Effect of feed form and delivery on the growth, feed efficiency and carcass quality of grow-finisher pigs

F. O’ Meara, A. Torres-Pitarch, T. Ryan, D. Clarke, J. O’ Doherty, G. Gardiner, P. Lawlor
Introduction: Feed delivery

• Up to 70% of pigs in Ireland are liquid-fed
• By-products + balancer = cheap balanced diet
• But now…
• Availability / quality?
• Labour saving?
• Liquid feeding vs dry feeding
  
  
  up: increased growth
  down: shorter time to slaughter

(Kim et al., 2001, Partridge et al., 1992, Hurst et al., 2008)

• Limited, good quality, information available comparing liquid, dry and wet/dry feed delivery systems, in controlled conditions
Introduction: Feed Form

Advantages of pelleting over meal:

- Nutrient digestibility and nutrient density per unit volume
- Feed wastage during feeding, dustiness
- Growth, palatability & improved feed conversion ratio
- Improved flow-ability

(Ball et al., 2015, Nemecheck et al., 2015)

- Reduced pathogen load?

(Attar et al., 2017, Burns et al., 2015)
Objective

• Compare feed form and delivery methods using a common diet on the growth, feed efficiency and carcass quality of grow-finisher pigs

• Examined in a 2x3 factorial arrangement

• Feed form: Meal and pellets

• Feed delivery: Dry, wet/dry and liquid feeding
Materials and Methods

Diet: 9.8MJ NE/kg, 9.97g SID lysine/kg – Start weight: ~ 33.6kg
Materials and Methods

- Microbial counts from feed
  - Lactic acid bacteria
  - *Enterobacteriaceae*
  - *E. coli*
  - Yeast
  - Mould
- Feed intake, growth and feed efficiency
- Carcass data
Materials and Methods

- 432 grow-finisher pigs (2 batches)
- 12 pens/treatment (6 pigs per pen)
- 2x 62 day batches
- All treatments were applied in the same house

- Dry meal
- Wet/dry meal
- Liquid meal
- Dry pellets
- Wet/dry pellets
- Liquid pellets
Microbial Counts

Batch 1, Lactic acid bacteria

Batch 2, Lactic acid bacteria

- Dry feed < Mixing tank < Troughs
- Dry feed: Pelleted < Meal
Microbial Counts

Batch 1, *Enterobacteriaceae*

- Highest in troughs, intermediate in mixing tanks
- Dry feed: Pelleted < Meal

Batch 2, *Enterobacteriaceae*
Microbial Counts

**Batch 1, E. coli**

- Troughs – faecal contamination?
- At or below detection limit in all other samples

**Batch 2, E. coli**

- Log 10 CFU/g

Detection limit

Day

Log 10 CFU/g

Dry pellets
Dry meal
Mix tank pellets
Mix tank meal
Troughs pellets
Troughs meal
Microbial Counts

Batch 1, Yeast

- Highest in troughs
- Temperature good for yeast growth

Batch 2, Yeast

- Temperature good for yeast growth

Detection limit

Day

Log 10 CFU/g

Dry pellets
Dry meal
Mix tank pellets
Mix tank meal
Troughs pellets
Troughs meal
Microbial Counts

Batch 1, Mould

Batch 2, Mould

- Variable counts
- Batch variation? Hotspots?
- Pelleting the diet reduced mould (dry)
Results: Statistical Analysis
Form*Delivery Interaction

FCR, g/g

<table>
<thead>
<tr>
<th>Form</th>
<th>Meal</th>
<th>Pellets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry</td>
<td>2.28b,c</td>
<td>2.34a,b</td>
</tr>
<tr>
<td>Wet/Dry</td>
<td>2.41a</td>
<td>2.22c,d</td>
</tr>
<tr>
<td>Liquid</td>
<td>2.14d</td>
<td>2.43a</td>
</tr>
</tbody>
</table>

