Feed for recirculating aquaculture systems

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Kim Schøn Ekmann

BioMar R&D

Background

- Strong growth in the recirculation segment in Denmark
- Large and growing production of salmon smolt in recirculated facilities
- Production of other species from larvae to grower in recirculation (European seabass, Gilthead sea bream and others)
- Generally, recirculation technology makes it possible to produce species far away from their natural habitat due to full control of water chemical and physical parameters

Development of recirculation diets - what have we done so far…

-many trials run since 2004…

-ReFeed I and II: Biofilter response of diets, pH regulation and total biofilter load

-ReFeed III: Focus on water quality and modelling of recirculation systems

- -2 lab-scale trials in Hirtshals
- -Several commercial trials

-Faecal design I+II

-Various raw material trials with focus on faeces 'quality'

-Protein:energy manipulated diets

-Amino acid optimization

-Phosphorus reduction

Main concepts of the recirculation diet

- Optimal DP:DE – assure sufficient protein for effective growth – without unnecessary waste
- Amino acid optimization
- Stabilize faecal structure – for easy removal of fecal matter by the means of fecal traps and/or mechanical filters (drum filters)
- Strict raw material demands – no negative effects on fecal structure and high digestibility

Possible add-on concepts…

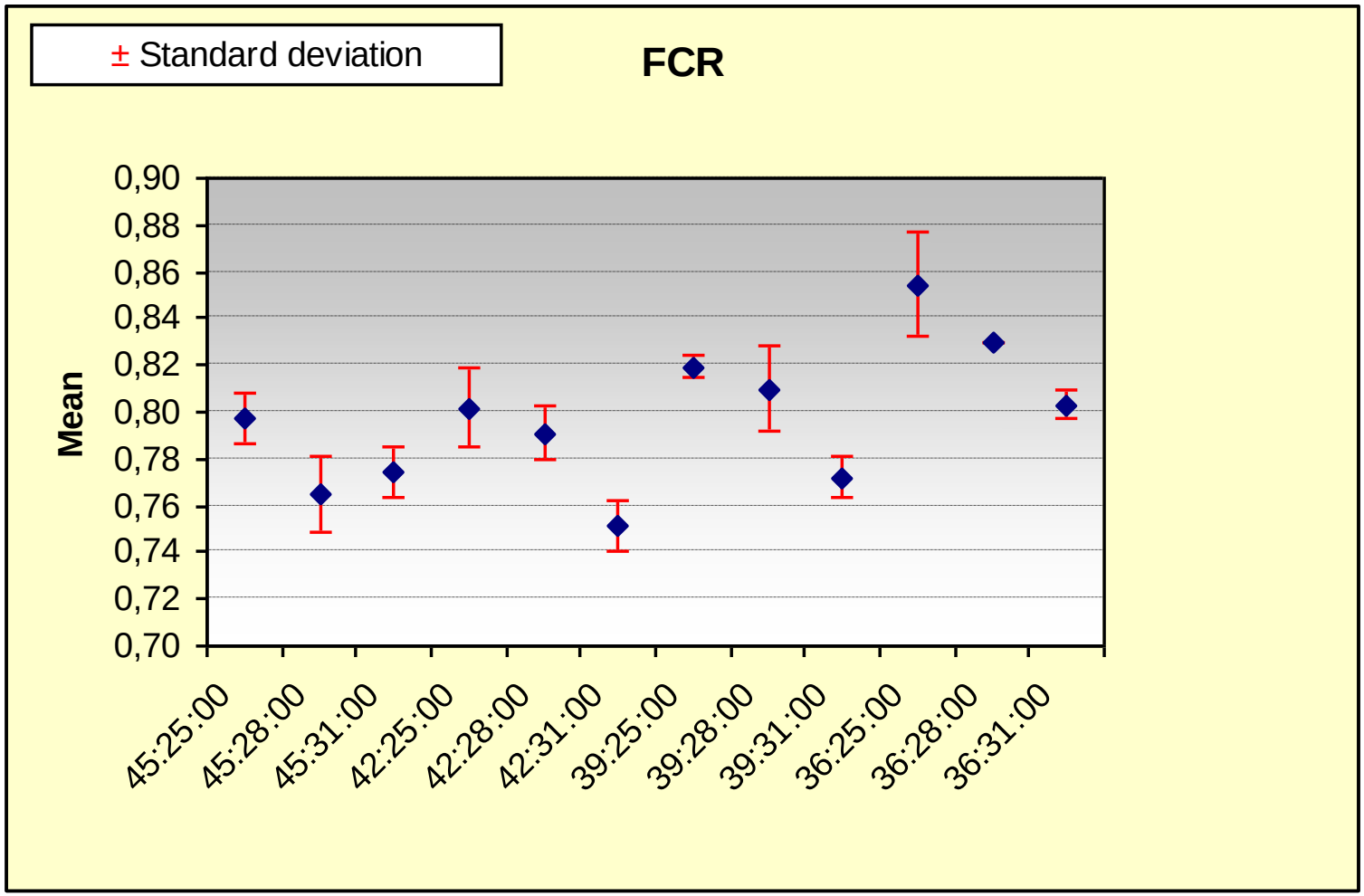
- Low phosphorus diets

  -use of RM's with low P content

  -Use of phytase
- Floating feed (indicator effect; minimize feed waste)
- Use of attractants – assure high feed intake
- A sustainable version of the diet (Concept 121; one-to-one), which gurantees the use of maximum one kg industrial fish to produce one kg farmed trout

