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Leading scientist: Dr.Ir. Johan W. Schrama
E-mail: Johan.Schrama@wur.nl






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Eating More or Eating Less: Role of Oxygen in Fish

S Saravanan, I Geurden, JAJ Verreth & JW Schrama

Introduction

- Oxygen is essential for all oxidative processes
- Getting oxygen from water and allocating it among physiological function is critical for fish
- **Limitation in water oxygen level → reduces feed intake** (FI) and growth of fish
- **Macronutrient composition of feed affects O_2 consumption**: > protein > starch > fat
- It is not known whether FI is affected by the difference in dietary O_2 demand (DOD) induced by dietary nutrients .

Objective

Thesis: Fish will adjust FI depending on **dietary oxygen demand** (DOD) induced by nutrients (mg O_2 consumed/ g dry matter intake) → i.e., *Oxystatic control of FI.*

Aim:

1. To test whether the difference in essential amino acid (EAA) balance of diet affects dietary oxygen demand
2. To elucidate the influence of dietary oxygen demand induced by EAA imbalance on FI of fish under normoxia (non-limiting O_2 availability) and hypoxia (limiting O_2 availability)

Methods

Factorial design 2x2 (diets x water oxygen levels) ***4 treatments***

Iso-proteic diets

EAA Balanced (**B**) EAA Imbalanced (**I**)

Rainbow trout

Metabolic tanks (200 L)

EAA Balanced diet → methionine 2.3% & lysine 5.1% protein

EAA Imbalanced diet → methionine 1.6% & lysine 2.7% protein

Normoxia (N) → inlet oxygen supply 80 mg O_2/min

Hypoxia (H) → inlet oxygen supply 20 mg O_2/min

Set up:

- 42 days trial in metabolic tanks
- 12 tanks (triplicates) - 30 fish/tank – initial BW ~52 g
- Fed to satiation – 2 times daily
- Faeces collected & O_2 measured

Measurements:

- Growth & daily feed intake
- Oxygen consumption
- Digestibility
- Nitrogen & energy balance
- NH_3 excretion

Conclusion

Difference in essential amino acid (EAA) balance → affects oxygen demand of diet

- EAA imbalance diet demands more oxygen per gram intake (DOD) than EAA balanced diet in rainbow trout

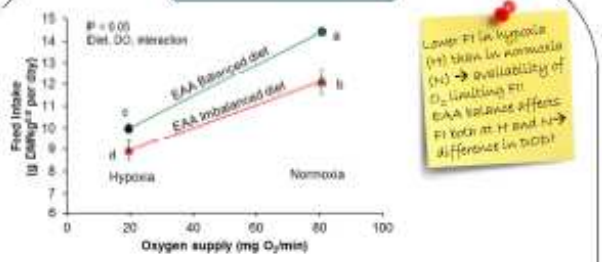
Feed intake of trout was limited by availability of oxygen from water

- Low FI in hypoxia than in normoxia

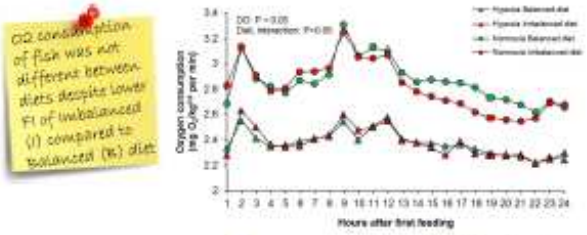
Regardless of water oxygen availability, FI was affected by DOD

- Fish eat more of low oxygen demanding diet and *vice versa*

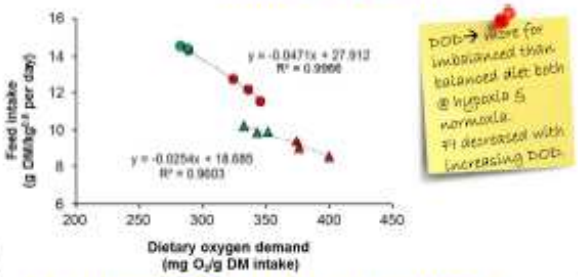
Results



Feed intake of rainbow trout (mean±SD)



