POZNAN UNIVERSITY OF LIFE SCIENCES

Laboratory of Inland Fisheries and Aquaculture,
Department of Zoology.

Aquaculture Canada 2023 Conference and Tradeshow

ADVANCING IN THE FACE OF ADVERSITY

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EFFECTS OF FISH MEAL DIETARY REPLACEMENT WITH *Hermetia illucens* and *Tenebrio molitor* LARVAL MEALS ON THE GROWTH PERFORMANCE AND ENVIRONMENTAL SUSTAINABILITY OF *Leuciscus idus* juveniles

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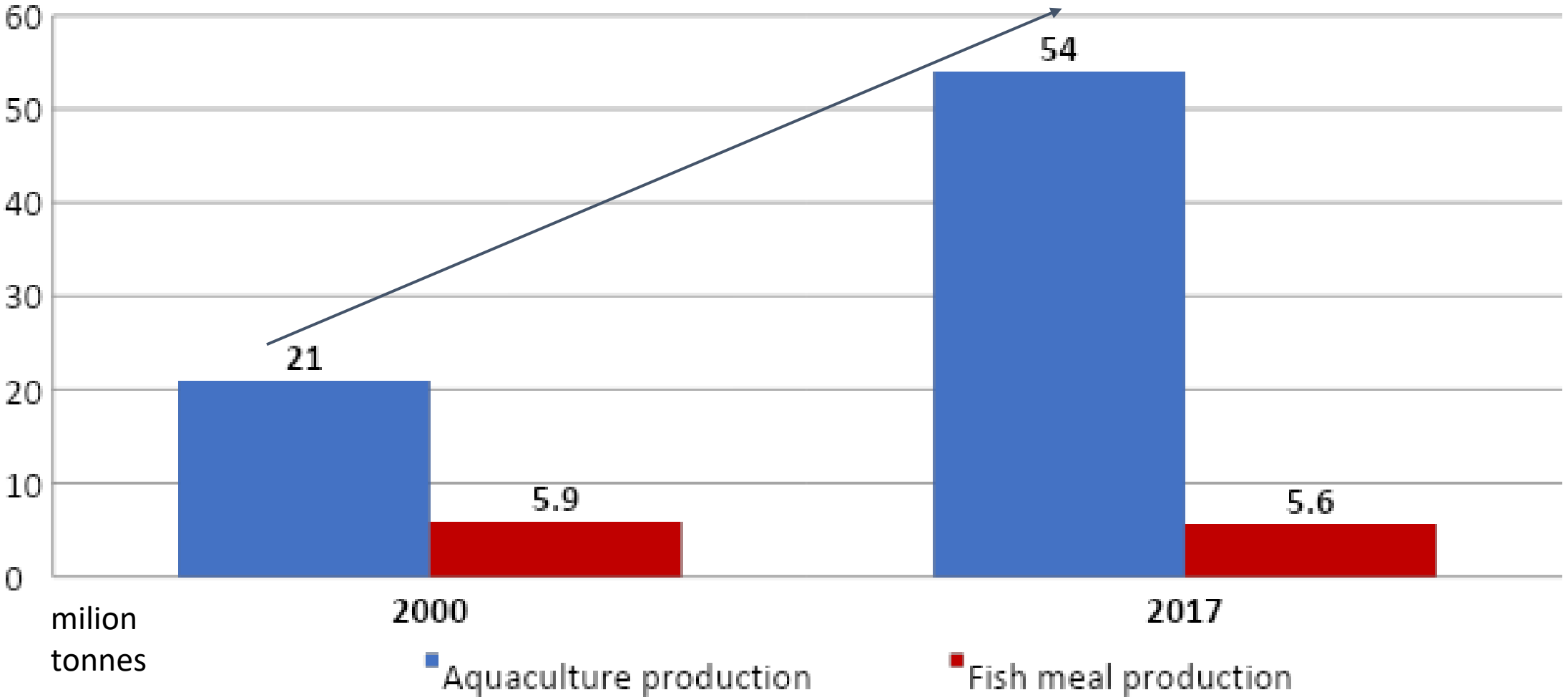
This research was funded by the project entitled “Innovative feed components in the nutrition of rheophilic fish–optimizing and increasing the efficiency of rearing juvenile stages” No. 00001-6521.1-OR1500001/17/19, Task 2.1 “Innovations” according to EU Regulation No. 508/2014, Priority 2—“Supporting environmentally sustainable, resource-efficient, innovative, competitive and knowledge-based aquaculture” realized in the Operational Program “Fisheries and Sea”.

Introduction: Aquaculture



Tacon, A. G. J. (2019). *Trends in Global Aquaculture and Aquafeed Production: 2000–2017. Reviews in Fisheries Science & Aquaculture, 1–14.* , FAO stats 2019

Introduction

Aquaculture

Compensating conservation efforts

A shift from commonly domesticated fish species

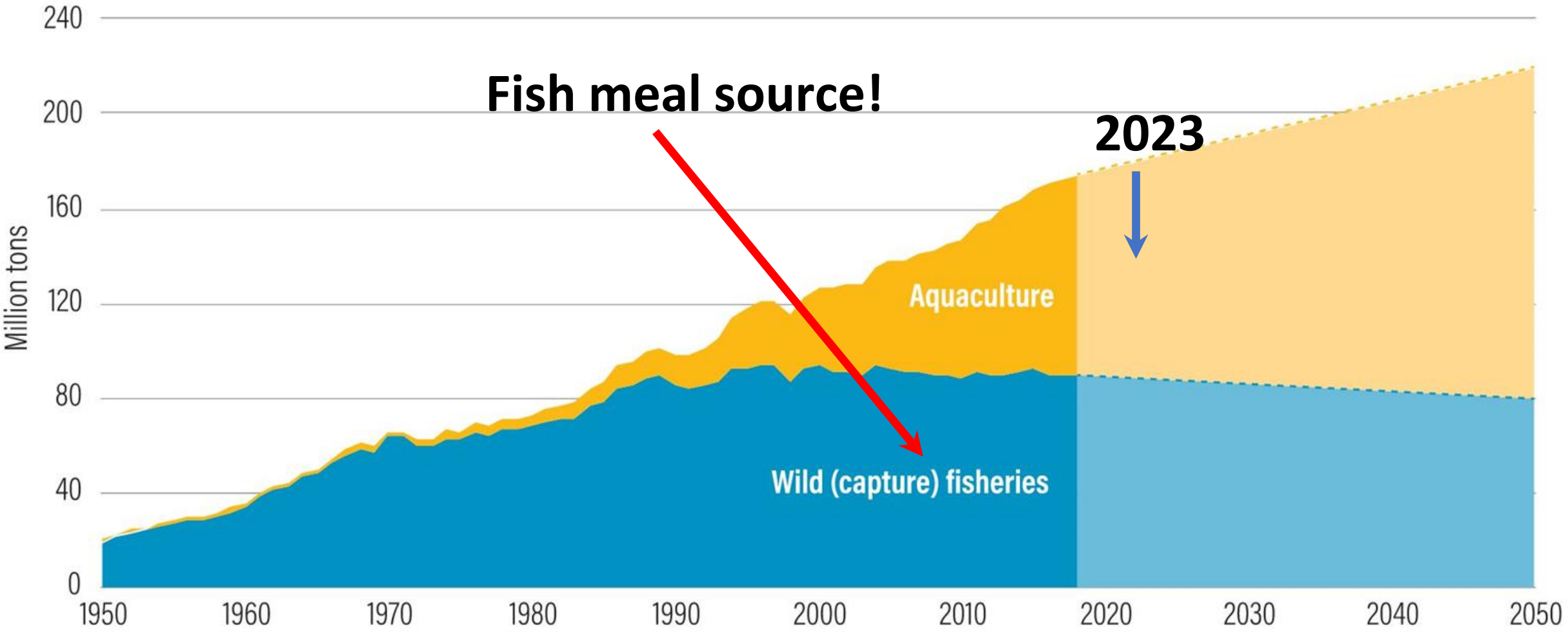
Why European Ide though?

