

# Immuno-modulatory effects of dietary macro- and microalgae on turbot (*Scophthalmus maximus*) breeders: non-lethal assessment through humoral immune parameters and skin mucus proteomics

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## Background

Reduce the reliance on fish meal and oil in feed formulations for farmed fish is a priority to **sustain aquaculture growth**

Microalgae and Macroalgae appear as a promising alternative aimed at **enhancing the nutritive value** of new feed formulations

Spirulina supplementation is an excellent replacement to existing protein diets given to fish;

**Bioactive compounds** from algae include phycobiliproteins, polyunsaturated fatty acids (PUFAs), pigments and enzymes;

**Iodine-rich macroalgae** (like Laminaria sp.) can provide this vital element essential for fish reproduction and the successful development of offspring.

**Boosts** immune status and protects against oxidative stress.

Microalgae & Macroalgae

Bioeconomy driven algae

## Objective?

Can the inclusion of a **macro- and microalgae blend** in aquafeeds enhance the **immune status** of turbot breeders?

## Material & Methods

**Feeding Trial**  
4 months

**2 isoenergetic Diets:**

- CTRL = a good quality commercial formula
- ALGAE = Micro- and Macroalgae blend (5% Spirulina and 1% Iodine-rich Macroalgae (*Laminaria digitata*))

**4 different broodstocks**  
FLATLANTIC

1st: 15h  
2nd: 15:30h  
2 photoperiods

♂ 5.24 ± 0.8  
♀ 7.49 ± 1.35  
n = 8/tank  
Final body weight (Kg)

