Novel chitosan/alginate hydrogels as carriers of phenolic-enriched extracts from saffron floral by-products using natural deep eutectic solvents as green extraction media

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Background

Saffron (*Crocus sativus* L.) is used in traditional medicine to treat various diseases and it is employed as a spice for its organoleptic characteristics. For its production, only flower stigmas are used, but tepals are discarded, generating several hundred tons of waste, since around 350 kg of tepals (230,000 flowers) are necessary to produce 1 kg of saffron. Consequently, the valorization of saffron floral by-products by developing stable functional extracts to use as ingredients leads to the environmental impact minimization.

Objectives

The main aim of this study was to develop innovative green extraction processes from saffron floral by-products by using natural deep eutectic solvents and ultrasound-assisted extraction as ecological extraction method, and to improve the stability of the optimal extracts by their incorporation into chitosan/alginate hydrogels.

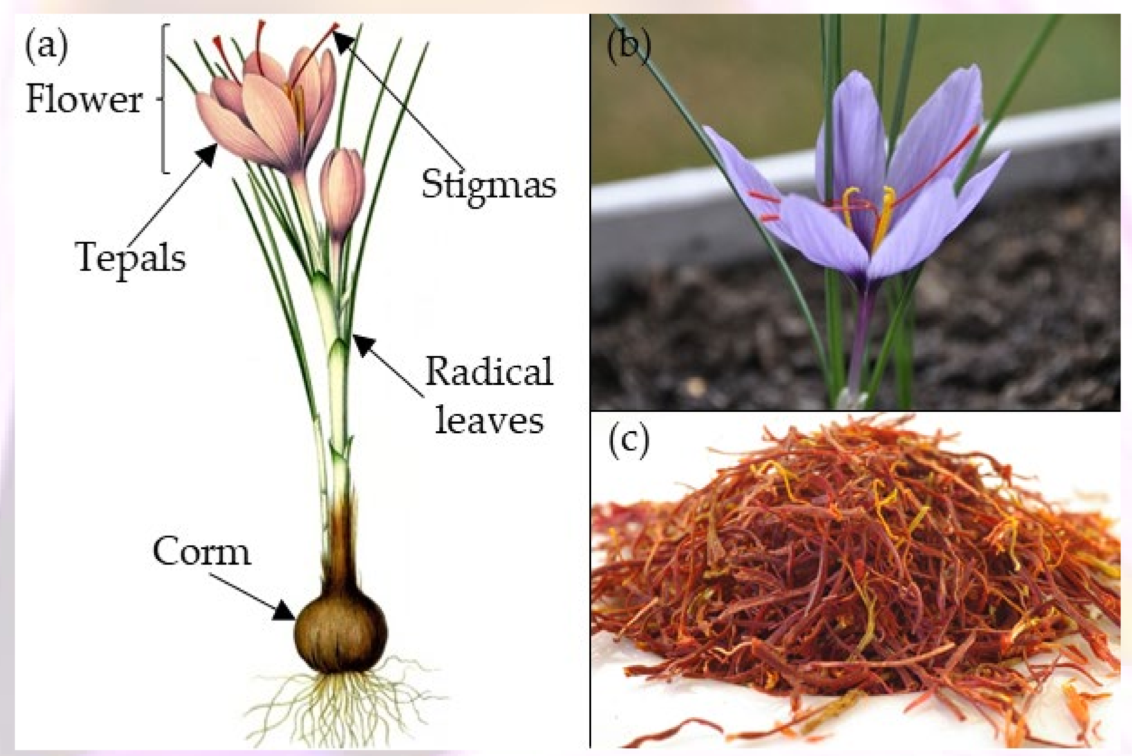
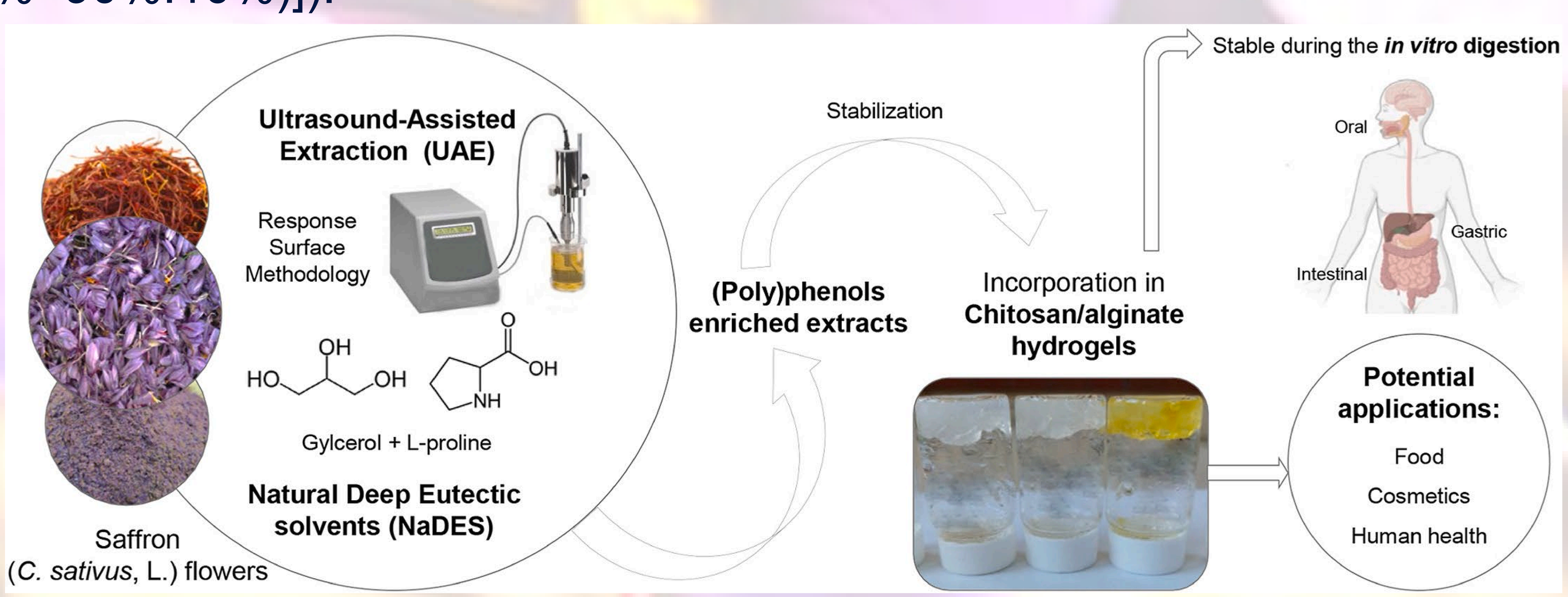