- Ornamental and recreational angling fish species in Poland
- Increased biodiversity

Central idea: Restocking

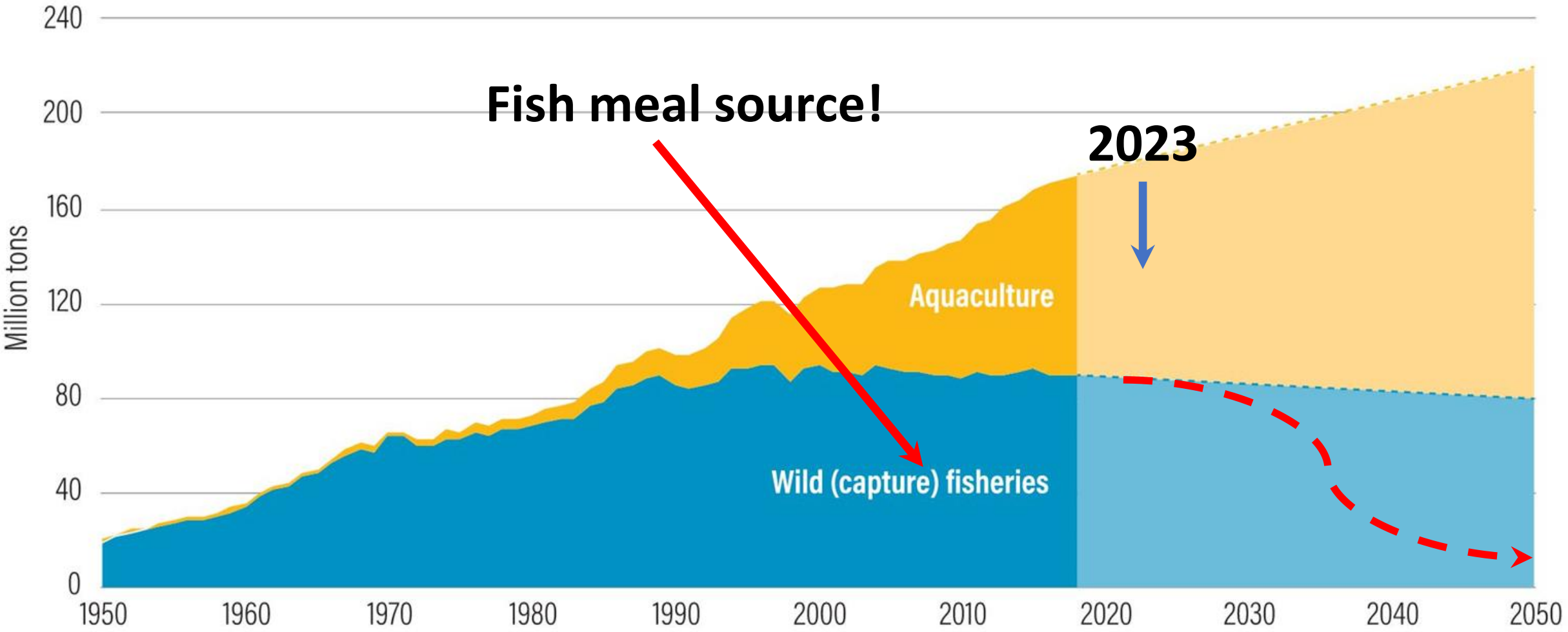
Why do we need alternatives?

Increasing Aquaculture production and constant fisheries

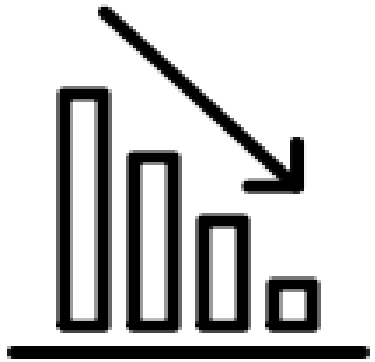


Why do we need alternatives?

