Environmental LCA of Irish dairy products

Dr William Finnegan, NUI Galway
Dr Jamie Goggins, NUI Galway
Dr Eoghan Clifford, NUI Galway
Prof Xinmin Zhan, NUI Galway
• Introduction

• Macro-scale study

• Environmental LCA using plant data

• Discussion points
• Introduction

• Macro-scale study

• Environmental LCA using plant data

• Discussion points
Irish milk production

Milk production (million litres)

Avg. (2007 - 2009)
2014
2015

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Task 6 objectives

- Carry out an environmental life cycle assessment of the Irish dairy processing industry
  - Macro-scale LCA of global warming potential (GWP) of Irish dairy products
  - Detailed environmental LCA for manufacture of main dairy products:
    - Fluid milk
    - Cheese
    - Butter/milk powder
    - Cream
    - Whey powder
    - Infant formula (powder)
- Return individual analysis results to participating plants
- Develop a framework for environmental life cycle assessment of dairy processing facilities in Ireland
  - waste management and water use
System boundaries

Lifecycle inventory analysis

• Most critical part of the LCA and is dependant on the quality of the data
• Surveying and data collecting at dairy processing plants will be at the epicentre of the study
• Data generated from the studies in the project will provide the information for the comparative LCA study
• Data from industry will be collected at two levels:
  – For plants with adequate monitoring in place, at each processing phase will be collected for a given product
  – Otherwise, an overview of the inputs and outputs, along with engineering estimates of allocation will need to be provided
• Introduction

• Macro-scale study

• Environmental LCA using plant data

• Discussion points
System boundaries


DairyWater
Macro-scale study of Irish dairy industry

Casey et al. (2005)
Macro-scale study of Irish dairy industry

<table>
<thead>
<tr>
<th>Dairy product</th>
<th>Fluid milk</th>
<th>Butter</th>
<th>Cheese</th>
<th>Cream</th>
<th>Milk powders</th>
<th>Whey powders</th>
</tr>
</thead>
<tbody>
<tr>
<td>kg CO₂eq kg⁻¹ product</td>
<td>1.468 (92.4%)</td>
<td>0.007 (0.4%)</td>
<td>0.114 (7.2%)</td>
<td>1.589</td>
<td>9.225 (95.3%)</td>
<td>0.041 (0.4%)</td>
</tr>
</tbody>
</table>

*GWP associated with the production of 1 kg of various dairy products (kg CO₂eq kg⁻¹ product)
Macro-scale study of dairy processing industry

GWP of fluid milk

<table>
<thead>
<tr>
<th>Country</th>
<th>kg CO₂ eq kg⁻¹ product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ireland</td>
<td>Present Study</td>
</tr>
<tr>
<td>Australia</td>
<td>*Halliday (2011)</td>
</tr>
<tr>
<td>USA</td>
<td>Nutter et al. (2013)</td>
</tr>
<tr>
<td></td>
<td>Tan et al. (2011)</td>
</tr>
<tr>
<td></td>
<td>Heller and Keoleian (2011)</td>
</tr>
<tr>
<td>Italy</td>
<td>*Fantin et al. (2012)</td>
</tr>
</tbody>
</table>

*Edited figure for comparison
Macro-scale study of dairy processing industry

GWP of milk powders

Ireland

Present Study

Australia

*Halliday (2011)

GWP of cheese

Ireland

Present Study

USA

Kim et al. (2013)

Sweden

Berlin (2002)

Holland

van Middelaar et al. (2011)

*Edited figure for comparison
• Introduction

• Macro-scale study

• Environmental LCA using plant data

• Discussion points
System boundaries

Present study

Potentially incorporated

Low data availability

Environmental LCA of Irish dairy processing plants

- Main input data required from plants:
  - Volume of milk processed
  - Production statistics (tonnes)
  - Raw milk transportation
  - Chemical usage
  - Energy usage (electrical & thermal)
  - Water consumption
  - Packaging materials used
  - Wastewater treatment
  - Solid waste disposal
Environmental LCA of Irish dairy processing plants

<table>
<thead>
<tr>
<th>Product</th>
<th>GWP</th>
<th>CED</th>
<th>FEP</th>
<th>MEP</th>
<th>AP</th>
<th>WD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk Powder</td>
<td>1.507</td>
<td>22.10</td>
<td>0.000120</td>
<td>0.000219</td>
<td>5.95E-03</td>
<td>1.1524</td>
</tr>
<tr>
<td>Butter</td>
<td>0.469</td>
<td>4.87</td>
<td>0.000065</td>
<td>0.000122</td>
<td>1.44E-03</td>
<td>0.5906</td>
</tr>
<tr>
<td>Fluid milk</td>
<td>0.188</td>
<td>3.72</td>
<td>0.000019</td>
<td>0.000030</td>
<td>7.72E-04</td>
<td>0.1774</td>
</tr>
<tr>
<td>Cream</td>
<td>0.187</td>
<td>4.25</td>
<td>0.000019</td>
<td>0.000027</td>
<td>7.13E-04</td>
<td>0.1896</td>
</tr>
<tr>
<td>Infant formula</td>
<td>2.906</td>
<td>27.61</td>
<td>0.000624</td>
<td>0.000372</td>
<td>8.14E-03</td>
<td>26.5856</td>
</tr>
<tr>
<td>Cheese</td>
<td>0.480</td>
<td>6.59</td>
<td>0.000084</td>
<td>0.000172</td>
<td>1.90E-03</td>
<td>0.7534</td>
</tr>
<tr>
<td>Whey powder</td>
<td>2.381</td>
<td>35.20</td>
<td>0.000202</td>
<td>0.000362</td>
<td>1.18E-02</td>
<td>1.8908</td>
</tr>
</tbody>
</table>