Oxygen consumption of rainbow trout



Relation between feed intake and dietary oxygen demand

SS, JAJV & JWS: Aquaculture and Fisheries group
Wageningen University, The Netherlands
SS & IG: INRA, UR 1052, Nutrition, Metabolism & Aquaculture, St-Pée-sur-Nivelle, France.
E-mail: saravanan.subramaniam@wur.nl

INRA

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Role of metabolic oxygen use in control of feed intake in fish, Nile tilapia

S. Saravanan, I. Geurden, J. A.J. Verreth and J. W. Schrama

Why this study?

- Amount of **feed intake (FI) determines the growth** of fish.
- FI affected by combination of animal, nutritional and environmental factors → which also influence metabolic O_2 use/consumption.
- **FI control mechanism little known in fish.**
- **Limitation in O_2 use by fish:** uptake limited & negative effect due to oxidative metabolism → production of ROS.

Objectives

To test 'oxystatic' theory: Are difference in FI induced by dietary composition determined by the maximal oxygen use/consumption of fish?

How → diets with different oxygen demand are formulated

Hypothesis: fish fed *ad-lib* with diets of different oxygen demand will

- have similar oxygen consumption
- but different digestible energy (DE) intake

Methods

4 iso-energetic diets
(2x2 factorial design)

Protein /energy ratio	Energy source	*Diets*
High (25 mg/kJ)	Fat	HP|Fat
	Starch	HP|Starch
Low (14 mg/kJ)	Fat	LP|Fat
	Starch	LP|Starch

48 days feeding trial
in triplicates

Respiration tanks
connected to common water system

200 L

20 fish/ tank

unlimited O_2 availability in water

During trial

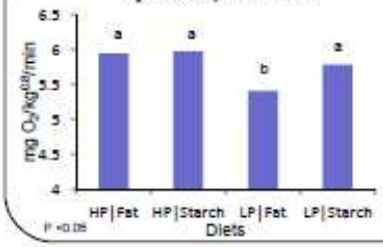
- optimal rearing condition
- fish fed *ad libitum*
- faeces collected
- measured O_2 consumption of fish

Measurements

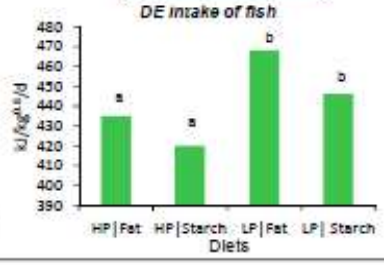
- growth
- daily feed intake
- digestibility
- nitrogen balance
- energy balance
- O_2 consumption

Results

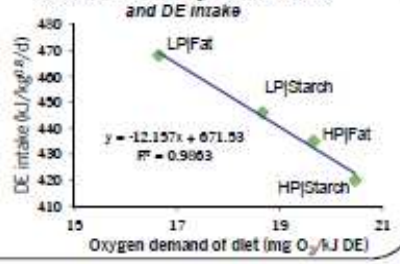
O_2 consumption of fish



DE intake of fish



Relation between O_2 demand of diet and DE intake



Conclusion

- Oxygen demand of diets were different
  → generated by contrast in macronutrient composition of diets
- Digestible energy intake was different between diet groups
  → affected by oxygen demand of diet
  → DE intake was negatively correlated with oxygen demand of diet
- Except one diet group, oxygen consumption was similar in 3 diet groups

Thus, hypothesis on '*oxystatic*' control of feed intake in fish can neither be rejected nor accepted

Aquaculture and fisheries group
Marijkeweg 40
Postbus 338
6700 AH Wageningen
Tel:(+31) 0317-484942
Fax:(+31) 0317-483962
E-mail: saravanan.subramaniam@wur.nl
Internet:http://www.afi.wur.nl

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