Environmental Sustainability, Food Security and Animal Food Production: Milk and Dairy as a Case Study

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One Health and Sustainable Development in Asia

http://barfblog.com/tags/one-health/
My Task for Today

• Sustainability of food animal production with emphasis on milk and dairy
• Environmental impact of milk and dairy production with consideration for nutrient supply for the average human
• Capability of nutrition models to help calculate the environmental impacts and role of byproducts in diets
• Role of intensification in the process of producing animal based and reduction of environmental impacts
Role of Animal Agriculture in the Future

• Opportunities
  – Great source of essential nutrients especially for children and older adults
  – Makes use of land that is not good for other crops
  – Makes use byproducts from human food production
  – Enhance indigenous animal resources and provide fertilizer and fuel
Role of Animal Agriculture in the Future

• Risks
  – Education, training, workforce
  – Resources and infrastructure – land, water, transportation, energy, (food processing and distribution), etc.
  – Failure to recognize/accept productivity as a solution and adopt technologies
  – Political stability and inability to engender appropriate working capital
Animal Source Foods – Key components of a balanced diet

- Animal source foods are included in dietary recommendations by public health organizations around the world

- Children with little or no animal source foods have significant development problems:
  - Poor growth
  - Impaired cognitive performance
  - Neuromuscular deficits
  - High mortality rates

Reviewed by: Nuemann et al. (Nutrition Research 22:193) and Murphy & Allen (J. Nutrition 133:3932S)
Dairy Products Contribution to U.S. Intake of Essential Nutrients

- % of calories & nutrients from dairy
- NHANES 2003-2006, ages 2 years and older
Past evaluations of environmental impact have often compared foods on the basis of mass (weight) or energy (calories) or even cow/animal unit.

Inexcusable to not consider the nutritional implications of alternative food choices.

Comparison of foods requires a functional unit that is relevant from both a nutritional and environmental perspective.
# Dietary Greenhouse Gas Emissions of Meat Eaters, Vegetarians and Vegans in UK

<table>
<thead>
<tr>
<th>Diet types</th>
<th>Age and Sex Adjusted Mean Dietary GHG Emissions, (kgCO2eq/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All meat eaters</td>
<td>5.93</td>
</tr>
<tr>
<td>High meat eaters (&gt;100g/d)</td>
<td>7.19</td>
</tr>
<tr>
<td>Medium meat eaters (50-99 g/d)</td>
<td>5.63</td>
</tr>
<tr>
<td>Low meat eaters (&lt;50g/d)</td>
<td>4.67</td>
</tr>
<tr>
<td>Fish eaters</td>
<td>3.91</td>
</tr>
<tr>
<td>Vegetarians</td>
<td>3.81</td>
</tr>
<tr>
<td>Vegans</td>
<td>2.89</td>
</tr>
</tbody>
</table>

Scarborough et al., 2014; Climatic Change 125:179-192
Beverages Vary in Nutrient Density and Greenhouse Gas Emissions

<table>
<thead>
<tr>
<th>Beverage</th>
<th>Nutrient Density</th>
<th>GHG Emissions g CO₂-eq/g product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk</td>
<td>53.8</td>
<td>99</td>
</tr>
<tr>
<td>Orange Juice</td>
<td>17.2</td>
<td>61</td>
</tr>
<tr>
<td>Soy Drink</td>
<td>7.6</td>
<td>30</td>
</tr>
<tr>
<td>Oat Drink</td>
<td>1.5</td>
<td>21</td>
</tr>
<tr>
<td>Red Wine</td>
<td>1.2</td>
<td>204</td>
</tr>
<tr>
<td>Soda</td>
<td>0.0</td>
<td>109</td>
</tr>
<tr>
<td>Water</td>
<td>0.0</td>
<td>101</td>
</tr>
<tr>
<td>Beer</td>
<td>0.0</td>
<td>10</td>
</tr>
</tbody>
</table>

Nutrient Density Must Be Included When Assessing Environmental Impact

Based on Smedmen et al. 2010
Integration of Health, Environment and Nutrient Supply: Milk Example

Fig. 1 Graphical representation of the combined nutritional and environmental health impact LCA framework. Dashed lines represent links between midpoint and endpoint categories that are useful to interpret impact scores, but whose quantification is also associated with a high degree of uncertainty.
Comparison made of current U.S. diet and alternatives adding or exchanging a 119 kcal serving of milk

The width of food groups corresponds to their caloric contribution to the total average US diet

Outcomes in Health Benefits (µDALY) Compared to the Standard U.S. diet by Addition or Exchange of 1 serving Fluid Milk

DALY = Disability Adjusted Life Years – gap between current health status and ideal health status

Population growth, food for animals, concerns about intensification

- The Food and Agriculture Organization of the United Nations indicates food production will have to increase by 20-50% to meet the needs of people.

- The majority of the basic food supply for humans will continue to be plant-based – which means we will have more byproducts to dispose of.

