Alaria esculenta aquaculture in Ireland

TEAGASC researchers are investigating harvest and primary post-harvest methods of seaweed aquaculture for their potential contribution to environmental food production.

Seaweed aquaculture

Seaweed grows in great abundance and diversity in Ireland, where 500 species are found (Morrissey *et al.*, 2001). *Alaria esculenta*, also known as winged kelp, Irish wakame or badderlocks, is a brown seaweed (order Laminariales). It is a nutritious and valuable source of proteins and bioactives. Seaweed aquaculture is a relatively new addition to the aquaculture industry, particularly in the Western world, while commercial seaweed farms have been growing in scale in Asia for some time. The development of a seaweed aquaculture industry in Ireland opens up many novel markets; as an island nation with a strong historical association with macroalgae, Ireland is in a unique position to become an industry leader.

FIGURE 1: Alaria esculenta aquaculture process. (Photos: Anthony Irwin, Dulra, Co. Mayo.)

Process

An *A. esculenta* aquaculture process is shown in **Figure 1**. While relatively straightforward, it requires manual labour and time. First, ropes are inoculated with spores, which are carefully embedded in thin fibre resembling twine. These fibres can be produced on site or obtained from a farm with an operating hatchery. As hatchery conditions need close monitoring, it is sometimes more cost-effective to purchase spores from an external source.

The seeded rope is 'planted' at sea, at the designated aquaculture site. A holdfast is established to ensure anchoring of the plant to the line.

Harvest will occur at species-specific seasonal times throughout the year, involving manual cutting of the plant from the rope. Some companies have developed automatic systems for this step. The crop is then brought ashore for post-harvest treatment. Common post-harvest processes include washing, drying, blanching, milling and storing.

A second round of post-harvest processes such as fermentation, cavitation or extrusion can be carried out, usually by an external company.

Table 1: Blanching treatments used on *A. esculenta*.

Treatment	Blanching technique	Description
1	HW	Hot water conventional blanching (70 °C, five minutes)
2	M1000	Microwave, 1,000 W, 120 s
3	M800	Microwave, 800 W, 120 s
4	U100	Ultrasound, 100 %, 300 s
5	U50	Ultrasound, 50 %, 300 s
6	U50M800	Ultrasound, 50 % + microwave, 800 W, 60 s
7	U100M1000	Ultrasound, 100 % + microwave, 1,000 W, 60 s

Post-harvest blanching and drying: examination of impacts on: a) volatile; and, b) mineral content

Seaweed blanching has benefits for extending shelf life through enzyme inactivation, killing pathogens, preserving colour and keeping biochemical compounds intact.

Different blanching methods were tested for their impact on colour, volatiles and mineral composition remaining post treatment. These are important factors to be considered when choosing a method to employ on a commercial seaweed farm. The blanching methods used were: conventional hot water; novel ultrasound; and, microwave. In some treatments, ultrasound and microwave technology were used together, at different power settings (W) for microwave and different amplitude levels (%) for ultrasound (**Table 1**). Following this, the samples were either oven or freeze dried and analysed for outputs.

a. Volatile compounds retention

Over 76 different volatile compounds, from at least nine chemical groups, were detected in blanched and dehydrated *A. esculenta* (solid-phase microextraction (SPME) and gas chromatography–mass spectrometry (GC–MS) analysis). There were significant differences ($P<0.05$) in levels of all pyrazines, furans, amines, acids, alcohols, ketones and aldehydes between drying methods, and in alcohols between blanching treatments.

Overall, freeze-dried samples retained more volatile compounds than oven-dried, in terms of total quantity. However, oven-dried samples had a higher diversity of volatile compounds, with 67 compounds detected compared with 60 compounds detected in freeze-dried samples. Freeze-dried samples that underwent blanching treatments of M1,000 and U50M800 displayed the best retention of volatile compounds.

b. Mineral composition

Overall, blanching treatments had a significant effect ($P<0.05$) on sodium (Na), copper (Cu), iron (Fe) and manganese (Mn). Drying methods significantly affected ($P<0.05$) calcium (Ca), cobalt (Co), Cu and Fe. M1,000 samples had the lowest relative mineral content.

Sustainability

Seaweed aquaculture can play a crucial role in ecosystem stability and recuperation. Macroalgal primary production is part of the global carbon, oxygen and nutrient cycle (Chung *et al.*, 2011), and aquaculture systems should be designed with this advantage in mind. Seaweed aquaculture systems can provide habitats for many animals, namely benthic and mobile invertebrates, as well as fish, to whom seaweed can offer protection during the nursery stage (Skjermo, *et al.*, 2014). A measure of these positive impacts as an ecosystem service could be a key metric to promote for the industry.

Evaluated product

A. esculenta is a well-evaluated product rich in amino acids and polyunsaturated fatty acids like eicosapentaenoic acid (EPA) and stearidonic acid (SDA). It has significant potential for the functional food and nutraceutical markets as products with high added value (Afonso *et al.*, 2020). Its opportunities include as an alternative salt, a flour to enrich traditional flours or make healthy snacks, a powder to enhance beverages, or in capsule form for targeted delivery of benefits.

Summary

Sustainable seaweed production not only provides a valuable protein source to help feed demand for alternative proteins, but also benefits the environment. The automation of harvesting methods, as well as the selection of the most productive post-harvest methods, are important factors determining success of this new industry in Ireland.

Acknowledgement

The authors would like to acknowledge the support of BiOrbic SFI Bioeconomy Research Centre, which is funded by Ireland's European Structural and Investment Programmes, Science Foundation Ireland (16/RC/3889), and the European Regional Development Fund.

References

Afonso, C., *et al.* (2021). 'Bioactive and nutritional potential of *Alaria esculenta* and *Saccharina latissima*'. *Journal of Applied Phycology*, 33: 501-513.

Chung, I.K., *et al.* (2011). 'Using marine macroalgae for carbon sequestration: a critical appraisal'. *Journal of Applied Phycology*, 23 (5): 877-886.

Morrissey, J., Kraan, S. and Guiry, M.D. (2001). 'A guide to commercially important seaweeds on the Irish coast'. Irish Bord Iascaigh Mhara/Irish Sea Fisheries Board.

Skjermo, J., *et al.* (2014). 'A new Norwegian bioeconomy based on cultivation and processing of seaweeds: Opportunities and R&D needs'.

Authors

Laura E. Healy
Teagasc Food Research Centre, Ashtown, Dublin 15, and Department of Food Science and Environmental Health, Technological University Dublin
Correspondence: laura.healy@teagasc.ie

Xianglu Zhu
Teagasc Food Research Centre, Ashtown, Dublin 15, and Food Refrigeration and Computerised Food Technology (FRCFT), School of Biosystems and Food Engineering, University College Dublin

Brijesh K. Tiwari
Teagasc Food Research Centre, Ashtown, Dublin 15

Anthony Irwin
Dulra Marine, Elly Bay, Belmullet, Co. Mayo