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Dehydration processes (cooling and drying) and their impact on the quality of feed pellets

Dejan Miladinovic, FôrTek
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Dehydration as necessity after feed pelleting
Temperature control, IR measurements

56,5 °C
72,5 °C

76,4 °C
25,9 °C
65,3 °C
Infra-red temp. measurement in the ring die
Infra-red temp. measurement after pelleting
Dehydration techniques can influence physical quality of animal feed
Dehydration

➢ Upon dehydration the new bonds are established between feed particles;  Thomas et al., 1997

➢ During dehydration technique by drying, the utilization of hot air is necessary;

➢ Dehydration by cooling process utilizes environmental air;

➢ The ability of feed particles to reconstitute without brakage depend on the internal structure and extent to which the water-holding components (proteins & starch) have been damaged during drying; Krokida & Philippopoulos, 2005

➢ The product structure affects the sorption characteristics of the product; Claussen et al., 2007

➢ Product porosity is affected by the drying temperature
Fluid bed dehydration technique
Counterflow cooler

Hot Pellets IN

Cold Pellets Out
Measurement techniques prior and after dehydration for the quality control oriented issues
Measurement after dehydration (finished product)

- Water activity ($a_w$) brings information which accounts for the availability of water for degradation reactions
Changing the moisture for 1% might be not important, BUT...

At constant temperature

\[ a_w = \frac{\text{Vapor Pressure of Water in Feed}}{\text{Vapor Pressure of Pure Water}} \]
Stability Map Based on $a_w$

**aw** analyses of the fish feed with novel ingredients (yeast)

<table>
<thead>
<tr>
<th></th>
<th>Diet 1 - Control</th>
<th>Diet 2 - NI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mash (Aw*) mean</td>
<td>0.285</td>
<td>0.263</td>
</tr>
<tr>
<td>Pellets (Aw*) mean</td>
<td>0.282</td>
<td>0.546</td>
</tr>
<tr>
<td>Pellet moisture (%)</td>
<td>4.21</td>
<td>4.82</td>
</tr>
</tbody>
</table>

*Constant temp. 19 C*
Cooling VS Drying

Different dehydration techniques and prolonged dehydration decreases physical properties of pellets

<table>
<thead>
<tr>
<th>Drying time comparison (min)</th>
<th>PDI % before oven</th>
<th>PDI (%) after 24h on 60°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooling (air temp. 20 C) 5 min.</td>
<td>85,39</td>
<td>67,47</td>
</tr>
<tr>
<td>Cooling (air temp. 20 C) 10 min.</td>
<td>84,81</td>
<td>70,49</td>
</tr>
<tr>
<td>Drying (air temp. 70 C) 5 min.</td>
<td>83,46</td>
<td>70,29</td>
</tr>
<tr>
<td>Drying (air temp. 70 C) 10 min.</td>
<td>81,88</td>
<td>67,62</td>
</tr>
</tbody>
</table>

p values

<table>
<thead>
<tr>
<th>Drying time comparison (min)</th>
<th>Moistures (%)</th>
<th>PDI (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry 5 / Dry 10</td>
<td>0,08</td>
<td>0,01</td>
</tr>
<tr>
<td>Cool 5 / Cool 10</td>
<td>&lt;0,001</td>
<td>0,27</td>
</tr>
<tr>
<td>Cool 5 / Dry 5</td>
<td>&lt;0,001</td>
<td>&lt;0,001</td>
</tr>
<tr>
<td>Cool 5 / Dry 10</td>
<td>&lt;0,001</td>
<td>&lt;0,001</td>
</tr>
<tr>
<td>Cool 10 / Dry 5</td>
<td>&lt;0,001</td>
<td>0,01</td>
</tr>
<tr>
<td>Cool 10 / Dry 10</td>
<td>&lt;0,001</td>
<td>0,001</td>
</tr>
</tbody>
</table>
Is there any other better technology?
Vacuum dehydration

Vacuum dehydration technique (VDT) helps to:

➢ Shorten processing time (Zheng and Sun, 2004).
➢ Extend the products shelf life (McDonald and Sun, 2000).
➢ Improve the product properties related to quality and safety issues (Possart, 2005; Zheng and Sun, 2004).

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Vacuum dehydration gives better physical properties of animal feed pellets

Figure 1. The schematic diagram of the research vacuum moisture removal apparatus: 1-Pressure release valve; 2-Vacuum chamber; 3-Pressure control valve and barometer; 4-Steam condenser; 5-Air filter, 6-Vacuum pump

Miladinovic et al., 2013
Experimental work done by measurements

- Moisture level (%) 
- Durability (PDI%)
- Hardness (kg)
Dehydration techniques influence the quality of animal feed.