We are in the point in which wild fish capture may collapse

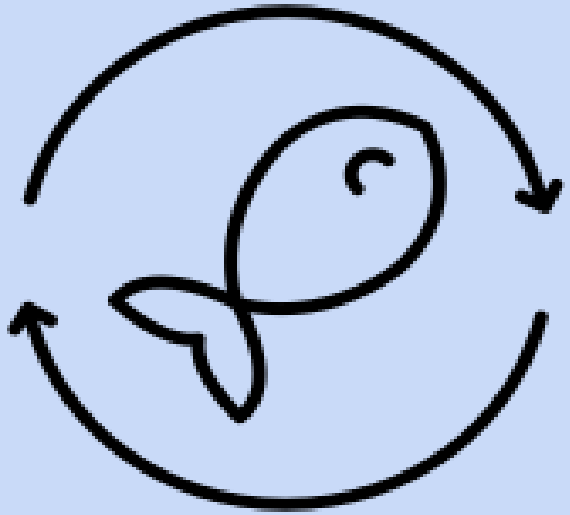


Aquaculture: Ultimate goal of production



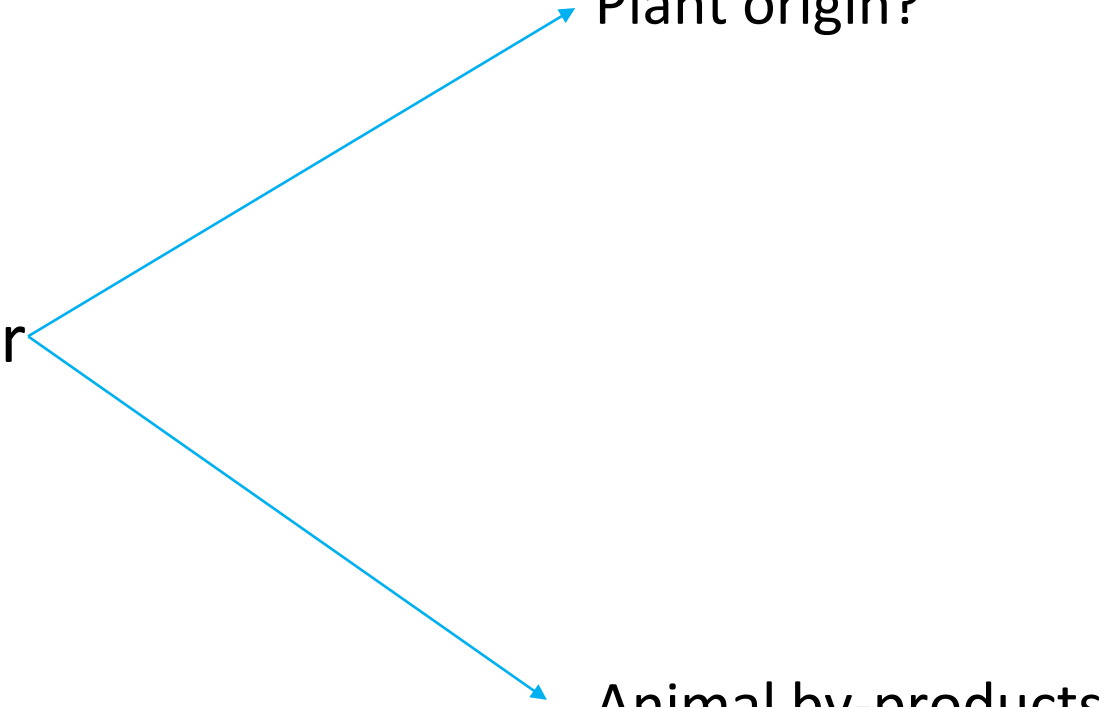
Fish meal

Alternative nutritional approaches



Cost effectiveness and Environmental sustainability

Marine independent raw materials for nutrition



Insects will play an important role in aquafeeds

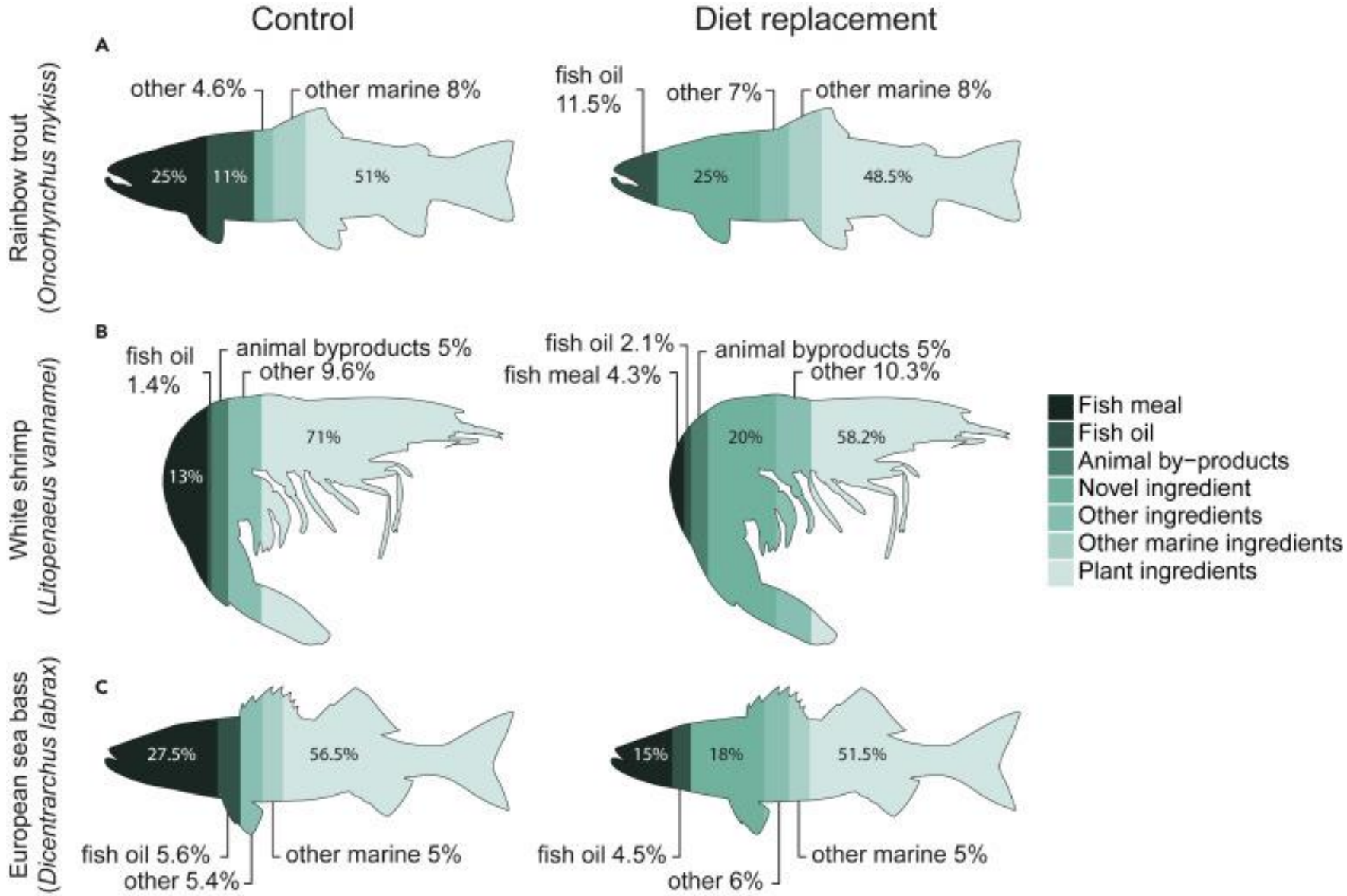
Predicted shares of novel ingredients in future fish diets

Plant ingredients disadvantages create a need for animal origin alternatives

Novel ingredients are the area for insect products

10-25%

of aquafeeds market

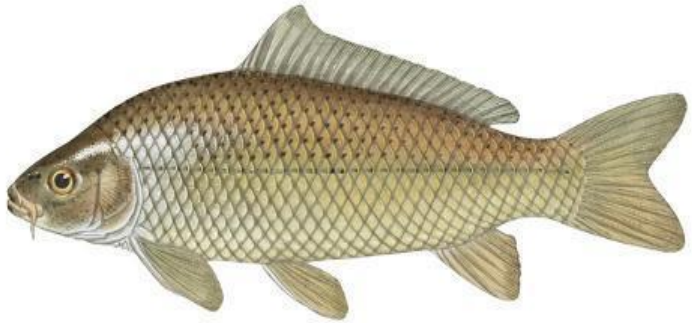


Insects are natural feed source for wild fish!
All farmed species consume insects in the wild

Trouts
Insects = up to 55% of the diet

Salmon
Insects = over 40% of the diet

Sturgeons
Insects = up to 67% of the diet



Carps
Insects = up to 95% of the diet!

Nogales Merida et al. 2018, Gerrity et al. 2014

Insects stimulate fish feeding behaviour and increase feed intake

Insects smell and taste natural and attractive for omnivorous and carnivorous fish

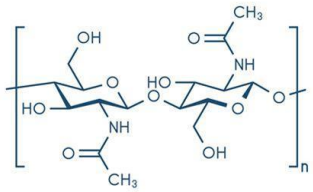
- ✓ **Increased feed palatability in comparison to fish meal and soybean meal**
- ✓ **Lower amount of uneaten and wasted feed**
- ✓ **Better water quality**
- ✓ **Higher feed acceptance = better fish growth**

Positive gastrointestinal tract microbiota modification

Fish health and product safety improvement

Antimicrobial peptides

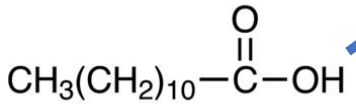
Pathogen decrease



Chitin

Beneficial bacteria increase

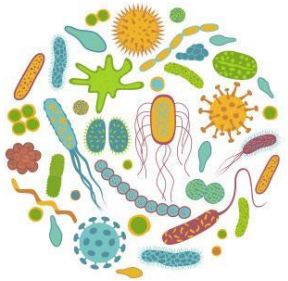
Immune system stimulation



Lauric acid

Bacteriostatic

Antiinflamatory



- Increase of *Bacillus* and *Lactobacillus* populations
- Decrease of *Aeromonas* pathogenic populations
- Gut health improvement
- Immune answer enhancement
  32 % higher lysosyme activity

Józefiak et al. 2018, Rimoldi et al. 2019, Xiao et al. 2018, Rawski et al. in press.,