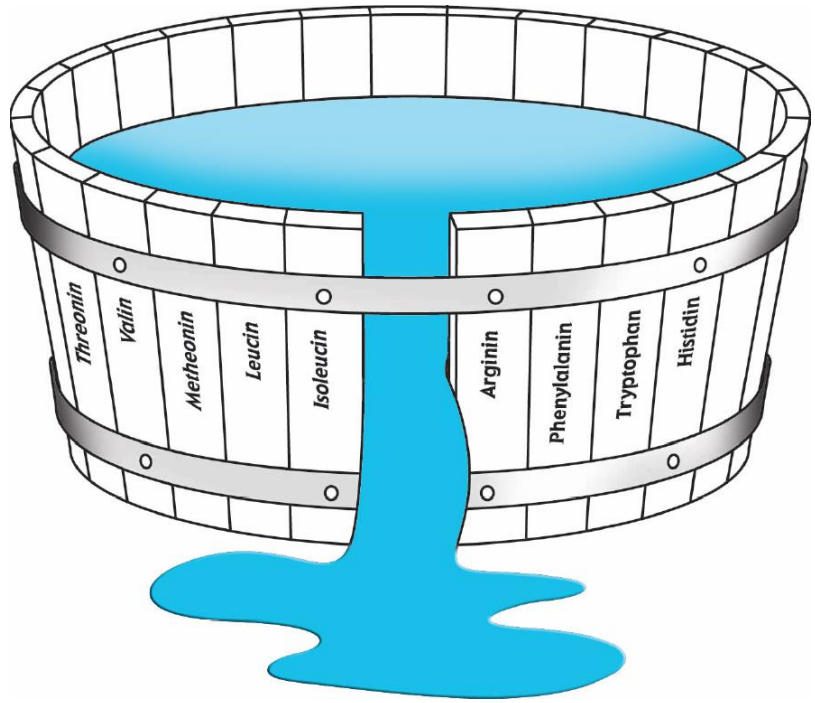
Main concept 1: Dietary DP:DE ratio

- The optimal dietary DP:DE ratio assures the most efficient utilisation of feed proteins (reduction of nitrogen (NH_4^+) discharge)



Main concept 2: Amino acid optimization - assuring the correct proportion of protein “building blocks”

- Proteins are built from amino acids
- 10 of those are essential, ie. they cannot be produced by the fish itself and have to be supplied in the feed
- If just one of them becomes deficient, it will decrease the performance of the feed
- This amino acid is called the first limiting amino acid
- It is the level of the first limiting amino acid that determines the performance of the feed, not the total protein level.



Main concept 3: Feces structure

- Faecal structure may be improved by choice of raw materials
- Binders in feed may have positive effects on faeces structure

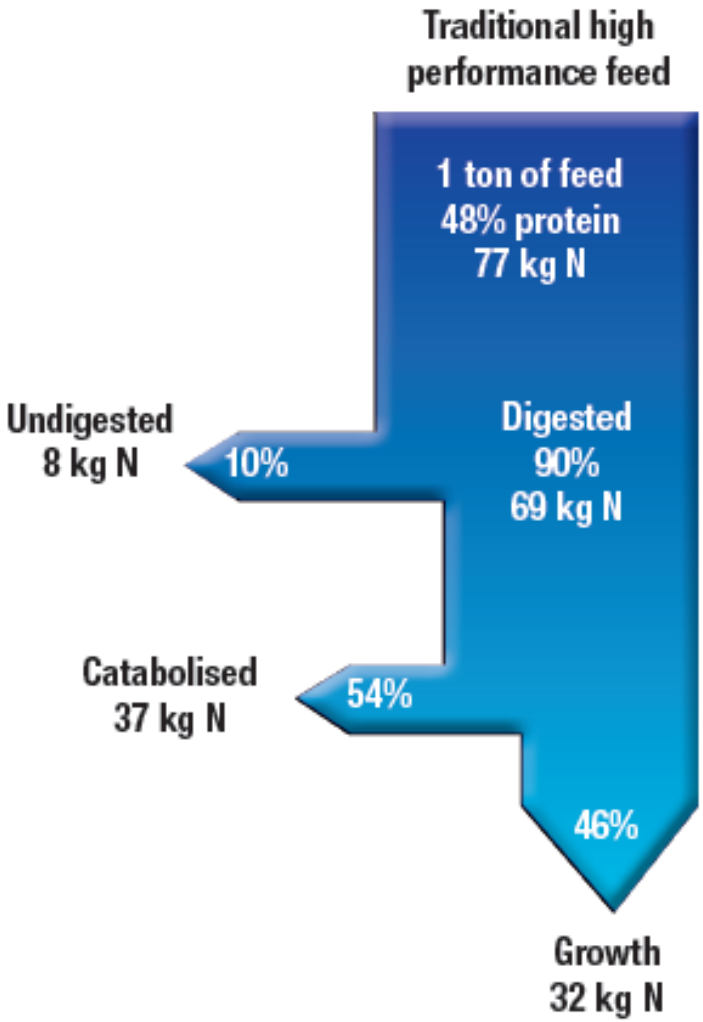
Faeces obtained from feeding 6 different commercially available diets (100 grams of feed)

