Sweetness in a New Light

Ecotoxicogenomic Evaluation of Photodegradation Products of Acesulfame-K

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Introduction

- Acesulfame-K (ACE) is one of the most used artificial sweeteners worldwide[1]
- its high stability and solubility lead to persistence and mobility in aquatic environments[2]
- to date, no comprehensive environmental risk assessment was conducted, although several studies have observed sublethal effects on aquatic organisms
- environmental concerns rise, including potential photodegradation products[3]

➢ this study used transcriptomics to investigate the ecotoxicity of ACE and its photodegradation products (ACE-UV) on the aquatic model organisms *Danio rerio* and *Daphnia magna*

Methods

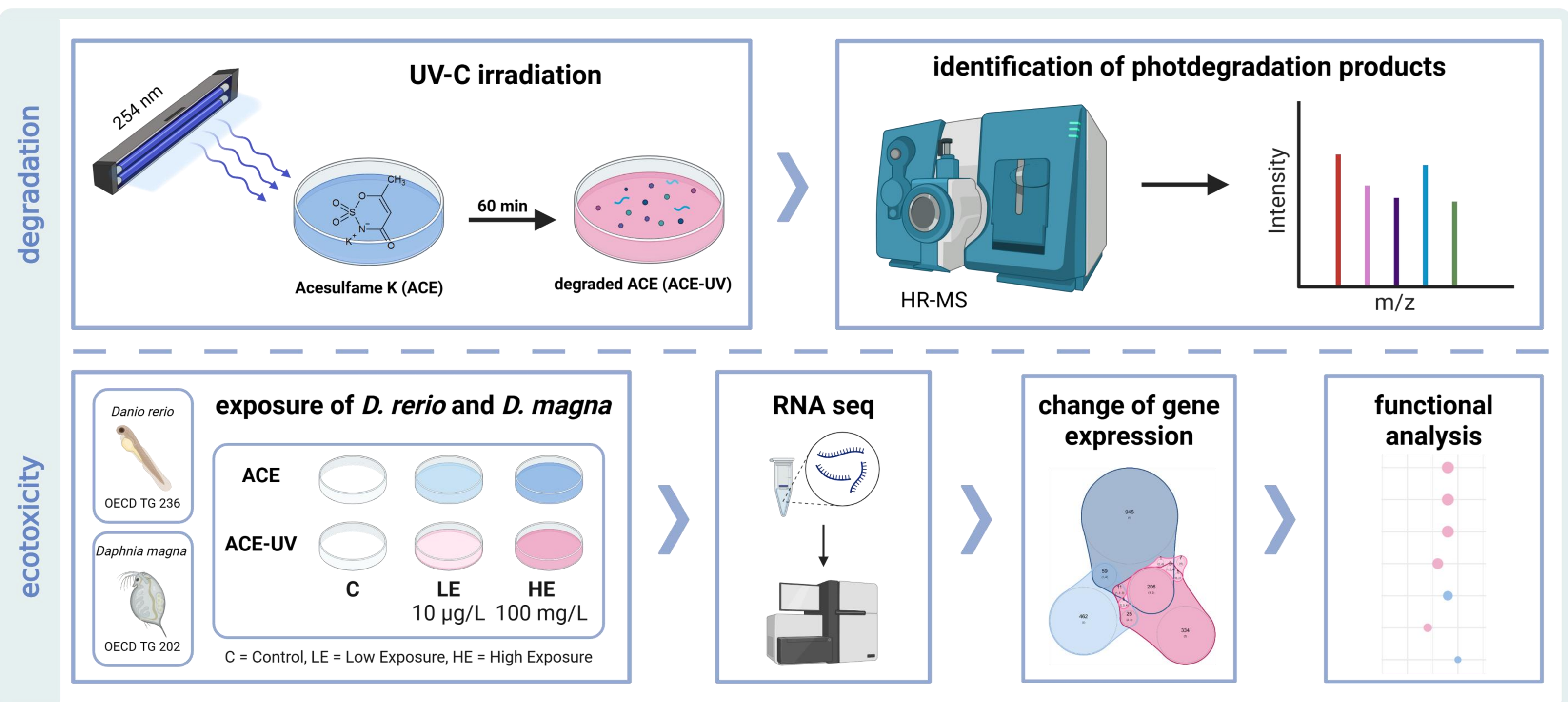


Figure 1: After UV-degradation of ACE and identification of its photodegradation products, both, the irradiated solution and ACE were used for ecotoxicity testing including transcriptomics.

