INDicatori Ambientali e CO_2

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LIFE CYCLE ASSESSMENT AND CARBON FOOTPRINT ANALYSIS OF HAY MILK PRODUCTION

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Abstract/
This report presents the results obtained from the Life Cycle Assessment (LCA) developed by INDACO2 in 2018, using the case study of an Austrian farm that produces milk from cows fed primarily on hay.

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INTRODUCTION

Indaco2's collaboration with the Slow Food Foundation for Biodiversity began in 2013 with the aim of enriching the "Narrative Label" project for the Slow Food Presidia by introducing the environmental characterization of food production chains.
In particular, the LCA (Life Cycle Assessment) methodology and the calculation of indicators make it possible to trace the environmental profile of agrifood products based on specific measurements. In other words, using quantitative information to support the narrative around the sustainability of the food production processes.

The results that emerged from the application of the LCA methodology to the Presidia products were striking. The indicators calculated, such as carbon footprint (the total emissions of greenhouse gases into the atmosphere generated by a product's life cycle) showed that Presidia products, as well as bringing added value to their areas of origin, clearly have a much greater level of compatibility with environmental resources compared to conventional, intensively produced foods. In practice, the consumption of reared or cultivated Presidia products—like meat, cheese, fruit and oil—is preferable not only because of their quality and taste but also because they avoid a level of environmental impact that leaves no doubt about the sustainability of their production.

"Our collaboration with Slow Food continues to be a rich opportunity for growth and we hope to have brought about another significant witness with our work: a demonstration that contributes to consolidating the importance of more informed food choices and the value of biodiversity and the resources of our territories."*

* Extract from Indaco2's statement published in the 2014 Social Report of the Slow Food Foundation for Biodiversity.

METHODOLOGY, STANDARDS AND REGULATORY REFERENCES

This report offers an overview of the results of the Life Cycle Assessment (LCA) of products from a selection of Slow Food Presidia. The analysis was prepared in conformity with the ISO/TS 14040-14044:2006 norms relating to *"Environmental Management: Life Cycle Assessment."*

The aforementioned technical specifications identify the general principles, requirements and guidelines that should be followed for the measurement and communication of the results of a product's LCA, in other words the potential environmental impacts generated by the various phases of its life cycle, with reference to specific impact categories.

The process involved a careful inventory analysis of all the processes of the product's life cycle, in other words the entire production chain from the management of cultivated fields to harvesting, storage and processing up to the packaging of the final product. In the case of livestock farming, the analysis considered the processes of animal management, feed, structures and product processing.

The impact category that was examined was the *Carbon Footprint* (CFP)*/Global Warming Potential* (GWP100), the estimate of emissions of greenhouse gases—such as CO2 (carbon dioxide), CH4 (methane) and N2O (nitrous oxide)—expressed in kilos of CO2 eq (carbon dioxide equivalent).

The study was carried out using the ecoinvent 3 database to support the inventory analysis. The model was developed with the aid of the SimaPro 8.0.3 LCA software, selecting the single issue GHG protocol, updated to the IPCC 2013 characterization factors. Because the current databases (e.g. ecoinvent) do not compute the direct emissions linked to the use of fossil fuels and the application of pesticides/fertilizers in the field, ad-hoc models were developed for the selected case study (IPCC, 2006 guidelines for fuels, EMEP/EEA et al., 2009 for the direct emissions in the air from pesticides and Audsley et al., 2003 and Berthoud et al., 2011 for emissions in the soil and surface water). The data obtained were compared with similar foods produced conventionally (using the average for European production) drawing on data from the international literature.

The present LCA report includes the results of analysis of the impacts associated with the life cycle of the products and a summary of the main conclusions taken from the interpretation of the results.

AUSTRIAN HAY MILK PRODUCTION: THE UNTERWEGER FAMILY'S MOUNTAIN LIFE

[Location] Kathrin and Martin Unterweger farm dairy cattle in the hamlet of Tscheltsch, near Liesing, in Lesachtal, Carinthia, Austria, at 1,350 meters above sea level. The farm is family run, and in addition to the farm buildings it also includes 17 hectares of forest and 7 hectares of pasture (2 hectares of which are rented).