Non-lethal sampling to assess breeders' immune status

**Blood**  
Temperature  
Immune condition  
Stress assessment

**Skin mucus**  
Contaminants  
Immune condition  
Stress assessment

### Immune status evaluation

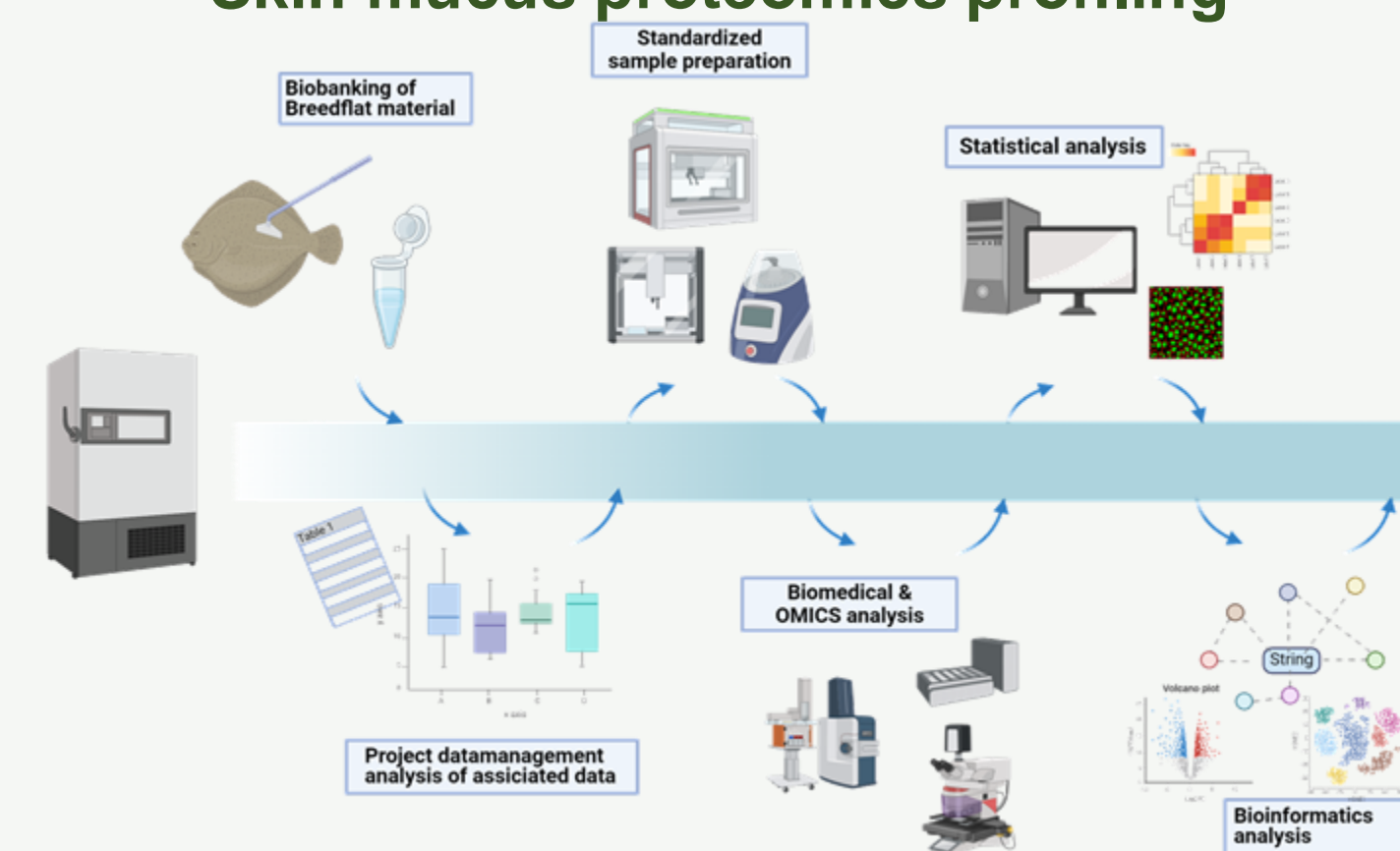
**Blood plasma humoral parameters**

- Bactericidal activity against *Tenacibaculum maritimum*
- IgM
- Peroxidase activity
- Lysozyme activity