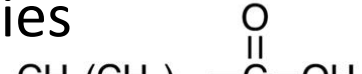
Environmental sustainability

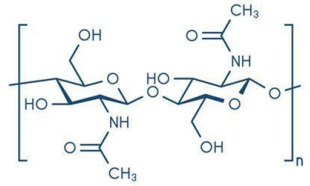
Insect products are the most sustainable protein source on the market

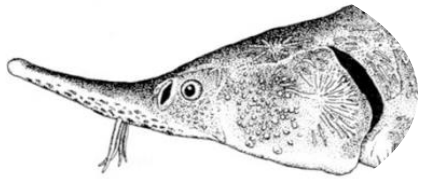
	Insect products	Fish meal	Soybean meal
Natural resources use consequences	No consequences, Renouvelable resources only	Overfishing of the oceans	Tropical forests degradation
Waste management	Waste bioconversion based production	Produces waste, and environment pollution	Produces waste, and environment pollution
Possibility of local production	Yes	No	No
Land and marine areas use	Low	High	High
Effect on supply chains	Positive – shortening of chains	Negative – worldwide supply chain needed	Negative – worldwide supply chain needed
Fossil fuels use in transportation	Low	High	High

Insect based feed

Simply the best in contemporary time in nutrition studies

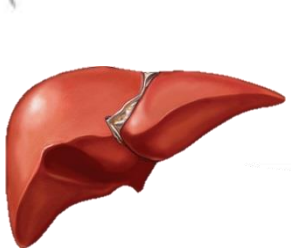


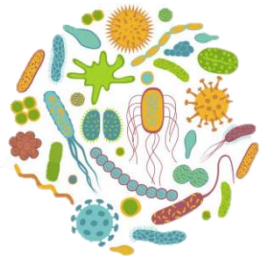




Attractive smell and taste increase feed intake

Bioactive compounds i.e. AMP, lauric acid and chitin affect liver function, microbiota development of gastrointestinal tract





Healthy liver, stabilized microbiota , and well developed gastrointestinal tract improve feed conversion, growth and fish health, which results in

higher profitability of production

Goal of the Study

Our study aimed to evaluate the possibility of using insect-derived meals as an alternative to fish meal in diets for the ide (*Leuciscus idus*) juveniles.

To evaluate the effectiveness of insect meals in the diet of European ide juveniles

to develop feeds best suited for practical application in rearing the highest quality ide juveniles to increase restocking success

Materials and Methods

Experimental Design

- Fish were kept in an experimental recirculation aquaculture system in 20 growth tanks, each with 400 dm3 net capacity.
- A total of 4000 ide juveniles with an average weight of 29g were randomly divided into four groups, with five replicates each (200 fish/tank).
- The effects of the various diets on the efficiency of rearing ide adults were assessed based on the following parameters
    - ❑ Feed physical properties
    - ❑ Feed utilization
    - ❑ Fish growth
    - ❑ Environmental sustainability

Materials and Methods

Experimental Design

- CON—diet with 300 g of fish meal per kilogram and no insect meal
- HI—diet with 150 g of fish meal and 200 g of *Hermetia illucens* meal per kilogram
- TM—diet with 150 g of fish meal and 200 g of *Tenebrio molitor* meal per kilogram
- ZM—diet with 150 g of fish meal and 200 g of *Zophobas morio* meal per kilogram.

Materials and Methods

Experimental Diet Design

Ingredient (g kg^{-1})	Diets			
	CON	HI	TM	ZM
Fish meal	300	150	150	150
Red blood cells	90	90	90	90
Insect meal	0	200	200	200
Soy protein isolate	80	80	80	80
Wheat gluten	100	100	100	100
Wheat meal	125	125	125	125
Corn starch	196	155	186	201
Fish oil	61	50	15	0
Soybean lecithin	10	10	10	10
Premix [1]	15	15	15	15
Vitamin premix [2]	1	1	1	1
Choline chloride	2	2	2	2
Fodder chalk	20	22	26	26
Vitamin C [3]	0.5	0.5	0.5	0.5

CON—diet with 300 g of fish meal per kilogram and no insect meal; HI—diet with 150 g of fish meal and 200 g of *Hermetia illucens* meal per kilogram; TM—diet with 150 g of fish meal and 200 g of *Tenebrio molitor* meal per kilogram; ZM—diet with 150 g of fish meal and 200 g of *Zophobas morio* meal per kilogram; [1] Premix–containing: vitamin D3 200,000 IU, vitamin A 1,000,000 IU, vitamin K 0.2 g, vitamin E 1.5 g, vitamin B1 0.05 g, vitamin B2 0.4 g, nicotinic acid 2.5 g, vitamin B12 0.001 g, D-calcium pantothenate 1.0 g, inositol 35 g, folic acid 0.1 g, choline chloride 7.5 g, methionine 150.0 g, lysine 150.0 g, Mn 6.5 g, Fe 2.5 g, Cu 0.8 g, Zn 4.0 g, Co 0.04 g, and J 0.008 g per 1 kg; [2] Vitazol AD3EC, BIOWET Drwalew, Poland–containing: vitamin D3 5000 IU, vitamin A 50,000 IU, vitamin C 100.0 mg, vitamin E 30.0 mg per 1 kg; [3] Stay C, DSM Nutritional Products Ltd., Mszczonów, Poland.

Materials and Methods

Analyzed chemical composition, amino acid profile, and energetic value of experimental feeds for ide adults

Nutrient (% Fresh Matter)	Diets			
	CON	HI	TM	ZM
Dry matter	91.2	91.0	91.8	91.6
Crude protein	42.3	44.0	44.7	43.5
Amino acids (g 100 g protein^{-1})				
Aspartic acid	6.52	6.25	6.29	6.16
Glutamic acid	16.24	15.48	15.55	15.66
Serine	4.23	4.32	4.41	4.23
Glycine	3.57	3.82	3.94	3.72
Histidine	2.65	2.75	2.77	2.71
Arginine	4.14	4.07	4.16	4.02
Threonine	2.86	3.05	3.06	2.99
Alanine	4.21	4.98	5.23	4.83
Proline	5.60	5.98	6.20	5.93
Tyrosine	2.22	2.86	2.75	2.99
Valine	3.90	4.14	4.18	4.09
Methionine	1.42	1.59	1.57	1.54
Cystine	0.66	0.64	0.65	0.60
Isoleucine	2.20	2.32	2.35	2.32
Leucine	6.97	7.00	7.23	7.10
Phenylalanine	4.44	4.41	4.32	4.34
Lysine	4.99	4.95	5.17	5.06
Crude fat	8.3	7.5	6.4	7.2
Ash	5.57	5.99	5.73	5.38
Crude fiber	1.4	2.4	2.1	1.6
Nitrogen-free extract	42.33	40.01	40.97	42.22
Calcium	1.24	1.20	1.28	1.27
Phosphorus	0.51	0.59	0.57	0.49
Gross energy (MJ kg^{-1})	18.77	18.57	18.48	19.05
Energy/protein ratio (kJ g^{-1} protein)	44.47	43.90	44.43	44.91

