

## CYNARA CARDUNCULUS L. BY-PRODUCTS AS A SUSTAINABLE SOURCE OF BIOACTIVE COMPOUNDS FOR INDUSTRIAL APPLICATIONS

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### Introduction

#### Valorisation of agro-industrial by-products

- By-products are rich in bioactive compounds for food, cosmetic, and pharmaceutical industries
- Promotes sustainability and circular economy

#### *Cynara cardunculus* L. (Cardoon)

- Belongs to the Asteraceae family Resilient and multipurpose crop
- Leaves are the main by-product generated
- Abundant in bioactive compounds that exhibit antioxidant and antimicrobial activities.

#### Aim

- Characterize the antioxidant and antimicrobial properties of fresh and dried *Cynara cardunculus* L. var. *altilis* leaves
- Compare bioactive compound extraction using methanol vs. ethanol and evaluate the impact of a greener solvent on their activity



### Material & Methods

#### Sample and extract preparation

- *Cynara cardunculus* var. *altilis* DC fresh and dry leaves
  - Solid-liquid extraction with methanol and ethanol
- Oven-dried at 35 °C for 48 h**

#### Antioxidant Assays

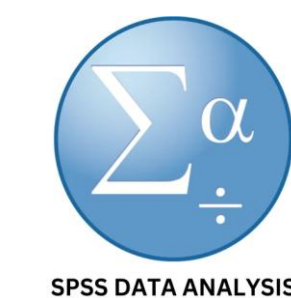
- Free Radical DPPH Inhibition System Assay
- β-Carotene Bleaching Assay
- Total Phenolic Content (TPC)
- Total Flavonoids Compounds (TFC)
- Phenolic profile by UHPLC-ToF-MS

#### Antimicrobial Assays

- Minimum Inhibitory Concentration (MIC)
- Minimum Bactericidal Concentration (MBC)
- Antifungal activity against *Aspergillus* spp. (mycelial growth)

