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CARBON FOOTPRINT OF BRETON PÂTÉ PRODUCTION: A CASE STUDY

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ABSTRACT

This study targeted nine different pork pâtés, produced with pork from different meat production systems (conventional, organic and other quality certifications). Besides Greenhouse Gas (GHG) emissions, the study also included a detailed analysis of product nutrition. Results show that the GHG emissions range from 200 g CO_2e per 100g of product conventional pork pâtés and 330 g CO_2e per 100g for organic pork pâtés. Results for organic pâtés are an indirect consequence of the lower productivity of swine feed ingredients. However, if the reference flow unit is nutritional indicator (e.g. calories, protein, etc.) instead of 100 g of product, results can be inverted. This fact highlights the difficulty of choosing a functional unit for studies on food products. The function of a food product is to provide quality nutrition, but since there are many different nutritional indicators life cycle assessment practitioners normally use simple comparisons between amounts. This issue, together with the choice of emissions allocation method between pork parts, are the main sources of uncertainty. Also, the life cycle of pork production is the main hotspot in the carbon footprint, accounting for more than 80% of the total emissions. Energy spent for processing and packaging, the only life cycle step that the producer controls directly, accounts for less than 10% of the impact.

KEYWORDS: Life Cycle Assessment, Product Carbon Footprint, Nutrition, Pâté, Pork.

INTRODUCTION

Product environmental footprint, and particularly product carbon footprint (PCF), is now driving sustainable business strategy. PCF is particularly important for food and agriculture companies since food products have high impacts throughout their lifecycle (Roy et al. 2009), particularly during the agricultural stage (Vermeulen et al. 2012). As the true impact of these products is increasingly disclosed, sustainability-oriented consumers are empowered to make informed choices (Schrader and Thøgersen 2011). Ensuring sustainability is as important today as ensuring nutritional quality of the product. This is a new reality to which companies must adapt.

Jean Hénaff (http://www.Hénaff.com/) is a centenary company from southern Finistère, Brittany (western coast of France). The company is specialized in pork food products, most importantly pâté. Hénaff is experienced with sustainability metrics, having concluded in 2008 a Bilan Carbone – an inventory of Greenhouse Gas (GHG) emissions generated by all of the company's activities (ADEME 2006). Following this initial company-level inventory, Hénaff wished to focus on their flagship line of pâtés using product-level assessments. A project in partnership with Bluehorse Associates and Ecole Centrale Paris was thus initiated in 2011 to assess the carbon footprint of its line of country-style pâté products. An objective from the onset was the integration of the nutritional profile of the products into the analysis and recommendations.

METHODS

Goals of the Study

Besides the carbon footprint assessment of the products considered, the goals of this study were:

- To identify the main sources of emissions for each product in its range of country-style pâtés, throughout their life cycle (hotspot assessment or screening);
- To compare country-style pâtés against each other (impact of meat type, recipe, packaging, etc.) taking nutritional quality into consideration (studying the impact of different functional units);
- To identify potential avenues for carbon footprint reduction.

Products Analysed

First, the number and type of products to analyse was determined. Considering the objectives Hénaff posed for this study, the study targeted nine pork-based products, with net weights of between 78 and 200 g, distinguished by recipe, type of pork meat (conventional, organic and other quality certifications), and type of packaging.

Four meat types, distinguished by the agricultural circuit from which they are obtained, were considered:

- Conventional agriculture: use of synthetic fertilizers and pesticides for the production of feeds is allowed, as is the use of standard antibiotics for pigs;

- Organic farming: no synthetic fertilizers or pesticides, strict restriction of the use of conventional veterinary medicine;
- Label Rouge: production certified by the French Ministry of Agriculture that can be verified to be of superior quality using sensorial analyses done with consumers; consumers test the product for organoleptic characteristics, as well as colour, tenderness and other factors (http://www.labelrouge.fr/);
- Bleu-Blanc-Cœur: pigs are fed a finishing phase feed with traditional and high-Omega 3 plant sources (grass, linseed, alfalfa, lupin, etc.) (http://www.bleu-blanc-coeur.com/).

