ANTIOXIDANT SYNERGY OF MEDITERRANEAN HERBS AND ALGAL POLYSACCHARIDES: POTENTIAL IN THE DEVELOPMENT OF FUNCTIONAL BEVERAGES

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INTRODUCTION

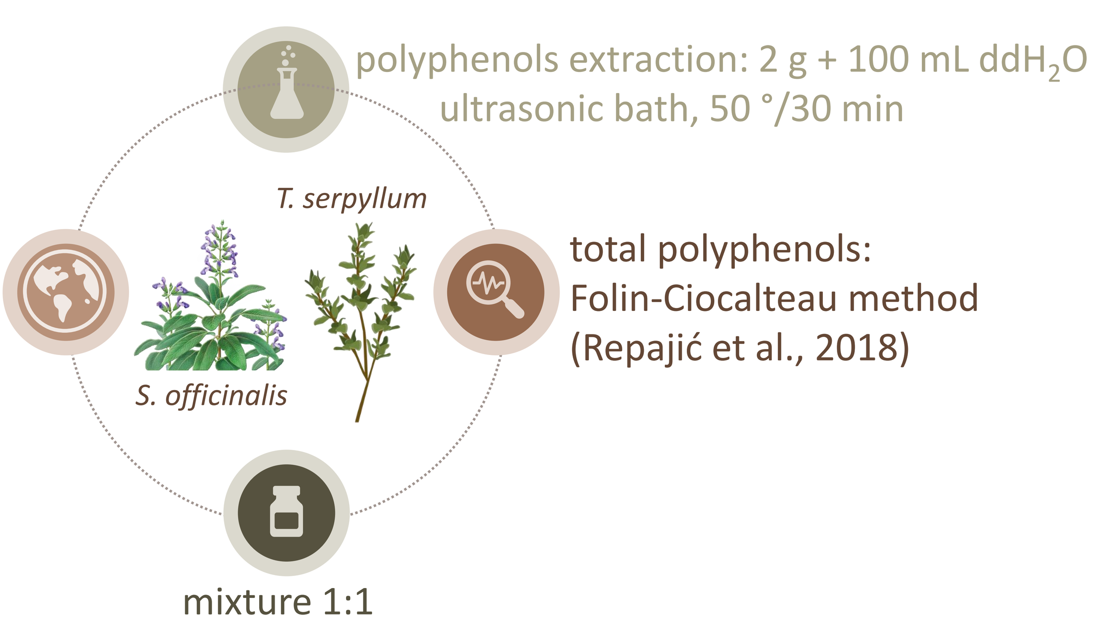
Herbal extracts and algae contain a wide range of bioactive molecules with positive effects on human health. However, their application in the production of functional beverages is still insufficient despite the fact that various plant species and their potential use as ingredients in different categories of functional beverages have been explored. *Salvia officinalis* and *Thymus serpyllum* are aromatic herbs from the Lamiaceae family native to the Mediterranean area. Due to their high antioxidant capacity, which is directly correlated with a high content of various polyphenolic and volatile compounds (Mrkonjić et al., 2021), they present a valuable source for the production of functional beverages. On the other hand, green alga *Ulva lactuca* is an important source of sulfated polysaccharide ulvan, while brown algae *Fucus virsoides* and *Cystoseira barbata* are important sources of sulfated polysaccharide fucoidan. All of these polysaccharides show a wide range of biological activities such as antioxidant, anti-inflammatory and antitumor, however they are strongly dependent on chemical composition of polysaccharides.

AIM

To evaluate antioxidant capacity of *S. officinalis* and *T. serpyllum* extracts, polysaccharides of *U. lactuca*, *F. virsoides* and *C. barbata* and their mixtures in order to test the possibility in the development of functional beverage on the basis of selected Mediterranean herbs extracts enriched with algal polysaccharides.