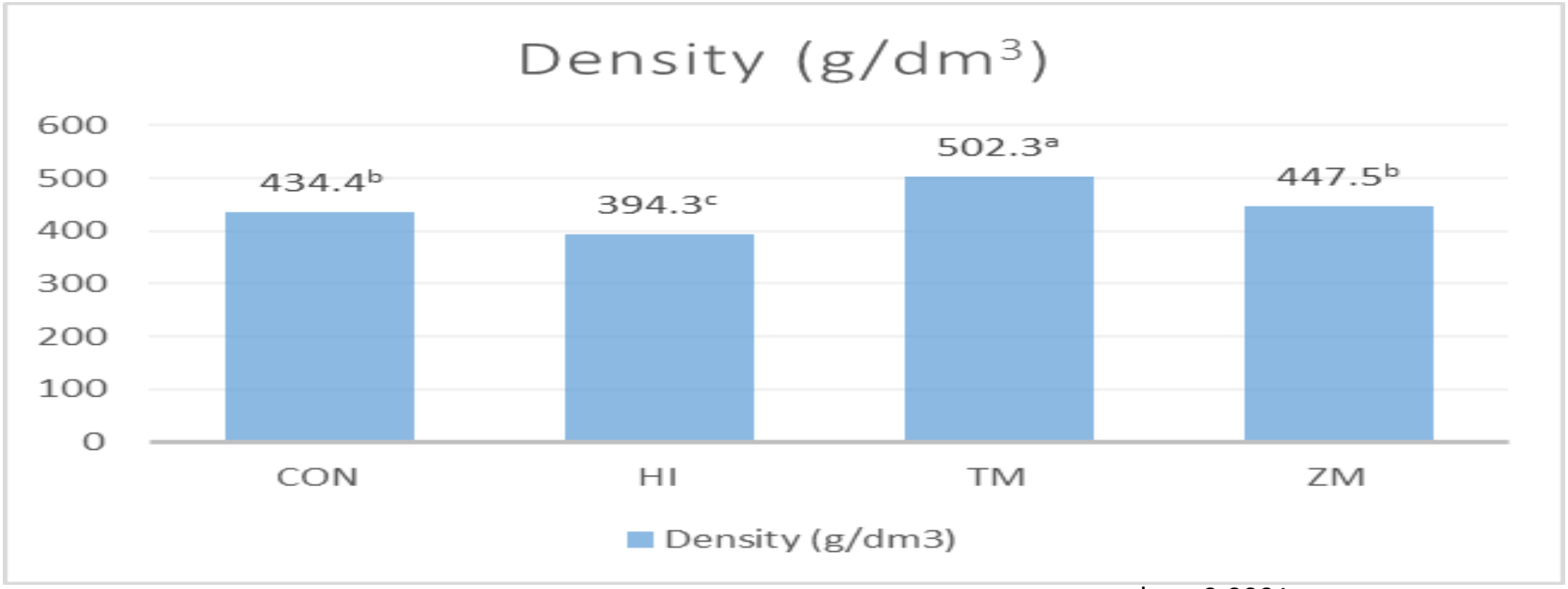
CON—diet with 300 g of fish meal per kilogram and no insect meal; HI—diet with 150 g of fish meal and 200 g of *Hermetia illucens* meal per kilogram; TM—diet with 150 g of fish meal and 200 g of *Tenebrio molitor* meal per kilogram; ZM—diet with 150 g of fish meal and 200 g of *Zophobas morio* meal per kilogram.

Results and Discussion

I. Result (Feed physical properties)

Fig 1: Density (g/dm3)

- Significant differences observed.
- This might suggest the density of the different feeds shows a correlation with the insect type.
- Somewhat contradicts the findings of Irungu et al., 2017 when 50% of fish meal was replaced by *Hermetia illucens* (427-719g/dm3)

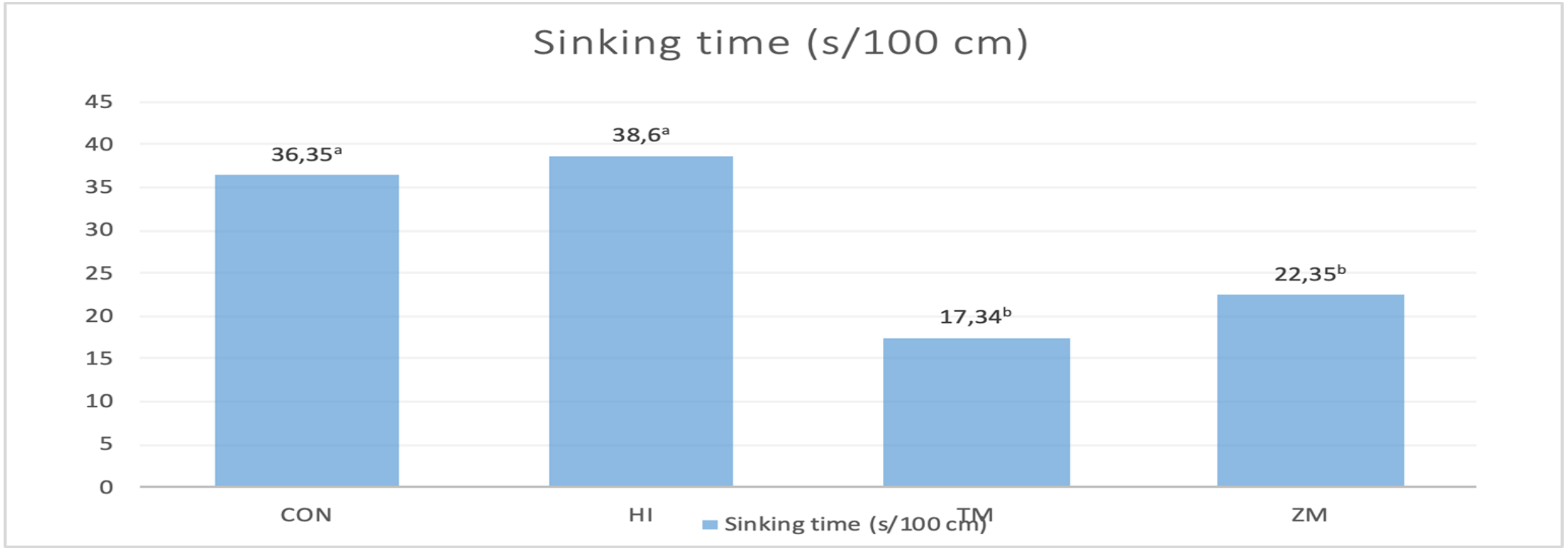


p-value <0.0001

I. Result (Feed physical properties)

Fig 2: Sinking velocity (s/100cm)

- There was no significant differences in sinking velocity in HI and CON treatment, however, a variation was observed between TM, ZM and CON treatment.
- Applied substitution affected sinking velocity in TM and ZM.