We considered also the following 3 packaging types:

- Tin can;
- Aluminium can;
- Glass jar with tin plate lid.

Scope and Functional Unit

Considering the objectives of the study, we chose a Life Cycle Assessment (LCA) methodology based on the BPX30-323 standard (AFNOR-ADEME 2009), the reference frame for the experimentation on the environmental display of consumer products conducted in France from mid-2011 to the end of 2012. We use this standard as a reference since Hénaff is based in France and subjected to country-specific mandates. The system boundaries are shown in Figure 1. The scope of the study included complete product life-cycle, from the production of raw materials in the agricultural phase (including the production of animal feed), all the raw material and finished product transport phases, the pâté production processes, consumption and end of life. The Functional Unit (FU) studied was a 78 g-equivalent pâté product eaten, with refrigeration for 24 hrs in the consumer's home included for products in excess of 180 g. Results are normalized and shown for 100 g of product.

Software and Life Cycle Inventory

The study was conducted by Bluehorse Associates in collaboration with Ecole Centrale Paris. Primary data for the pâté recipe used, packaging composition, processing energy consumption and transport was primarily obtained from the Bilan Carbone report or, where it was missing, collected by Jean Hénaff and its suppliers.

For GHG emission data, the Carbonostics (2012) online food LCA application was used. Carbonostics is a lifecycle assessment tool designed to pinpoint the hotspots of food products or menus along three criteria: cost, carbon and nutrition. Carbonostics' built-in database includes GHG emission factors to assess all the life cycle stages in Figure 1, as well as nutritional information on ingredients. So, this tool enabled the integration of GHG and six nutritional indicators in the analysis, namely calories, protein, lipids, carbohydrates, sodium and sugar. Results obtained in Carbonostics for the nutritional indicators were validated using internal laboratorial measurements.

Local data was also collected for the life cycle stages with higher influence in final results, namely the agricultural production phase. Basset-Mens and van der Werf (2005) provide GHG emissions factors at the farm outlet for pigs reared in Brittany in three agricultural circuits: conventional (2.30 kg CO_2e/kg live pig), Label Rouge (3.46 kg CO_2e/kg live pig) and organic (3.97 kg CO_2e/kg live pig). We then used a local study by Chevillon et al. (2011) to allocate GHG emissions for rearing pigs amongst the different parts of the carcass (liver, throat, breast, skin, etc.). We used mass allocation, in line with the BPX 30-323 guidelines.

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We used a simplified LCA approach as defined by Weitz et al. (1996) and Graedel (1998), which consider as possible simplifications (1) reducing the number of environmental criteria included (we considered only Global Warming Potential, GWP100 measured for a 100-years horizon, as defined in Pandey et al. 2011); and (2) feeding the study with results from other previous LCA studies (each data record in the Carbonostics database is a LCIA result from other studies). In agreement between all parties, it was decided that this approach was appropriate for the objectives of the study.

Amongst the assumptions made, the following should be noted:

- Table 1 shows the main emission records used for the processes in Figure 1.
- The emission factors for Bleu-Blanc-Cœur (BBC) pork are the same as those for conventional meat. Indeed, the specific feeding phase is of relatively short duration (2 months) and the proportion of high-Omega 3 plants in the food ration is low, circa 2%.
- Emissions ascribed to secondary and tertiary packaging are negligible when compared to those of the product. They were thus not included in the study.

Finally, a sensitivity analysis (study of the impact of modelling different input variables on end result variation) was conducted and the main results are presented in the following section. As part of the sensitivity analysis we also changed the procedure for allocating emissions to pork parts from mass to economic.

RESULTS

GHG Emissions for Each Pâté Line

The carbon footprint of pâté products is between 205 g and 333 g CO_2e for 100 g (Figure 2). These results are lower than the only international benchmark present in the Carbonostics database – a data record by the Center for Agriculture and Environment

(CLM) in the Netherlands for average pâtés in Europe (proprietary data, can be accessed from https://discover.amee.com/categories/CLM_food_lifecycle_emissions).