MATERIALS & METHODS

I)



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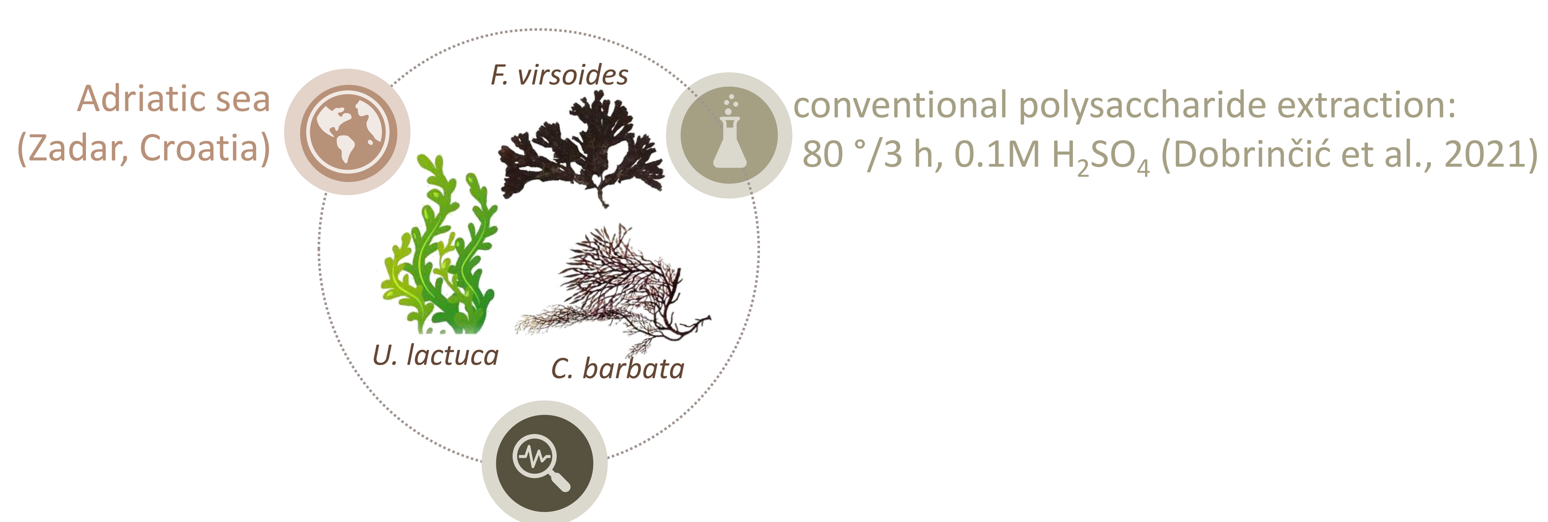
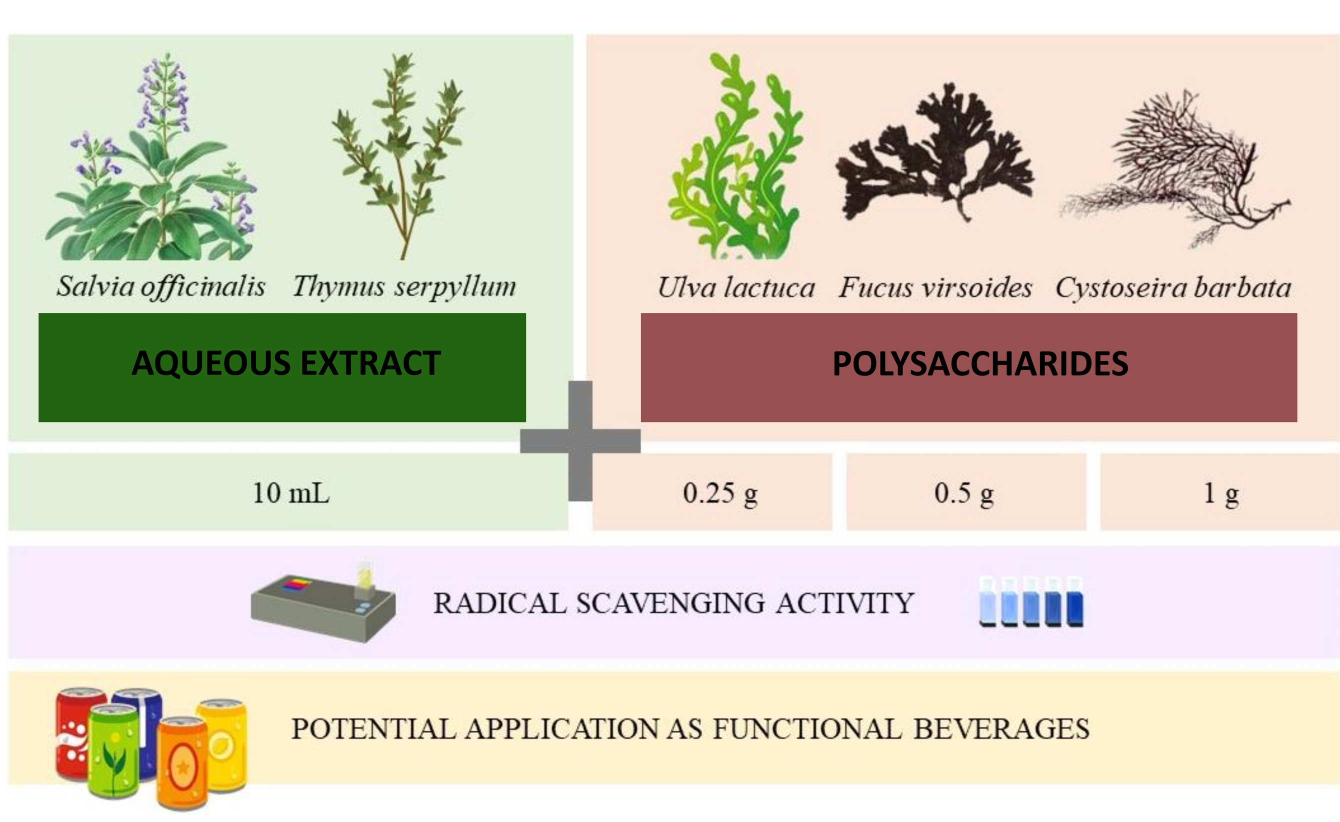