Main concept 4: Choice of raw materials

- The choice of raw materials will affect digestibility, fecal stability and general performance of the diet
- Raw materials used for recirculation feeds should be highly digestible and have no negative effects on fecal structure
- Especially protein digestibility and amino acid profile of the raw materials are of utmost importance, since these two parameters will determine how much protein is lost during fish production
- Wasted protein is released from the fish in the form of NH_4^+ which, by the biofilters, needs to be converted into NO_3^- (or N2). This is a typical bottleneck in recirculated systems.

or

Calculated example of nitrogenous waste load



From theory to real life:

RD08040:
“Commercial recirculation and sustainable feeds”

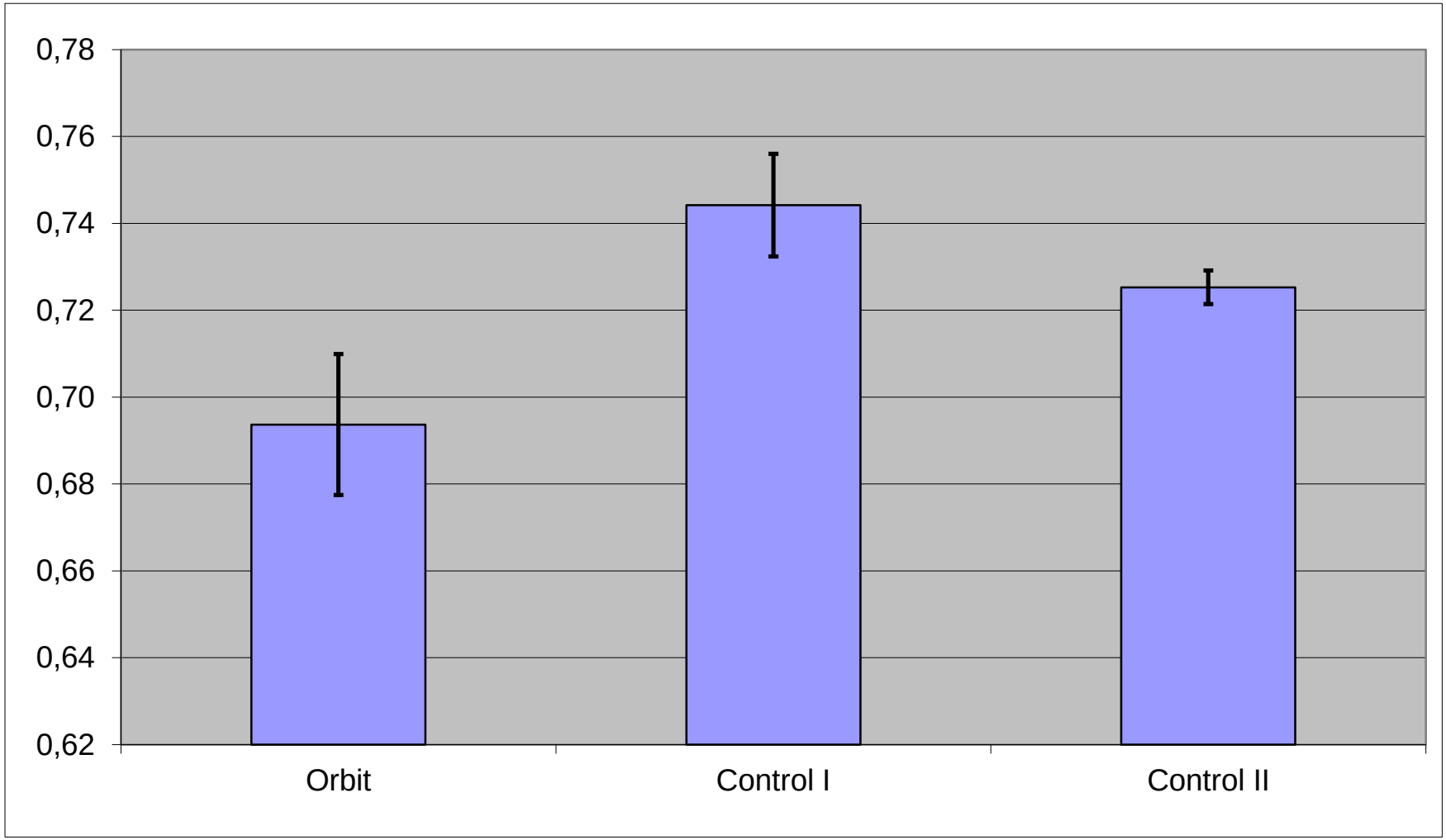
Materials and methods

- 1 trial diet and 2 commercial diets tested in triplicate tanks (9 tanks)
- Each tank was stocked with approximately 2 kg of trout with an individual weight of approximately 63 grams
- Water temperature during trial was 9,7±0,4ºC
- Oxygen content during trial was 7,2±2,0 mg/l
- The fish had an acclimation period of 6 days, after which a growth trial of 25 days was conducted. After this a digestibility trial was conducted using a modified Guelph settling column setup.
- At the end of the digestibility trial water samples as well as whole fish were taken for N and P analyses, in order to make a total phosphorus and nitrogen budget

