Replacement of vegetable oils with the oleaginous yeast *Rhodotorula toruloides* biomass in the diet of Arctic char (*Salvelinus alpinus*), effects on fish growth performance

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Background/introduction/summary

A current and main limitation in fish production is the fish feed formulation as more sustainable ingredients should be included in the fish feed for the long-term perspective of sustainable aquaculture.

The aim of this study was to replace part of the fish feed by the biomass of the oleaginous yeast *Rhodotorula toruloides* in the diet of Arctic char (*Salvelinus alpinus*), to evaluate its safety and to investigate the fish performance with the feed change.

R. toruloides was used for its capacity to produce considerable amounts of oil as well as for its ability to grow on abundant, non-edible plant biomass such as lignocellulosic hydrolysate (Brandenburg et al., 2021).

Materials and Methods

A feeding trial was performed at an aquaculture center with fish divided into two groups: a control group and a yeast group of fish fed with yeast biomass from *R. toruloides.*

Aquaculture Center

Formulation of both feeds was strictly controlled to remain iso-nitrogenous and iso-energetic. Yeast biomass and its hydrolysate were investigated for heavy metals and organic pollutants.

Several fish growth parameters were measured in addition to the enzyme activity of ethoxyresorufin-O-deethylase (EROD) in fish livers.

Lastly, a sensory analysis was conducted to evaluate potential differentiated fish taste, smell or texture, as a result of feeding with *R.toruloides* biomass.

Results

Table 1: Composition of control and treatment feeds (%).

Feed ingredients	Control feed (%)	Yeast biomass feed (%)
Fish meal	52.8	53.5
Fish oil	12.5	12.6
Vegetable oil	5.80	-
Mineral mix	0.48	0.49
Vitamin mix	0.96	0.97
Red mineral mix	0.14	0.15
Gelatine	0.48	0.49
Wheat meal	18.7	14.1
Casein	5.76	-
Ca_2SO_4	2.40	2.43
Yeast	-	15.3 (5.8% oil)
Total	100	100

Table 2: Analysis of heavy metal concentrations in yeast biomass and its hydrolysate ($mg.kg^{-1}$ or $mg.l^{-1}$). ALS Scandinavia, Sweden (Commission Regulation (EC) No 1881/2006 and No 835/2011).

Element	EU legislation $mg.kg^{-1}$	Hydrolysate $mg.l^{-1}$	Yeast $mg.kg^{-1}$
Al	1	0.3360	0.5390
As	0.01	0.0053	<LOQ
Cd	0.05	0.0058	0.0196
Hg	0.50	<LOQ	<LOQ
Pb	0.30	0.0164	0.0343

Table 3: Concentrations of organic pollutants in hydrolysate and yeast samples (mean ± SD, n = 3).

	ΣPAH_{17}	ΣPCB_{20}
Hydrolysate, $ng.g^{-1}$	<LOQ or n.d	n.d
Yeast, $ng.g^{-1}$lipid weight	200±12	n.d

Fish feed formulation

Arctic char (*Salvelinus alpinus*)

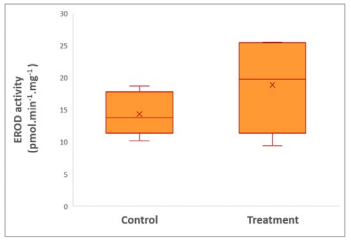


Figure 1: EROD activity in hepatic microsomes of Arctic char fed with two different diets for 53 days (n=12), $pmol.min^{-1}.mg^{-1}$.

Table 4: Fish performance in both feed groups (mean ± SD, n=96).

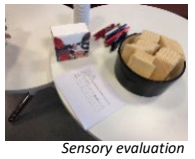
Growth parameters	Control group	Yeast group	p-value
Initial weight (g)	209±65.4	200±62.9	0.7360
Final length (cm)	29.4±2.20	29.2±2.54	0.7417
Final weight (g)	314±99.1	303±94.3	0.5882
Liver weight (g)	**3.75±2.07**	**4.61±1.91**	**0.0365**

Conclusions

Heavy metals and organic pollutants analyses showed no toxic levels of fish feed with yeast biomass as levels were below European legislation and no significant effects were observed in enzyme activity of EROD in fish liver between the two groups of fish.

Fish from both feed performed similar in their growth except for the liver weight. No significant difference in the sensory evaluation was detected.

Additional studies at a bigger scale should to be conducted to confirm the results observed.



Sensory evaluation

Reference

Brandenburg J, Blomqvist J, Shapaval V, Kohler A, Sampels S, Sandgren M, Passoth V (2021). Oleaginous yeasts respond differently to carbon sources present in lignocellulose hydrolysate. Biotechnol Biofuels 14:24 https://doi.org/10.1186/s13068-021-01974-2

Commission Regulation (EC) No 1881/2006. (2006). Setting maximum levels for certain contaminants in foodstuffs. http://data.europa.eu/eli/reg/2006/1881/oj.

Commission Regulation (EC) No 835/2011. (2011). Regulation (EC) No 1881/2006 as regards maximum levels for polycyclic aromatic hydrocarbons in foodstuffs.

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