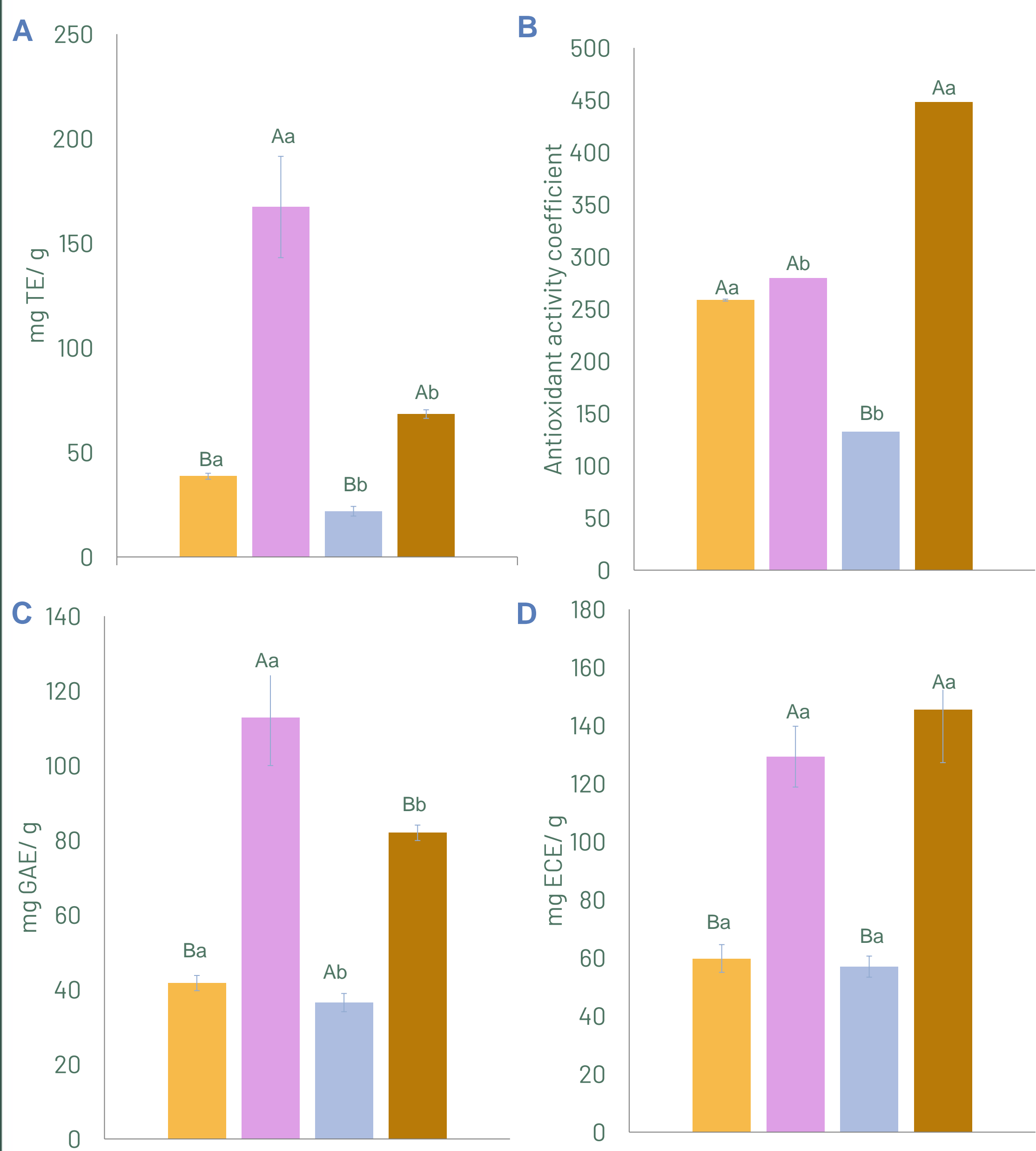


All assays done in triplicates



One Way ANOVA  
Tukey Test

### Results and Discussion



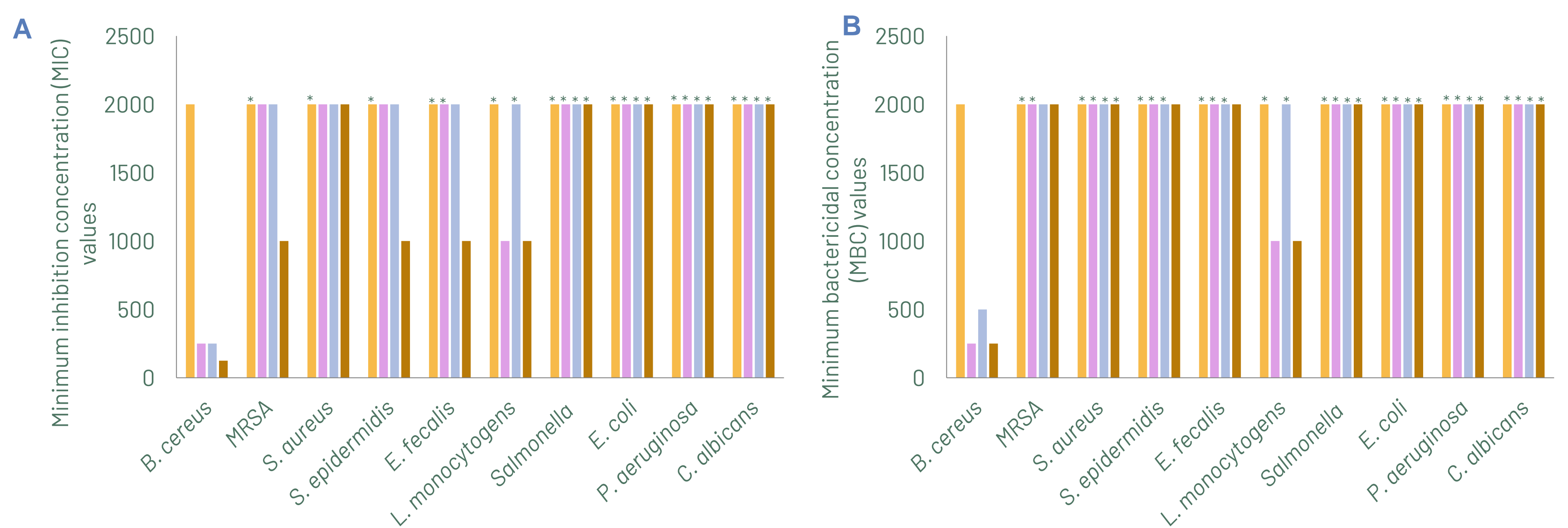
**Figure 1** – Free radical DPPH inhibition system (A), β-Carotene bleaching assay (B), total phenolic content (C), and total flavonoid content (D) of fresh and dried cultivated cardoon leaf extracts results. Results expressed as mean ± SD. Different capital letters indicate significant differences among samples ( $p < 0.05$ ), and lowercase letters indicate differences between extraction solvents ( $p < 0.05$ ).

