Benchmark the environmental sustainability of Irish dairy industry with life cycle assessment

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DPTC-UCD
Dairy Processing Technology Centre

http://www.dptc.ie/

• Industry–academic collaborative research centre, hosted by the University of Limerick, with a research agenda driven by the long-term growth opportunities for the dairy sector

• Funded by Enterprise Ireland and the Dairy Industry Partners
DPTC Research Programs

Pillar 5
ENVIRONMENTAL SUSTAINABILITY: TOWARDS A ZERO EMISSIONS IRISH DAIRY INDUSTRY
Life cycle assessment for environmental sustainability

LCA can quantify environmental sustainability throughout a product’s “life cycle” (cradle to grave), from raw material acquisition through production, use, recycling and final disposal, regardless of where these stages take place (ISO, 2006)
ISO14000 family

Initially
• ISO 14040 Principles and Framework
• ISO 14041 Goal and Scope definition and Inventory Analysis
• ISO 14042 Life Cycle Impact Assessment
• ISO 14043 Interpretation

Now replaced with (since 2006)
• ISO / DIS 14040 Principles and Framework
• ISO / DIS 14044 Requirements and Guidelines
LCA: sustainability along the supply chain
Popular LCA concepts

Carbon footprint: LCA of greenhouse gas emissions

Water footprint: LCA of water usages

6 steps to reduce your farms carbon footprint and save up to €29,000

Amy Forde  6:15 am  February 25, 2016  0 Comment  Share  Tweet  Email  10 Share
Europe: the world’s largest *virtual water* import region

Rough estimation: $100 \times 10^9 \text{ m}^3/504060345/365 = 543 \text{ L per person per day in 2012}$

Hoekstra and Mekonnen, 2012
LCA in policy

The European Commission has proposed EU-wide methods to measure the environmental performance of products and organisations based on LCA. Since 2013, 26 product pilots have been launched, including dairy products.
LCA in industry

Origin Green
IRLAND

BASF
We create chemistry

AgBalance™ – a Life Cycle Assessment

Unilever’s 1st sustainable movement

Our approach to lifecycle assessment

Bulletin of the International Dairy Federation
A common carbon footprint approach for dairy
The IDF guide to standard lifecycle assessment methodology for the dairy sector
Four stages of LCA

1. Goal and Scope
2. Life Cycle Inventory (LCI)
3. Life Cycle Impact Assessment (LCIA)
4. Interpretation
LCA of dairy products (cradle to grave)

Cradle → Dairy farm → Processing → Retailer → Consumer

Energy & water

Packaging & chemicals
Current project scope (gate to grave)

Energy & water

Packaging & chemicals

Dairy farm gate  

Processing gate
What are the environmental impacts (energy, water, GHG) associated with producing 1 ton of cream/butter/cheese...?
Allocation for multi product system

Inputs (energy, water, materials)

On-site energy, water, GHG, waste

Down graded products
- Cream
- Butter
- Cheese
- Casein/ate
- Whey
- Powder etc.

Other salable outputs

Emissions & waste
Common impact categories used for dairy products LCA

1. Greenhouse gas emissions
2. Fossil fuels, minerals
3. NH3, NOx, SO2 emissions
4. Nutrient discharged
5. Toxic chemicals
6. Water scarcity
LCA software tools

- There are extensive software tools available (usually at a cost)
  

Some common software

- [SimaPro](http://www.eiolca.net/)
- [Gabi](http://www.eiolca.net/)
- [openLCA](http://www.eiolca.net/) (software, site)
Literature: carbon footprint

Range of carbon footprints of various dairy products

kg CO2 eq/kg

- Pasteurised milk
- UHT milk
- Cream
- Butter
- Margarine
- Cheese
- Yoghurt
- Powder and whey based
Literature: impact of waste

1 before consumption, 2 after consumption
Flysjo et al. 2011
Literature: dominance of milk, lack of process details

Carbon footprint
Flysjo et al. 2014
Data source: Arla Foods
Literature: energy intensity on-site

- FAO 2010
- Flysjo et al. 2014
- Ramirez et al. 2006

<table>
<thead>
<tr>
<th>Product</th>
<th>Energy, MJ/kg product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid milk</td>
<td>0.5</td>
</tr>
<tr>
<td>Yoghurt</td>
<td>2.0</td>
</tr>
<tr>
<td>Butter</td>
<td>4.0</td>
</tr>
<tr>
<td>Cheese</td>
<td>7.0</td>
</tr>
<tr>
<td>Whey powder</td>
<td>8.0</td>
</tr>
<tr>
<td>Milk powder</td>
<td>9.0</td>
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</tbody>
</table>
Sensitivity analysis

Change in total carbon footprint for +/-10% in individual inputs (Aguirre-Villegas et al. 2012)
Uncertainty analysis: data quality

<table>
<thead>
<tr>
<th></th>
<th>Process 1</th>
<th>Process 2</th>
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</thead>
<tbody>
<tr>
<td>Data reliability</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Completeness</td>
<td></td>
<td></td>
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<tr>
<td>Temporal correlation</td>
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<tr>
<td>Geographical correlation</td>
<td></td>
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<tr>
<td>Future technological correlation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample size</td>
<td></td>
<td></td>
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<tr>
<td><strong>Total uncertainty</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Table 5-5: Results of the uncertainty analysis for 1 kg of semi-cured Gouda cheese.)

<table>
<thead>
<tr>
<th>Impact category</th>
<th>Unit</th>
<th>Mean</th>
<th>SD*</th>
<th>CV* (Coefficient of Variation)</th>
<th>2.50%*</th>
<th>97.50%*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate change</td>
<td>kg CO2 eq</td>
<td>8.83</td>
<td>1.26</td>
<td>0.143</td>
<td>6.9</td>
<td>11.8</td>
</tr>
<tr>
<td>Terrestrial acidification</td>
<td>kg SO2 eq</td>
<td>0.192</td>
<td>0.0306</td>
<td>0.159</td>
<td>0.146</td>
<td>0.264</td>
</tr>
<tr>
<td>Freshwater eutrophication</td>
<td>kg P eq</td>
<td>0.00299</td>
<td>0.00051</td>
<td>0.171</td>
<td>0.00225</td>
<td>0.00425</td>
</tr>
<tr>
<td>Marine eutrophication</td>
<td>kg N eq</td>
<td>0.0652</td>
<td>0.0111</td>
<td>0.171</td>
<td>0.0478</td>
<td>0.0916</td>
</tr>
<tr>
<td>Agricultural land occupation</td>
<td>m2a</td>
<td>6.41</td>
<td>1.03</td>
<td>0.16</td>
<td>4.88</td>
<td>8.89</td>
</tr>
<tr>
<td>Fossil depletion</td>
<td>kg oil eq</td>
<td>0.857</td>
<td>0.114</td>
<td>0.133</td>
<td>0.678</td>
<td>1.13</td>
</tr>
</tbody>
</table>

* SD: Standard Deviation; CV: Coefficient of Variation; 95% CI: 95% confidence interval

(Broekema et al. 2014)
Knowledge gaps

• Mass balance missing: DM, nutrient etc.
• Processes missing: CIP, WWTP
• Poor resolution: process specific data lacking
• Limited studies beyond carbon footprint
• Limited Irish studies (Geraghty 2011)
• Efficiency improvement: LCA can’t do it alone
Thank you!