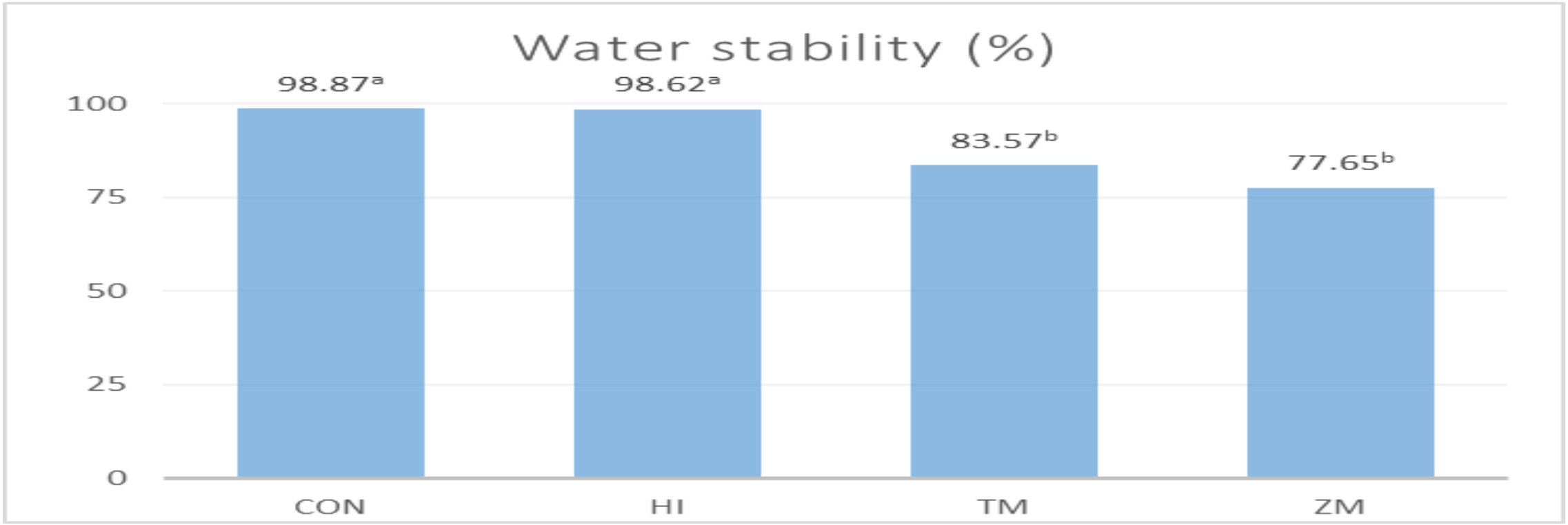


p-value <0.0001

I. Result (Feed physical properties)

Fig 3: Water stability(%)

- There was no significant differences in water stability in HI and CON treatment, however, a variation was observed between TM, ZM and CON treatment.
- Applied substitution affected water stability in TM and ZM.

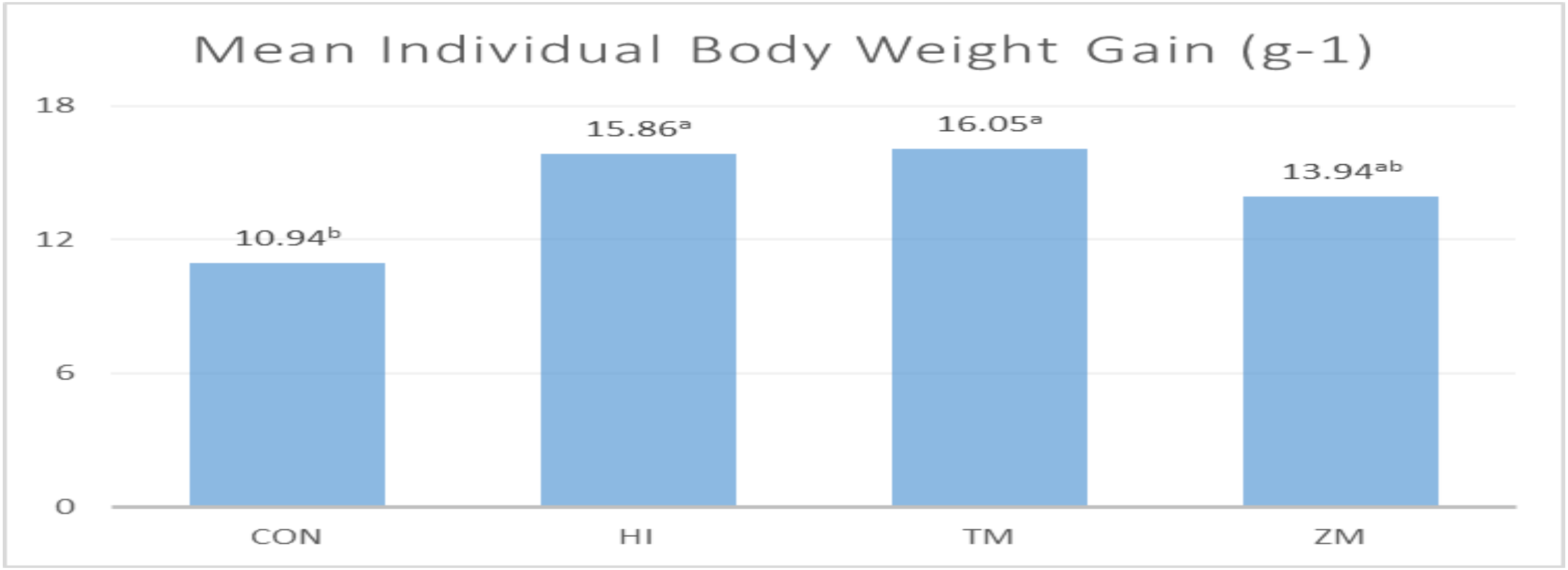


p-value <0.0001

II. Result (Growth and Feed Utilization Parameters)

Fig 1: Mean Individual Body weight Gain (g-1)

- The highest increase in fish weight gain was observed in the HI and TM groups, while the lowest values were observed in the CON and ZM groups.

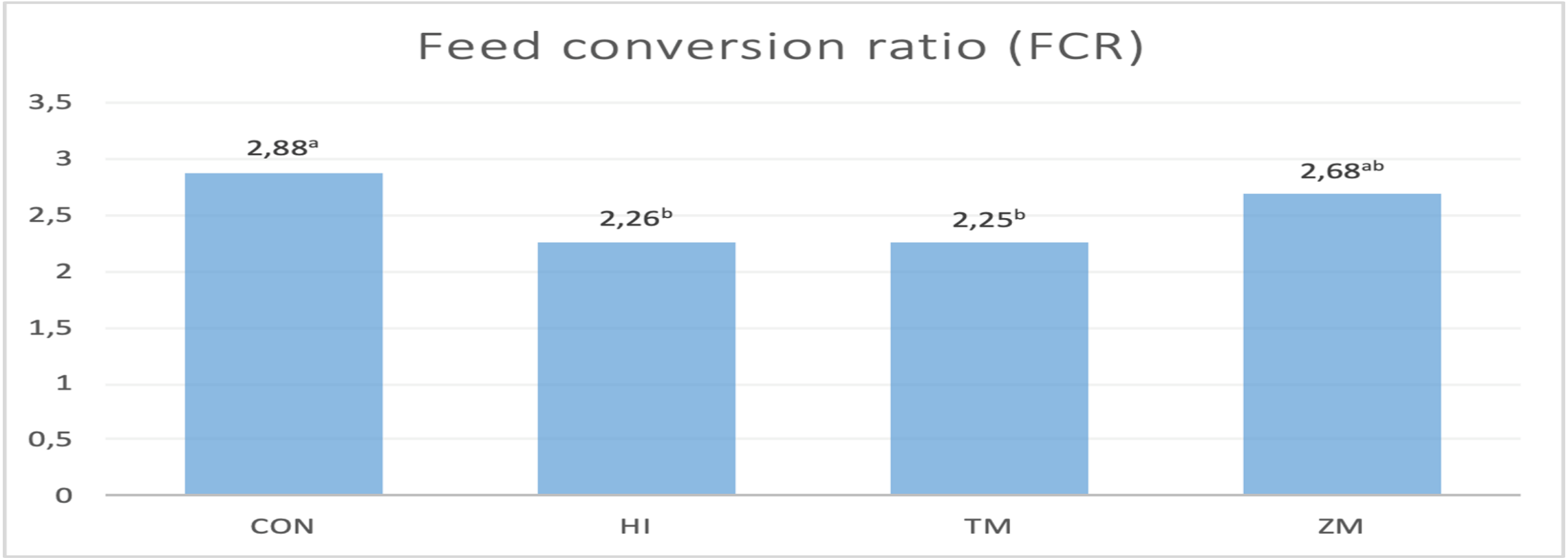


p-value <0.0447

II. Result (Growth and Feed Utilization Parameters)

Fig 2: Feed conversion ratio

- Comparable results were noted for the feed conversion ratio, which was most favorable in the HI and TM groups and increased in the ZM group

