Life Cycle Assessment to eco-design food products: study on industrial cooked dish

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✓ Presentation of AZTI
✓ Project justification and objectives
✓ Methodology
✓ Partial and final results
✓ Conclusions
AZTI-Tecnalia, Technological Centre, is a non-profitable organisation committed to the social and economic development of the food and fishing industries, and to the protection of the marine environment and its natural resources.

- Technological research and development
- Technology transfer
- Technical services
  - Technical advice and consultancy services
  - Analysis and testing
  - Technological training and diffusion

- 197 personnel (162 employees & 35 trainees)
- 16 Million € (income)
- 30 European Projects running

Marine Research Division
Food Research Division

AZTI-Tecnalia
Sukarrieta (Bizkaia)
Pasaia (Gipuzkoa)

2 Research Centres (5,000 m²)
3 Technical Offices in South-America
(Chile, Argentina and Ecuador)
The costs and environmental impacts attributed to the sale and consumption of any food product are associated to:

- Type of converted product,
- Its raw materials,
- Type and design of used packaging,
- Necessary manufacture to produce it,
- Distribution and commercialization,
- Consumer’s use,
- etc.

The total costs and the global impact are accumulated throughout the whole agri-food chain.

During the design or development of the product, a great part of those costs and environmental impacts are determined.

The objective is to identify and develop techniques, measures and strategies to minimize those necessities during the development and design of the food products. It will allow to reduce costs and impacts along the whole agri-food chain, but maintaining the alimentary quality and safety
Methodology

• PHASE 1: Selection of a food product as a model to develop and design. Definition of the product.


• PHASE 3: Scenario analysis. Identification of main causes and critical stages in the food chain.

• PHASE 4: Improvement objectives and measures development to increase the efficiency and to reduce losses in origin.

• PHASE 5: Definition of the new improved food product considering the previous measures. Evaluation of the improvement achieved.
PHASE 1: Selection and definition of the product

- **Product selected**: Tuna with tomato cooked dish pasteurized tray of 2 kg. (functional unit)
- **Reason of selection**: one of the highest complexity level in food sector (high number of raw materials; many stages of life cycle, etc.)
- **Product characteristics definition** to understand and respect its needs:

<table>
<thead>
<tr>
<th>Product function:</th>
<th>Food ready to be packaged and sold by portions.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target client:</td>
<td>Catering, retail store chains and distributors at national level</td>
</tr>
</tbody>
</table>
| Product formulation: | Base: tuna  
Sauce: crushed tomato, onion, green pepper, red pepper, sunflower oil, fried tomato, sugar, salt, sweet pepper, dust garlic, fish soup |
| Package:          | Rectangular tray of HDPE (high density polyethylene) of 70 g  
Top: film of OPA (oriented polyamide) and PE (polyethylene) with a weight of 10.2 g and a thickness of 30 µm |
| Preservation necessities: | Refrigeration at 4ºC  
Avoid perforations  
Preserve the vacuum maintenance |
| Shelf life:       | 90 days |
| Return level:     | Rejections: 0.47 %  
Expiries are insignificant |
| Product characteristic: | Needs cold for its preservation  
It has no presentation for final consumer  
Microwavable package |
| Consume preparation: | Transference to a ceramic recipient of high esthetic value  
Transference to a ration package for final consumer sale.  
Cover retire, transference of the food to a plate or recipient, heating at 35ºC and consume. |
| Post-use necessities: | Washing of metallic recipient and/or plate and cutlery  
Cover+tray waste management |
PHASE 2: Life cycle definition

- **Tomato farming**
  - Washing and packaging
- **Onion farming**
  - Washing and packaging
- **Peppers farming**
  - Washing and packaging
- **Oil (Sunflower) farming**
  - Manufacturing and packaging
- **Flavouring raw material extraction**
  - Manufacturing of plastic HDPE
  - Manufacturing of HDPE package
  - Manufacturing of cardboard
  - Manufacturing of packing
- **Petroleum extraction**
  - Wood extraction
- **Oil (Sunflower) farming**
  - Manufacturing and packaging
- **Flavouring raw material extraction**
  - Manufacturing of plastic HDPE
  - Manufacturing of HDPE package
  - Manufacturing of cardboard
  - Manufacturing of packing
- **Petroleum extraction**
  - Wood extraction

**Fishing and supply of tunids**
- **Electricity generation**
- **Collection, potabilization and supply of water**
- **Tuna fishing and sea transport**
  - Air transport
  - Tuna steaks manufacture
  - Transport to distributing plant

**Product elaboration**
- **Reception and storage of RM**
  - Sauce preparation
  - Mixing and packaging
  - Preservation process
  - Packaging and final storage

**Distribution and sale**
- **Repackaging and/or sale**
- **Distribution**
- **Consume of cooked dish**
  - Plastic recycling
  - Plastic elimination
  - Sewage treatment

**Use and elimination**
- **Plastic recycling**
- **Plastic elimination**
- **Sewage treatment**
PHASE 2: Ecobalance

- **Identification and quantification of inputs** (water, energy and materials consumption) and **outputs** (releases to the air, land and water) for every stage.