Figure 1. (a) Diagram of the different parts of saffron plant; (b) The saffron flower; (c) Dry stigmas used as saffron spice.

Material and methods

- ✓ Saffron flowers were from Spain and saffron stigmas from Greece.
- ✓ Response surface methodology was used to optimize UAE process parameters: time (5−35 min), power (60−180 W) and NaDES (Glycerol:L-proline)/water ratio ([v:v (30%:70%−90%:10%)]).



Results

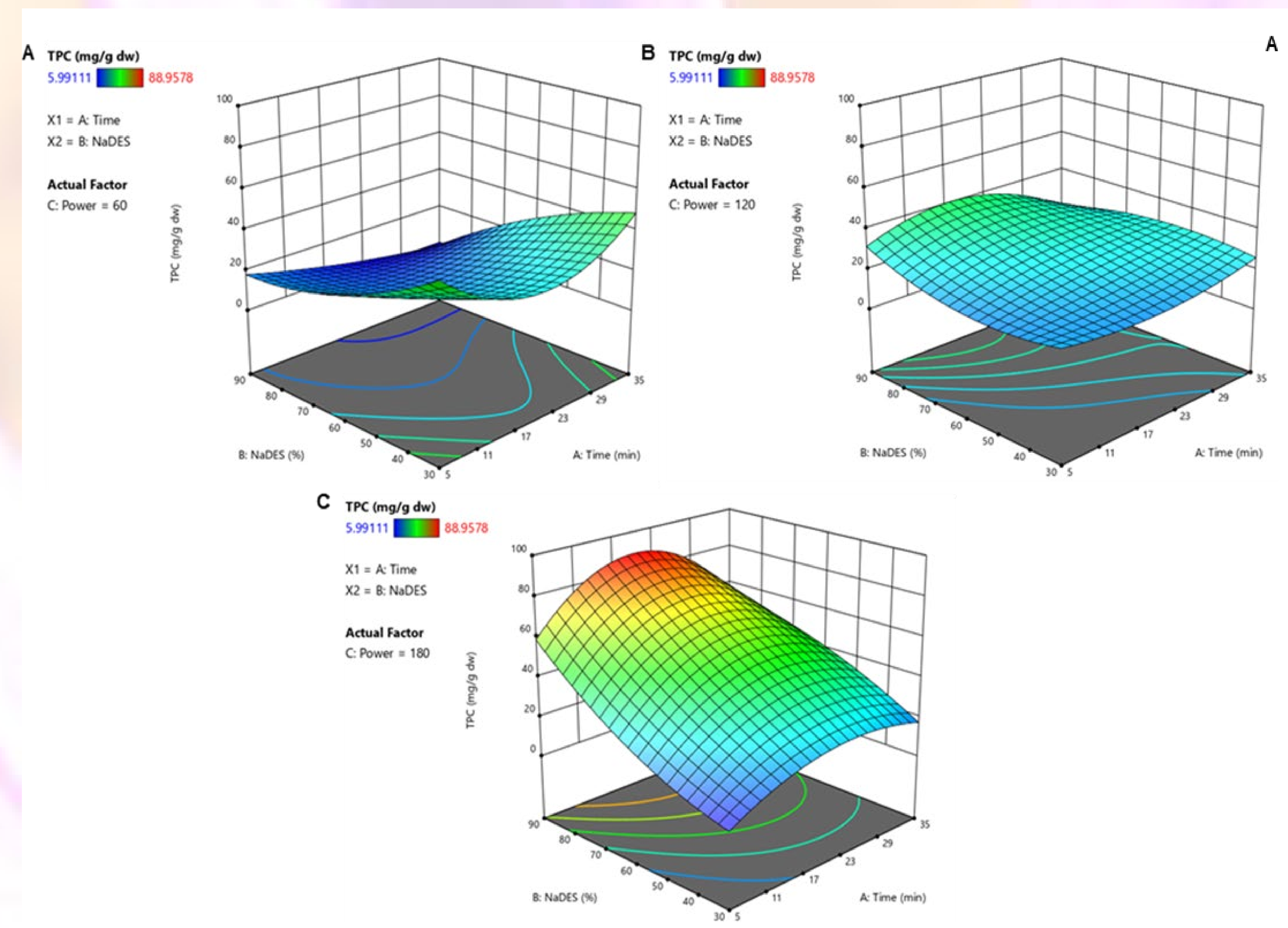


Figure 2. Response surface plot representing the effects of time, temperature and NaDES solvent ratio on Total Phenolic Content (TPC) from saffron floral by-products. (A) Power was kept constant at 60 W. (B) Power was kept constant at 120 W. (C) Power was kept constant at 180 W. Lower values are represented in blue and higher values in red.