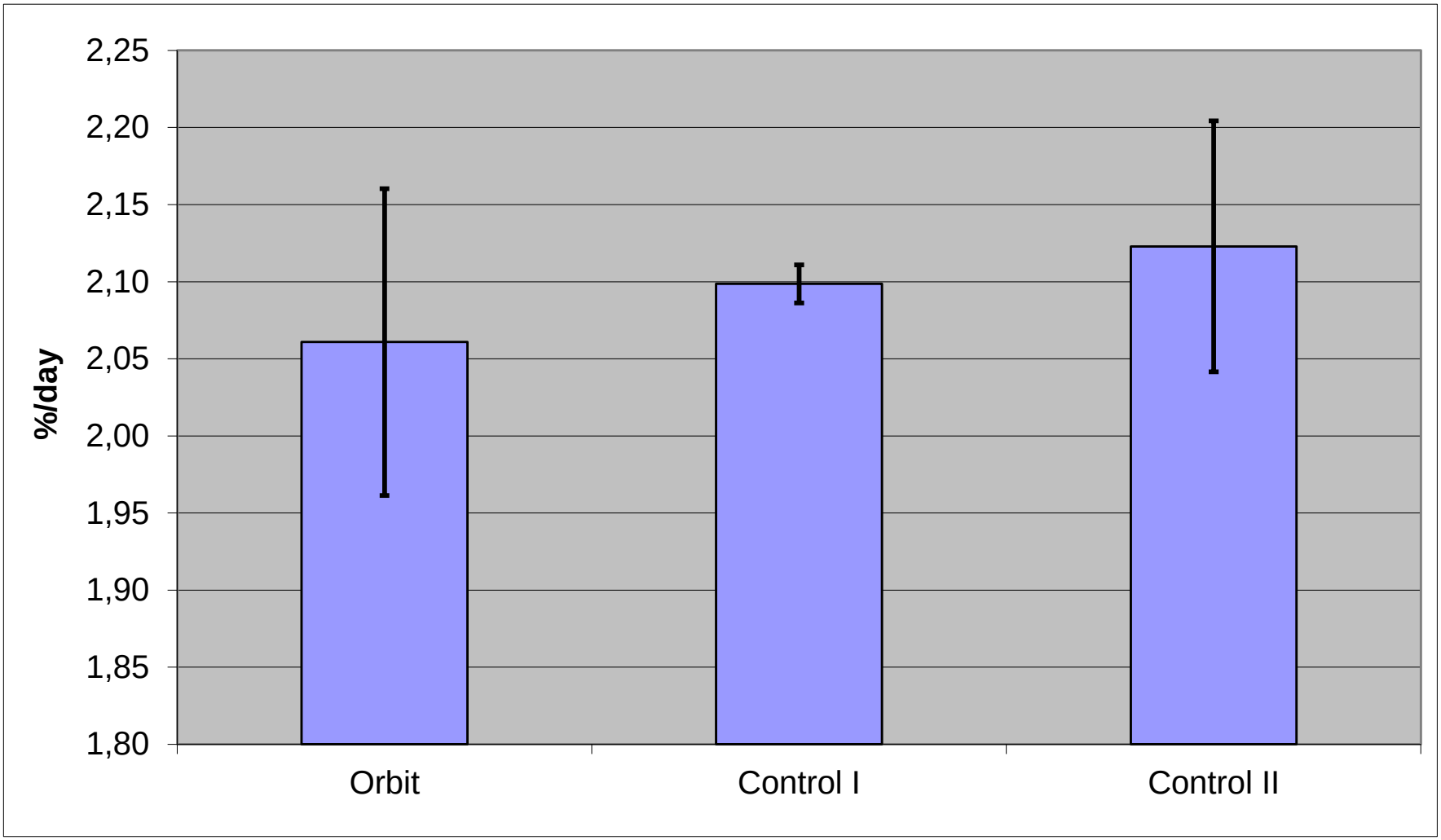
Feed analyses

Analysis	Orbit	Control I	Control II
Protein (%)	42,1	43,7	46,9
Lipid (%)	31,3	28,6	31,1
Ash (%)	5,7	7,0	8,6
Water (%)	8,4	7,8	5,5
Phosphorus (%)	0,94	1,10	1,21
DE (MJ/kg)	21,7	20,9	22,0