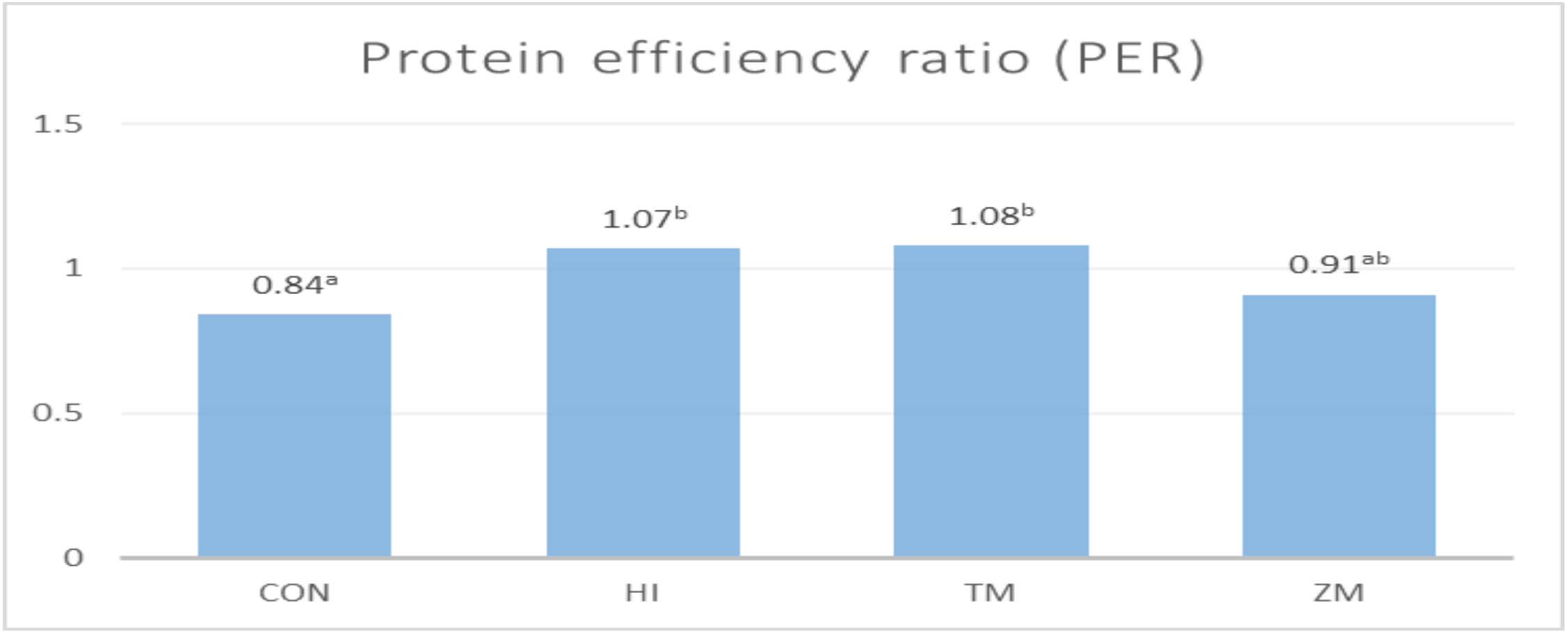


p-value <0.0463

II. Result (Growth and Feed Utilization Parameters)

Fig 3: Protein efficiency ratio

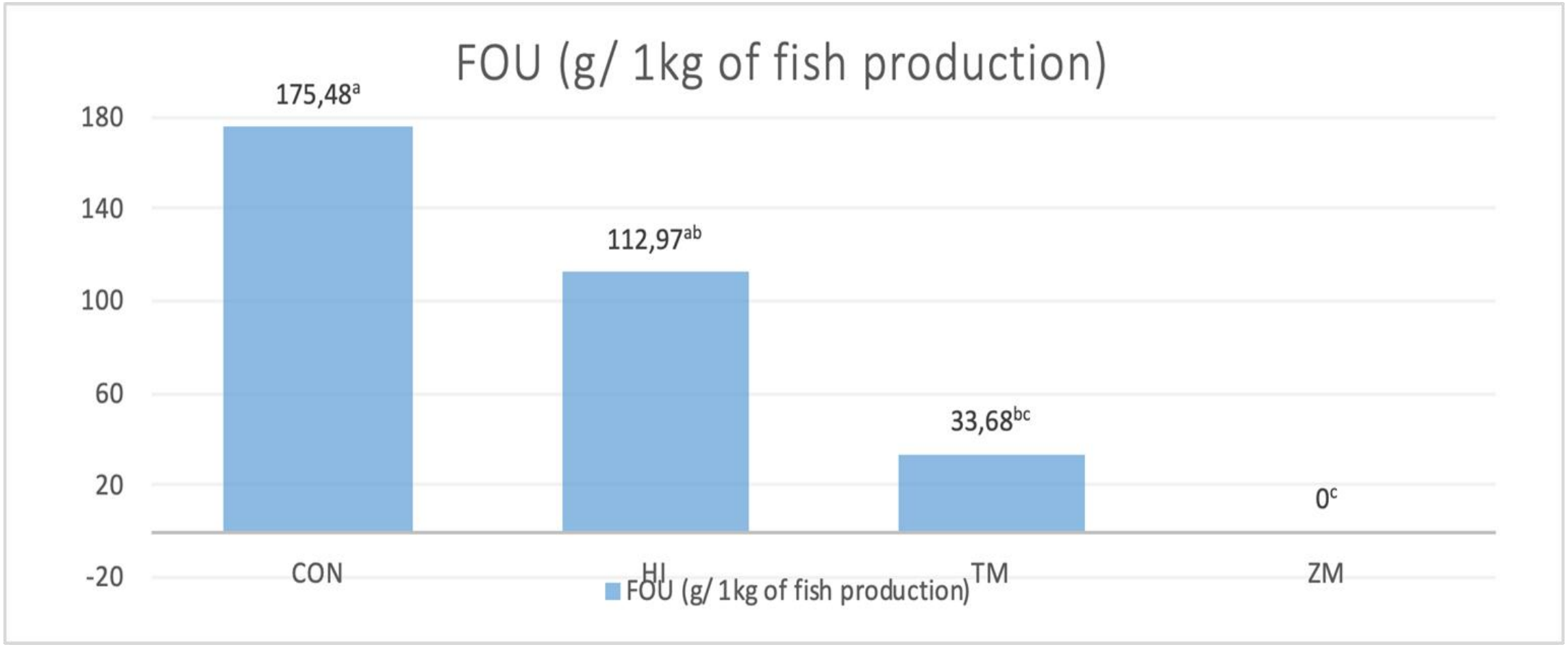
- The highest increase in protein efficiency ratio was observed in the HI and TM groups, while the lowest values were observed in the CON and ZM groups.



