Algal Research 47 (2020) 101885

Contents lists available at ScienceDirect

Algal Research

journal homepage: www.elsevier.com/locate/algal

Assessment of long-term effects of the macroalgae *Ulva ohnoi* included in diets on Senegalese sole (*Solea senegalensis*) fillet quality

M.I. Sáez[a], A. Vizcaíno[a], A. Galafat[a], V. Anguís[b], C. Fernández-Díaz[b], M.C. Balebona[c], F.J. Alarcón[a], T.F. Martínez[a,*]

[a] Departamento de Biología y Geología, Campus de Excelencia Internacional CEIMAR, Universidad de Almería, 04120 Almería, (Spain)
[b] IFAPA "El Toruño", Junta de Andalucía, 11500 - El Puerto de Santa María, Cádiz, (Spain)
[c] Facultad de Ciencias, Universidad de Málaga, 29071 Málaga, (Spain)

ARTICLE INFO

Keywords:
Fish quality
Frozen fish
Functional additive
Lipid oxidation
Macroalgae
Solea senegalensis
Ulva ohnoi

ABSTRACT

Macroalgae are a promising source of a vast variety of bioactive compounds with potential interest in aquaculture. In addition to their sustainable and renewable nature, numerous evidences have been reported pointing to positive effects on fish growth, nutrient utilization, and disease resistance. Nevertheless, the effects on fish quality objective parameters have been scarcely explored. In this study we assessed the influence of *Ulva ohnoi* included at low level (5%) in a diet for Senegalese sole (*Solea senegalensis*) on several quality attributes of fish (proximate analysis, texture profile analysis, lipid oxidation, fatty acid profile, pH, water holding capacity, and colour parameters). A 270-d feeding trial was carried out, in which juvenile animals were fed with an *Ulva*-enriched diet only for 90 d out of the total 270-d study. This enabled to evaluate whether the possible effects on fish were transitory or persistent at the end of the assay. Besides modest effects on fish growth at early stages, the differences attributable to *Ulva* supplementation were mostly focused on the lipid fraction, texture, and colour parameters. Thus, *Ulva* diet reduced muscle total lipid content and favoured muscle selective retention of n-3 polyunsaturated fatty acids (PUFA), not least eicosapentaenoic acid (EPA) and docosahexaenoic (DHA) acid, and also diminished lipid oxidation, especially after a period of frozen storage. In terms of consumers' acceptability, seaweed supplementation impacted favourably on fillet texture and colour attributes, namely by increasing lightness (L^*) and yellowness (b^*), whilst reducing redness (a^*). These results are particularly remarkable taking into account that low inclusion level was considered (5%), and above all, that *Ulva* supplementation was interrupted after 90 d, but the effects mentioned persisted at least up to 270 d. These deferred long-term effects might well be of practical interest when it comes to modifying quality attributes of edible fish.

1. Introduction

Macroalgae have been proposed as an alternative and renewable feeding resource for a sustainable aquaculture [1]. Thus, several studies have reported positive effects of seaweed-enriched aquafeeds on fish growth, nutrient utilization [2,3], resistance to infectious diseases [4], as well as on objective quality parameters in different fish species [5–7].

However, several issues hinder the utilization of macroalgae as an ingredient at industrial scale, not least those related to the drying process, a necessary but costly step prior to any practical application in feed manufacturing [1]. As a result, the interest raised for macroalgae in the last years is turning from their role as a main quantitative ingredient, towards their potential as a natural source of qualitative bioactive compounds. Indeed, seaweeds contain potentially nutraceutical or functional substances, such as polysaccharides, fibre, pigments, polyphenols and vitamins [8,9]. Thereby, the practical utilization of macroalgae in aquafeeds is nowadays more focused on their interest as additive at low inclusion levels, than to their consideration as main ingredient [1,7,10].

Ulva sp. is one of the most widely assessed genera of edible macroalgae in aquaculture feeding trials, owing to its richness either in identified [11,12] or in still unknown bioactive compounds [13]. As mentioned, a vast array of benefits regarding growth performance and health strengthening has been reported for different fish species, but potential effects on fish quality have been studied less extensively [14].

The interest of macroalgae as feed additive at early stages of the fish production cycle (namely pre-ongrowing and ongrowing periods)

* Corresponding author at: Departamento de Biología y Geología, Universidad de Almería, 04120 Almería, (Spain).
E-mail address: tomas@ual.es (T.F. Martínez).

https://doi.org/10.1016/j.algal.2020.101885
Received 25 October 2019; Received in revised form 12 March 2020; Accepted 16 March 2020