Fishmeal for FEED – Physical quality effects

NORDIC CENTRE OF EXCELLENCE NETWORK IN FISHMEAL AND FISH OIL
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Presentation outline

• Extrusion processing and biopolymer transformation
• Plasticizer
• Impact of ingredients on physical feed quality
• Plasticization effect of water-solubles and amino acids
• Conclusions
Extrusion

Extrusion processing is a technology that enables the production of high quality feed

- Balanced for optimal feed intake and feed utilization
- High physical quality to minimize product loss
- Water stable to minimize degradation
- Expanded to adsorb desired amount of oil but dense enough to sink
- Optimal microstructure to minimize oil leakage

Bin Feeder

Moisture: 18 - 30%
Temp: 77 - 95 °C
1.5 - 4 min.

Preconditioner

Moisture: 18 - 30%
Temp: 120 - 145 °C
< 1 min.

Extruder

Moisture: 18 - 30%
Temp: 120 - 145 °C
< 1 min.

Moistening
Heating
Kneading
Cooking
Texturizing

thereafter cut into extrudate pieces, dried and coated with lipids
Biopolymer transformation in the extruder

Step 1: Open up the powdery structure

Step 2: Create new intermolecular binding networks

Why add water to the process?

- Energy (heat) and water is needed for the transformation from powder to a high viscous melt in the extruder.
- Water reduces the energy needed for this transformation.
- Water is called a plasticizer.
- Other low molecular components can also act as plasticizers.

http://www.4college.co.uk/a/dp/polymers.php
How to measure the plasticization effect?

Glass transition
- a temperature where the biopolymer transits from a brittle glassy to a soft rubbery state
- glass transition temperature ($T_g$)

Flow-starting
- a state where the biopolymer can be considered as a highly viscous melt or fluid (start to flow)
- flow-starting temperature ($T_f$)

Phase Transition Analyzer
- closed-chamber capillary rheometer
- measure $T_g$ and $T_f$ of a biopolymer

Plasticizer
- reduces both $T_g$ and $T_f$ of a biopolymer
Impact of ingredients on physical feed quality

Two high quality fishmeal, A and B

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
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</thead>
<tbody>
<tr>
<td>Protein (%)</td>
<td>75,9</td>
<td>75,2</td>
</tr>
<tr>
<td>Water (%)</td>
<td>7,1</td>
<td>8,4</td>
</tr>
<tr>
<td>Ash (%)</td>
<td>9,9</td>
<td>8,7</td>
</tr>
<tr>
<td>Fat (%)</td>
<td>9,4</td>
<td>8,8</td>
</tr>
</tbody>
</table>

Fishmeal 74 %
Whole wheat flour 20 %
+ fish oil, vitamin- and mineral mix and astaxanthin

Same diet composition and standardised extrusion conditions
Fishmeal from herring:

Water-soluble protein
A: 26 g/100g protein
B: 15 g/100g protein
### Two high quality fishmeal, A and C

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<th>C</th>
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<tbody>
<tr>
<td><strong>Protein (%)</strong></td>
<td>75.9</td>
<td>74.9</td>
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<tr>
<td><strong>Water-soluble protein (%)</strong></td>
<td>26.3</td>
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<tr>
<td><strong>Water (%)</strong></td>
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Fishmeal from different species:
A: Herring
C: Sand eel
Fishmeal from different species:
A: Herring
C: Sand eel

Low shear:

High shear:

Extruded, coated pellet

Extruded, coated pellet

Hardness

Samuelsen Nofima ©
Fishmeal from different species:
A: Herring
C: Sand eel

Sand eel meal contains more mechanical energy than herring meal based feed mixes.

Low shear:
High shear:
Water-soluble protein increase physical pellet quality:

- Long-chain water-soluble proteins

→ Gelatine

Large amount in:  
Small amount in:

Water-soluble protein increase physical pellet quality:

- Amino acids and small peptides act as plasticizers similar to water

Compared to water also increase melt viscosity and cooking efficiency

Plasticization effect of solubles in fishmeal

A central composite design
- variables: moisture and water-soluble protein
- responses: glass transition ($T_g$) and flow-starting temperature ($T_f$)

Small particles with fibrous structure increase physical pellet quality:

- High level increase extruder specific mechanical energy (viscosity) and cooking efficiency due to increased particle to particle contact area and higher friction and easier to hydrate

Fishmeal has unique technical properties which differs extensively from plant-based protein ingredients.
Compared to fish meal, soy protein concentrate (SPC) are generally:

- low in water-soluble proteins
  → less plasticizing effect
- low in lipids (FM ~10% lipids, SPC ~1% lipids)
  → higher viscosity/shear and energy input
- higher water input
  → increased energy input for production and drying

Is it possible to plasticize SPC with water-solubles or amino acids?

An additive with triple benefits

nutrient, plasticizer and binder in extruded fish feed
Research challenges

An additive with triple benefits

• Can this information be used to develop a higher value fishmeal product that can act as a nutrient, plasticizer and binder in extruded fish feed?
Thank you for your attention!