**ADT**
- Average air speed 1.5 m/s

**VDT**
- Residual pressure of 200 mbar

5 min.
Moisture analysis (EU 71/393); Target <12%
Differences in moisture (%) and PDI (%) to be addressed to pellet diameter, particle size distribution and dehydration technique

Unscrambles Partial Least Square (PLS) II regression test with jack knifing

Miladinovic et al., 2013

Products’ moisture content do not influence PDI %
Dehydration method can influence final moisture content

Unscramble: Partial Least Square (PLS) I regression

Miladinovic et al., 2013

RESULT9, X-expl: 25%,25%  Y-expl: 74%,74%

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New Holmen durability analysis
VDT vs. ADT

Miladinovic et al., 2013
Vacuum dehydration

- For moisture removal from animal feed pellets;
- A significant contribution to better quality and easier feed manufacturing;
- Shortening product hold up time, increasing production throughput, and minimizing microbial growth;
- Easier to remove large proportions of water molecules from high water content products (ex. extruded fish feed and pet food) where vit. E & C can be damaged;
- More hygienic process since the air goes only into the chamber at the end of the cooling process when the chamber is open to release vacuum, thus number of microorganisms can be diminished;
- VDT is carried out in a static state, there is no mechanical load thus damage (final physical quality) is lower than other dehydration techniques
Desirable properties of feed

• Durable pellet that does not break during transportation or in the feeders

• Pellet that produce minimal amount of dust

• Reduced loss
Pelleting - Reminder

- The aim of pelleting processing is to agglomerate ingredients particles by mechanical action, in combination with moisture, pressure and temperature,

- Pellet quality - Ability to resist fragmentation and abrasion of the pellets during handling, without breaking up and reaching the animal feeders without generating a high proportion of fines
Pellet durability index (PDI)

- One of the main parameters used to determine pellet quality, as it indicates % of pellets that remain intact after being submitted to mechanical forces.

- Pellets are submitted to friction, impact and pressure during storage, transport and dispatch from the feed mill to the farms.

- Poor-quality pellets disintegrate, resulting in a feed consisting of a few pellets and fines.
Several factors affect pellet quality:

- Dietary nutritional composition
- Feedstuff particle size
- Conditioning time and temperature
- Feed moisture content
- Compression rate of pellet die
- Gap between the pellet press roll and die, etc.

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Or to be more precise..
Strategi to better PDI %

- Changes in diet formulation (lowering fat),
- Feedstuff particle size optimization
- Adjustment of conditioning parameters

- The biggest influence on PDI%:
  - Heat processing
  - Feed formulation,
  - Higher fat inclusion level,
Feeder rate and roller/die gap influences PDI %

<table>
<thead>
<tr>
<th>Distance between Roller and Die (mm)</th>
<th>Feeder Rate (kg)</th>
<th>PDI means (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>500</td>
<td>85.6</td>
</tr>
<tr>
<td>0.1</td>
<td>1000</td>
<td>82.8</td>
</tr>
<tr>
<td>1</td>
<td>500</td>
<td>87.7</td>
</tr>
<tr>
<td>1</td>
<td>1000</td>
<td>85.8</td>
</tr>
<tr>
<td>2</td>
<td>500</td>
<td>90.6</td>
</tr>
<tr>
<td>2</td>
<td>1000</td>
<td>85.6</td>
</tr>
</tbody>
</table>

Die size – 3mm hole, 42mm die thickness
Feeder rate and die thickness (hole length) influences the compaction ratio, hence the PDI %

Miladinovic & Svihus, 2005
The die hole diameter can influence the PDI %

Miladinovic & Svihus, 2005

![Graph showing PDI % for different hole diameters and diets.](image-url)
Ring die / rollers can give the grinding effect to conditioned mash

![Graph showing particle size distribution for different sieve sizes and gap sizes.](image)

*Miladinovic & Svihus, 2005*
Die Specification – Knifes

Sharp VS. Worn

During feed pelleting the pellet press knives have the role to cut (if enough shearing) or more precisely, to brake the feed pellets.

Photo source: FôrTek
Cutting the feed pellets

**Knifes Settings:** distances from the pellet press die surface for first and second test were adjusted manually for all knife condition on 10 & 20 mm

Photo source: FörTek
Worn knife VS. Sharp knife

![Bar chart showing PDI (%) comparison between Worn Knife and Sharp Knife for Wheat 10 mm and Wheat 20 mm.](chart.png)