p-value <0.0611

III. Result (Environmental Sustainability Parameters)

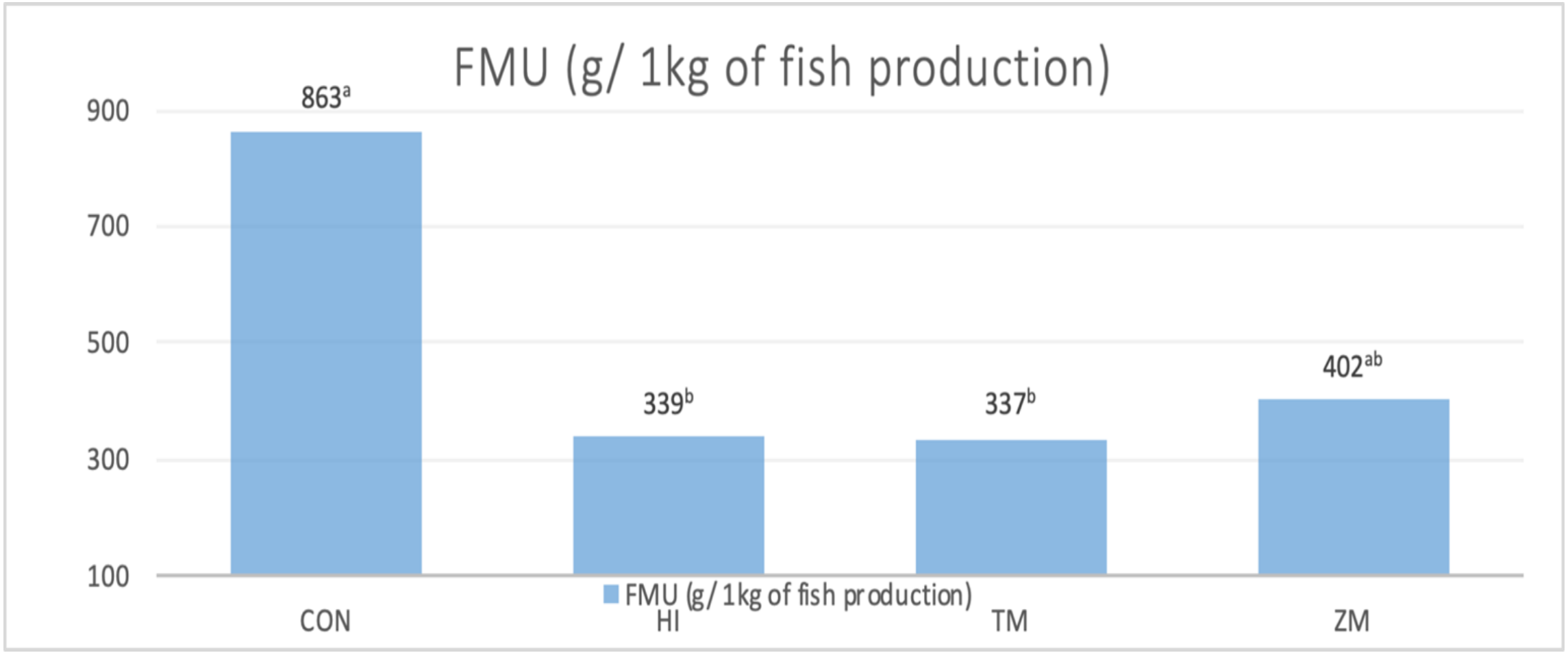
Fig 1: Fish Oil Use (FOU g/1kg of fish production)



p-value <0.0004

III. Result (Environmental Sustainability Parameters)

Fig 2: Fish Meal Use (FMU g/1kg of fish production)

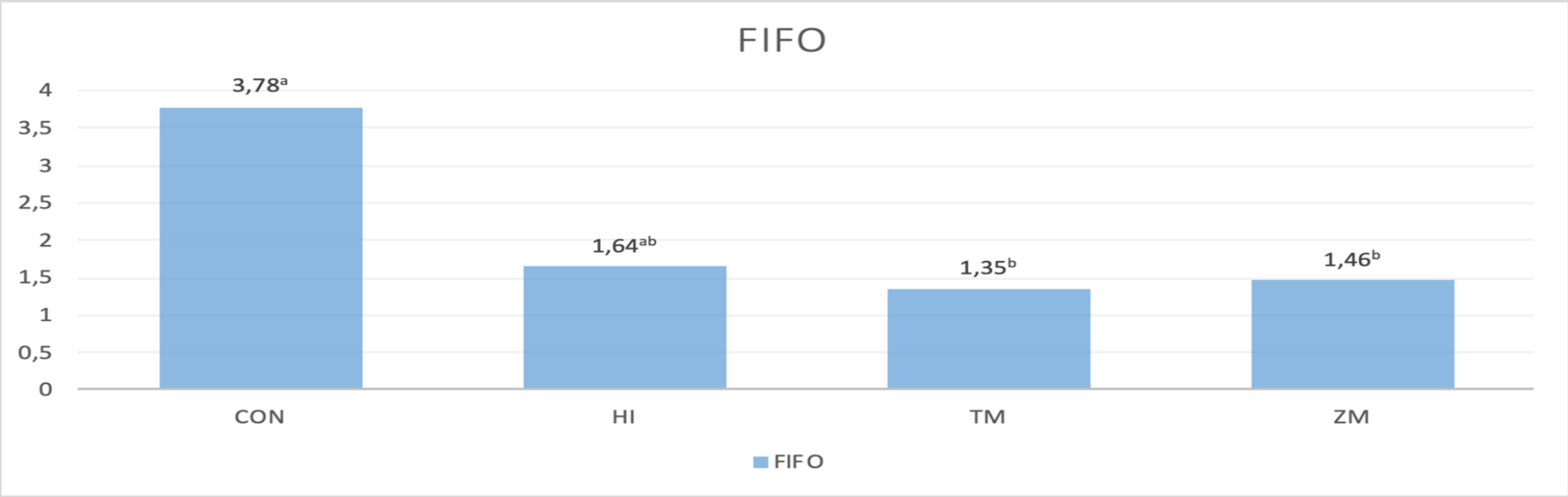


p-value <0.0075

III. Result (Environmental Sustainability Parameters)

Fig 3: Fish-in-fish-out (FIFO)

- The FIFO decreased significantly from 3.78 in the CON treatment to as low as 1.35 in TM treatment which shows a high environmental sustainability of insect meals in Ide juveniles production for conservation purposes.



p-value <0.0056

Conclusion and Future Studies

- The growth performance results for ide juveniles from all experimental groups except for ZM were satisfactory which might support the inclusiveness and potential of insect meals in *Leuciscus idus* diets.
- The mean individual body weight gain and PER in this present study was lower than that of common carp as observed by Askale et al., 2021 depending on the level of incorporation of *Hermetia illucens.*

Summary

- The use of black soldier fly and mealworm larval meal in the diets of ide juveniles had a positive effect on rearing results and its environmental sustainability

FUTURE STUDIES

➔ The effects of these insect meals on the gastrointestinal tract development and digestibility coefficients of ide juveniles.

➔ Effects of different level of incorporation of these insect meals on the growth performance of ide juveniles so that maximum level of incorporation can be established.

This research was funded by the project entitled “Innovative feed components in the nutrition of rheophilic fish–optimizing and increasing the efficiency of rearing juvenile stages” No. 00001-6521.1-OR1500001/17/19, Task 2.1 “Innovations” according to EU Regulation No. 508/2014, Priority 2—“Supporting environmentally sustainable, resource-efficient, innovative, competitive and knowledge-based aquaculture” realized in the Operational Program “Fisheries and Sea”.