➢ UV-C irradiation was chosen to mimic disinfection in wastewater treatment plants (WWTP)

Results and Discussion

Degradation of ACE

- >88% ACE were degraded within 60 min of UV-C irradiation
- identified photodegradation products included TP-180, TP-137, TP-136 and TP-96 which were already described by other studies[3,4]
- TP-96 (sulfamic acid) is an environmentally relevant and stable end-product[2]

Ecotoxicity comparison of ACE and ACE-UV

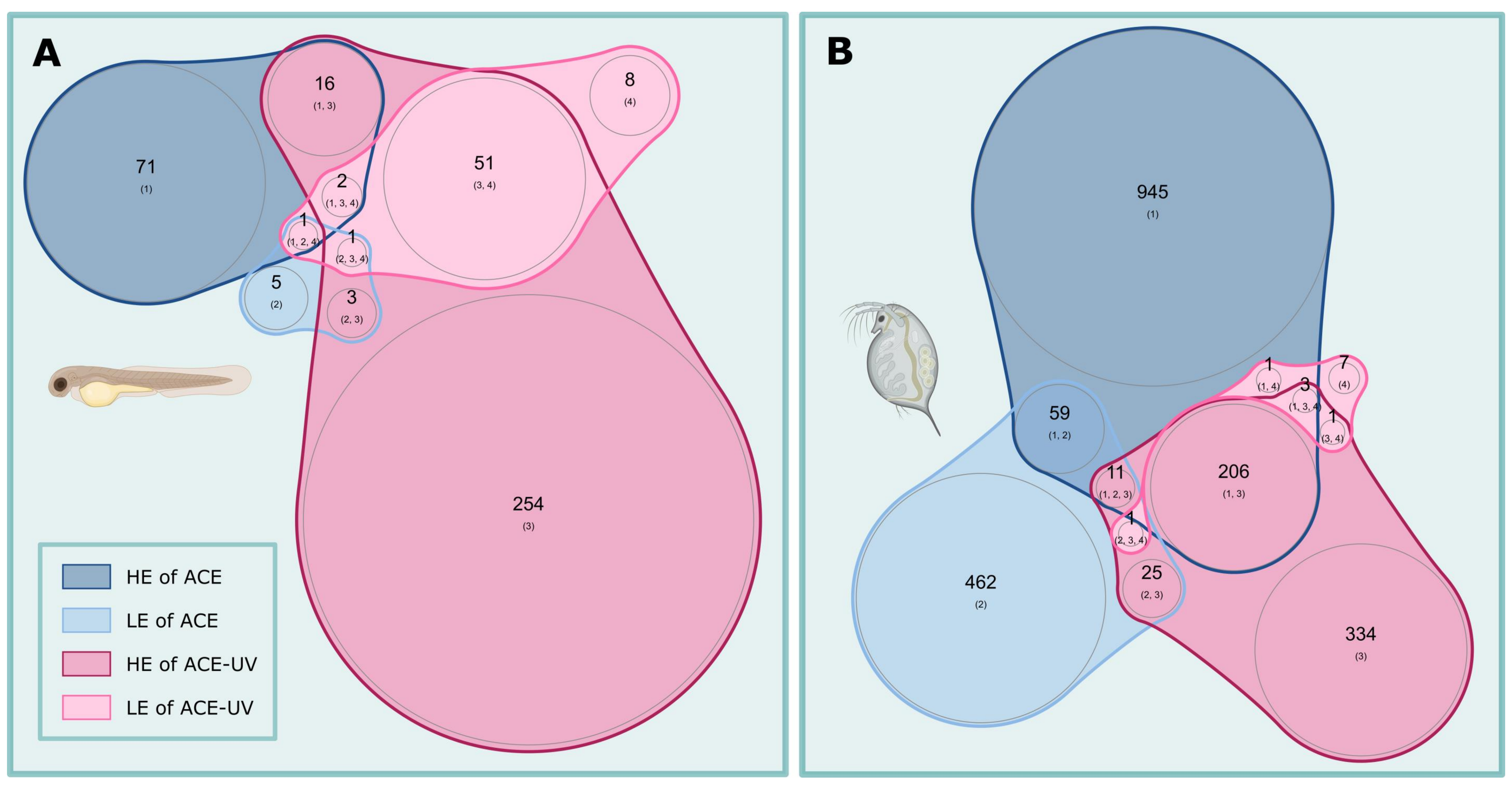


Figure 2: Venn-diagrams showing the significantly ($p_{adj} < 0.05$) differentially expressed genes (DEGs) of D. rerio (A) and D. magna (B) after exposure to ACE (blue) and UV-C-degraded ACE (red). Both were tested in two different concentrations: Low (LE) and High Exposure (HE).

Figure 2 shows:

- *D. rerio* and *D. magna* were both molecularly affected by ACE and ACE-UV
- number of differentially expressed genes (DEGs) was concentration dependent in all cases
- small overlaps indicate differences in modes of action of ACE and ACE-UV
- photolysis of ACE led to enhanced gene response in *D. rerio* (panel A), consistent with literature[5]

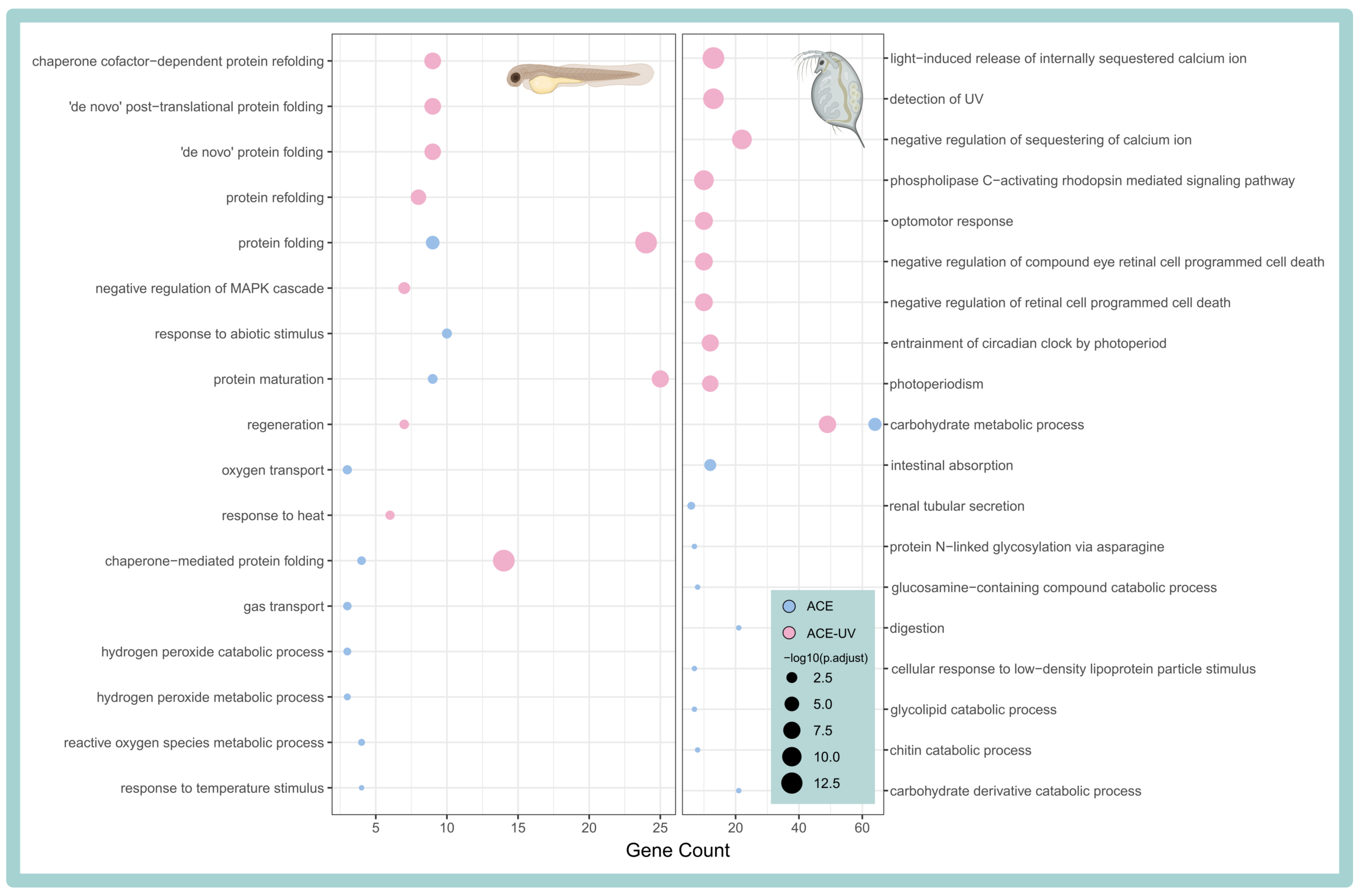
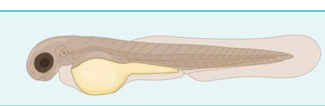
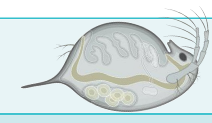