- total sugars: colorimetric phenol-sulfuric acid method (Dubois et al., 1956)
- L-fucose: L-cysteine colorimetric assay (Dische & Shettles, 1948)
- sulfate content: acid hydrolysis (1M HCl at 105 °C/5 h); turbidimetric BaCl$_2$-gelatin method (Dodgson & Price, 1962)
- uronic acid: modified sulfamate/*m*-hydroxydiphenyl colorimetric method (Filisetti-Cozzi & Carpita, 1991)

III)



IV) Statistical analysis: one-way ANOVA + Tukey's HSD test ($p \leq 0.05$)

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RESULTS & DISCUSSION

I)

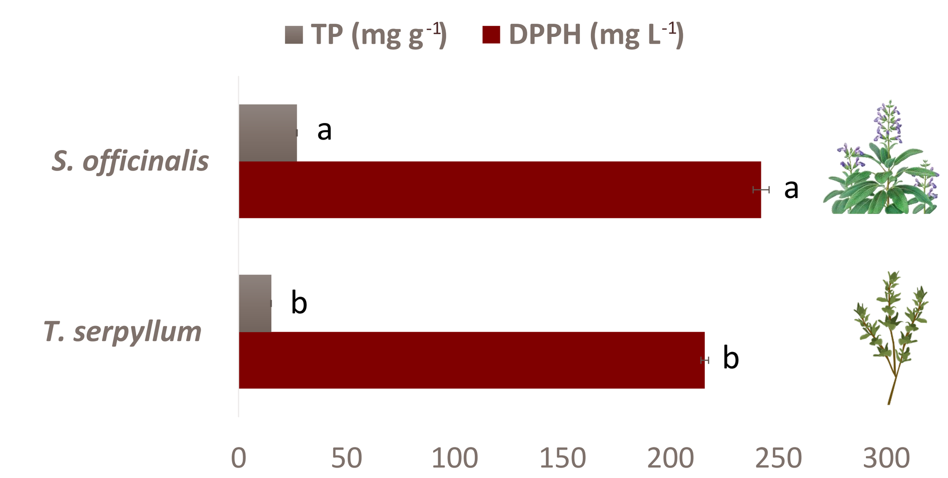

Figure 1. Total polyphenols (TP) and DPPH activity of *S. officinalis* and *T. serpyllum* extracts