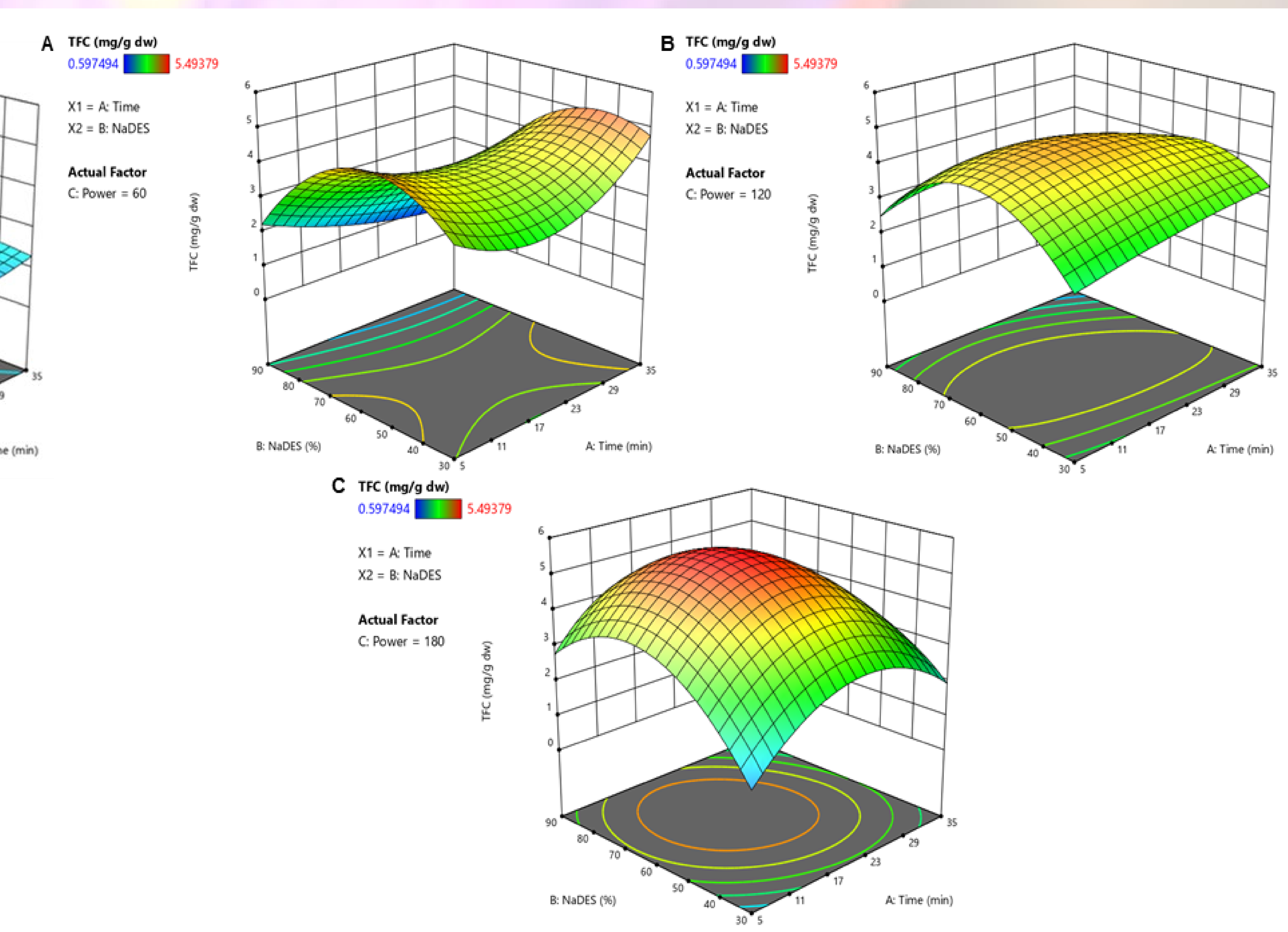


Figure 3. Response surface plot representing the effects of time, temperature and NaDES solvent ratio on Total Flavonoid Content (TFC) from saffron floral by-products. (A) Power was kept constant at 60 W. (B) Power was kept constant at 120 W. (C) Power was kept constant at 180 W. Lower values are represented in blue and higher values in red.

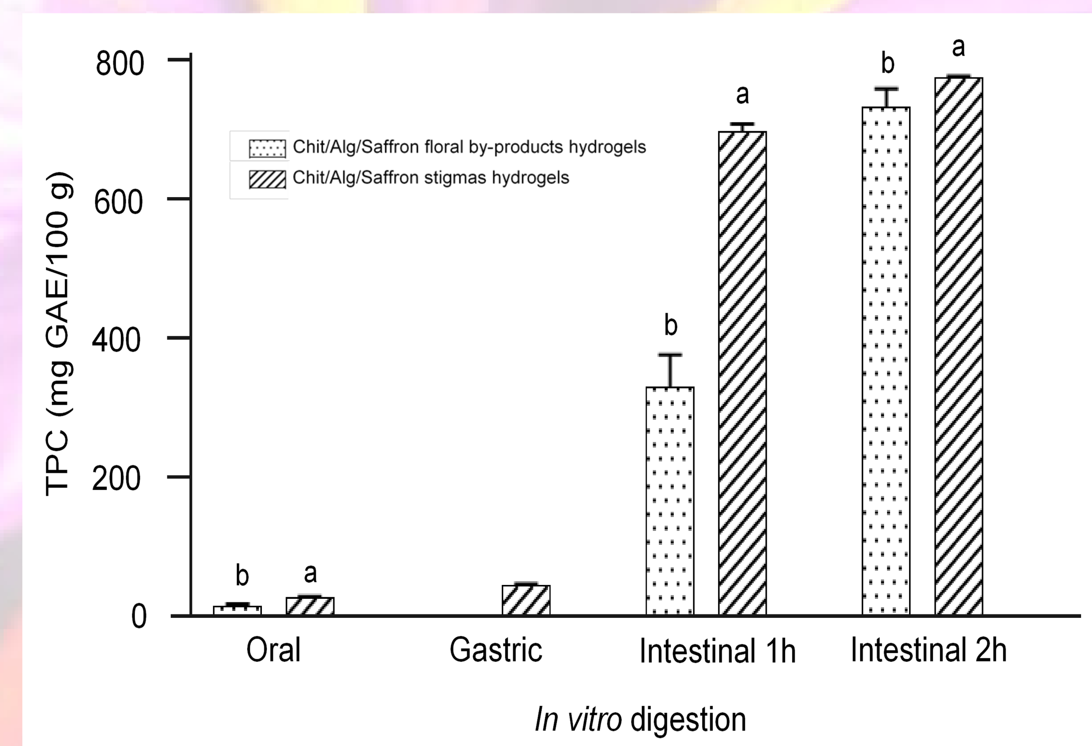


Figure 4. Total Phenolic Content (TPC) of chitosan/alginate hydrogels during the oral and gastrointestinal *in vitro* digestion. The error bars represent the standard deviation and different lowercase letters indicate statistically significant differences ($p \leq 0.05$) for each sample in each phase (n = 3).

Conclusions

NaDES combined with UAE was an efficient green strategy in order to obtain high added value compounds of saffron flowers and the novel chitosan/alginate hydrogels were suitable matrices to incorporate bioactive extracts which may be used as promising candidates for various applications like food or cosmetic, among others.