to Fig. 1, the chromatographic analysis of the concentrated extract of wild *Prunus spinosa* L. allowed the identification of a polyphenolic profile consisting of two hydroxybenzoic acids, four hydroxycinnamic acids, three flavonols, three flavan-3-ols, three anthocyanins, and one flavanone.
- Among the eleven quantified phenolic compounds, catechin, epicatechin, and chlorogenic acid were found in the highest concentrations, these being reported in the literature as the predominant compounds in these wild fruits.

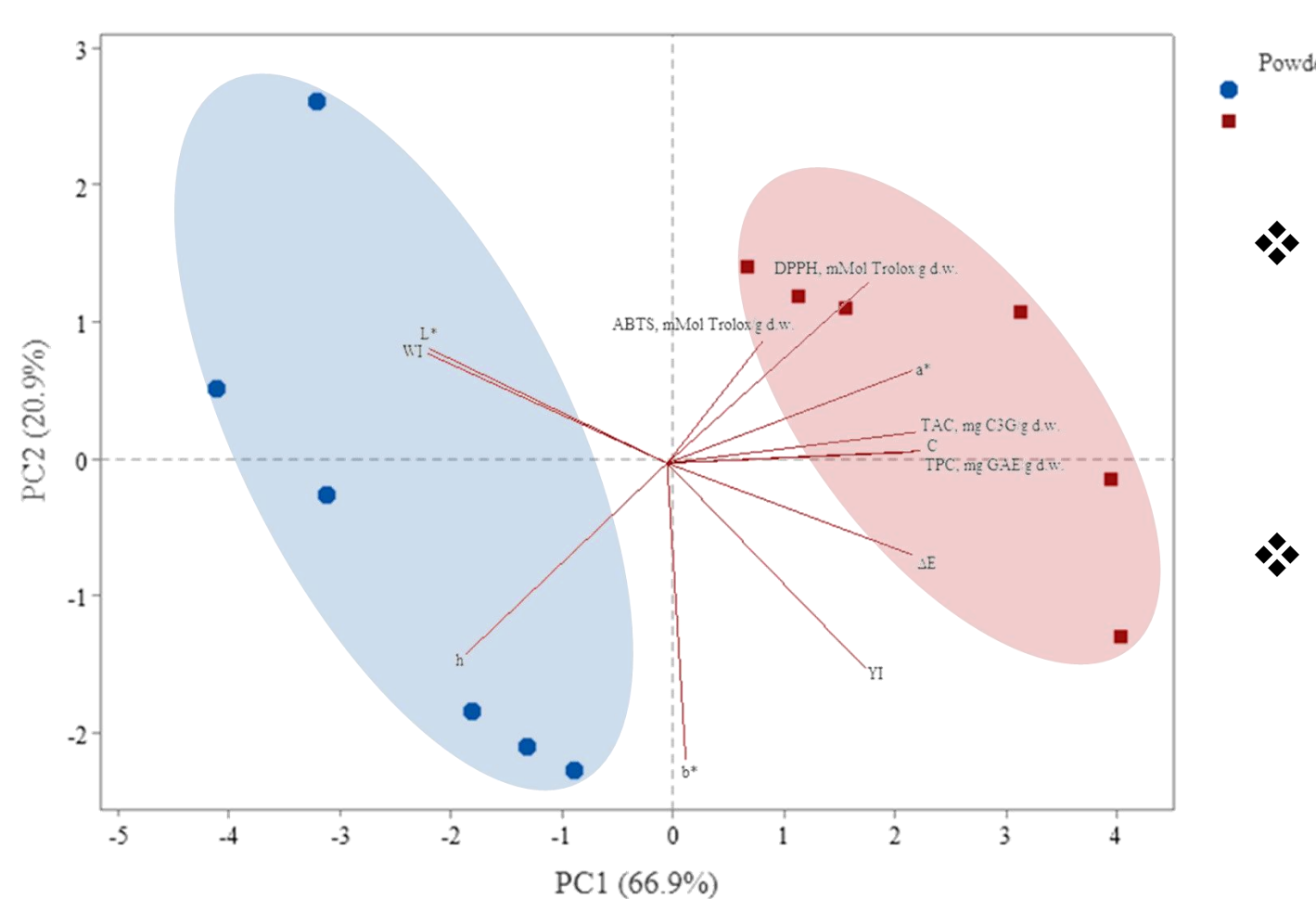


Figure 3. PCA loading and score plots illustrating the clustering of samples according to powder concentration, based on PC1 and PC2.

Table 1. Eigenvalue analysis of the correlation matrix computed for the dependent variables

	PC ₁	PC ₂	PC ₃	PC ₄	PC ₅	PC ₆	PC ₇
Eigenvalue	8.03	2.50	0.89	0.26	0.15	0.09	0.03
Proportion	66.9	20.9	7.4	2.2	1.5	0.9	0.3
Cumulative	66.9	87.8	95.2	97.3	98.8	99.7	100

- According to Table 1, the first two principal components explained 87.8% of the variation in color parameters and bioactive compounds in low glycemic index ice cream and were used to generate the plot in Fig. 3.
- The addition of 2% and 6% wild *Prunus spinosa* L. powder led to sample clustering: samples with low powder content (quadrants 1 and 4) showed higher lightness, yellowness, and whiteness index, while those with higher powder content (quadrants 2 and 3) exhibited increased color intensity, total color difference, redness, and higher levels of bioactive compounds.