Legend: Fresh Cultivated Cardoon Leaves (Methanol) (orange), Fresh Cultivated Cardoon Leaves (Ethanol) (blue), Dry Cultivated Cardoon Leaves (Methanol) (purple), Dry Cultivated Cardoon Leaves (Ethanol) (brown)

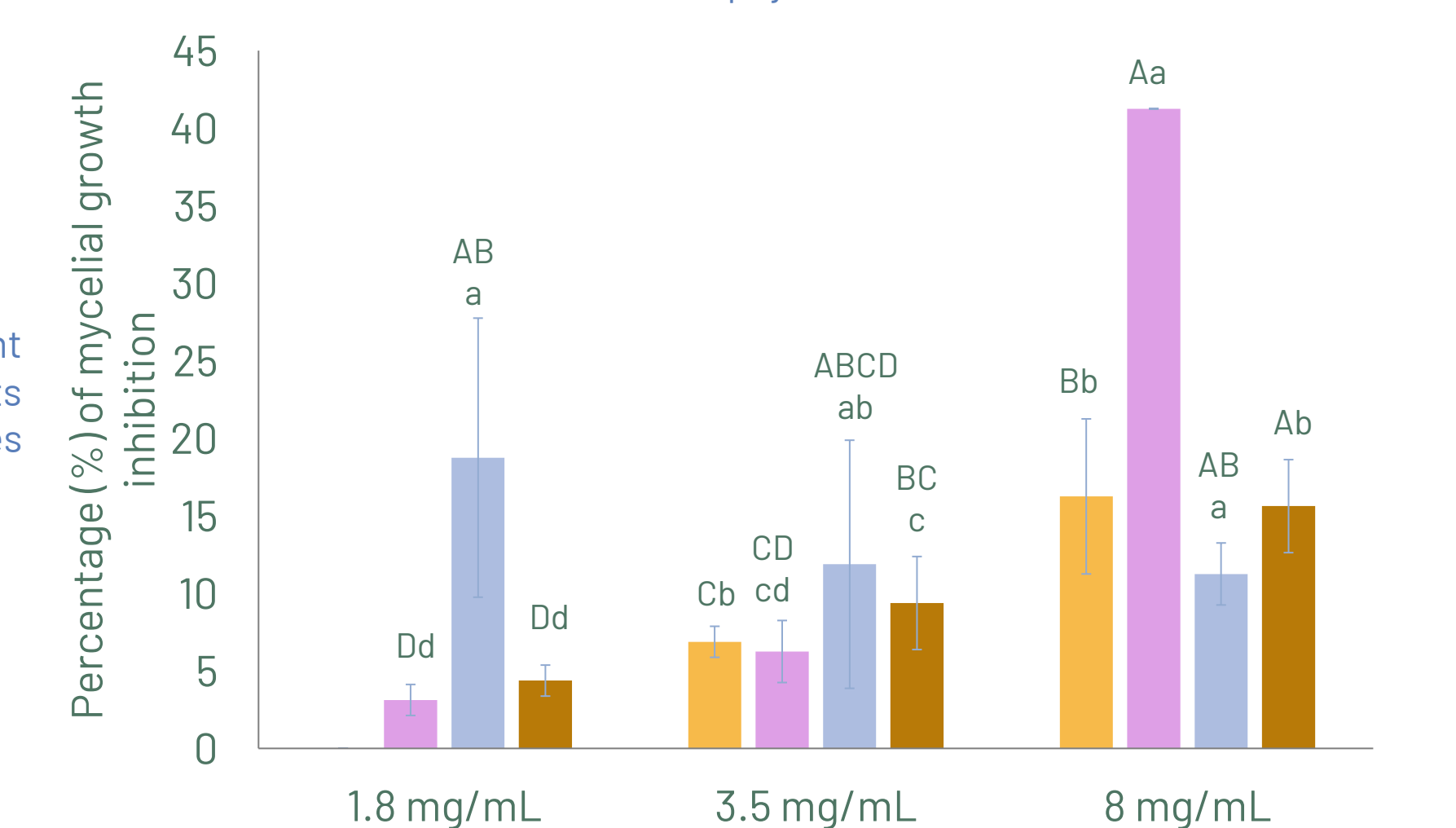
- Drying significantly enhanced antioxidant capacity, TPC, and TFC in cultivated cardoon leaf extracts.
- Methanolic extracts showed higher antioxidant activity, while ethanolic extracts performed better in the β-carotene assay.