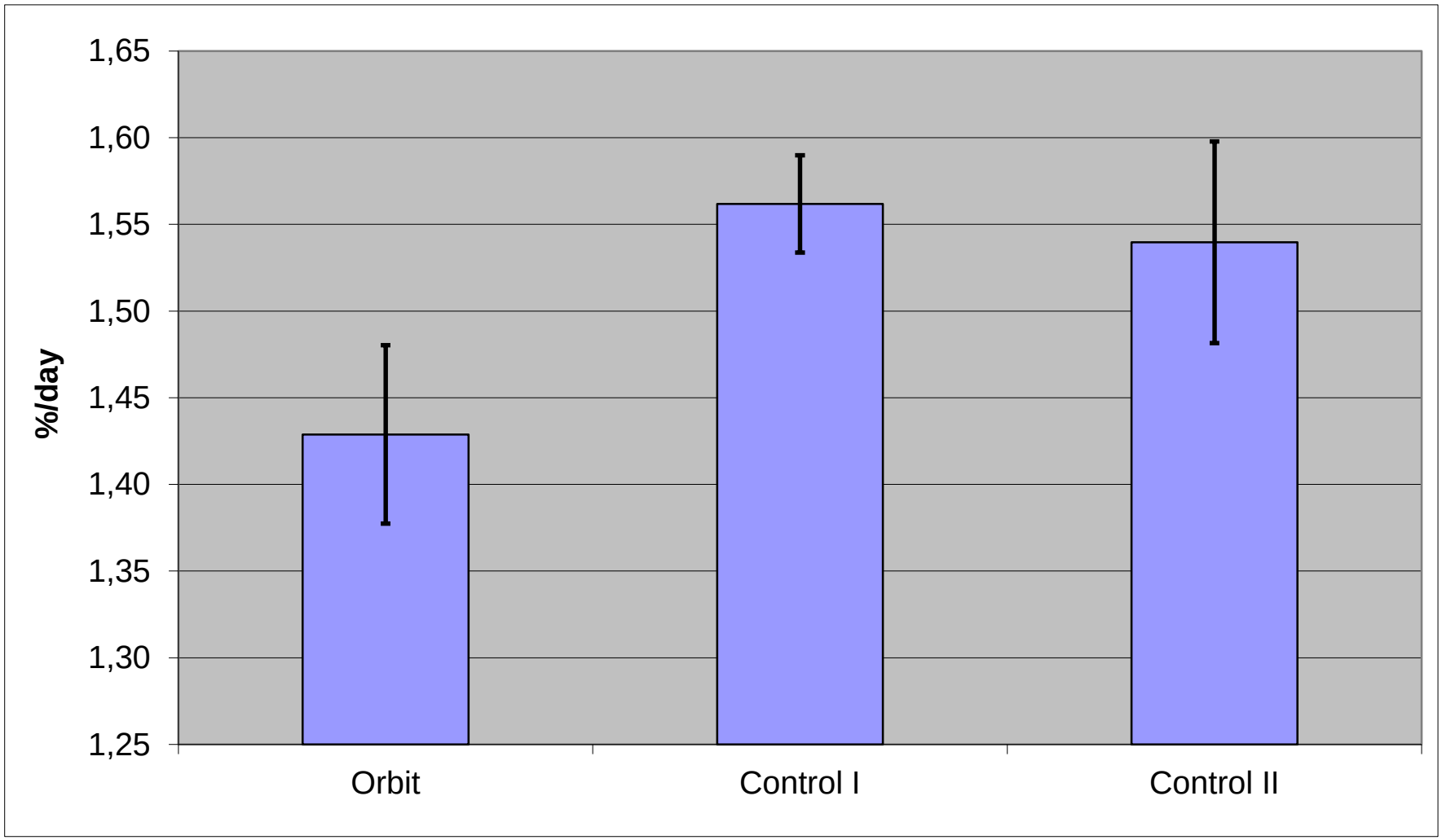
Feed conversion ratios



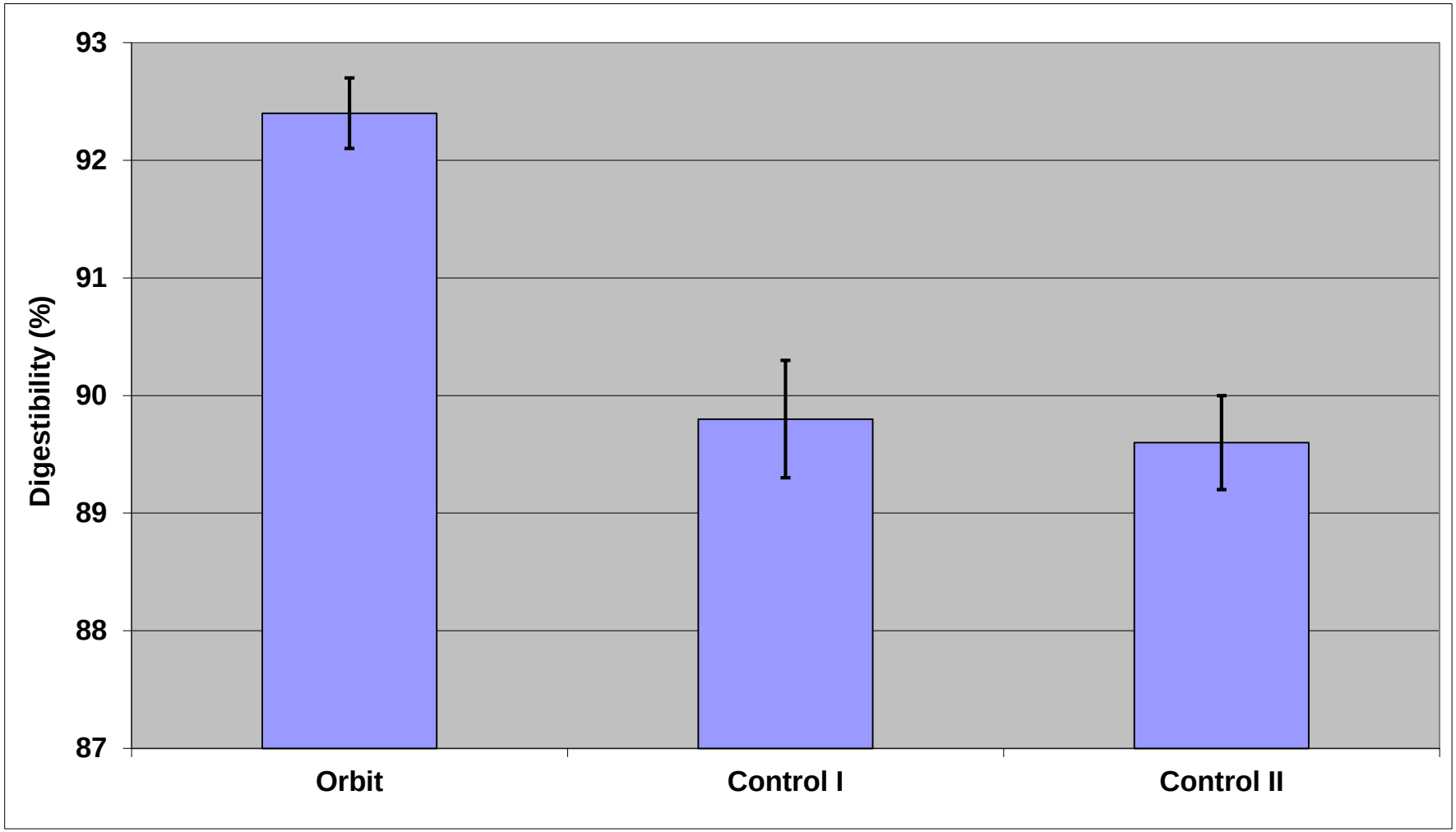
