SAFE Final Workshop

MEALWORM: BIOCONVERSION OF BY-PRODUCTS INTO SUSTAINABLE AQUAFEED

Pablo Ramirez

R+D Director

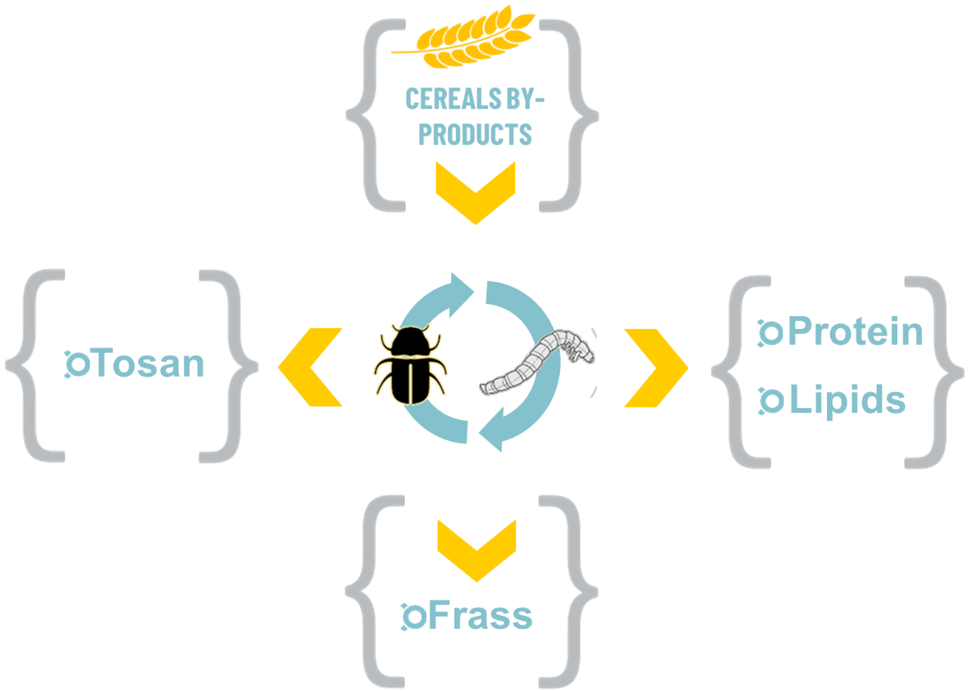
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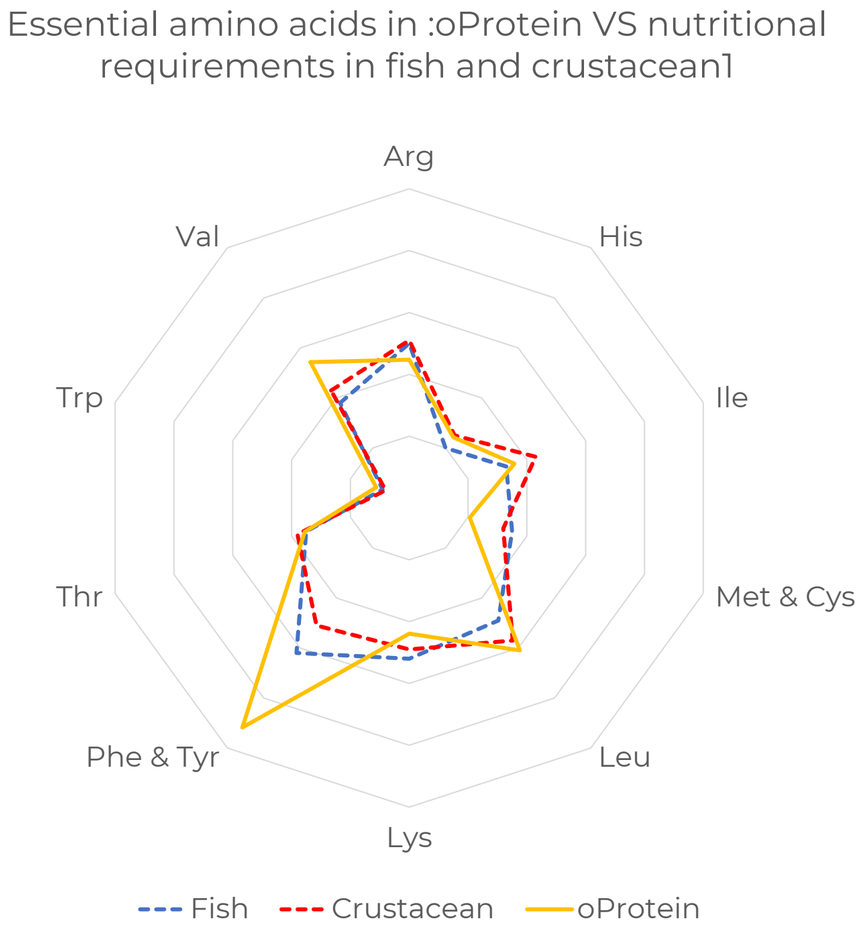
Yellow mealworm