Moreover, the organic country-style pâté has the highest carbon footprint, while Label Rouge and conventional/Bleu-Blanc-Cœur pâtés have a comparable footprint. This result is explained not only because organic pork production in Brittany has higher emissions (Basset-Mens and van der Werf 2005), but also because the proportions of the different pork cuts in the recipe vary.

An analysis of results per life-cycle phase for GHG shows that raw materials are responsible for over 80% of the total impact. Pork is the main hotspot amongst raw materials. The contribution of packaging to emissions reveals that glass has the greatest impact, followed by tin plate and aluminium. Although packaging emissions are not comparable to pork emissions, the difference between packaging materials is sufficient to differentiate between pâtés. Energy spent for processing, the only life cycle step that Hénaff controls directly, lags far behind with only 10% of the total impact. The transport-related impact appears negligible. These percentages are consistent with the Bilan Carbone findings for the bundle of Hénaff products.

Combined Analysis of GHG Emissions and Nutrition

Each 100 g portion of Label Rouge pâtés contains approximately 354 Kcal and 14 g of protein; the organic pâté contains 377 Kcal and 11.5 g of protein in a similar portion; as for conventional and BBC pâtés, the results range between 420-462 Kcal and 9-10 g protein. So, Label Rouge pâtés cause higher emissions than conventional pâtés, despite providing less calories and more protein. The organic pâté falls between the two on the calories scale and has a carbon footprint similar to Label Rouge. These nutritional variations are mainly explained by recipe variations. One way to understand the consequences of this is to see the emissions vs. nutrition plot in Figure 3. The organic pâté is an outlier, but conventional pâtés and Label Rouge pâtés are (separately) tightly clustered; however they are on opposite sides (lower/higher) depending on whether the analysis focuses on calories or protein. This means that if we chose a different FU (nutritional units instead of mass units), results would change, and favour Label Rouge. Results in Figure 4 show that if the FU was the energy contents (measured in Kcal) the relative order of pâtés would be similar to Figure 1; but if the FU was the protein content, then one conventional pâté would have the highest emissions and all of them would have higher emissions than Label Rouge pâtés. The same can be said of the other four nutritional indicators: depending on which one is used as the FU, so results vary.

Sensitivity Analysis

The following simulations were performed in the context of the sensitivity analysis. We list next the analysis made and the changes in results (not presented in this article).

- Economic allocation of emissions for pork parts (instead of mass) - the magnitude of emissions for two Label Rouge pâtés increases significantly, and emissions become similar to those of the organic pâté (Figure 5). This is because the recipe of each pâté is different; those incorporating more noble parts are now assigned a higher share of pork production impacts. The gap between organic and conventional pâtés also widens. However, the hotspots in the production chain are the same.
- Economic allocation of energy consumption at the pâté production site – Hénaff measured the energy consumption of all machinery involved in the production of the pâté and then physically allocated the energy step by step to each unit produced. As an alternative, quicker route, we allocated the total energy bill to each pâté produced using economic allocation, ie, attributing a fraction of total energy consumed at the production

site to each unit of product according to its contribution to total turnover. Overall, there was no signifficant difference in results (less than 1%).

- Using foreign emission factors for pork parts – we used other emission factors from the Carbonostics database, which correspond to records in international databases for different pork parts. For example, we used an emission factor from the LCA Food Denmark database (Nielsen et al. 2003) for pork neck, and a CLM (2010) database record for tenderloin. The final carbon footprint of all pâtés increased. However, the relative results did not change.
- Considering freezing of certain meat parts instead of refrigeration, and considering the impacts from the slaughtering process, not included at first due to low quality data: there was no significant impact in total emissions and no change in relative results.

DISCUSSION

This study pinpointed hotspots in the production chain of Hénaff pâtés where future efforts can be focused. Hénaff learned that the ingredients, and mainly pork, are the leading GHG source of emissions. The recipe, and more specifically the proportions of the various pork cuts used, have a significant influence on carbon footprint and of course on the nutritional profile. These choices are made primarily according to the desired organoleptic profile of the end product: its taste, texture, etc.

