Evaluation of HP-DDG and DDGS in high protein or low protein diets for rainbow trout *Onchorhynchus mykiss*

V. Denstadli, G. Shurson, M. Penn, Å. Krogdahl, M. Øverland
Bioethanol co-products

Used in our study (DM basis):
- **DDGS**
  - Crude protein: 29.7%
  - Crude lipid: 14.4%
- **HP-DDG**
  - Crude protein: 47.4%
  - Crude lipid: 5.7%

Fractionation:
- Germ
- Endosperm
- Pericarp
The protein requirement

140 g

43-45% CP

LT-FM
65-70% CP

DDGS
23-28% CP
Aims

• To replace typical plant ingredients with HP-DDG and DDGS in high or low protein diets for rainbow trout, and
  – To evaluate the effect of protein level (high or low) on fish performance
  – To investigate the nutritional value of both co-products
  – To determine whether HP-DDG or DDGS affect gut health

• General remarks
  – FM inclusion levels were kept constant
    • DDGS or HP-DDG can not replace FM
  – Lys and Met were supplemented to meet/exceed requirements
## Experimental diets

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<tr>
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<th>High CP</th>
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<th>Low CP</th>
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<tbody>
<tr>
<td></td>
<td>HPDDG 0%</td>
<td>HPDDG 50%</td>
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<td>HPDDG 0%</td>
<td>HPDDG 50%</td>
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<tr>
<td>Sunflower expeller</td>
<td>144</td>
<td>72</td>
<td>0</td>
<td></td>
<td>125</td>
<td>67.5</td>
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<td>Soy protein conc</td>
<td>162</td>
<td>81</td>
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<tr>
<td>Rapeseed meal</td>
<td>144</td>
<td>72</td>
<td>0</td>
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<td>125</td>
<td>67.5</td>
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<tr>
<td>Peas</td>
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<td>0</td>
<td></td>
<td>250</td>
<td>125</td>
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<tr>
<td>DDGS</td>
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<td>Fishmeal</td>
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<td>Fish oil</td>
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**Analysed**

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<tbody>
<tr>
<td>N*6.25, %</td>
<td>45.4</td>
<td>45.0</td>
<td>44.9</td>
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<td>36.9</td>
<td>37.1</td>
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<tr>
<td>Gross energy, MJ/kg</td>
<td>22.1</td>
<td>22.6</td>
<td>22.4</td>
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<td>21.6</td>
<td>21.9</td>
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<tr>
<td>Total P, g/kg</td>
<td>11.2</td>
<td>10.8</td>
<td>10.4</td>
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<td>9.9</td>
<td>10.2</td>
<td>10.8</td>
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## Fish and husbandry

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- Rainbow trout, initial weight 142 g
- Fresh water, 9-13°C
- 3 tanks per diet, 20 fish per tank
- Feeding 5-10% in excess
- 77 days, 152-194% weight gain
Experimental design

Factorial
-protein level (high or low)
-replacement level (0, 50, 100%)
## Experimental design

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### One-way Diets
Responses

• Performance
  • Feed intake, weight gain, feed conversion ratio

• Nutrient digestibilities
  • Main nutrients + AA
  • Phosphorus

• Gastrointestinal indicators
  • Enzyme activities (Trypsin and LAP)

• Histology (distal intestine)
Feed intake and weight gain, g

HiPro vs LoPro: n.s.
Replacement level: n.s
Diets: n.s.

LOW PROTEIN DIET

DDGS 0%  DDGS 50%  DDGS 100%

Gain  Fl
Feed conversion ratio

HiPro vs LoPro: $P<0.001$
Replacement level: $P<0.001$
Diets: $P<0.001$

HiPro vs LoPro: $P<0.001$
Replacement level: $P<0.001$
Diets: $P<0.001$
N digestibility, %

HiPro vs LoPro: P<0.001
Replacement level: P<0.001
Diets: P<0.001

HIGH PROTEIN DIET

LOW PROTEIN DIET

HP-DDG 0% HP-DDG 50% HP-DDG 100% DDGS 0% DDGS 50% DDGS 100%

a a b b b b
AA digestibilities, %
Energy digestibility, %

HiPro vs LoPro: $P<0.001$
Replacement level: $P=0.005$
Diets: $P<0.001$

HiPro vs LoPro: $P<0.001$
Replacement level: $P=0.005$
Diets: $P<0.001$
P digestibility, %

HiPro vs LoPro: P<0.001
Replacement level: P<0.001
Diets: P<0.001

HIGH PROTEIN DIET

HiPro

LOW PROTEIN DIET

LoPro

Replacement level: P<0.001

Diets: P<0.001
Relative DI weights, %

HiPro vs LoPro: n.s
Replacement level: n.s
Diets: n.s

HP-DDG
0%  50%  100%

DDGS
0%  50%  100%
Relative Liver weights, %

HiPro vs LoPro: n.s
Replacement level: P<0.1
Diets: n.s
### GI enzymes and histology

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Leucine Amino Peptidase

mmol/h/kg fish

Pyloric intestine

Distal intestine

HP-DGS
0% 100%

DDGS
0% 100%

HP-DGS
0% 100%

DDGS
0% 100%
Trypsin activity
U/mg DM

n.s.
Histology of the distal intestine

Normal intestine (Fish meal fed)

SBM-induced enteritis
(20% extracted SBM in the diet)
No significant differences in tissue architecture.

All groups appeared within normal limits.
DDGS and HP-DDG fed fish: High numbers of large cellular material within the intestinal lumen. The material does not appear to be tissue origin as little epithelial sloughing was observed. The epithelium appeared otherwise normal. Yeast remnants?

PAS-staining could confirm/refute if this is yeast.
Effect of yeast on N digestibility

- Reduced digestibility of N
- Partly caused by intact undigested yeast?
Conclusions

• CP level has a major impact on feed utilization
• Increased co-product inclusion supports increased feed utilization
• Inclusion of dephytinized co-products improves P digestibility → reduced MCP supplementation
• No detrimental effects of HP-DDG or DDGS on DI histology
• Does *Saccharomyces cerevisiae* resist degradation, which in turn may reduce N digestibility?
• Not addressed in this study, but: ”wrong” pigment for salmonids
Acknowledgements

• CHS: providing co-products
• Personell at the UMB fish laboratory, Aas Norway
Thank you!