Inclusion of seaweed wracks in diets for grass carp *Ctenopharyngodon idella*

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Introduction

Stranding of macroalgal wracks that regularly appear in coasts are usually removed, causing an increased pressure on the handling and management of beach maintenance (Mossbauer et al., 2012). Inclusion of certain amounts of algae in fish feed has been recently described to have several physiological benefits such as an improvement in growth performance and lipid metabolism (Moutinho et al., 2018). The use of Macaronesian macroalgal wracks as a supplement in aquafeeds from a feasible ecological and economical perspective is proposed in the present study. For this purpose, two feeding experiments with juveniles of grass carp (*Ctenopharyngodon idella*), a freshwater species with rapid growth and easy adaption to captivity were conducted. Grass carp is the major fish species produced in the world with more than 5 million tons/year (FAO, 2020).

Materials and Methods

E1 Experimental design

- **RAS**. N=45. Initial weight: 8.6±1.9 g. 133 days.
- **Dietary intake:** 2.5-3.0% of biomass (twice daily).
- **Control diet:** diet for tilapia (Skretting) (TD)
- **Experimental diet:** TD + 15% of a 1 mm multispecific macroalgae wrack (MU)*
- **4 individuals** of each treatment were sacrificed, and the remaining individuals were used for E2.

E2 Experimental design

- **RAS.** N=41. Initial weight: 33.5±8.0 g. 99 days.
- **Dietary intake:** 2.5-3.0% of biomass (twice daily).
- **Control diet:** TD
- **Experimental diet 1:** TD + 7% MU
- **Experimental diet 2:** TD + 7% of a 1 mm virtually monospecific macroalgae wrack (~95% *Lobophora* sp.) (MO)

***MU COMPOSITION**

33.8% *Asparagopsis taxiformis*
28.6% *Lobophora* sp.
22.6% *Dictyota* sp.
14.5% *Cymopolia barbata*
0.5% *Laurencia* sp.

Table 1. TL and main FA composition (% of total FA) of diets used in E1 and E2 (Mean±SD, n=2).

	TD	TD+15% MU	TD+7% MU	TD+7% MO
TL (% dw)	9.2±1.4	8.1±0.2	8.9±0.1	9.3±0.7
∑SFA	24.0±0.5	20.7±0.6	23.8±0.1	23.7±0.5
∑MUFA	41.0±0.4	54.5±0.6	40.4±0.3	40.3±0.7
20:4n-6	0.7±0.1	0.5±0.0	0,7±0.1	0,7±0.0
20:5n-3	3.1±0.2	2.1±0.0	3.5±0.0	3.3±0.2
22:6n-3	2.2±0.3	1.6±0.0	2.5±0.0	2.3±0.2

Statistical analysis

- E1: t-student (p<0.05)
- E2: One way- ANOVA (p<0.05); Posthoc test: Tukey

Parameters analyzed

- Fish growth and survival
- Hepatosomatic index (HSI), Viscerosomatic index (VSI) and Visceral-fat index (VFI)
- Total lipid (TL) and fatty acid (FA) composition of muscle
- Peroxides index and antioxidant enzymes activities
- Digestive enzymes activities

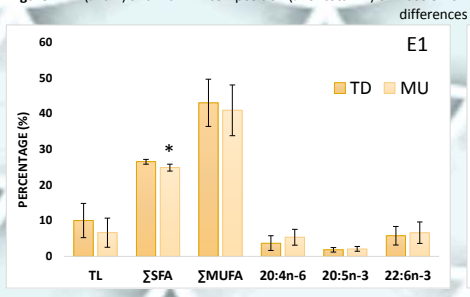
Results and Discussion

Table 2. Survival, growth parameters and morphological measurements of *C. idella* fed the experimental diets in E1 and E2.

	E1		E2		
	TD	TD+15% MU	TD	TD+7% MU	TD+7% MO
Survival (%)	100.0	100.0	83.3	85.7	95.5
WG (%)	345.0	194.5	41.5	95.6	47.3
SGR (% day^{-1})	1.1	0.8	0.4	0.7	0.4
HSI (%)	1.7±0.2	0.8±0.2*	1.5±0.4	1.3±0.5	1.5±0.6
VSI (%)	7.3±0.8	5.6±1.6	8.0±1.3^{b}	6.9±0.9^{a}	7.7±1.4^{ab}
VFI	2.7±0.5	1.0±0.0*	2.8±0.4^{b}	2.1±0.5^{a}	2.7±0.5^{b}

WG, weight gain; SGR, specific growth rate. VFI was calculated from visible fat of organs: 1 (low), 2 (medium) or 3 (high). * differences between treatments in E1 (P<0.05); different superscript letters denote significant differences in E2 (P<0.05).