- The antidiabetic potential of the concentrated extract on α -amylase showed that $6.59 \pm 0.01 \text{ mg/mL}$ was required to inhibit 50% of enzymatic activity, indicating moderate inhibitory capacity. This relatively high value may also be influenced by the presence of reducing sugars in the extract.
- The three compounds present in the highest concentrations in the wild *Prunus spinosa* L. extract were further used in in silico simulations of enzyme inhibition. As shown in Fig. 2, catechin (-9.0 kcal/mol) and chlorogenic acid (-8.0 kcal/mol) exhibited the lowest docking energy values, interacting with amino acid residues located in the active site of the enzyme (Asp³⁰⁰, Asp¹⁹⁷, and Glu²²³), which are considered essential for catalytic activity.
- In contrast, epicatechin (Fig. 2a) showed a docking energy value of -9.1 kcal/mol and was located within the cavity corresponding to the enzyme's active site, in close proximity to amino acids essential for catalytic activity.

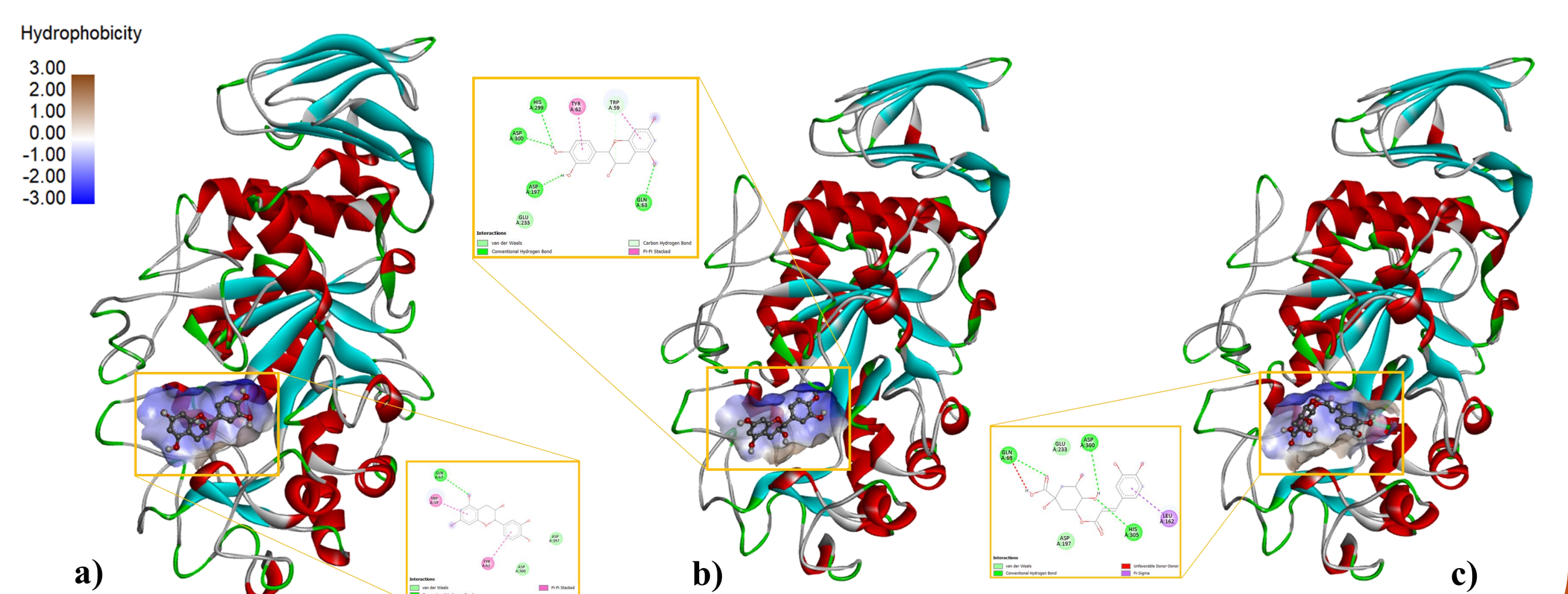


Figure 2. Binding modes of epicatechin (a), catechin (b), and chlorogenic acid (c) in the active site of α -amylase

5 CONCLUSIONS

- The findings indicate that catechin, epicatechin, and chlorogenic acid are the dominant phenolic compounds in these wild fruits and likely play a key role in their biological activity. Their interaction with the enzyme suggests a possible mixed inhibition mechanism, contributing to reduced enzymatic function.
- Additionally, the incorporation of fruit powder into ice cream formulations not only improves color attributes but also enhances the content of bioactive compounds, supporting its potential use in developing functional foods that meet current consumer preferences.