- Intensification of animal agriculture is considered a sustainability issue, but not well described in context of current systems (e.g. approx. 10-60% of dairy cow diets world-wide are made up of byproducts of the human food chain.)
Human Food & Fiber By-product Examples

**Oil extraction**
- Canola meal
- Cotton hulls
- Cotton seed meal
- Linseed meal
- Peanut meal
- Soy hulls & meal
- Sunflower hulls & meal

**Fruit/Vegetable processing**
- Pomace (apple, tomato, carrot)
- Vine silage (peas & legumes)
- Corn stover
- Potato peels
- Almond hulls

**Sugar processing**
- Beet pulp
- Molasses

**Brewing & Spirits**
- Brewers grains
- Brewers solubles
- Brewers yeast
- Distillers grains

**Fish processing**
- Fish meal

**Grain milling**
- Bran (corn, wheat, rice)
- Cereal fines
- Midds (corn, wheat, barley)

**Citrus processing**
- Citrus pulp

**Cheese manufacturing**
- Whey

**Ethanol production**
- Distillers grains (corn, milo, barley, sorghum)

**Baking industry**
- Bakery by-products
- Expired product

**Chocolate manufacturing**
- Candy by-products
- Confectionary waste

**Dry corn milling for corn flour & grits**
- Corn bran
- Hominy feed

**Human foods that fail grading**
- Starches, oils
- Grains, flour
- Vegetables

**Wet corn milling for starch, sweeteners & oil**
- Corn germ meal
- Corn gluten feed
Almond Growers keep good records
http://www.almondboard.com

• They produced 2.1 billion kg of almond hulls this past year - all currently disposed of through cattle
Cornell Net Carbohydrate and Protein System (CNCPS)

In development for over 30 yr and most published model of its type (>30 publications of the model and capability)

Used to evaluate and formulate diets for cattle, both dairy and beef - estimated to be used to formulate diets for >75% of cattle in North America and up to 15% of cattle world wide

Developed the CNCPS to predict carbon dioxide and methane emissions per cow per day and per unit of milk production
CO₂ and CH₄ production predicted by the CNCPS compared with observed from 5 studies and 22 treatments

Van Amburgh et al., 2015; J. Dairy Sci
Milk yield versus predicted carbon dioxide emissions (kg/cow/d)

\[ \text{CO}_2 \text{ (kg/d)} = 0.12 \times \text{milk yield (kg/d)} + 9.69 \quad (R^2 = 0.69; \text{RMSE} = 0.64 \text{ kg/d}) \]
Predicted CO$_2$ emissions per kg of milk versus milk yield

CO$_2$ Kg/kg milk = -0.006 × milk yield (kg/d) + 0.59 ($R^2 = 0.81$; RMSE = 0.02 kg CO$_2$/ kg milk.)
Milk yield versus predicted methane emissions (kg/cow/d).

\[ \text{CH}_4 \text{ (kg/d)} = 0.004 \times \text{milk yield (kg/d)} + 0.43 \quad (R^2 = 0.75; \text{RMSE} = 0.02 \text{ kg/d}). \]
kg CH$_4$/Kg milk = -$0.0003 \times$ milk yield (kg/d) + 0.03 ($R^2 = 0.89$; RMSE $= 0.0005$ kg CH$_4$/ kg milk.)
Predicted carbon dioxide and methane release based on the total amount of dry matter consumed (DMI), byproduct inclusion (kg) and as a ratio of the milk yield

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DMI</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>kg CO₂/kg DMI</td>
<td>0.576</td>
<td>0.011</td>
<td>0.557</td>
<td>0.618</td>
</tr>
<tr>
<td>kg CH₄/kg DMI</td>
<td>0.024</td>
<td>0.001</td>
<td>0.021</td>
<td>0.027</td>
</tr>
<tr>
<td><strong>Byproduct</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>kg CO₂/kg BP</td>
<td>0.050</td>
<td>0.018</td>
<td>0.029</td>
<td>0.117</td>
</tr>
<tr>
<td>kg CH₄/kg BP</td>
<td>0.002</td>
<td>0.001</td>
<td>0.001</td>
<td>0.005</td>
</tr>
<tr>
<td><strong>Milk Yield</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>kg CO₂/kg milk</td>
<td>0.353</td>
<td>0.031</td>
<td>0.283</td>
<td>0.423</td>
</tr>
<tr>
<td>kg CH₄/kg milk</td>
<td>0.014</td>
<td>0.001</td>
<td>0.012</td>
<td>0.018</td>
</tr>
</tbody>
</table>
Comparison of gas released from byproduct disposal between dairy cows and combustion

<table>
<thead>
<tr>
<th>Variable</th>
<th>Byproduct inclusion</th>
<th>CO\textsubscript{2} byproducts</th>
<th>CH\textsubscript{4} byproducts</th>
<th>Total gas\textsuperscript{1}</th>
<th>CO\textsubscript{2} combust</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% ration DM</td>
<td>kg CO\textsubscript{2} Eq./cow/d</td>
<td>kg</td>
<td>kg</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>31</td>
<td>4.5</td>
<td>4.6</td>
<td>9.0</td>
<td>15.2</td>
</tr>
<tr>
<td>SD</td>
<td>9</td>
<td>1.4</td>
<td>1.4</td>
<td>2.8</td>
<td>4.9</td>
</tr>
<tr>
<td>Min</td>
<td>13</td>
<td>1.8</td>
<td>1.9</td>
<td>3.7</td>
<td>7.4</td>
</tr>
<tr>
<td>Max</td>
<td>57</td>
<td>7.4</td>
<td>7.9</td>
<td>15.3</td>
<td>26.7</td>
</tr>
</tbody>
</table>

\textsuperscript{1}Total gas release = CO\textsubscript{2} (kg/d) + CH\textsubscript{4} (kg CO\textsubscript{2} Eq./d)
Final Reflections

Agriculture is about Food Production!

• All food production has an environmental impact and environmental stewardship is a critical responsibility in production agriculture.

• Essential to evaluate environmental impact per unit of output using science-based procedures.

• Productivity is a key factor in reducing the environmental impact of animal agriculture, indeed of all production agriculture.

• Sustainability comparisons among foods need to be based on supply of nutrients, especially essential nutrients.
Agriculture is about Food Production!

- Animal source foods are important and affordable sources of key nutrients.
- Essential that we understand and discuss the role of technology in food production and the environmental consequences of our choices.
Thank you for your attention

Scientists have pointed the finger at humans as the major cause of greenhouse gases and global warming.

Phew... I thought they were going to try and pin it on us.