Herbal extracts contained 27.00 (*S. officinalis*) and 15.03 mg GAE g^{-1} (*T. serpyllum*) of total polyphenols and their DPPH radical scavenging activity was 242.03 and 215.9 mg L^{-1}, respectively (Fig. 1).

II)

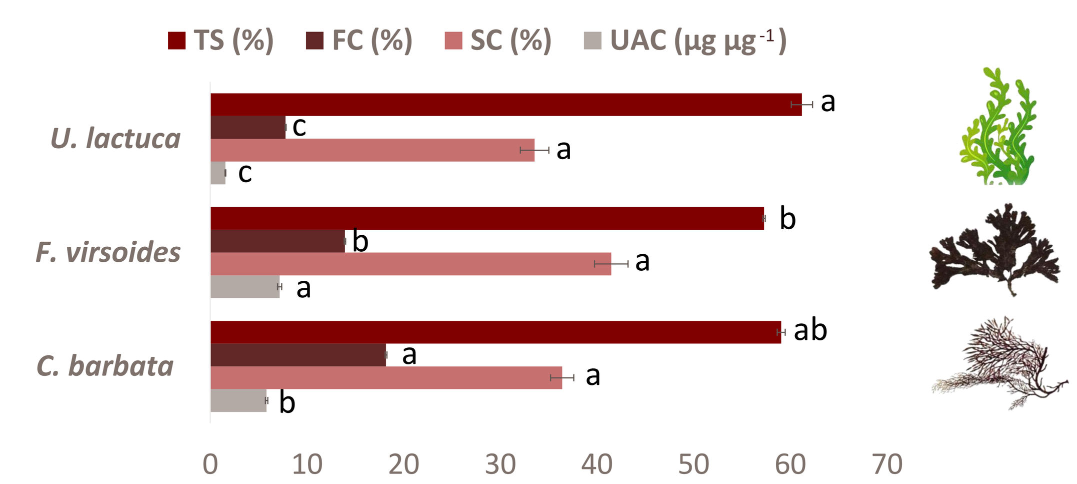

Figure 2. Total sugars (TS), fucose content (FC), sulfate content (SC) and uronic acid content (UAC) of algal polysaccharides

Total sugars in all three algal polysaccharides ranged from 57.28 to 61.21%, while sulfate group content ranged from 33.55 to 41.86%. *U. lactuca* polysaccharides had significantly lower content of fucose and uronic acid, while *C. barbata* polysaccharides contained the highest fucose content. The highest content of uronic acid was found in *F. virsoides* polysaccharides (Fig. 2).

III)