P<0.01
Form*Delivery Interaction

Slaughter wt, kg

- Dry: 95.8c
- Wet/Dry: 98.1b,c
- Liquid: 105.1a
- Dry: 98.8b,c
- Wet/Dry: 101.5a,b
- Liquid: 104.9a

P<0.001
Main effects, Feed Form

**ADFI (g/day)**
- Meal: 2557
- Pellets: 2567

**ADG (g/day)**
- Meal: 1092 (P<0.01)
- Pellets: 1134

**FCR (g/g)**
- Meal: 2.34 (P<0.001)
- Pellets: 2.26
Main effects, Feed Form

**Live-weight (kg)**

- Meal: 102.7
- Pellets: 105.5

**Carcass weight (kg)**

- Meal: 76.7
- Pellets: 79.2

**Kill out (%)**

- Meal: 74.6
- Pellets: 75.1

**Lean meat (%)**

- Meal: 57.4
- Pellets: 57.5
Main effects, Feed Delivery

**ADFI (g/day)**
- Dry: 2334a
- Wet/Dry: 2488b
- Liquid: 2864c

**ADG (g/day)**
- Dry: 1058a
- Wet/Dry: 1094a
- Liquid: 1188b

**FCR (g/g)**
- Dry: 2.21a
- Wet/Dry: 2.28b
- Liquid: 2.42c
Main effects, Feed Delivery

**Live-weight (kg)**

- Dry: 100.4a
- Wet/Dry: 102.9b
- Liquid: 108.9c

**Carcass weight (kg)**

- Dry: 75.0a
- Wet/Dry: 77.2b
- Liquid: 81.7c

**Kill out (%)**

- Dry: 74.7
- Wet/Dry: 75.0
- Liquid: 75.0

**Lean Meat (%)**

- Dry: 57.5
- Wet/Dry: 57.6
- Liquid: 57.2

*P<0.001*
Main findings

- Pelleting increased growth, improved FCR and increased KO%
Main findings

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- Liquid feeding increased feed intake and growth to slaughter but worsened FCR.
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- Liquid feeding increased feed intake and growth to slaughter but worsened FCR.
- Dry feeding resulted in better FCR compared with all other methods of feed delivery, especially liquid feeding.
Main findings

- Pelleting increased growth, improved FCR and increased KO%.
- Liquid feeding increased feed intake and growth to slaughter but worsened FCR.
- Dry feeding resulted in better FCR compared with all other methods of feed delivery, especially liquid feeding.
- Overall, in dry form, pelleted diets had lower Enterobacteriaceae, E. coli, yeast and mould counts.
Main findings

- Pelleting increased growth, improved FCR and increased KO%
- Liquid feeding increased feed intake and growth to slaughter but worsened FCR
- Dry feeding resulted in better FCR compared with all other methods of feed delivery, especially liquid feeding
- Overall, in dry form, pelleted diets had lower Enterobacteriaceae, E. coli, yeast and mould counts
- Data pending, ongoing analyses will help to further explain results
Conclusions

- If maximising growth rate is a priority, liquid feeding is preferable.
- If maximising feed efficiency is a priority, dry feeding a pelleted diet is preferable.
- Pelleting reduces the pathogen load of dry feed & increases growth rate over meal feeding.
Acknowledgements

• Farm staff and technicians in Pig Development Department, Teagasc

• Project partners:  
  
• Industry partners:  
  
• Funding body:  
  

SUPPLEMENTARY SLIDES
Industry Application

- If Dry or Wet/Dry feeding:
  Feeding a pelleted diet is worth €20-21/tonne of feed

- If finishing pigs to a target slaughter weight and space is not an issue:
  Dry and Wet/Dry feeding will increase margin over feed by €3.47 and €2.62 /pig, respectively

- If space is an issue and maximising growth is essential:
  Liquid feeding will increase margin over feed per pig by €0.30/pig
## Cost Benefit of Pelleting