- Yellow mealworm (*Tenebrio molitor*)
- Phylum Arthropoda, Class Insecta, Order Coleoptera
- Life cycle holometabolous: egg, larva, pupa and adult
- Duration: from 12 to 20 weeks
- Photophobic habits
- Detritivore and phytophagous, but eats all kind of substrates
- First insect enabled as fit for human consumption in EU

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Yellow mealworm meal



- >70% protein
- Digestibility >95%
- Rich in essential amino acids (covers most of nutritional requirements in fish and crustacean)
- Rich in vitamins B and choline
- Source of bioactive proteins and peptides
- Other bioactive compounds: chitin, nucleotides, beta-glucans, polyphenols

Xing, S., Liang, X., Zhang, X., Oliva-Teles, A., Peres, H., Li, M., ... & Xue, M. (2024). Essential amino acid requirements of fish and crustaceans, a meta-analysis. Reviews in Aquaculture, 16(3), 1069-1086.

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Yellow mealworm meal in aquafeed

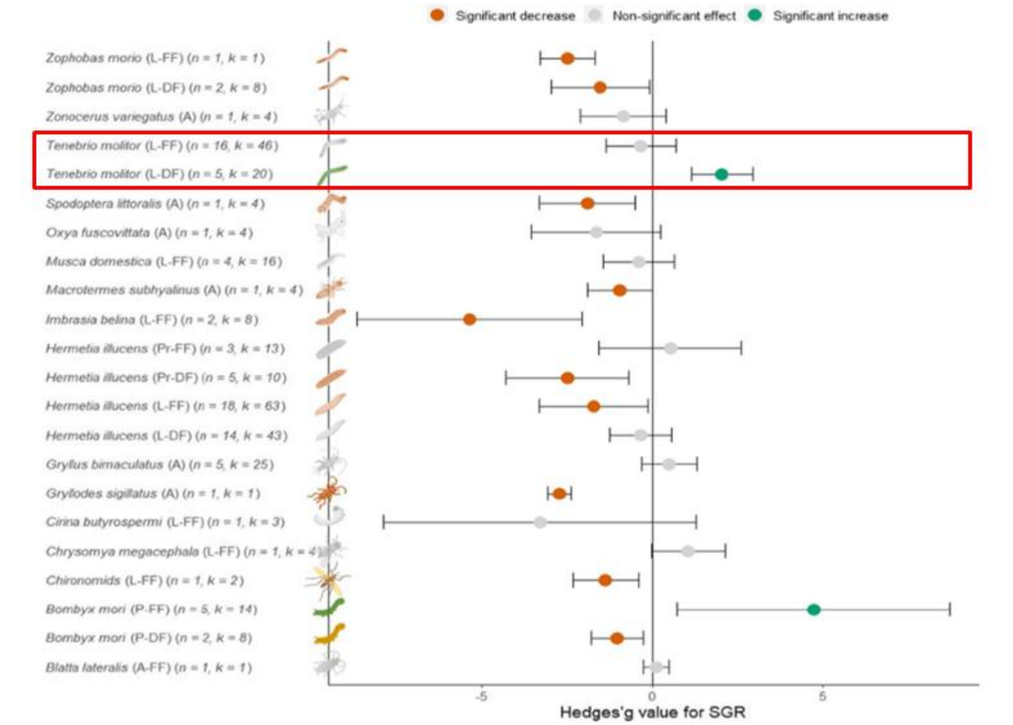


FIGURE 3 Forest plot for Hedges' *g* effect size (mean and 95% confidential interval) of special growth rate (SGR). *n* indicates the number of studies; *k* is the number of comparisons (treatment vs. control group). The letters in the brackets indicate life stage (A, adult; L, larvae; P, pupae; Pr, prepupae) and fat-processed form (DF, defat; FF, full fat) of insect meals