- Introduction of data in LCA software TEAM 4.0. **Local ecobalance** generation and **global ecobalance calculation**.

**Example: Mixing and packaging**

<table>
<thead>
<tr>
<th>Inputs:</th>
<th>Info</th>
<th>F</th>
<th>Flow</th>
<th>Units</th>
<th>Formula Value</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>(9)</td>
<td></td>
<td></td>
<td>_lomos desembalados</td>
<td>kg</td>
<td>1.05991</td>
<td>BOP*0.3825</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>_salsa</td>
<td>kg</td>
<td>0.94</td>
<td>0.94</td>
</tr>
<tr>
<td></td>
<td>i</td>
<td></td>
<td>Electricity</td>
<td>MJ elec</td>
<td>0.0216</td>
<td>0.006*3.6</td>
</tr>
<tr>
<td></td>
<td>i</td>
<td></td>
<td>Polyamide (PA 6)</td>
<td>kg</td>
<td>0.0051</td>
<td>PA</td>
</tr>
<tr>
<td></td>
<td>i</td>
<td></td>
<td>Polyethylene (HDPE)</td>
<td>kg</td>
<td>0.07</td>
<td>HDPE</td>
</tr>
<tr>
<td></td>
<td>i</td>
<td></td>
<td>Polyethylene (LDPE)</td>
<td>kg</td>
<td>0.0051</td>
<td>LDPE</td>
</tr>
<tr>
<td></td>
<td>i</td>
<td></td>
<td>Polypropylene (PP)</td>
<td>kg</td>
<td>0</td>
<td>PP</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Water Used (total)</td>
<td>litre</td>
<td>5.5</td>
<td>inflow(&quot;Water: Public I&quot;)</td>
</tr>
<tr>
<td></td>
<td>i</td>
<td></td>
<td>Water: Public Network</td>
<td>litre</td>
<td>5.5</td>
<td>5.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Outputs:</th>
<th>Info</th>
<th>F</th>
<th>Flow</th>
<th>Units</th>
<th>Formula Value</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>(4)</td>
<td></td>
<td></td>
<td>[w] Water (unspecified)</td>
<td>litre</td>
<td>5.5</td>
<td>inflow(&quot;Water: Public I&quot;)</td>
</tr>
<tr>
<td></td>
<td>X</td>
<td></td>
<td>_atún con tomate</td>
<td>kg</td>
<td>1.89153</td>
<td>inflow(&quot;_lomos deseml</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Waste (total)</td>
<td>kg</td>
<td>0.00153</td>
<td>outflow(&quot;Waste: Non l</td>
</tr>
<tr>
<td></td>
<td>i</td>
<td></td>
<td>Waste: Non Mineral (inert)</td>
<td>kg</td>
<td>0.00153</td>
<td>(PA+LDPE)*0.15</td>
</tr>
</tbody>
</table>
PHASE 2: Global ecobalance

☑️ 63 inputs
☑️ 261 outputs

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Oxygen</strong></td>
<td>g</td>
<td>10933.31</td>
<td>6674.90</td>
<td>1929.70</td>
<td>418.34</td>
<td>1910.43</td>
</tr>
<tr>
<td><strong>Minerals</strong></td>
<td>g</td>
<td>181.70</td>
<td>34.50</td>
<td>70.43</td>
<td>18.55</td>
<td>58.22</td>
</tr>
<tr>
<td><strong>Fossil fuels</strong></td>
<td>g</td>
<td>4332.83</td>
<td>3563.21</td>
<td>635.63</td>
<td>133.86</td>
<td>0.12</td>
</tr>
<tr>
<td><strong>Biomass</strong></td>
<td>g</td>
<td>2722.62</td>
<td>2613.71</td>
<td>108.52</td>
<td>0.39</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>Land use</strong></td>
<td>cm²</td>
<td>24.14</td>
<td>7.81</td>
<td>16.32</td>
<td>0.01</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>Water Used (total)</strong></td>
<td>litre</td>
<td>49.83</td>
<td>22.50</td>
<td>19.98</td>
<td>2.75</td>
<td>4.60</td>
</tr>
<tr>
<td><strong>Outputs:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Air emissions</strong></td>
<td>g</td>
<td>13738.40</td>
<td>11128.65</td>
<td>2117.34</td>
<td>492.08</td>
<td>0.39</td>
</tr>
<tr>
<td><strong>Land emissions</strong></td>
<td>g</td>
<td>0.07</td>
<td>0.01</td>
<td>0.02</td>
<td>0.00</td>
<td>0.04</td>
</tr>
<tr>
<td><strong>Water effluents</strong></td>
<td>g</td>
<td>317.67</td>
<td>297.59</td>
<td>17.46</td>
<td>2.61</td>
<td>0.02</td>
</tr>
<tr>
<td><strong>Sewage water</strong></td>
<td>litre</td>
<td>27.51</td>
<td>2.18</td>
<td>18.42</td>
<td>2.30</td>
<td>4.61</td>
</tr>
<tr>
<td><strong>Recovered Matter (total)</strong></td>
<td>g</td>
<td>20.33</td>
<td>3.97</td>
<td>5.88</td>
<td>0.12</td>
<td>10.36</td>
</tr>
<tr>
<td><strong>Waste (total)</strong></td>
<td>g</td>
<td>1887.17</td>
<td>1456.11</td>
<td>237.30</td>
<td>76.34</td>
<td>117.43</td>
</tr>
</tbody>
</table>
PHASE 2: Impact assessment