[Farming system] The family's cattle farming was certified organic in 1992. The farm has seven dairy cattle, who graze year-round in the farm's own pastures. They are kept indoors only at night. The animals' diet is based almost entirely on hay (around 22 kilos a day provided throughout the whole year) and supplemented by a feed mix (1 kilo a day provided throughout the whole year, for a total of 400 kilos per animal, composed of 20% chopped grass, 20% wheat, 20% rye, 15% barley, 15% corn, 5% bran and the remaining percentage molasses and mineral salts) bought in Klagenfurt (around 135 kilometers away). The hay is produced on the farm from the grass that grows naturally in the pastures (not sown). It is cut twice a year (in June and August), left to dry in the fields for about two days, then collected and brought to the hayloft, where it dries from a moisture level of 40% to around 10%, assisted by an automated electric dryer with a humidity sensor. The hayloft, in the upper part of the barn, is directly connected to the cowshed underneath, where the animals are fed. The manure produced is collected in an aerobic tank in the lower level, where it is left to mature before being spread on the pastures for fertilization in the autumn, and to a lesser extent in the spring. The cows start to produce milk in their third year of life. The cows are milked using an electric milking machine with three positions, directly connected to the processing room, where the milk is collected in a steel tank. Each cow produces milk for 10 months a year, with an average of 5,000 liters milked each year per animal. The majority of the milk (around 75%) is produced during the winter period, and the rest between June and August. The calves are kept in the shed and consume only their mother's milk for four months (around 1,500 liters in total), after which they are sold. The cows produce milk on average until the age of 12, but in many cases even up to 17 years.

After being heated, a small share of the daily milk is used for the farmers' own consumption and breakfasts for their B&B, while the majority is immediately processed for the production of cheese, ricotta, butter or yogurt. Each batch is used for a single product (either cheese, ricotta, butter or yogurt). The processing room is washed with water at different temperatures. The water comes from the farm's own stream, while half of the electricity needed comes from the farm's own solar panels. The remaining half comes from the mains, and is produced by local hydroelectric plants.

[Functional unit and system boundaries] The Life Cycle Assessment includes the entire milk production chain, from the production of feed, livestock management and milking up to the milk ready to be used in various products. The study does not include the packaging of the milk, transport to sales outlets and farm and home storage, because the product is not usually sold. The processing into cheese/ricotta/butter/yogurt is not included in the calculations. The process was divided into three phases: Phase 1: production of feed (i.e. fuel, manure and electricity for the hay; purchased feed; transport); Phase 2: livestock management (i.e. animals' biogenic emissions, few electricity for illumination of the cowshed); Phase 3: milking and milk processing (i.e. electricity for the milking machine and boiling).

The analysis considered the biogenic emissions generated by enteric fermentation and by the management of the animals' manure, using models developed ad hoc for the case study, taking into consideration the unusual nature of the animals' diet, the type of farm and the geographic location. The carbon footprint calculated through the LCA refers to 1 liter of milk, ready for use (the Functional Unit, or FU).

Because the system is multifunctional, it was necessary to carry out the allocation of inputs and outputs. The process of allocation between milk and calf followed a physical standard, in other words the impacts were attributed based on the actual quantities of milk milked and milk destined for calves (77% and 23% respectively), out of the total milk produced by a cow in one year.*

*Note: An alternative allocation procedure is recommended in the PCR (Product Category Rules) for the EPD (Environmental Product Declaration, ISO14025), which suggests allocating inputs and outputs with a formula that uses constant standards relating to calf mass and FPCM (Fat- and Protein-Corrected Milk) mass. The PCRs introduce formulas calculated on the basis of industrial models that allow assumptions and processing in the absence of specific data. This alternative option would therefore be reductive and approximate, given that the data gathered is sufficiently comprehensive and specific for the case study.

Nonetheless, a model was developed that conforms to the standard suggested by the PCRs, as a comparison. The process led to a division of 83% and 17% between milk produced and milk for calves respectively.