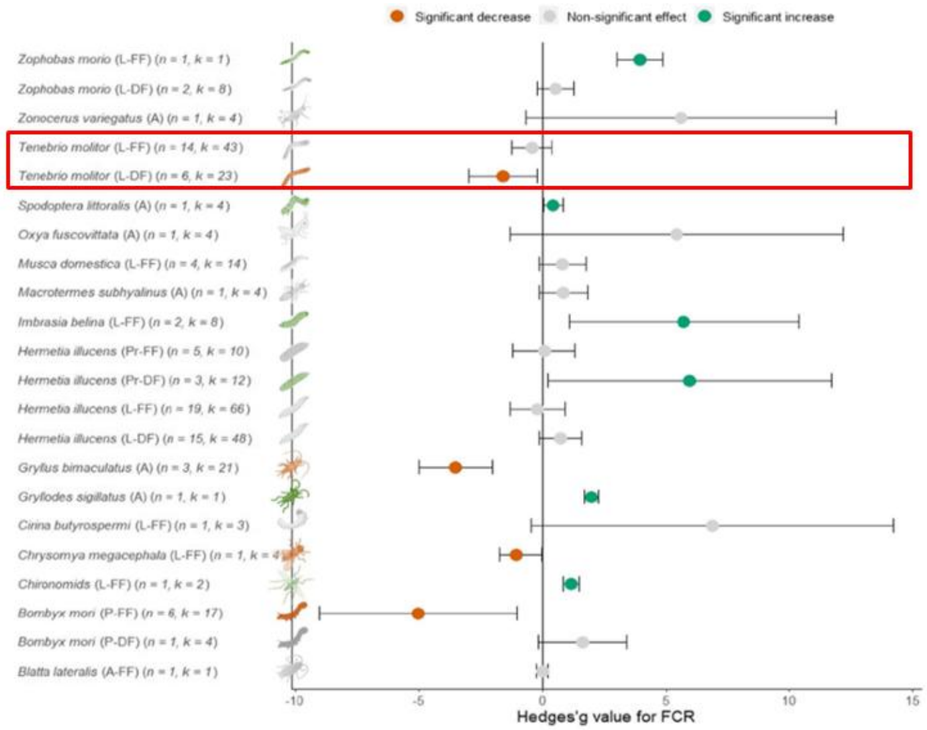


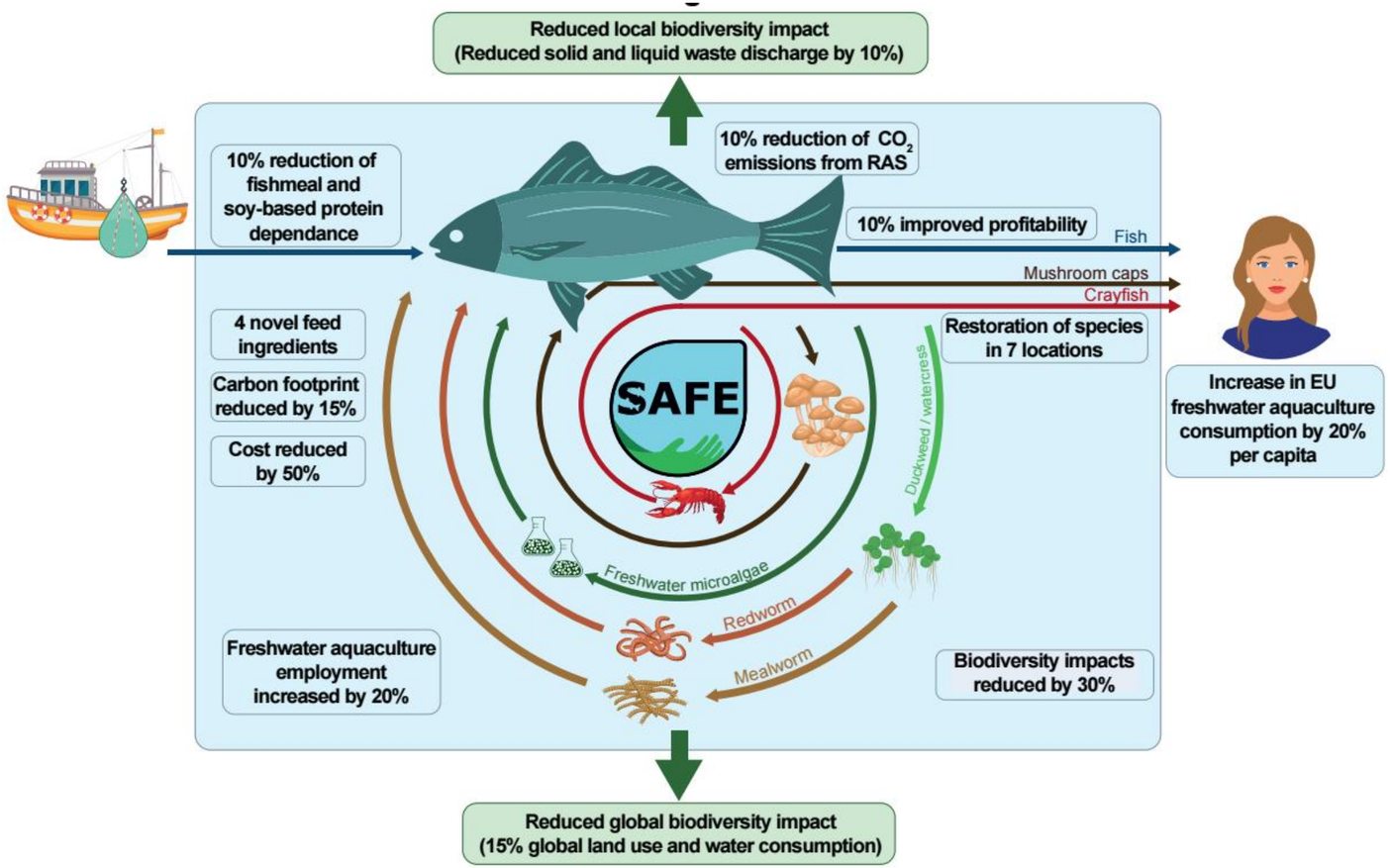
FIGURE 4 Forest plot for Hedges' *g* effect size (mean and 95% confidential interval) of feed conversion ratio (FCR). *n* indicates number of studies; *k* is number of comparisons (treatment vs. control group). The letters in the brackets indicate life stage (A, adult; L, larvae; P, pupae; Pr, prepupae) and fat-processed form (DF, defat; FF, full-defat) of insect meals

- **Meta-analysis** including 107 studies (1990-2021) targeting **23 freshwater and 17 marine fish species** fed 17 insect species as a replacement for fishmeal
- Defatted Tenebrio molitor meal has a significant **positive effect on specific growth rate (SGR)** and **feed conversion ratio (FCR)**; Full-fat Tenebrio molitor has no effect

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Yellow mealworm in the SAFE Project

1. Investigate the bioconversion of aquaculture residues and by-products into yellow mealworm aquafeed ingredients
2. Scale-up the production of mealworm meal and oil based on the SAFE diet
3. Characterization and biological activities assessment
4. Develop new aquafeeds
5. Validate in fish trials