- **Impact categories** and **assessment methods** have been selected
- LCA software has generated the **quantification of each impact** for the total life cycle and main steps

<table>
<thead>
<tr>
<th>Environmental impacts</th>
<th>Method</th>
<th>LCA tuna with tomato</th>
<th>1. Fishing and supply of tunids</th>
<th>2. Product elaboration</th>
<th>3. Distribution and sale</th>
<th>4. Use and disposal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air acidification</td>
<td>geq.SO₂</td>
<td>CML2000</td>
<td>70.01</td>
<td>52.54</td>
<td>14.38</td>
<td>3.09</td>
</tr>
<tr>
<td>Aquatic toxicity</td>
<td>geq.1,4-DCB</td>
<td>CML2000</td>
<td>102.39</td>
<td>82.06</td>
<td>18.01</td>
<td>2.31</td>
</tr>
<tr>
<td>Depletion of the stratospheric ozone</td>
<td>geq.CFC-11</td>
<td>CML2000</td>
<td>0.0012</td>
<td>0.0008</td>
<td>0.0003</td>
<td>0.0001</td>
</tr>
<tr>
<td>Eutrophication</td>
<td>geq.PO43</td>
<td>CML2000</td>
<td>11.19</td>
<td>8.59</td>
<td>1.98</td>
<td>0.63</td>
</tr>
<tr>
<td>Greenhouse effect</td>
<td>geq CO₂</td>
<td>CML2000</td>
<td>13822.95</td>
<td>11126.15</td>
<td>2186.63</td>
<td>509.85</td>
</tr>
<tr>
<td>Human toxicity</td>
<td>geq 1,4-DCB</td>
<td>CML2000</td>
<td>1057.01</td>
<td>782.03</td>
<td>242.56</td>
<td>32.39</td>
</tr>
<tr>
<td>Terrestrial toxicity</td>
<td>geq 1,4-DCB</td>
<td>CML2000</td>
<td>29.71</td>
<td>23.28</td>
<td>5.23</td>
<td>1.19</td>
</tr>
<tr>
<td>Depletion of non renewable resources</td>
<td>yr-1</td>
<td>EB(R*Y)</td>
<td>0.25</td>
<td>0.20</td>
<td>0.30</td>
<td>0.00</td>
</tr>
</tbody>
</table>

CML: Centre of Environmental Science
EB: Ecobilan
PHASE 3: Scenario analysis

• Establish different hypothetical changes in the product under study to:
  ➢ Identify main causes of the global inputs, outputs and impacts
  ➢ Find stages in which those impacts are produced
  ➢ Focus the most important changes in the product to obtain the maximum environmental and cost improvement

• Hypothetical “what if” scenarios analysed:

<table>
<thead>
<tr>
<th>Hypothetical Scenario</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elimination of PP</td>
<td>No road transport for distribution</td>
</tr>
<tr>
<td>Total elimination of LDPE and double OPA</td>
<td>No rejections</td>
</tr>
<tr>
<td>Elimination of HDPE</td>
<td>No repacking water</td>
</tr>
<tr>
<td>Reduction of sea transport</td>
<td>No natural gas consumption in preservation</td>
</tr>
<tr>
<td>No air transport</td>
<td>No water and power consumption in manufacturing</td>
</tr>
</tbody>
</table>
PHASE 3: LCA conclusions

• Most critical aspects and steps:
  - Tuna fish air transport: ingredient with more weight and longer distances.
  - Power consumption: raw materials and final product storage, preservation process
  - Plastic package: HDPE
  - Final product road transport for distribution
PHASE 4: Identification of improvements

