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CAN SOLUBILITY BE USED TO PREDICT AVAILABILITY?

THE EXAMPLE OF ZINC, SELENIUM AND MANGANESE IN SALMON DIETS

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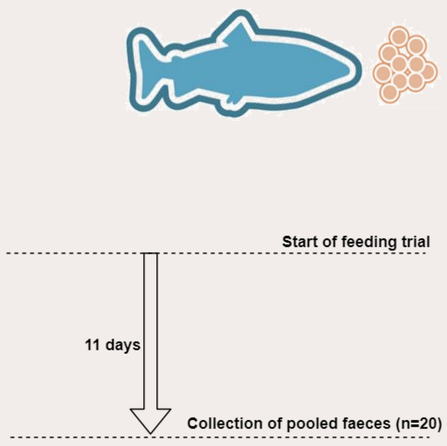
BACKGROUND

- Zinc (Zn), selenium (Se) and manganese (Mn) are naturally present in ingredients of salmon diets [1]. However, the amount present is not always enough to meet the mineral requirements and some compounds in the ingredients can reduce mineral availability [2]. Thus, Zn, Se and Mn are usually supplemented to diets as inorganic or organic forms to ensure that mineral requirements of Atlantic salmon are met. Applying mineral forms with higher availability can reduce the amount of minerals supplemented to the diets. Consequently, there is an increasing interest in investigating the availability of inorganic and organic mineral forms.
- Dietary mineral availability is usually studied *in vivo* but having an *in vitro* method for estimating dietary mineral availability can facilitate the evaluation of new feed ingredients and feeds. Minerals from the dietary matrix become soluble before being available for absorption [3]. Therefore, determining the amount of soluble mineral provides some information on mineral availability.

AIMS AND METHODOLOGY

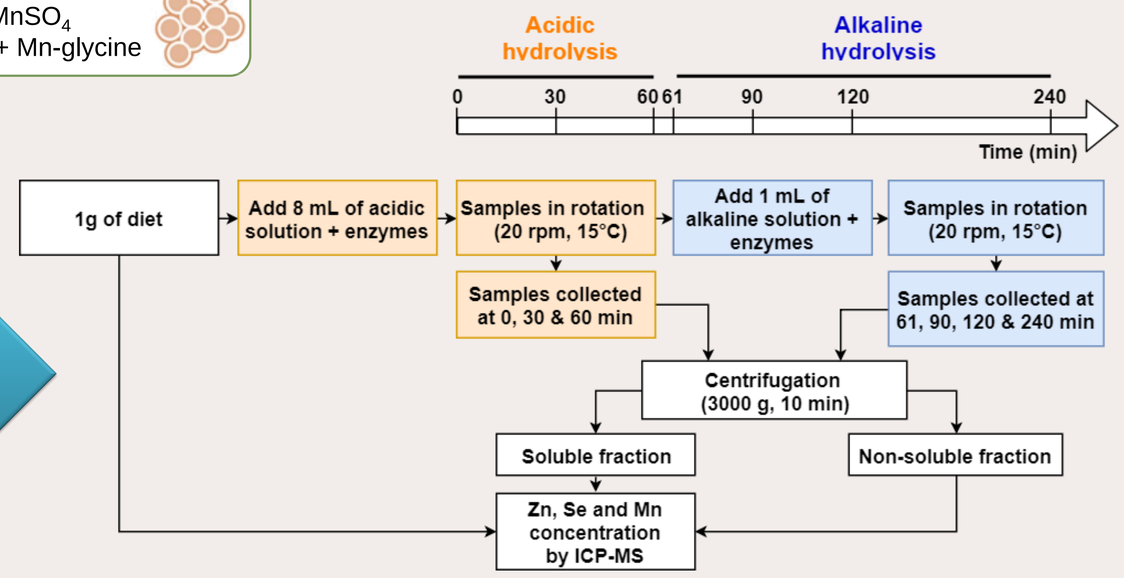
- In this study, correlation of solubility and apparent availability of Zn, Se and Mn was evaluated. For this purpose, estimation of apparent availability and solubility of an inorganic mineral (IM) diet and an organic mineral (OM) diet were performed as following described:

Estimation of apparent availability



Experimental diets (tested in triplicate):
- IM diet: $ZnSO_4$ + Na_2SeO_3 + $MnSO_4$
- OM diet: Zn-glycine + SeMet + Mn-glycine

Estimation of solubility



$$\textbf{Apparent availability}\ (\%) = 100 - \left(100\frac{\textit{yttrium in diet}}{\textit{yttrium in faeces}} * \frac{\textbf{Zn or Se or Mn } \textit{in faeces}}{\textbf{Zn or Se or Mn } \textit{in diet}}\right)$$

$$\textit{Solubility at 240 min}\ (\%) = \frac{\textit{Zn or Se or Mn in the soluble fraction}}{\textit{Zn or Se or Mn in diet}} * 100$$

Figure 1. Apparent availability was evaluated in a feeding trial where Atlantic salmon was fed the IM diet and OM diet for 11 days; at the end of this period, faeces were collected; concentration of Zn, Se and Mn in the diets and the faeces were determined by ICP-MS and apparent availability of Zn, Se and Mn estimated.

Figure 2. Flowchart of the *in vitro* digestion method; the method includes two steps: acidic and alkaline hydrolysis; acidic solution (1 mg mL $^{-1}$ pepsin in 10 mM HCl); alkaline solution (1 mg mL $^{-1}$ protease, trypsin and α-chymotrypsin in 100 mM NaOH); the *in vitro* digestion method was applied to the IM diet and OM diet.

RESULTS

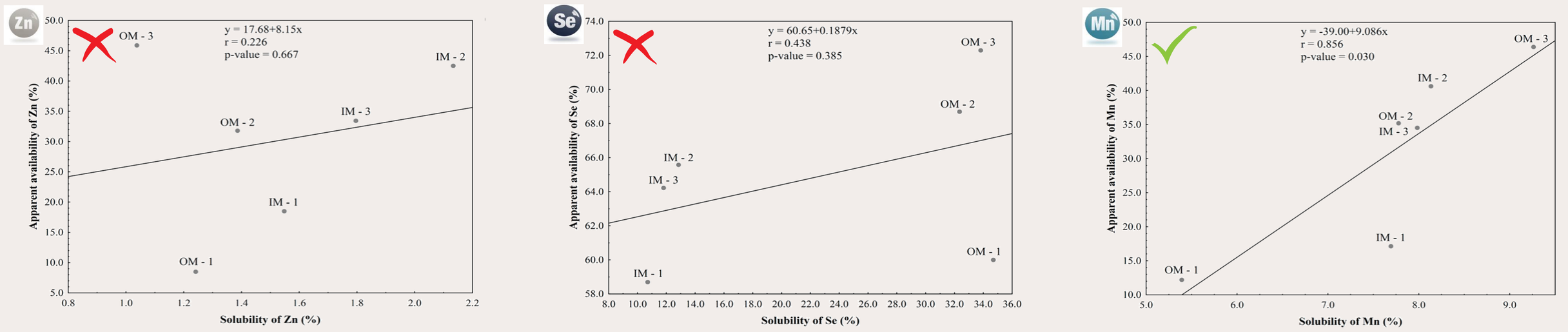


Figure 3. Correlation between solubility (%) and apparent availability (%) of Zn, Se and Mn; IM diet = diet supplemented with inorganic mineral sources (Zn sulphate, selenite and Mn sulphate); OM diet = diet supplemented with organic mineral sources (Zn chelate of glycine, selenomethionine, Mn chelate of glycine); OM/IM-1, OM/IM-2, OM/IM-3 refers to the number of replicates (n=3).

CONCLUSIONS AND FUTURE PERSPECTIVES

- A positive strong correlation between solubility and apparent availability was obtained for Mn but not for Zn or Se.
- **Solubility can be used to predict Mn apparent availability but cannot be used to predict Zn or Se apparent availability.**
- More feeds will be evaluated, as more data points could lead to stronger correlation for Zn and Se.
- Future work will focus on improving the *in vitro* digestion method to better estimate mineral availability.

REFERENCES

[1] Sanden *et al.* (2017) Surveillance program for fish feed. Yearly report for samples collected in 2016; [2] National Research Council (2011) Nutrient Requirements of Fish and Shrimp, The National Academies Press; [3] Fairweather-Tait SJ (1992) Bioavailability of trace elements. Food Chem 43 (3):213-217.

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