[Carbon footprint] The overall carbon footprint for producing 1 liter of hay milk is 1.07 kg CO2 eq (comparable to the emissions generated by a car driving for over 3 kilometers). Looking at the results in detail, it can be seen that the emissions associated with the farm's activities (e.g. consumption of fuel for harvesting the hay and spreading manure, electricity for drying the hay, purchased feed), equal to 0.13 kg CO2 eq, represent 13% of the total. The remaining 87% of the impact comes from enteric fermentation and manure management (biogenic emissions). Analyzing the results by phase, we can see that feed production counts for 21% (10% from the fuel consumed to spread the manure and harvest the hay, <0.1% from the electricity used for drying the hay, 8% from biogenic emissions from the manure spread on the pastures, 2.7% from purchased feed), while livestock management counts for 79% (55% enteric fermentation, 24% indoor and outdoor manure management). Milking and milk processing account for less than 0.1%.

Alternatively, if we were to apply the allocation criterion suggested by the PCRs (see note above), the carbon footprint for 1 liter of hay milk would be 1.15 kg CO2 eq.

[Traditional vs. industrial production] The carbon footprint of 1 liter of hay milk (1.07 kg CO2 eq) is around 31% less than milk obtained from conventional/industrial farms (1.54 kg CO2 eq). The production of 1 liter of hay milk avoids emissions equal to around 0.5 kg CO2 eq (i.e. the emissions generated by a car driving for around 1.5 kilometers).

The production of milk from cows farmed conventionally produces greater impacts, primarily from the production of industrial feed (e.g. fat- and protein-rich silage, cultivated using synthetic fertilizers and other chemical products) and livestock management (e.g. energy for cattlesheds and manure management).

[Carbon footprint offsetting] If we look at the theoretical compensation of greenhouse gases emitted, considering their absorption by the plant ecosystems (forests and pastures) on the farm (239 t CO2/year), the results show that total emissions (48 t CO2 eq) are completely compensated for by this carbon uptake. The absorption surplus (190 t CO2 eq) would mean another 27 animals could be farmed before reaching parity (absorption equaling emissions). In practice, the "biocapacity" of the farm in terms of greenhouse gas emissions (in other words, the number of animals that the farm could theoretically keep while avoiding the emission of more greenhouse gases than would be absorbed by the farm's plant ecosystems) is 34 animals.

[Hotspots and best practices] The critical points (hotspots) of the production chain are the following:

- enteric fermentation: the hay-based diet affects biogenic emissions, which also increase due to supplementation with purchased feed.
- manure management: the fact that the cows graze in pastures means higher emissions.
- consumption of fuel for cutting and harvesting the hay: the location of the pastures, on steeply sloping land, makes the hay cutting and harvesting difficult, and results in higher fuel consumption.

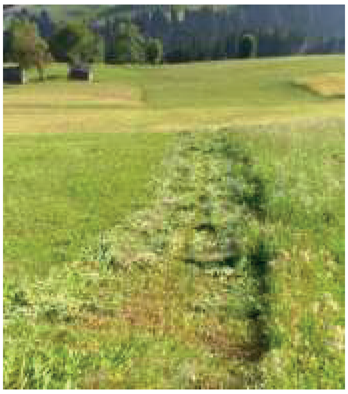
The farm's good practices deserve to be highlighted, and include the following:

- the presence of natural pastures makes it possible to avoid emissions from sowing seeds, as well as giving the hay unique sensory properties due to the different plants growing naturally in the fields.
- the farm's own production of the majority of the feed and the pasture grazing means silage and industrial feed are avoided.
- the fertilization of the farm with manure rather than chemical fertilizers reduces emissions, as well as naturally increasing the organic matter in the soil and maintaining the biodiversity of the ecosystems.
- the electricity comes entirely from renewable sources (i.e. solar and hydroelectric), with half being produced by the farm itself.
- the milk is used/processed immediately, without lengthy storage, and the product is distributed through a short supply chain.

[Inventory data extract] This table shows a selection of inventory data that characterize the livestock farming and hay milk production and represent crucial factors for determining the product's carbon footprint.