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>PRODUCT OPTIMIZATION MEASURE through an expert panel</th>
<th>IMPROVEMENT EXPECTED</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tuna from the Pacific transported by plane once steaked in origin</td>
<td>55% reduction of transport effort</td>
</tr>
<tr>
<td></td>
<td>Triple wave cardboard separator replaced by bee nest ones</td>
<td>18% reduction of cardboard</td>
</tr>
<tr>
<td></td>
<td>HDPE package replaced by a new one of PP</td>
<td>20% weight reduction</td>
</tr>
</tbody>
</table>

TRAY FORM OPTIMIZATION:

- Transport effort saving (smaller empty space 10%)
- Film saving 7%
- Storage and cold preservation effort saving
## PHASE 5: Obtained results

<table>
<thead>
<tr>
<th></th>
<th>ORIGINAL product</th>
<th>ECODESIGNED product</th>
<th>% Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inputs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oxygen</td>
<td>10933.31 g</td>
<td>8493.91 g</td>
<td>22.31%</td>
</tr>
<tr>
<td>Minerals</td>
<td>181.70 g</td>
<td>182.68 g</td>
<td>-0.54%</td>
</tr>
<tr>
<td>Fossil fuels</td>
<td>4332.83 g</td>
<td>3134.87 g</td>
<td>27.65%</td>
</tr>
<tr>
<td>Biomass</td>
<td>2722.62 g</td>
<td>2342.55 g</td>
<td>13.96%</td>
</tr>
<tr>
<td>Land use</td>
<td>24.14 cm²</td>
<td>24.58 cm²</td>
<td>-1.82%</td>
</tr>
<tr>
<td>Water Used</td>
<td>49.83 litre</td>
<td>48.90 litre</td>
<td>1.88%</td>
</tr>
<tr>
<td><strong>Outputs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air emissions</td>
<td>13738.40 g</td>
<td>9996.38 g</td>
<td>27.24%</td>
</tr>
<tr>
<td>Land emissions</td>
<td>0.07 g</td>
<td>0.07 g</td>
<td>-0.74%</td>
</tr>
<tr>
<td>Water effluents</td>
<td>317.67 g</td>
<td>309.20 g</td>
<td>2.67%</td>
</tr>
<tr>
<td>Sewage water</td>
<td>27.51 litre</td>
<td>26.37 litre</td>
<td>4.14%</td>
</tr>
<tr>
<td>Recovered matter</td>
<td>20.33 g</td>
<td>18.06 g</td>
<td>11.17%</td>
</tr>
<tr>
<td>Waste</td>
<td>1887.17 g</td>
<td>1615.85 g</td>
<td>14.38%</td>
</tr>
</tbody>
</table>
### PHASE 5: Obtained results

<table>
<thead>
<tr>
<th>Impacts</th>
<th>ORIGINAL product</th>
<th>ECODESIGNED product</th>
<th>% Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Air Acidification</strong></td>
<td>geq.SO₂</td>
<td>70.01</td>
<td>58.09</td>
</tr>
<tr>
<td><strong>Aquatic Toxicity</strong></td>
<td>geq.1,4-DCB</td>
<td>102.39</td>
<td>103.42</td>
</tr>
<tr>
<td><strong>Depletion of the stratospheric ozone</strong></td>
<td>geq.CFC-11</td>
<td>0.01</td>
<td>0.001</td>
</tr>
<tr>
<td><strong>Eutrophication</strong></td>
<td>geq.PO₄3</td>
<td>11.19</td>
<td>9.41</td>
</tr>
<tr>
<td><strong>Greenhouse effect</strong></td>
<td>geq CO₂</td>
<td>13822.95</td>
<td>10104.68</td>
</tr>
<tr>
<td><strong>Human Toxicity</strong></td>
<td>geq.1,4-DCB</td>
<td>1057.01</td>
<td>1047.52</td>
</tr>
<tr>
<td><strong>Terrestrial Toxicity</strong></td>
<td>geq.1,4-DCB</td>
<td>29.71</td>
<td>29.78</td>
</tr>
<tr>
<td><strong>Depletion of non renewable resources</strong></td>
<td>yr-1</td>
<td>0.25</td>
<td>0.19</td>
</tr>
</tbody>
</table>
Conclusions

- There are a wide range of improvable aspects in food products although a priori have a low degree of freedom.
- That makes necessary to focus the effort in the aspects of greater impacts in the LCA.
- The modifications raised in the product generate potential satisfactory reductions, that could be greater designing a completely new product.
- LCA is an effective tool although requires an arduous data collection and a complex analysis.
- Currently it exists difficulties to overcome in the ecodesign of agri-food products
  - Criteria of different managers of the agri-food chain
  - Lack of environmental awareness (economic costs)
- It is necessary to publicise the economic, environmental and image benefits of the eco-design to promote the understanding between the different agents of the agri-food chain.
Thanks very much for your attention