1. To a target slaughter weight of 105kg

<table>
<thead>
<tr>
<th></th>
<th>Meal</th>
<th>Pellet</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Final weight (kg)</strong></td>
<td>105</td>
<td>105</td>
</tr>
<tr>
<td>Margin over feed (€/pig)</td>
<td>33.90</td>
<td>36.10</td>
</tr>
<tr>
<td>Benefit of feeding pellets (€/pig)</td>
<td>2.20</td>
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<tr>
<td>Margin over feed (€/tonne of feed)</td>
<td>202.91</td>
<td>224.01</td>
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<td>Benefit of feeding pellets (€/tonne of feed)</td>
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</table>

€21/T
## Cost Benefit –

### 2. Finishing over a fixed number of days

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<thead>
<tr>
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<tr>
<td><strong>Final weight (kg)</strong></td>
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<td>105.5</td>
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<tr>
<td>Margin over feed for period (€/pig)</td>
<td>32.91</td>
<td>36.33</td>
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<tr>
<td>Benefit of feeding pellets (€/pig)</td>
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€20/T
Cost Benefit –
1. To a target slaughter weight of 105kg

<table>
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<tr>
<th></th>
<th>Dry</th>
<th>Wet/Dry</th>
<th>Liquid</th>
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<tbody>
<tr>
<td>Final weight (kg)</td>
<td>105</td>
<td>105</td>
<td>105</td>
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<tr>
<td>Margin over feed for period (€/pig)</td>
<td>36.44</td>
<td>35.59</td>
<td>32.98</td>
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<tr>
<td>Benefit of dry over liquid feeding (€/pig)</td>
<td>3.47</td>
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</tr>
<tr>
<td>Benefit of wet/dry over liquid feeding (€/pig)</td>
<td></td>
<td>2.62</td>
<td></td>
</tr>
</tbody>
</table>
Cost Benefit –
2. Finishing over a fixed number of days

<table>
<thead>
<tr>
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<th>Wet/Dry</th>
<th>Liquid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final weight (kg)</td>
<td>100.4</td>
<td>102.9</td>
<td>108.9</td>
</tr>
<tr>
<td>Margin over feed for period (€/pig)</td>
<td>34.30</td>
<td>34.64</td>
<td>34.60</td>
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<tr>
<td>Benefit of dry over liquid feeding (€/pig)</td>
<td>-0.30</td>
<td></td>
<td></td>
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<tr>
<td>Benefit of wet/dry over liquid feeding (€/pig)</td>
<td></td>
<td>0.04</td>
<td></td>
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## Results: Interaction

### FORM*DELIVERY

<table>
<thead>
<tr>
<th></th>
<th>Dry meal</th>
<th>W/D meal</th>
<th>Liq meal</th>
<th>Dry pellets</th>
<th>W/D pellets</th>
<th>Liq pellets</th>
<th>SEM</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADFI, g/day</td>
<td>2343</td>
<td>2472</td>
<td>2855</td>
<td>2325</td>
<td>2504</td>
<td>2873</td>
<td>38.7</td>
<td>0.7845</td>
</tr>
<tr>
<td>ADG, g/day</td>
<td>1029&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1058&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1188&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1086&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1130&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1187&lt;sup&gt;a&lt;/sup&gt;</td>
<td>23.1</td>
<td>0.084</td>
</tr>
<tr>
<td>FCR, g/g</td>
<td>2.28&lt;sup&gt;b,c&lt;/sup&gt;</td>
<td>2.34&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>2.41&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.14&lt;sup&gt;d&lt;/sup&gt;</td>
<td>2.22&lt;sup&gt;c,d&lt;/sup&gt;</td>
<td>2.43&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.043</td>
<td>0.0108</td>
</tr>
<tr>
<td>Initial wt, kg</td>
<td>33.5</td>
<td>33.7</td>
<td>33.6</td>
<td>33.8</td>
<td>33.6</td>
<td>33.7</td>
<td>0.83</td>
<td>1</td>
</tr>
<tr>
<td>Slaughter wt, kg</td>
<td>95.8&lt;sup&gt;c&lt;/sup&gt;</td>
<td>98.1&lt;sup&gt;b,c&lt;/sup&gt;</td>
<td>105.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>98.8&lt;sup&gt;b,c&lt;/sup&gt;</td>
<td>101.5&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>104.9&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.83</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>
## Results: Interaction