Equally important to Hénaff is to know where not to focus efforts. Transport, cold storage of ingredients and slaughterhouse processes did not have a significant impact for any of the 9 varieties of country-style pâté products studied. They thus do not appear to constitute an interesting avenue for achieving a rapid and significant reduction of the carbon footprint of country-style pâtés. This study thus raised questions concerning certain preconceived notions of the relative importance of the various sources of emissions (e.g., "food-miles").

To effectively reduce the carbon footprint of its products, while maintaining or improving their nutritional properties, Jean Hénaff must therefore consider optimizing its choices in terms of recipe, type of meat and packaging, while pursuing its nutritional commitments. Hénaff now has a platform in this study that allows the company to start combining these different angles. Naturally, since this study was a first step using only one environmental indicator, namely carbon emissions, other indicators can be used in the future to draw additional conclusions.

Hénaff also discovered that their pâtés denote lower emissions than the only available international benchmark. This is probably due to the fact that the GHG emissions for pork production in Basset-Mens and van der Werf (2005) were lower than the equivalent emission factors for other countries in the literature. Wiedemann et al. (2010) convert the results from seven studies on pork to the same FU and Basset-Mens and van der Werf's study (2005) is the lowest estimate. Also de Vries and de Boer (2010) present results from five studies with different FUs. We converted these results to comparable FUs in Table 2. Again, Basset-Mens and van der Werf's results (2005) are the lowest except for a study in Sweden. We cannot rule out Basset-Mens and van der Werf (2005) as an outlier, since it is geographically specific and Wiedemann et al. (2010) show that emissions are distributed differently throughout the lifecycle in the studies assessed, indicating a structural difference in production.

If further studies validate that pork pâté produced in Brittany indeed causes less emissions, this information can be used as an export marketing strategy. For example, Hénaff is the only French meat manufacturer to be USDA-certified in the United States and so can use sustainability-related communications in that market. Although Hénaff did not participate in the labelling project led by ADEME-AFNOR (2013) in France, communicating on this specific effort may be an even more effective way to reach sustainability-guided consumers than labelling, as suggested recently by Upham et al. (2011). Whether this communication strategy would work or not in the specific case of Hénaff's customers is beyond the scope of this work.

Significant differences in results were noted depending on the FUs. We discovered that if the reference flow is the nutritional content (e.g. unit of calories, protein, etc.) instead of mass, results can be inverted. This fact highlights the difficulty of choosing a FU for studies on food products (Peacock et al. 2011; Roy et al. 2009). The function of a food product is to provide quality nutrition; but since there are many different nutritional indicators, LCA practitioners normally resort to simple comparisons between mass amounts that bias results. Consequently, the issue of a universally accepted and comprehensive FU for food is not yet resolved. Some authors like Christiansen et al. (2006) suggest using monetary value as a universal FU. Others use one meal/portion or the fraction of daily dietary requirements provided by the product as the FU (Saarinen et al. 2012). Schau and Fet (2008) suggest a quality-corrected FU that calculates LCIA results as a linear function of mass, fat, protein and carbohydrate content, each weighed with specific parameters.

Pork meat was particularly challenging as a case study also because the choice of allocation method for pork parts has a dramatic effect on absolute results. Pâtés use parts such as pork neck and fat, which share the majority of the pork production impacts. Although not enough to alter conclusions (relative scale between conventional/organic or Label Rouge pâtés and supply chain hotspots remain the same), results changed significantly (more than 10%) when we switched from mass to economic allocation. Some international standards like PAS2050 (BSI 2010) in the UK prefer economic allocation, while others like BPX30-323 (AFNOR-ADEME 2009) and the GHG Protocol (WRI/WBCSD 2011) prefer mass allocation. The choice for mass allocation in this work was due to the standard applicable in the country where the company is based, but other companies following other standards could obtain different results. In attributional LCA studies this discrepancy is a strong limitation to inter-study comparability.