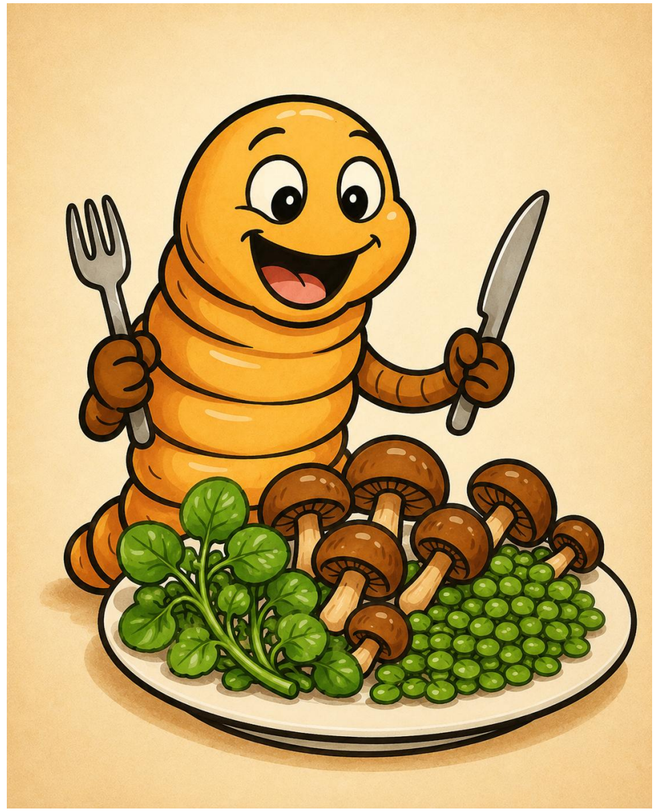


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Bioconversion

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Larvae feeding trials



- Mealworm larvae
- By-product inclusion in the standard diet at increasing levels
- Control
- 3 replicates per treatment
- 4 weeks feeding trial
- Weekly control (biomass, growth yield, FCR, frass production)
- Larvae composition

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Bioconversion

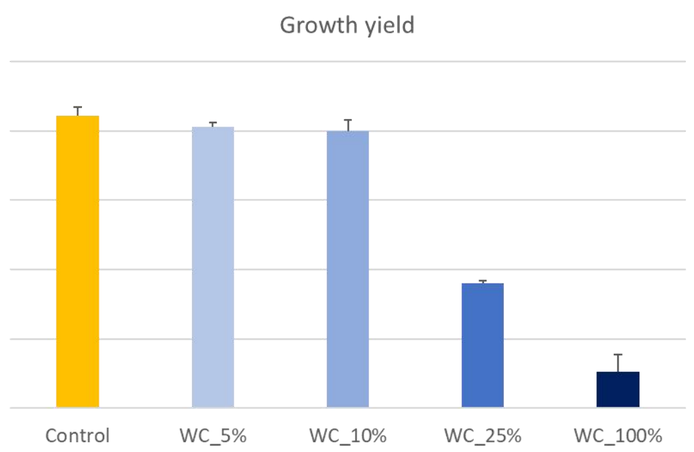
West Pomeranian University of Technology in Szczecin