Figure 3: Over-Representation Analysis for significantly enriched "biological process" gene ontology terms (clusterProfiler) in D. rerio (left) and D. magna (right). Top 10 terms per substance, sorted by p_{adj}.

Figure 3 shows:

- minority of biological processes were affected by both, ACE and ACE-UV
  - ➢ supports assumption of individual modes of action
- higher biological process significances by ACE-UV indicate stronger toxicity by photodegradation products
- Table 1 → overview of main modes of action per substance and organism

Table 1: Main modes of action per treatment and organism, drawn from the analysis in Figure 3.

transcriptome response		
ACE	oxidative stress	metabolic and transport stress
ACE-UV	proteotoxicity	light-responsive signaling disruption

Conclusion

- photodegradation products of ACE may be formed during wastewater treatments (WWT) and reach aquatic environments
- ACE and its photolytic TPs induce effects in *D. rerio* and *D. magna*
  - ➢ photolysis of ACE enhances its toxicity
  - **→ ACE and its photodegradation products, that may be built in WWTPs, might induce long-term effects on aquatic organisms**

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[1] Xu *et al*. (2024). The review: effects of acesulfame K on human health. *IJAFSR*, *1*, 64–70.
[2] Perkola *et al*. (2016). Degradation of artificial sweeteners via direct and indirect photochemical reactions. *Environ Sci Pollut Res, 23,* 13288-13297.
[3] Ren *et al*. (2016). The oxidative stress in the liver of Carassius auratus exposed to acesulfame and its UV irradiance products. *Sci Total Environ*, *571*, 755-762.
[4] Chow *et al*. (2021). Degradation of acesulfame in UV/monochloramine process: Kinetics, transformation pathways and toxicity assessment. *J Hazard Mater, 403,* 123935.
[5] Li *et al.* (2016). Photocatalytic transformation of acesulfame: Transformation products identification and embryotoxicity study. *Water Res*, *89*, 68-75.

Graphs and illustrations were generated using R, R Studio, Inkscape, Biorender and ChemSketch.

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