<table>
<thead>
<tr>
<th>FORM*DELIVERY</th>
<th>Dry Meal</th>
<th>W/D Meal</th>
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<th>Dry pellets</th>
<th>W/D pellets</th>
<th>Liq pellets</th>
<th>SEM</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liveweight, kg</td>
<td>98.1</td>
<td>101.0</td>
<td>108.9</td>
<td>102.8</td>
<td>104.8</td>
<td>108.8</td>
<td>1.08</td>
<td>0.0074</td>
</tr>
<tr>
<td>Carcass wt, kg</td>
<td>73.1</td>
<td>75.7</td>
<td>81.3</td>
<td>76.8</td>
<td>78.8</td>
<td>82.1</td>
<td>0.74</td>
<td>0.0525</td>
</tr>
<tr>
<td>Kill out, %</td>
<td>74.6</td>
<td>74.9</td>
<td>74.5</td>
<td>74.8</td>
<td>75.1</td>
<td>75.5</td>
<td>0.29</td>
<td>0.1915</td>
</tr>
<tr>
<td>Muscle depth, mm</td>
<td>51.1</td>
<td>51.2</td>
<td>51.0</td>
<td>51.1</td>
<td>52.0</td>
<td>52.2</td>
<td>0.62</td>
<td>0.3942</td>
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<tr>
<td>Fat depth, mm</td>
<td>12.1</td>
<td>12.4</td>
<td>12.3</td>
<td>12.1</td>
<td>12.0</td>
<td>12.9</td>
<td>0.51</td>
<td>0.3923</td>
</tr>
<tr>
<td>Lean meat, %</td>
<td>57.5</td>
<td>57.3</td>
<td>57.4</td>
<td>57.6</td>
<td>57.8</td>
<td>57.0</td>
<td>0.42</td>
<td>0.4642</td>
</tr>
</tbody>
</table>
Pelleting method

- Step 1, Conditioning: Feed subject to steam and pressure prior to pelleting, important to produce good quality pellets with low levels of fines (Lawlor et al., 2000)

- Step 2: Feed is forced through the die of the pelleting machine to give a frictional heating effect (Lawlor et al., 2000)

- 3mm pellets manufactured at Moorepark feed mill at 55-60°C
Feeder Space

- ‘We concluded that 12 pigs can be fed from a single-space feeder without affecting productivity’ *(Gonyou and Lou, 2000)*

- Advised feed space per pig:
  - *Ad-libitum* feeding: 7.5cm per pig
  - Restricted feeding: 30cm per pig

My space allowance:

- Single-space feeders: 30.48cm @6 pigs/pen = 5.08cm/pig
- Double-space feeders: 60.96cm @ 6 pigs/pen = 10.16cm/pig
Feeder Space

- ‘The general rule of thumb is that 2 inches per pig space are needed for conventional dry and tube feeders, with 1 inch per pig space needed for wet-dry feeders.’ (De Rouchey and Richert, 2010)
- Single space wet/dry feeder: 12 inches /6 pigs=2 inches per pig
- Double space dry feeder: 24 inches /6 pigs= 4 inches per pig
## Cost Benefit of Pelleting

