Are Seaweeds the Food of the Future? Challenges for its Conservation and Introduction in the Portuguese Diet

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Introduction

Seaweeds are well known for their nutritional value (1). The ALGA4FOOD project [https://alga4food.wixsite.com/page/] (2) aims: i) researching new seaweed conservation processes (e.g. lyophilization, pascalization, MAP, etc.) which optimize functional and organoleptic characteristics; ii) developing strategies for its introduction in the Portuguese diet.

Material and Methods

Raw Materials: Seven seaweed species (*Ulva rigida*, *Codium tomentosum*, *Undaria pinnatifida*, *Saccorhiza polyschides*, *Gracilaria gracilis*, *Osmundea pinnatifida*, *Chondracanthus teedei* var. *Lusitanicus*) – see **Fig. 1** – were collected in north and central Portugal. *Porphyra* sp. and *Ulva rigida* for sensory analysis were cultivated in an IMTA system.

Instrumental Analysis: Each seaweed was frozen with liquid nitrogen and ground. Samples were maintained at -20° C until microextraction by HS-SPME, using 30 g of fresh seaweed and 104 g of milli-Q water with 30% NaCl (pa). *Ulva rigida* was also dried and 6.75 g of the dried seaweed and 117 g of the saline solution were used. Compounds extracted were analyzed and identified by GC-MS.

Product Development and Sensory Analysis: Dried pastas enriched with *U. rigida* and *Porphyra* sp. were developed and affective acceptance tests, using as control a 100% semolina (*Triticum durum*) pasta, were performed. The panel was composed by 60 untrained testers, and a structured hedonic scale of 1 to 9 points was used for the evaluation of appearance, color, aroma, texture, flavour, overall impression and food suitability. Data was submitted to analysis of variance (ANOVA), and Tukey's multiple comparison tests (3).

Figure 1 Examples of seaweeds collected in north and central coast of Portugal.
A – Codium tomentosum. B – *Osmundea pinnatifida*. C – *Porphyra* sp.

Results

Instrumental analysis: GC-MS identified 57 different organic compounds: 28 aldehydes, 4 alcohols; 10 hydrocarbons; 3 ethers; 8 ketones; 4 other functional groups (1 containing sulphur, 2 iodine and 1 bromine). For *U. rigida*, results

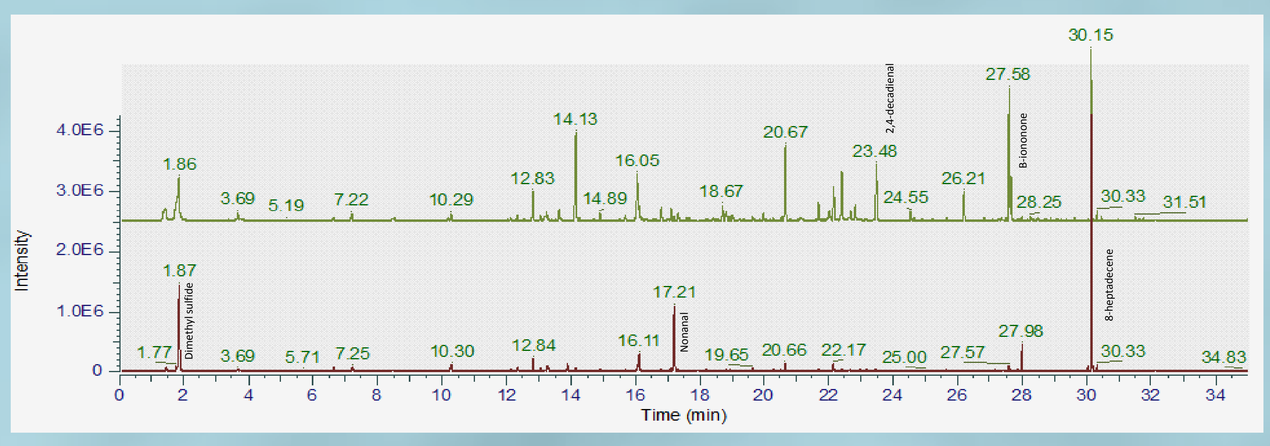

Figure 2 GC-MS chromatogram.
Comparison between fresh (green) and dry (red) *Ulva rigida*.

showed that the main compounds contributing for its fresh flavour profile (β-ionone and 2,4-decadienal) were different from those for the dried seaweed, meaning that fresh *U. rigida* has a higher aromatic richness than the dried one **(Fig. 2)**.

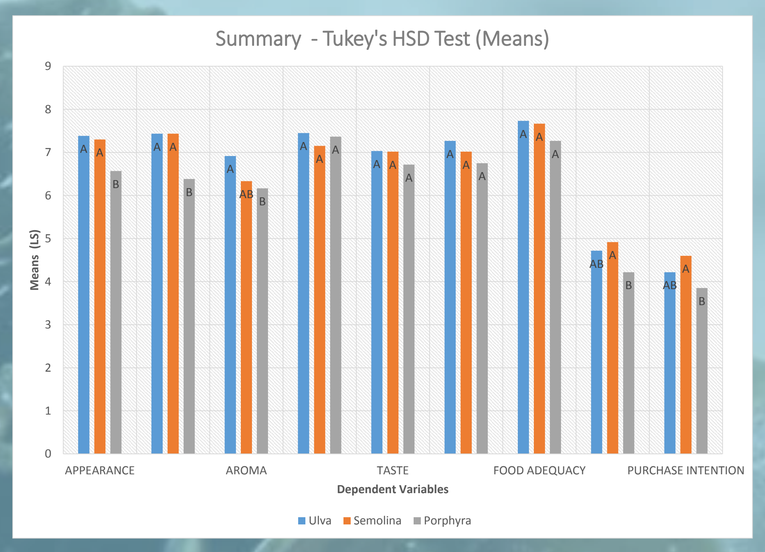

Figure 3 ANOVA. Summary of the means for the evaluated samples of three pastas (*Ulva* sp., semolina and *Porphyra* sp).

Sensory analysis: The results showed no significant differences between the average values for texture, flavour, overall impression and food suitability. However, the appearance, colour and aroma attributes were significantly different particularly for the control and *Porphyra* sp. formulations **(Fig.3)** (3).

Discussion and Conclusions

The exploratory process showed that both instrumental and sensory analysis, as well as the concepts underlying cooking creativity (3), are of great value for the development of new seaweed food products. GC-MS technique, together with sensory analysis, showed similarities between *Undaria pinnatifida* and collard greens (*Brassica oleracea* var. *acephala*). Based on this, *U. pinnatifida* was introduced in the traditional soup «caldo-verde», and preliminary tests showed good acceptance **(Fig. 4)**. Sensory analysis of pasta showed that green seaweeds, due to their subtle maritime flavour, have a greater potential for cooking applications than the red seaweeds (2,3).

Figure 4 «Caldo-verde» soup.
Adaptation with wakame (*Undaria pinnatifida*).

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