Watercress







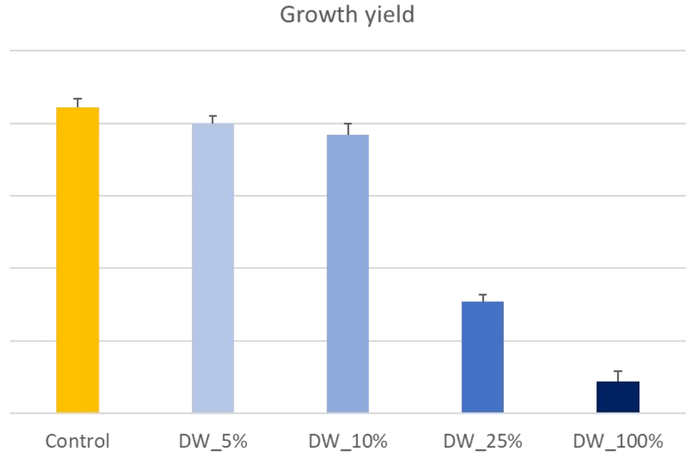


Duckweed









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Bioconversion

Carp sludge collection system

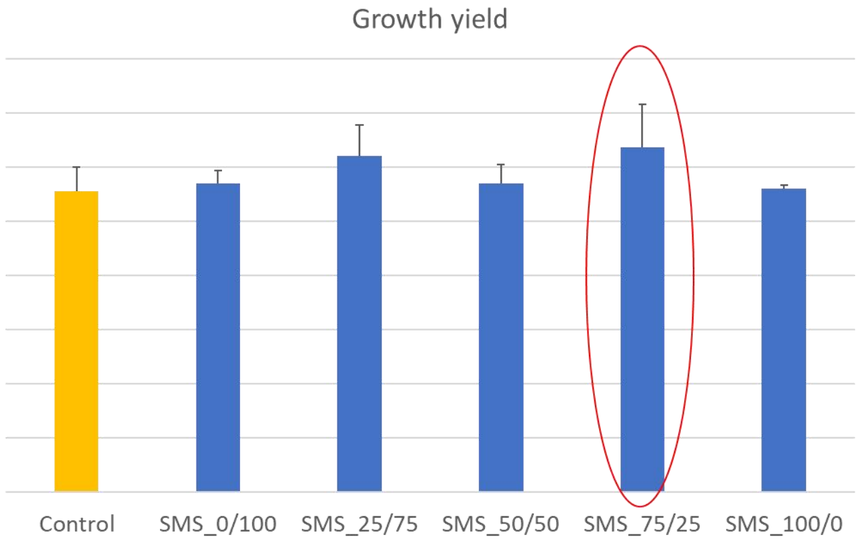


Carp sludge + Spent Mushroom Substrate (SMS)



20% inclusion





- All experimental diets **outperformed the control**
- SMS_75/25 and SMS_25/75 resulted in growth improvements of 14.4% and 11.2% respectively, compared to the control
- **SMS_75/25** was selected as the **SAFE diet** to be scaled up

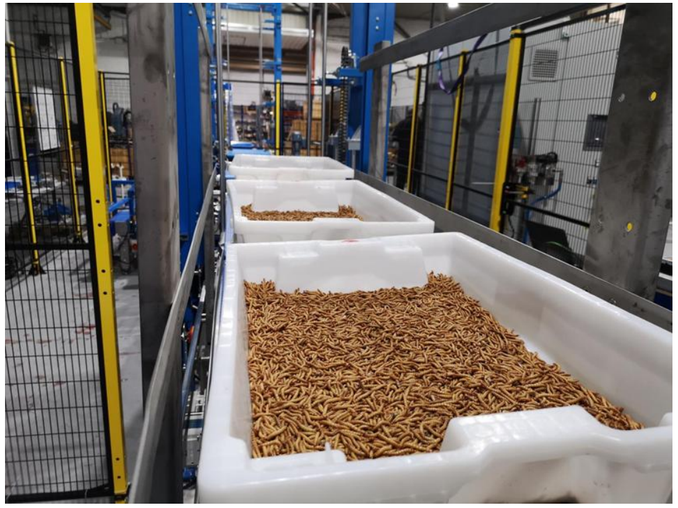
Upscaling

- The SAFE diet was successfully scaled up at Tebrio industrial facility
- 350 Kg of defatted mealworm meal produced for fish trials
- Technological adaptation needed
    - Preservation
    - Drying
    - Milling