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<table>
<thead>
<tr>
<th></th>
<th>Meal</th>
<th>Pellet</th>
</tr>
</thead>
<tbody>
<tr>
<td>FCR</td>
<td>2.34</td>
<td>2.26</td>
</tr>
<tr>
<td>Initial wt (kg)</td>
<td>33.6</td>
<td>33.7</td>
</tr>
<tr>
<td>Kill Out (%)</td>
<td>74.6</td>
<td>75.1</td>
</tr>
<tr>
<td><strong>Final weight (kg)</strong></td>
<td>105</td>
<td>105</td>
</tr>
<tr>
<td>Feed price (€/tonne)</td>
<td>262</td>
<td>262</td>
</tr>
<tr>
<td>Total Feed/ pig (Kg)</td>
<td>167.08</td>
<td>161.14</td>
</tr>
<tr>
<td>Total feed cost (€/pig)</td>
<td>43.77</td>
<td>42.22</td>
</tr>
<tr>
<td>Price per kg DW (€/kg)</td>
<td>1.40</td>
<td>1.40</td>
</tr>
<tr>
<td>Carcass weight increase (kg)</td>
<td>55.48</td>
<td>55.94</td>
</tr>
<tr>
<td>Value of increased Carcass weight (€)</td>
<td>77.67</td>
<td>78.31</td>
</tr>
<tr>
<td>Margin over feed (€/pig)</td>
<td>33.90</td>
<td>36.10</td>
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</tbody>
</table>
Table 1. Calculated chemical composition of the basal diet

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Content</th>
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</thead>
<tbody>
<tr>
<td>DM, g/kg</td>
<td>875.138</td>
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<tr>
<td>Protein, g/kg</td>
<td>170</td>
</tr>
<tr>
<td>Ash, g/kg</td>
<td>43.332</td>
</tr>
<tr>
<td>Fat, g/kg</td>
<td>25.656</td>
</tr>
<tr>
<td>Fibre, g/kg</td>
<td>36.878</td>
</tr>
<tr>
<td>Starch + Sugar, g/kg</td>
<td>480.755</td>
</tr>
<tr>
<td>Sugar, g/kg</td>
<td>34.277</td>
</tr>
<tr>
<td>Starchew g/kg</td>
<td>446.478</td>
</tr>
<tr>
<td>NDF, g/kg</td>
<td>132.313</td>
</tr>
<tr>
<td>ADF, g/kg</td>
<td>42.49</td>
</tr>
<tr>
<td>DE Pig, MJ/kg</td>
<td>13.814</td>
</tr>
<tr>
<td>NE IFIP, MJ/kg</td>
<td>9.8</td>
</tr>
<tr>
<td>Lysine, g/kg</td>
<td>11</td>
</tr>
<tr>
<td>SID LYSpig, g/kg</td>
<td>9.97</td>
</tr>
<tr>
<td>SID M+C as % LYS</td>
<td>60</td>
</tr>
<tr>
<td>SID THR as % LYS</td>
<td>67.393</td>
</tr>
<tr>
<td>SID TRP as % LYS</td>
<td>20.013</td>
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<tr>
<td>SID LYS/MJDE</td>
<td>0.722</td>
</tr>
<tr>
<td>Ca, g/kg</td>
<td>6.585</td>
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<tr>
<td>Phosphorus, g/kg</td>
<td>4.065</td>
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<tr>
<td>Digestible P, g/kg</td>
<td>2.554</td>
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<tr>
<td>Na, g/kg</td>
<td>1.321</td>
</tr>
</tbody>
</table>
Table 2. Ingredients of the diet

<table>
<thead>
<tr>
<th>Ingredient, kg/tone</th>
<th>Basal diet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley</td>
<td>382.67</td>
</tr>
<tr>
<td>Wheat</td>
<td>400</td>
</tr>
<tr>
<td>Soya Hi-Pro</td>
<td>183.01</td>
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<td>Limestone flour</td>
<td>11</td>
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<tr>
<td>Lysine HCl (78.8)</td>
<td>3.75</td>
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<td>Mono DiCal Phos</td>
<td>1.0</td>
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<tr>
<td>Salt feed grade</td>
<td>3.0</td>
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<tr>
<td>L-Threonine (98)</td>
<td>1.7</td>
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<tr>
<td>Fat, soya oil</td>
<td>9.69</td>
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<tr>
<td>Vit-Min Mpk Finisher</td>
<td>1.0</td>
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<tr>
<td>DL-Methionine</td>
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<td>Celite</td>
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<td>L-Tryptophan</td>
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<td>Natuphos</td>
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