Specific growth rates (%/day)



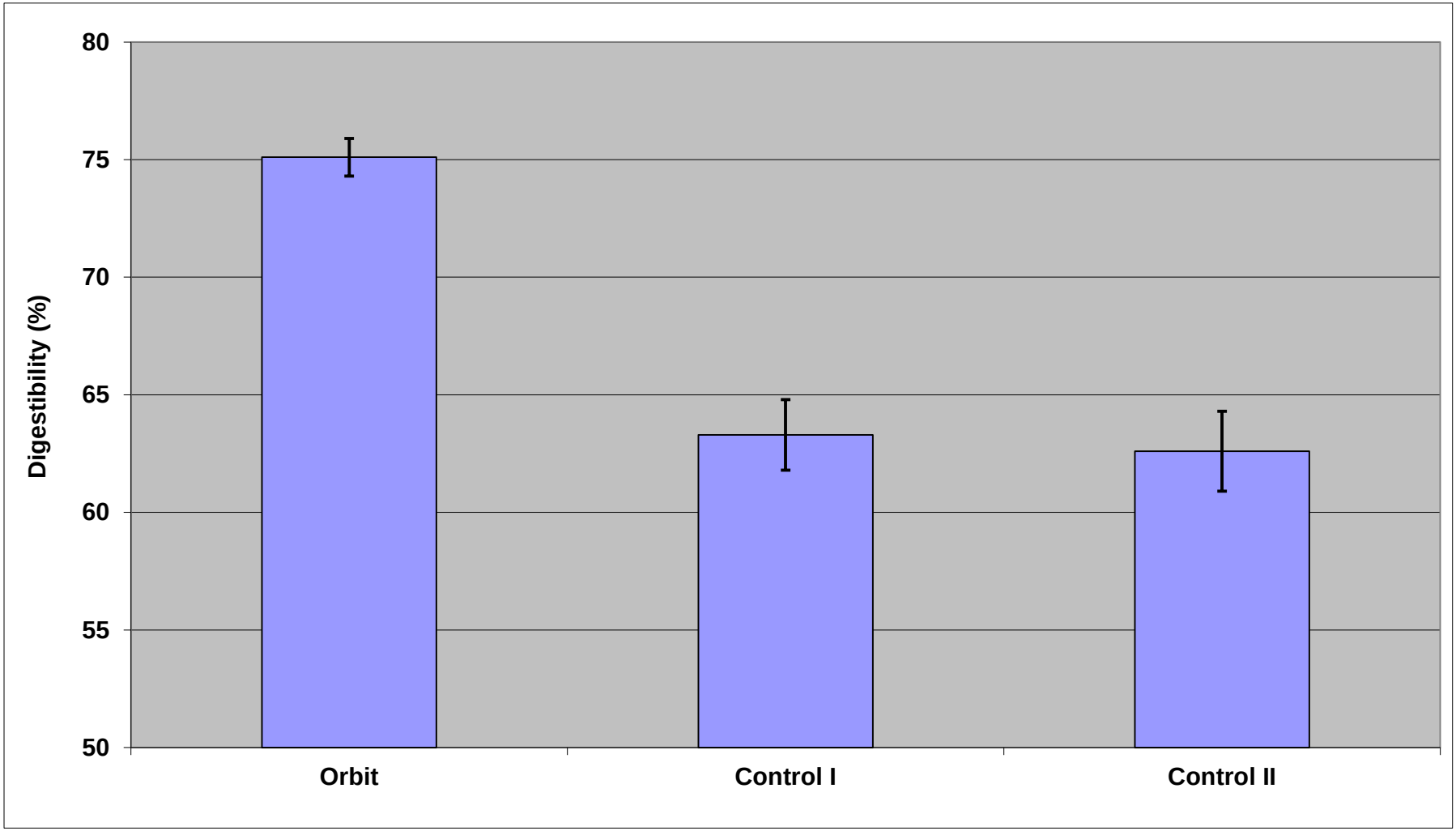
Daily feed intakes (%/day)



