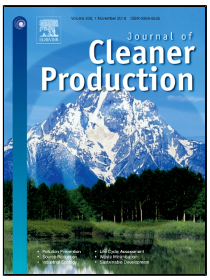
# Accepted Manuscript




Environmental Impacts and Sustainability of Low-Value Roach Fish When Used as Food

Ville Uusitalo, Virgilio Panapanaan, Paavo Vallas, Anna Kuokkanen, Katariina Koistinen

| | |
|---|---|
| PII: | S0959-6526(18)32761-6 |
| DOI: | 10.1016/j.jclepro.2018.09.047 |
| Reference: | JCLP 14182 |
| To appear in: | *Journal of Cleaner Production* |
| Received Date: | 12 January 2018 |
| Accepted Date: | 05 September 2018 |

Please cite this article as: Ville Uusitalo, Virgilio Panapanaan, Paavo Vallas, Anna Kuokkanen, Katariina Koistinen, Environmental Impacts and Sustainability of Low-Value Roach Fish When Used as Food, *Journal of Cleaner Production* (2018), doi: 10.1016/j.jclepro.2018.09.047

# ENVIRONMENTAL IMPACTS AND SUSTAINABILITY OF LOW-VALUE ROACH FISH WHEN USED AS FOOD

Ville Uusitalo*[a], Virgilio Panapanaan[a], Paavo Vallas[b], Anna Kuokkanen[a], Katariina Koistinen[a]

[a] Lappeenranta University of Technology, School of Energy Systems, Sustainability Science, P.O. Box 20, 53851 Lappeenranta, Finland

[b]Aalto University, School of Chemical Technology, Environmental management, P.O. Box 20, 00076 Aalto, Espoo, Finland

* Corresponding Author. Current address: Lappeenranta University of Technology, P.O. Box 20, 53851 Lappeenranta, Finland. Tel.: +358 40 586 4486, fax: +358 5 621 6399, E-mail: ville.uusitalo@lut.fi

## Abstract

One of the major global environmental challenges is the overuse of nutrients and related eutrophication problems. Specifically in Finland, the roach fish population is rapidly increasing in eutrophic water systems. Currently roach fish does not have economic value, and it is mainly composted despite the fact that it could provide a direct protein source for human needs. This paper assumes that new business could be established by removing roach fish from eutrophic water systems and using them as a protein source for human consumption. Removing roach fish directly removes nutrients and indirectly impacts the vicious cycle of eutrophication. This paper assesses different environmental sustainability perspectives of roach fish removal and utilization. It also aims to present different environmental impacts on the planetary boundary framework. The research is carried out using life cycle assessment methodology.

Based on the results, the use of roach fish as a protein source would help in returning to a safe operational zone in biochemical flows. Phosphorous removal with roach fish is 5.8 (1.9-10.3) g $kg^{-1}$ while nitrogen removal is 28.4 (26.4-30.4) g $kg^{-1}$. However, the production has also climate change impacts which are 2.9-5.2 $kgCO_{2eq}$ $kg^{-1}$ roach protein. Nevertheless, the climate change impacts are 12-57 times lower than positive impacts on eutrophication.

Different environmental impacts are assessed regarding whether or not they help to avoid crossing planetary boundaries. Roach fish should be marketed especially for green consumers, and creating new markets for roach fish could also help in eutrophic lake restoration projects. Additionally, new business could be created from nutrient offsetting by roach fish removal.

Roach removal from eutrophic water systems and use as food helps in returning to a safe operational zone in biochemical flows and the positive impacts are far greater than the negative impacts on climate change from fishing and fish processing.

*Key words: fish, life cycle assessment, carbon footprint, environmental impact, nutrient offsetting, eutrophication*