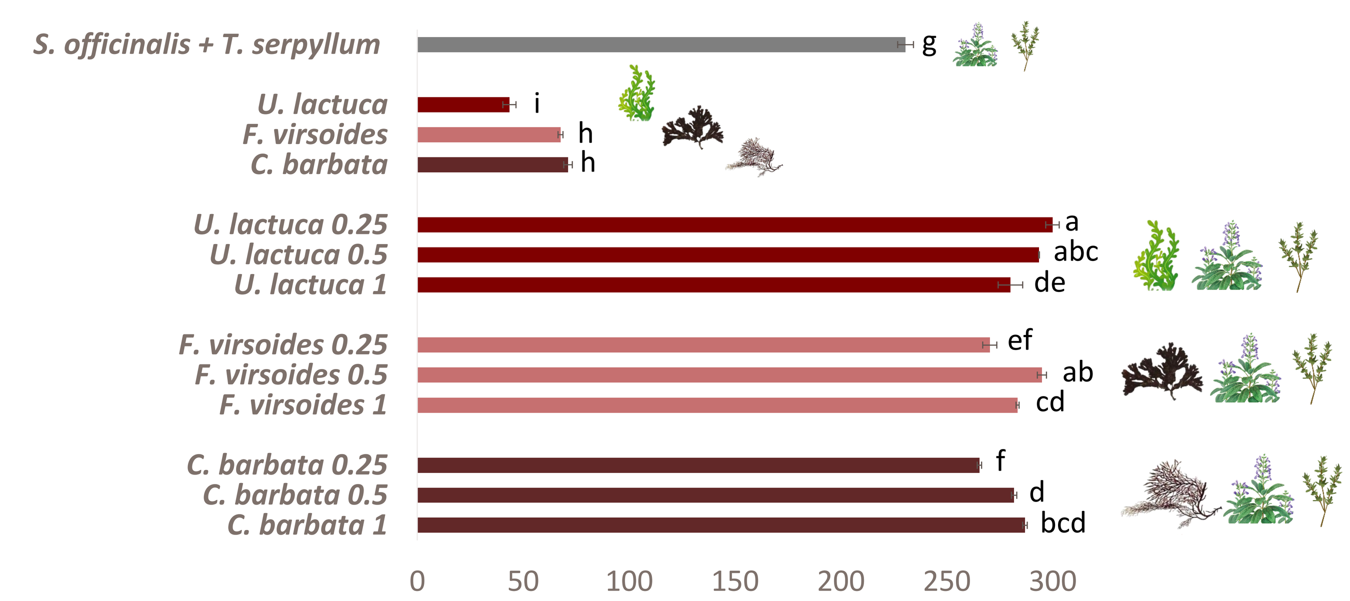

Figure 3. DPPH activity (mg L^{-1}) of herbal extract, algal polysaccharides and their mixtures

Mixture of herbal extracts (1:1 ratio) showed DPPH radical scavenging activity of 230.53 mg L^{-1}, while DPPH radical scavenging activity of *U. lactuca*, *F. virsoides* and *C. barbata* polysaccharides was 43.51, 67.64 and 71.14 mg L^{-1}, respectively. Addition of polysaccharides into the herbal extract increased DPPH radical scavenging activity (280.03 to 299.9 mg L^{-1}) regardless of the algal species and the amount added. However, increase of polysaccharides addition from 0.25 to 1 g increased scavenging activity in *F. virsoides* and *C. barbata* herbal mixtures, but not in herbal mixture of *U. lactuca* (Fig. 3).

Various biological activities of algal polysaccharides are often associated with their chemical composition, e.g. high levels of L-fucose, high degree of sulfation and low levels of contaminants such as uronic acid and protein (January et al., 2019). However, significant discrepancies in structural properties makes it impossible to precisely relate the bioactivity of polysaccharides with just one structural property but rather a combination of several properties. Green algae *U. lactuca* is a source of ulvan whose major monosaccharide unit is L-rhamnose, while L-fucose is predominant monosaccharide in brown algae polysaccharides. Lower fucose and sulfate group content, despite low level of uronic acid, could explain lower DPPH radical scavenging activity of *U. lactuca* polysaccharides. On the other hand, *S. officinalis* and *T. serpyllum* extracts contain various polyphenols which are known as strong antioxidants. The chemical structure of polyphenols varies upon number of aromatic rings and hydroxyl substituents which enable polyphenols to scavenge free radicals and reacting oxygen species through direct reaction with free radicals and from the chelation of free metals (Leopoldini et al., 2011).

CONCLUSION

Obtained results revealed a synergistic action of polyphenols from Mediterranean herbs and algal polysaccharides by which antioxidant activity of herbal extracts increased with the addition of algal polysaccharides, even in low amounts. These observations present an excellent base for the further development of functional beverages enriched with natural antioxidants.

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