Protein digestibility (%)



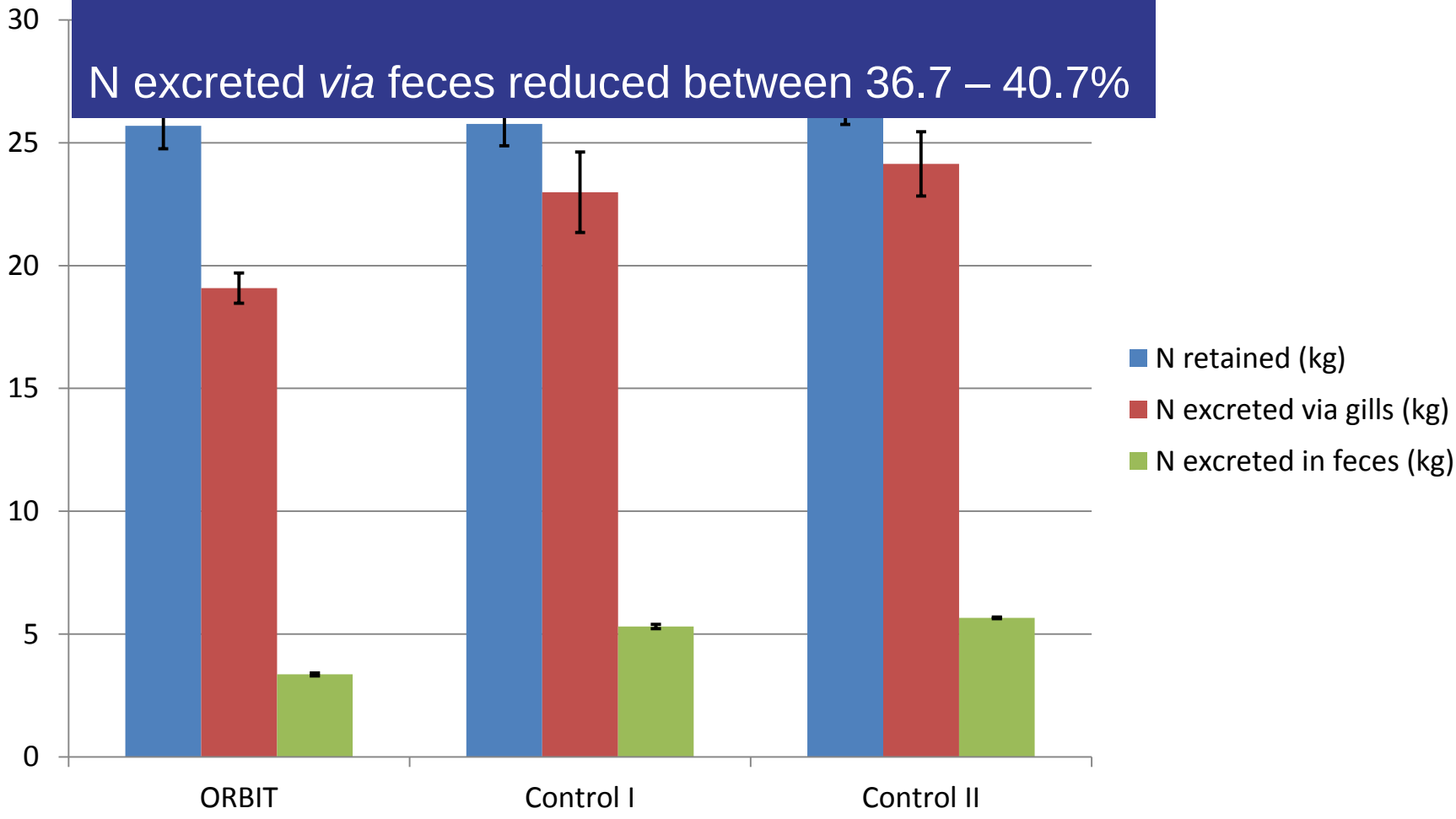
Phosphorus digestibility (%)