 OD

<table>
<thead>
<tr>
<th>kg CFC-11 eq</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0E-07</td>
</tr>
<tr>
<td>5.0E-08</td>
</tr>
<tr>
<td>1.6E-08</td>
</tr>
<tr>
<td>1.5E-08</td>
</tr>
<tr>
<td>2.5E-07</td>
</tr>
<tr>
<td>5.9E-08</td>
</tr>
<tr>
<td>2.9E-07</td>
</tr>
</tbody>
</table>
## Environmental LCA of Irish dairy processing plants

<table>
<thead>
<tr>
<th>Product</th>
<th>GWP</th>
<th>CED</th>
<th>FEP</th>
<th>MEP</th>
<th>AP</th>
<th>WD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk Powder</td>
<td>1.507</td>
<td>22.10</td>
<td>0.000120</td>
<td>0.000219</td>
<td>5.95E-03</td>
<td>1.1524</td>
</tr>
<tr>
<td>Butter</td>
<td>0.469</td>
<td>4.87</td>
<td>0.000065</td>
<td>0.000122</td>
<td>1.44E-03</td>
<td>0.5906</td>
</tr>
<tr>
<td>Fluid milk</td>
<td>0.188</td>
<td>3.72</td>
<td>0.000019</td>
<td>0.000030</td>
<td>7.72E-04</td>
<td>0.1774</td>
</tr>
<tr>
<td>Cream</td>
<td>0.187</td>
<td>4.25</td>
<td>0.000019</td>
<td>0.000027</td>
<td>7.13E-04</td>
<td>0.1896</td>
</tr>
<tr>
<td>Infant formula</td>
<td>2.906</td>
<td>27.61</td>
<td>0.000624</td>
<td>0.000372</td>
<td>8.14E-03</td>
<td>26.5856</td>
</tr>
<tr>
<td>Cheese</td>
<td>0.480</td>
<td>6.59</td>
<td>0.000084</td>
<td>0.000172</td>
<td>1.90E-03</td>
<td>0.7534</td>
</tr>
<tr>
<td>Whey powder</td>
<td>2.381</td>
<td>35.20</td>
<td>0.000202</td>
<td>0.000362</td>
<td>1.18E-02</td>
<td>1.8908</td>
</tr>
</tbody>
</table>

### Graph

- **GWP** (Global Warming Potential)
- **CED** (Cumulative Energy Demand)
- **FEP** (Freshwater Eutrophication Potential)
- **MEP** (Marine Eutrophication Potential)
- **AP** (Acidification Potential)
- **WD** (eutrophication Potential)

#### OD (ODors)
- **CFC-11 eq**
  - CFC-11 equivalent
  - 2.0E-07
- **Wastewater**
  - 5.0E-08
- **Packaging**
  - 1.6E-08
- **Other (process)**
  - 1.5E-08
- **Fuel**
  - 2.5E-07
- **Electricity**
  - 5.9E-08
- **Milk tran**
  - 2.9E-07
<table>
<thead>
<tr>
<th>Product</th>
<th>GWP (kg CO₂ eq kg⁻¹ product)</th>
<th>IPCC (kg CO₂ eq kg⁻¹ product)</th>
<th>NOx (kg NO₂ eq kg⁻¹ product)</th>
<th>SO₂ (kg SO₂ eq m⁻³ kg⁻¹ product)</th>
<th>CFC-11 (kg CFC-11 eq kg⁻¹ product)</th>
<th>Energy (MJ kg⁻¹ product)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk Powder</td>
<td>1.507</td>
<td>0.000</td>
<td>5.95E⁻⁰³</td>
<td>1.1524</td>
<td>2.0E⁻⁰⁷</td>
<td>0.514</td>
</tr>
<tr>
<td>Butter</td>
<td>0.469</td>
<td>0.000</td>
<td>1.44E⁻⁰³</td>
<td>0.5906</td>
<td>5.0E⁻⁰⁸</td>
<td>0.314</td>
</tr>
<tr>
<td>Fluid milk</td>
<td>0.188</td>
<td>0.000</td>
<td>7.72E⁻⁰⁴</td>
<td>0.1774</td>
<td>1.6E⁻⁰⁸</td>
<td>0.066</td>
</tr>
<tr>
<td>Cream</td>
<td>0.187</td>
<td>0.000</td>
<td>7.13E⁻⁰⁴</td>
<td>0.1896</td>
<td>1.5E⁻⁰⁸</td>
<td>0.056</td>
</tr>
<tr>
<td>Infant formula</td>
<td>2.906</td>
<td>0.000</td>
<td>8.14E⁻⁰³</td>
<td>26.5856</td>
<td>2.5E⁻⁰⁷</td>
<td>1.111</td>
</tr>
<tr>
<td>Cheese</td>
<td>0.480</td>
<td>0.000</td>
<td>1.90E⁻⁰³</td>
<td>0.7534</td>
<td>5.9E⁻⁰⁸</td>
<td>0.251</td>
</tr>
<tr>
<td>Whey powder</td>
<td>2.381</td>
<td>0.000</td>
<td>1.18E⁻⁰²</td>
<td>1.8908</td>
<td>2.9E⁻⁰⁷</td>
<td>0.791</td>
</tr>
</tbody>
</table>

Environmental LCA of Irish dairy processing plants
Presentation contents

- Introduction
- Macro-scale study
- Environmental LCA using plant data
- Discussion points
Discussion points

• This study will serve as a benchmark for processors
  – Identify opportunities to reduce impacts

• Inform policy makers of the significant contributors to environmental impacts

• Next steps:
  – Increase the number of plants in study
  – To explore the affect of seasonal variation of milk production on these impacts
  – Feedback to participating dairy plants
Questions???

Dr William Finnegan, NUI Galway
William.finnegan@nuigalway.ie