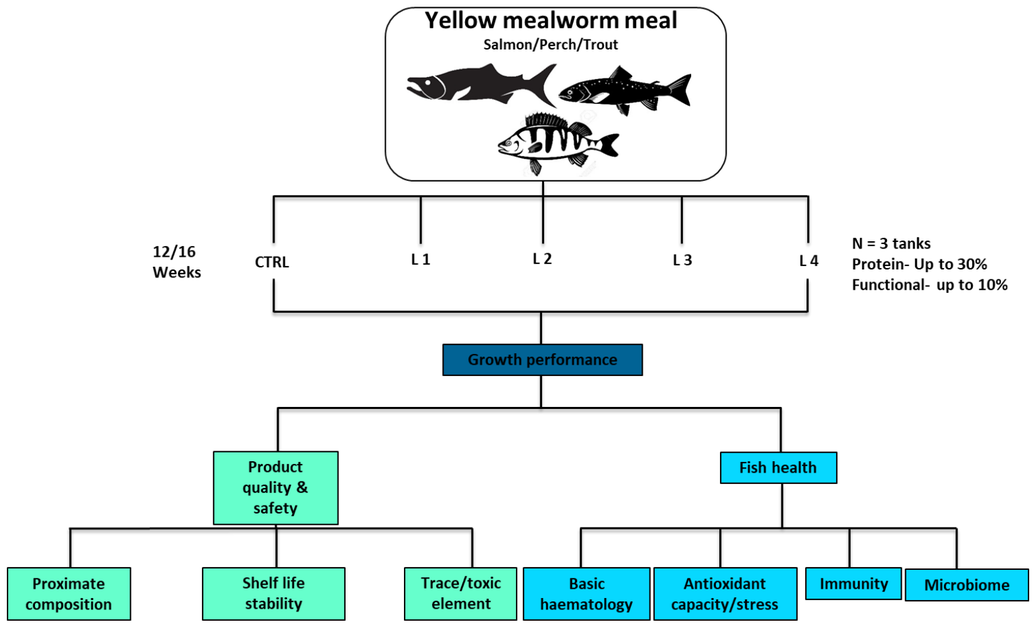


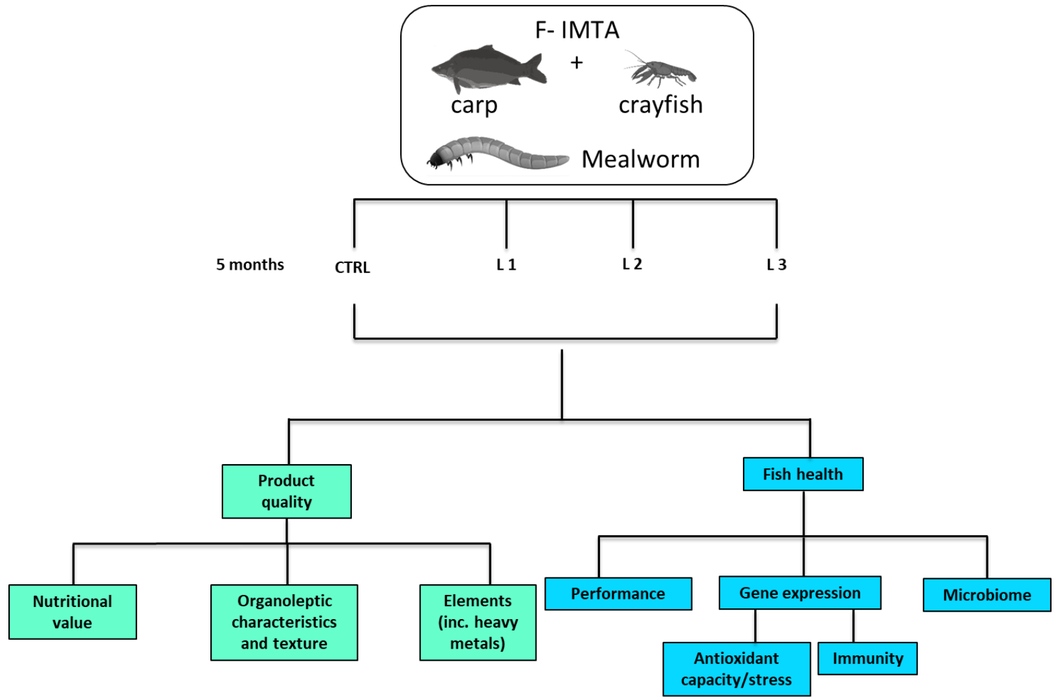




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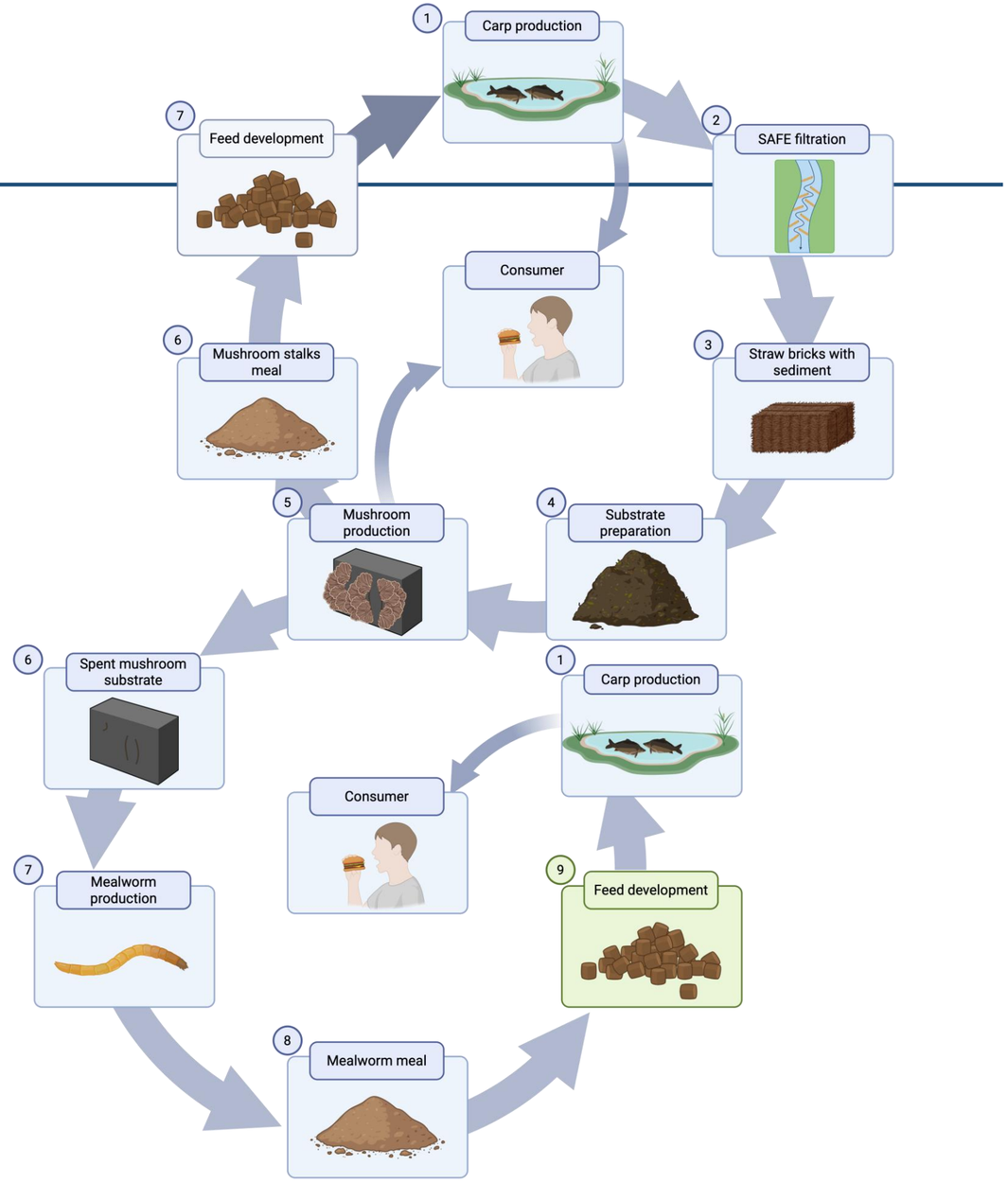
Product validation





Conclusions

- Yellow mealworm can be effectively used as a bioconversion platform to transform organic residues into innovative and sustainable aquafeed ingredients
- Technological optimization needed for side-stream integration
- Regulatory and economic implications



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HOW WILLING WOULD YOU BE TO EAT FISH FED ON INSECTS? (1) No way; (5) Absolutely

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