Figure 1. TL (% dw) and main FA composition (% of total FA) of muscle from *C. idella* in E1 and E2. (Mean±SD, E1: n=4; E2: n=5). * Denote significant differences (P<0.05)



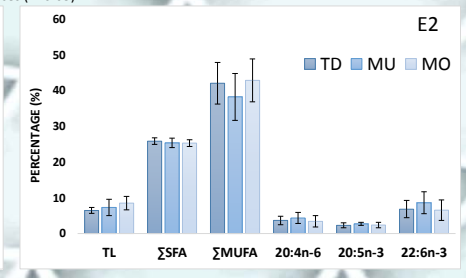


Table 3. Specific activity (U/mg protein) of digestive enzymes from *C. idella* (anterior and posterior intestine) fed the experimental diets in E1 and E2 (Mean±SD, E1: n=4; E2: n=5).

	E1				E2					
	Anterior		Posterior		Anterior			Posterior		
	TD	TD+15% MU	TD	TD+15% MU	TD	TD+7% MU	TD+7% MO	TD	TD+7% MU	TD+7% MO
Lipase	29.4±9.5	9.4±1.1*	11.8±8.2	10.1±0.8	25.6±14.3	34.2±21.9	13.3±7.9	10.1±6.7	4.9±1.3	6.2±2.5
Amylase	558.1±101.4	41.2±12.5*	731.4±322.5	307.3±79.8	167.2±78.0	289.3±120.9	223.2±46.3	290.5±88.6	433.6±132.0	277.8±101.7
Protease	510.6±152.3	77.8±30.1*	623.3±446.5	291.1±118.1	226.0±94.5	185.9±44.3	255.6±155.2	205.5±189.8	215.3±152.5	146.8±118.0

Table 4. PI (meqO_2/Kg), GST, CAT and GR activities (U/mg protein) of muscle and liver from *C. idella* fed the experimental diets in E1 and E2 (Mean±SD, E1: n=4; E2: n=5)

	E1				E2					
	Muscle		Liver		Muscle			Liver		
	TD	TD+15% MU	TD	TD+15% MU	TD	TD+7% MU	TD+7% MO	TD	TD+7% MU	TD+7% MO
PI	19.2±1.1	11.0±3.1*	-	-	8.7±1.0	7.7±2.5	8.4±0.9	-	-	-
GST	14.9±2.7	12.9±2.8	82.2±23.7	99.3±39.0	35.6±6.1	32.0±14.4	27.5±6.6	274.1±92.0	237.6±11.8	281.4±66.5
CAT	0.5±0.1	0.5±0.1	12.7±3.2	14.7±4.1	1.0±0.4	0.9±0.1	0.8±0.3	23.3±8.0^{b}	13.0±3.5^{a}	12.5±5.4^{a}
GR	0.9±0.1	0.7±0.2	1.5±0.4	2.8±0.9*	0.6±0.1	0.9±0.3	0.9±0.4	2.7±0.7	3.0±1.0	2.7±0.7

PI, peroxides index; GST, glutathione-S-transferase; CAT, catalase; GR, Glutathione reductase. * Differences between treatments in E1 (P<0.05); different superscript letters denote significant differences in E2 (P<0.05). - Not determined

- A 15% of macroalgal wrack inclusion reduced fish growth and digestive activity, whereas a lower supplementation of 7% did not negatively affect these parameters, with a trend for a better growth being attained with 7% MU.
- The lower digestive activity when fish were fed the diet with a 15% of macroalgal wrack may be related to the presence of anti-nutrients in macroalgae that reduced digestibility, giving rise to a lower growth and fat deposition in fish.
- The inclusion of MU seaweed reduced both fish perivisceral fat and liver deposition regardless of the percentage of inclusion, without affecting fish muscle TL and FA profiles, also suggesting a lipolitic action of the seaweed (Bourgougnon, 2014).
- Fish fed with a 15% of algae inclusion showed a better oxidative status of muscle, and an improved GR activity in liver. A 7% supplementation of both MU and MO macroalgal wrack caused a better CAT defense in liver.

Conclusion

The use of a 7% of multispecific seaweed as a feed additive seems to have beneficial effects in terms of growth, visceral fat deposition and oxidative status in *C. idella*.

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