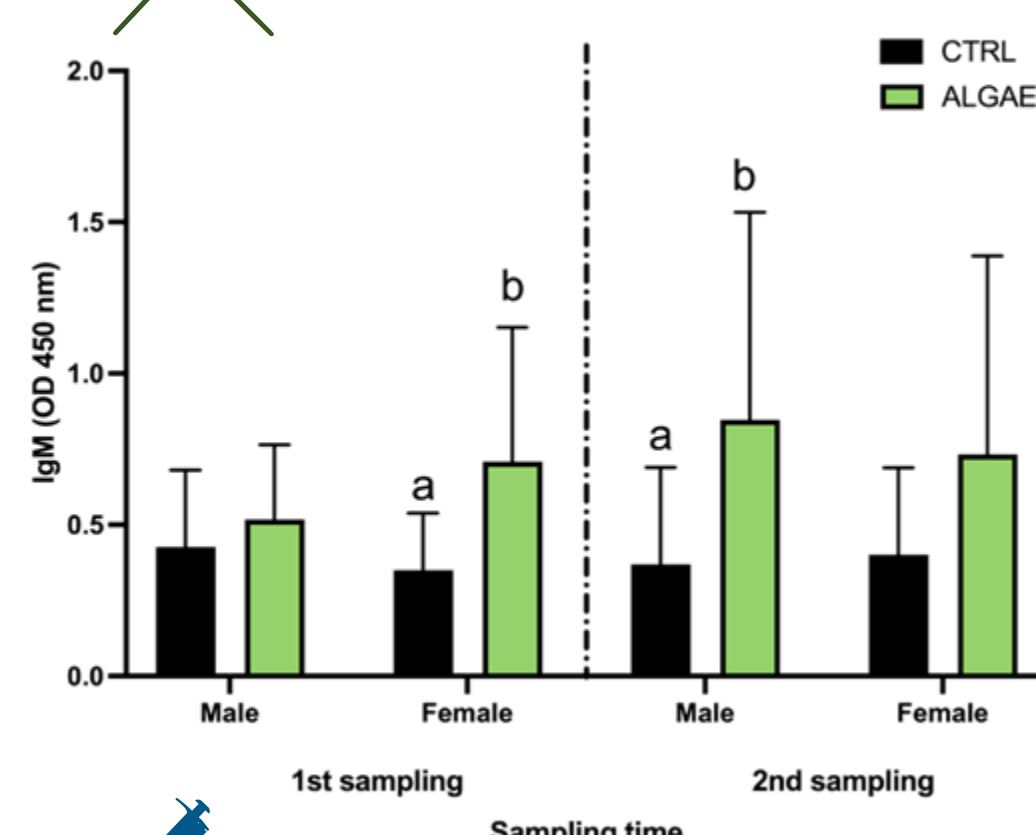
**Skin mucus humoral parameters**

- IgM
- Peroxidase activity

### Skin mucus proteomics profiling

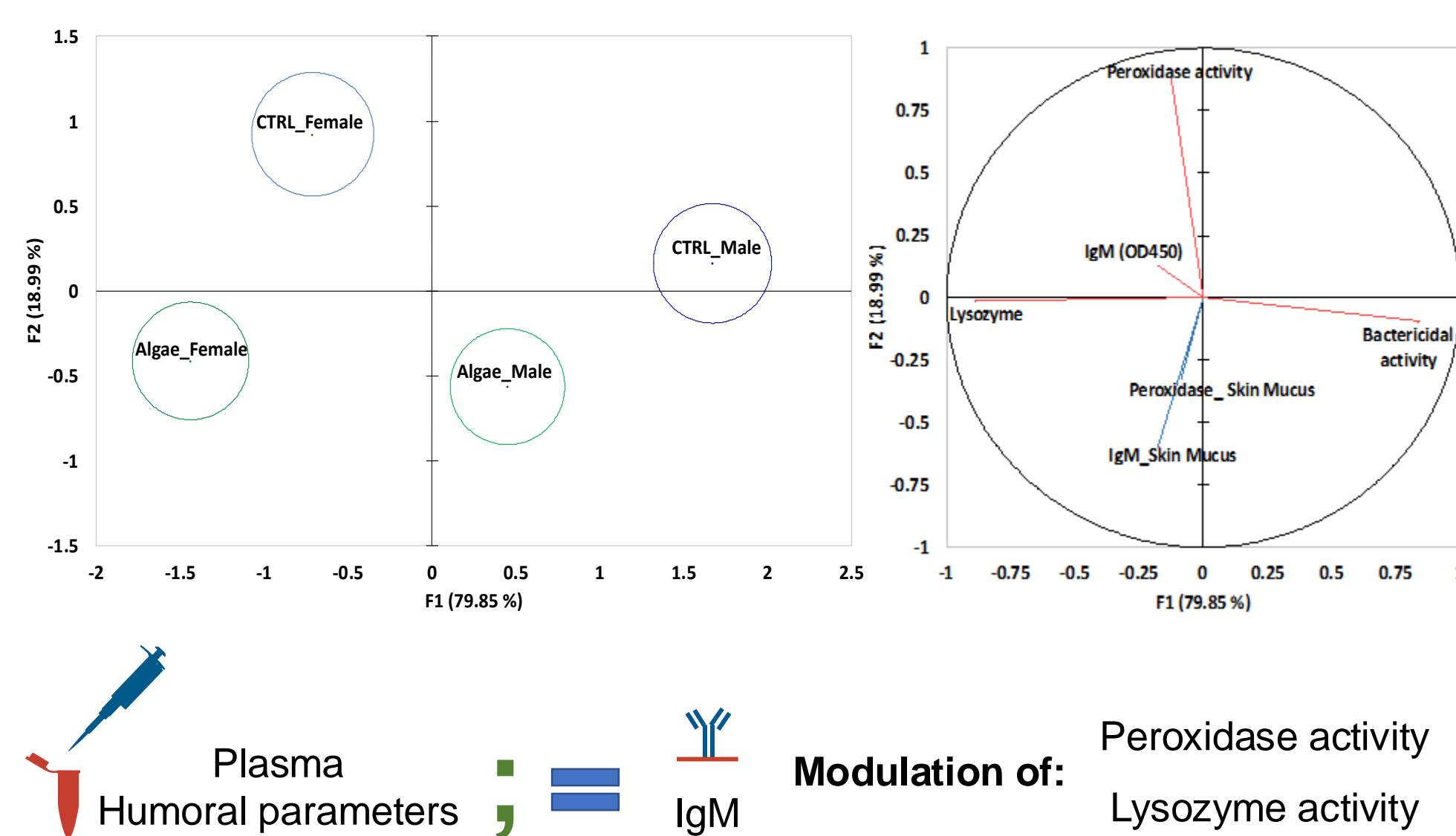


## Results & Discussion



IgM values in skin mucus increased in fish fed the ALGAE diet compared to those fed the CTRL diet, particularly in female breeders in both sampling points.

The observed modulation of immune parameters, especially IgM, in turbot breeders fed with the ALGAE blend seems to indicate a potential enhancement in their immune response.



Photoperiod was excluded from this multivariate analysis for noise reduction.

Group discrimination was significant (Wilk's lambda = 0.0299, p < 0.0001) highlighting the differences between experimental diets and gender.

It was observed a tendency for higher lysozyme activity (plasma) and a decrease in peroxidase activity in fish fed the ALGAE diet, particularly in female breeders.

The inclusion of both *Spirulina* and *Laminaria digitata* blend does not negatively affect the turbot breeders survival and **modulates** their immune status.

**Proteomic analysis** of skin mucus revealed **significant differences** based on diet and gender. A total of 3,394 proteins were identified; 144 varied by gender, while 126 distinguished CTRL from ALGAE fed fish.

∴ Calpains, bactericidal permeability-increasing protein, superoxide dismutase [Cu-Zn] were found to be differently expressed

## Conclusions

This work suggests that dietary supplementation with this micro- and macroalgae blend **could improve the immune status** of turbot breeders, which is crucial for their overall health and resilience against pathogens.

### References

(1) Salinas, I., Fernandez-Montero, A., Ding, Y., Sunyer, J.O., 2021. Mucosal immunoglobulins of teleost fish: A decade of advances. Dev Comp Immunol. 121, 104079.

### Acknowledgements

This work is part of the BREEDFLAT project (EEA.BG.CALL4.019.2020), supported by Iceland, Liechtenstein and Norway through the EEA Grants. Through the Agreement on the European Economic Area (EEA), Iceland, Liechtenstein and Norway are partners in the internal market with the Member States of the European Union. BC and AC were supported by FCT - Foundation for Science and Technology (IF/00197/2015 and PD/BDE/135541/2018, respectively).

