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Contribution of nuclear applications to better understand bioaccumulation of contaminants in aquaculture species

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1. Introduction

Wild- or farmed-marine fish are an important source of high-quality animal protein and long-chain polyunsaturated fatty acids, but are also a potential source of contaminants such as toxic trace elements that could be introduced to seafood, especially as one moves up the trophic food chain. Aquaculture of marine fish is regarded as the future of aquaculture, and thus, the safety of these farmed fish is paramount particularly as 50 % of fish consumed by humans are now farmed¹. Therefore, a better understanding of bioaccumulation kinetics and processes of such contaminants with current aquafarming practices is essential. Such an effort will yield important new information on the role the fish food or key environmental parameters on contamination of fish that could potentially impact the health of the cultured species and/or the human consumer. This is commonly performed in representative wild fish species.

In traditional aquaculture practices, caged fish can be fed different types of food such as natural prey, including, 1) forage fish, crustaceans, polychaetes or by-products of seafood processing, 2) artificial pellets produced by dedicated manufacturers with various formulations developed to improve the aquaculture performances. Common to all these feeding practices is that both natural prey and ingredients used in artificial pellet formulations are likely to contain contaminant residues. Thus, the forage fish and fish meal may be rich in organic mercury, and squid viscera meal (used as additives to stimulate growth) is a potentially high cadmium source^{2,3}.

Key environmental parameters have been shown to affect trace element bioaccumulation in aquatic organisms⁴. Among these factors, water salinity and temperature are key parameters in aquaculture as they both exert a strong influence on production performances (by affecting farmed fish physiology). Nevertheless, there is still limited information available about the influence of these factors on trace element trophic transfer in farmed fish.

In order to better understand the contamination risk of farmed species, a series of nuclear-based methods can be applied such as for example, high efficiency gamma-spectrometry. This is a very powerful and very sensitive approach that allows identifying the susceptibility of farm-raised fish to be contaminated by trace elements and radionuclides in particular through the measurement of the dietary assimilation efficiency (AE).

In this context, the aim of this presentation is to provide some examples of radiotracer studies such as the influence of food items and environmental conditions (salinity and temperature of the water) on a farmed fish, the turbot *Scophthalmus maximus* (reaching 72 000 tonnes in 2014) using radiotracer techniques

2. Materials and Methods

2.1. Origin and acclimation of the fish

Juvenile turbot was purchased from a fish farm (France Turbot, France) and shipped to the International Atomic Energy Agency premises in the Principality of Monaco. Fish were acclimated to laboratory conditions for several weeks. During the acclimation period, the fish were fed a daily ration of 2% of their biomass.

2.2. Radiolabelling of the different foods

For food radiolabelling, radiotracers of high specific activity were used. Live food were exposed to contaminants through dissolved phase for at least 4 days and pellets were dipped in radiolabelled seawater for 1h. Then, radioactive pellets were dried and stored in dry conditions. The use of gamma-emitting isotope allowed accurate measurements using environmentally realistic concentrations.

2.3. Assimilation efficiency

The experiments were performed in 20-L or 70-L aquaria (open-circuit, same conditions that during acclimation). Two weeks before the start of the experiments, juvenile turbot was randomly transferred from

the acclimation tank to the aquaria used for experiments and slits cut into the fins were used to facilitate individual recognition. Two hours after the unique radiolabelled feeding, all the turbot from the different experiments were counted using a high-resolution gamma-spectrometer system composed of 4 Germanium detectors to determine the ingested radioactivity. Then, turbot were counted after 24h and 48h of depuration. The assimilation efficiency (AE) was calculated as the percentage of radioactivity remaining in fish after 48h of depuration. Differences between AE were tested using non-parametric tests (Wilcoxon Mann-Whitney & Kruskal-Wallis). The level of significance for statistical analyses was always set at $\alpha = 0.05$.

3. Results and discussion

The quality and type of food is already known to directly influence trace element content in fish⁵. Here, we found that, using juvenile turbot, ¹⁰⁹Cd assimilation efficiency (AE) was significantly different depending the type of ingested food (Fig. 1A). These results can be explained by differences in Cd bioavailability in the foods as has been demonstrated in another species of fish, the grunt *Terapon jarbua*⁶.

Concerning the influence of salinity and temperature, our results shown that temperature had no significant influence on ^{110m}Ag AE in turbot (Fig. 1B). Nevertheless, a significant effect of salinity was observed in the ¹³⁷Cs (Fig. 1C). This finding can be related to the osmoregulation processes in marine fish that control the diffusive ion invasion and excreted the excess ions to maintain their osmolarity⁷. Based on these physiological mechanisms, the lower observed ¹³⁷Cs AE in turbot maintained in the highest salinity condition can be explained by (1) a limited entrance of dietary ¹³⁷Cs in the gastrointestinal tract, and/or (2) a higher excretion rate of ¹³⁷Cs.

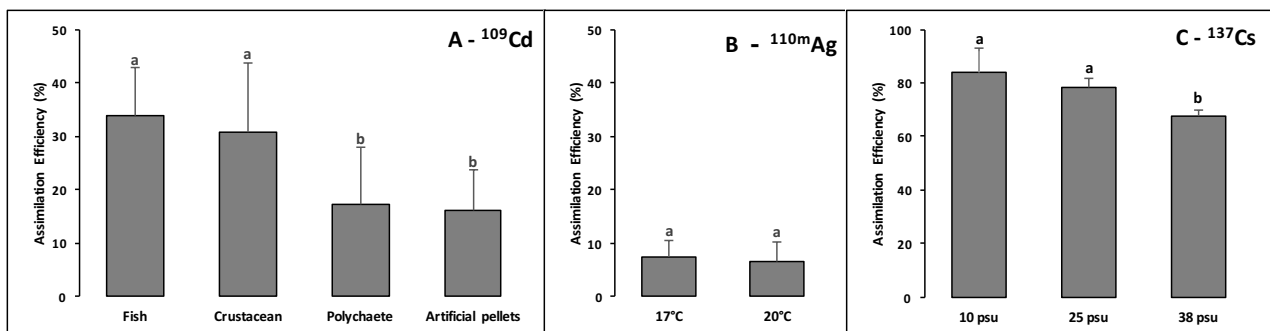


Figure 1: Assimilation efficiencies, measured in turbot (n=5-8), of (A) ¹⁰⁹Cd in turbot fed with different foods, (B) ^{110m}Ag under two water temperature conditions and (C) ¹³⁷Cs under three water salinities.

Conclusions

In summary, this study has shown varying effects of food, water salinity and temperature in the AE of trace elements and radionuclides in farmed fish. Such findings set the stage for further investigations on the potential use of nuclear techniques in aquaculture and food safety.

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