Fate of nitrogen per tonne of fish produced

N excreted *via* gills reduced between 17.0 – 20.9%

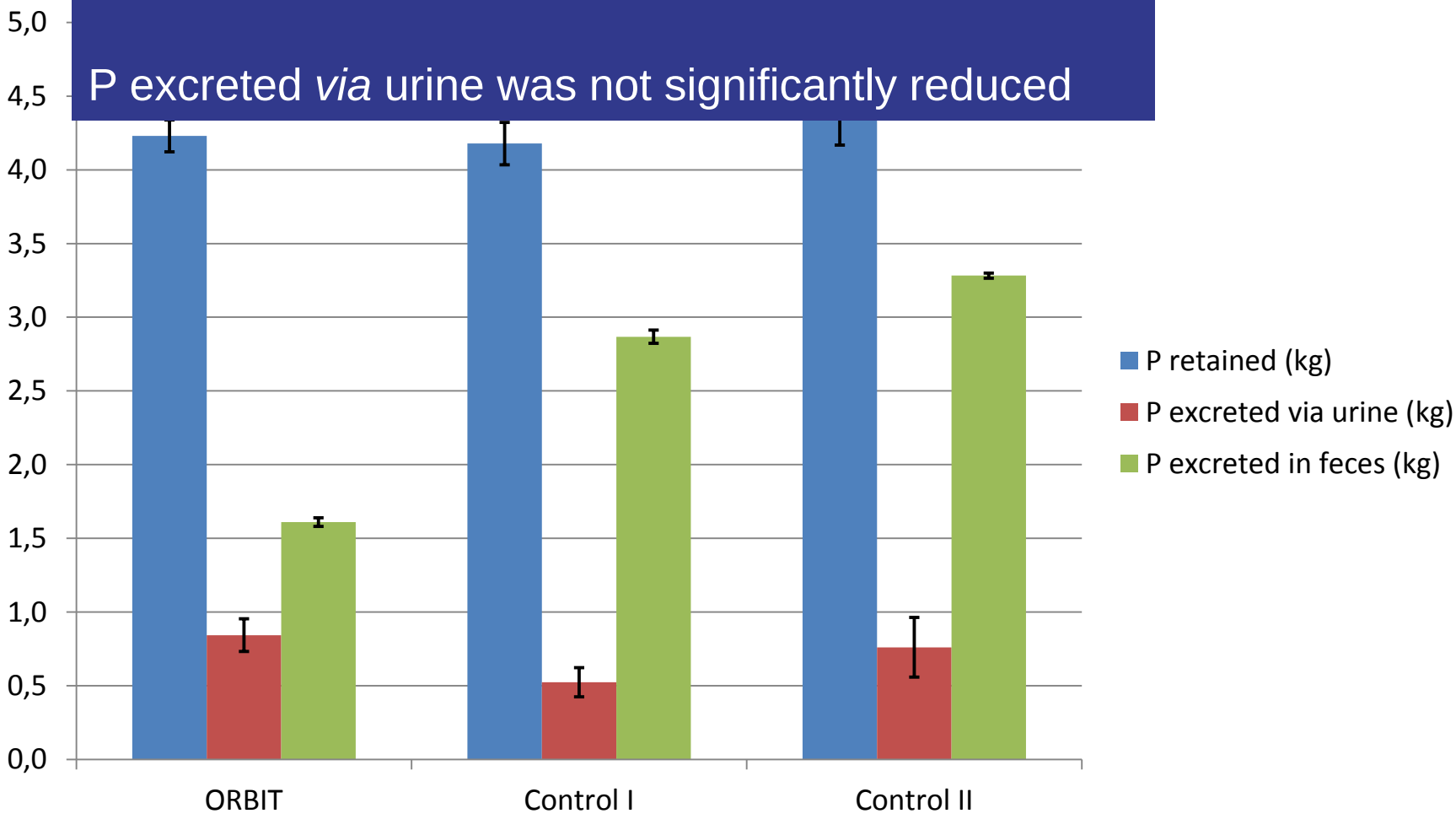
N excreted *via* feces reduced between 36.7 – 40.7%



Fate of phosphorus per tonne of fish produced

P excreted *via* feces reduced between 43.8 – 50.9%

P excreted *via* urine was not significantly reduced



Achieved

- A diet performing similarly or better than commercial products concerning growth and feed conversion
- Improved feces structure allowing efficient removal of fecal matter from system water
- Up to 3% improvement of protein digestibility
- Up to 20% improvement of phosphorus digestibility
- Up to 21% lower ammonium (NH_4^+) excretion per tonne of fish produced
- Up to 41% lower nitrogen excretion *via* feces per tonne of fish produced
- Up to 51% lower phosphorus excretion *via* feces per tonne of fish produced
- No significant reduction of phosphorus released *via* urine
- Confirmation of feed performance results in 7 commercial trials

Thank you for your attention!