CONCLUSION

This study raised interesting methodological points that should be addressed by the LCA community in the future in its efforts to standardize the methodology and promote inter-study comparability. Just to name a few, conclusions change substantially depending on the FU chosen, and the magnitude of results depends on the impact allocation procedure – but international standards do not stipulate yet which FU and impact allocation method are preferable. Moreover, pork production seems to display a high rate of variability depending on the region/country of production- whether this is a study-dependent effect or translates the underlying reality of the local production structure is still undetermined. Finally, for food products, environmental aspects should never be covered separately from nutrition. A combined analysis of carbon-related and nutritional aspects provides more extensive and reliable information – but the best method to do so is still unclear, as nutritional information may be used as part of the FU or in parallel.

The present study is also an example of how LCA/PCF can be applied to provide useful information to companies. A life-cycle approach can identify the main sources of emissions and eliminate preconceived ideas concerning the relative significance of transport, packaging or production methods. In the case of Hénaff, knowledge of the carbon footprint of its country-style pâtés, along with the main sources of emissions, can leverage the optimization of its manufacturing processes and inform its sustainability agenda. Hénaff can also use the attributes discovered in the study, like the fact that the emissions per 100g of pâté are lower than international benchmarks, for marketing purposes, in particular for foreign sales of its top-of-the-line products. This is independent of the labelling projects currently active in Europe.

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Table 1 – Main data sets and sources used for processes involved in the life cycle of pâtés represented in Figure 1.

Input/process	Data used	Source
Pork parts	Data for pork production	Basset-Mens and van der Werf (2005)
	Allocation between parts	Chevillon et al. (2011)
Salt	Salt, Powder, Average, Europe	ecoinvent 2012
Egg	Egg whites, Conventional, Netherlands	CLM 2012
Aroma	Aroma, Powder, Europe	ecoinvent 2012
Glass Tin plate Tin can Aluminium	Calculated using data from	ADEME 2010
	Using method for recycled content by	AFNOR-ADEME 2009
Electricity	Electricity, Average Mix, France	ecoinvent 2012
Transportation	Road, Freight, 3.5-7.5t, EURO3, Europe	ecoinvent 2012

Table 2 – Results of Life Cycle Assessment studies for pork, adapted from de Vries and de Boer (2010).

Study	Location	Emissions (kg CO2e)	Original functional unit	Conversion factor* (Original unit/kg dead weight)	Emissions (kg CO2e/kg dead weight)
Zhu-XueQin and Van Ierland (2004)	Netherlands	77.88	kg protein	1/3	**11.80
Basset-Mens and Van der Werf (2005)	France	2.3	kg live weight	75/55	3.14
Basset-Mens and Van der Werf (2005)	France	3.5	kg live weight	75/55	4.77
Williams et al. (2006)	UK	6.08	kg dead weight	1	6.08
Williams et al. (2006)	UK	6.42	kg dead weight	1	6.42
Williams et al. (2006)	UK	6.33	kg dead weight	1	6.33
Williams et al. (2006)	UK	6.36	kg dead weight	1	6.36
Cederberg and Darelius (2002)	Sweden	4.8	kg bone-fat-free meat	25/55	2.62
Blonk et al. (1997)	Netherlands	3.7	kg live weight	75/55	5.05

* Approximate estimated conversion factors used for illustration purposes only.
** Considers that the factor applies to the bone-fat-free equivalent.

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Figure 1 – System boundaries and main unit processes of the life cycle studied.

Figure 2. Results per life-cycle phase. Pork production impacts allocated by mass. Raw material production is the hotspot (bar on the bottom). Second highest bar is for processing. LR – Label Rouge; Org – Organic; BBC - Bleu-Blanc-Cœur; Conv - Conventional pâté.

Figure 3 - Results for carbon emissions vs. calories and protein. Pork production impacts allocated by mass. 1-3: Label Rouge pâtés; 4: Organic pâté; 5-9: Conventional/Bleu-Blanc- Cœur pâtés.

Figure 4 - Results for nutritional functional units. LR – Label Rouge; Org – Organic; BBC - Bleu-Blanc-Cœur; Conv - Conventional pâté.

Figure 5 - Results per life-cycle phase. Pork production impacts allocated by economic value. Raw material production is the hotspot (bar on the bottom). Second highest bar is for processing. LR – Label Rouge; Org – Organic; BBC - Bleu-Blanc-Cœur; Conv - Conventional pâté.