**Table 1** – Quantification of phenolic compounds (mg/ g extract) in the different extracts

Phenolic Compounds	Fresh cardoon leaves	Dry cardoon leaves
Apigenin	0.089 ± 0.001 <sup>c</sup>	0.137 ± 0.003 <sup>b</sup>
Luteolin	1.751 ± 0.019 <sup>b</sup>	0.143 ± 0.000 <sup>a</sup>
Chlorogenic acid	3.270 ± 0.011 <sup>a</sup>	0.015 ± 0.001 <sup>c</sup>
Neochlorogenic acid	0.046 ± 0.000 <sup>d</sup>	0.007 ± 0.001 <sup>d</sup>
p-coumaric acid	0.006 ± 0.001 <sup>c</sup>	0.016 ± 0.001 <sup>e</sup>



**Figure 2** – Minimum inhibitory concentration (MIC) (µg/mL) (A) and Minimum bactericidal concentration (MBC) (µg/mL) (B) of fresh and dried cultivated cardoon leaves extracts. MRSA – Methicillin resistant Staphylococcus aureus. \* MIC value > 2000 or MBC > 2000.



**Figure 3** – Percentage (%) of *Aspergillus fumigatus* mycelial growth inhibition by fresh and dried cardoon leaves extracts, after 16 days at 25 °C. Different capital letters indicate significant differences among samples ( $p < 0.05$ ), and lowercase letters indicate differences between extraction solvents ( $p < 0.05$ ).

- Despite the reduction of some phenolic compounds after drying, dried extracts exhibited stronger antioxidant and antimicrobial activity.
- Ethanolic dried extracts were more effective against *B. cereus*, while no significant effects were observed on Gram-negative bacteria.
- Antifungal activity was also improved by drying, with methanolic extracts showing the strongest inhibition against *A. fumigatus*.

### Conclusions

The drying process enhanced the bioactive potential of cultivated cardoon leaves, improving their antioxidant, antimicrobial, and antifungal properties. These effects are associated with higher levels of phenolic and flavonoid compounds. The choice of solvent also influenced the results, with methanol generally showing stronger activity. Overall, drying and solvent selection are key factors to add value to cardoon leaves, supporting their use as sustainable sources of bioactive compounds.

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