INPUT	QUANTITY	UNIT	NOTES
farm area	24	ha	hay production, grazing (7 ha) and forest-land (17 ha)
cows per year	7	n	cows for milk production
milk per head per year	5000	L/yr	1500 L/cow per yr dedicated to veal
milk per year	35000	L/yr	mainly processed to produce cheese, ricotta and butter
chemicals in field	/	kg/yr	no chemical used
fertilizers in field	/	kg/yr	no chemical used
gasoline	1290	kg/yr	for hay production
electricity	44000	kW/yr	20% of which used for hay drying, 6% for milking and milk processing; from renewable sources
water	/	m3/yr	from farm river
hay	22	kg/head/day	all year
feed mix	400	kg/head/yr	all year

[Farm visit] Series of photographs taken during the visit to the Unterweger farm to collect the inventory data and other information useful for understanding the philosophy, history and characteristics of the farm in conversation with Kathrin, Martin and the rest of the family.



AUSTRIAN HAY MILK	Producers: **Kathrin and Martin Unterweger**	FU: **1 liter milk**
Description: Cows farmed for the production of hay milk		Result: **1.07 kg CO2 eq**

Fig.1 Location of the Unterweger farm in Tscheltsch, Liesing, Lesachtal, Austria

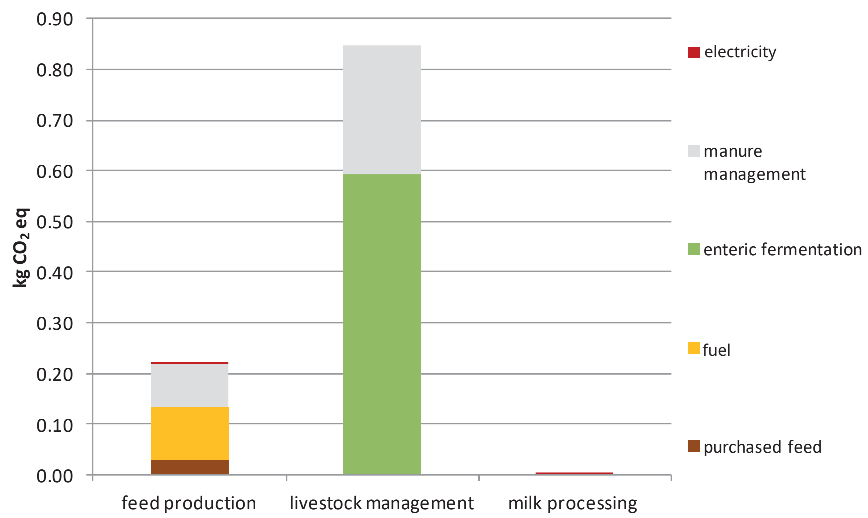


Fig.2 Carbon Footprint

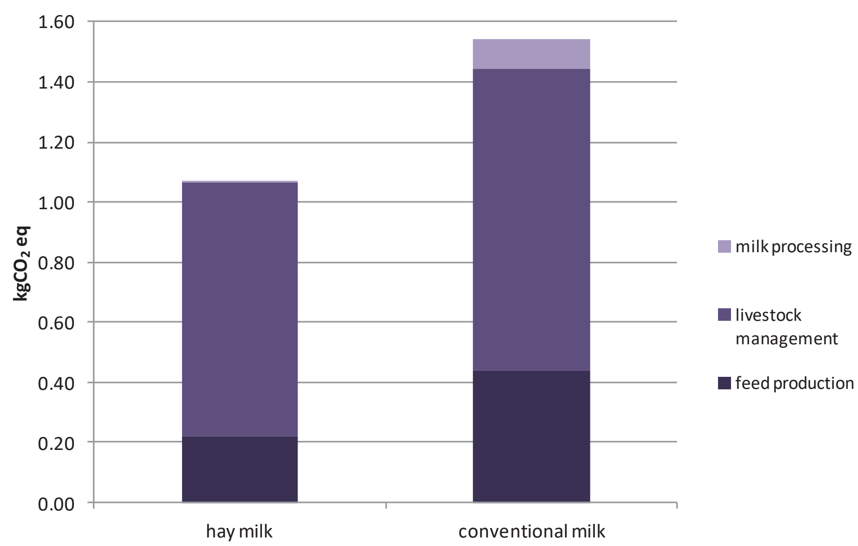


Fig.3 Presìdio vs Industriale

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CONCLUSION

The research team from Indaco2, which started as a spin-off from the University of Siena, was responsible for analyzing the life cycle of Slow Food Presidia products from the agricultural sector. The process involved a visit to the farm and a careful inventory analysis covering all the processes of the product's life cycle, including cultivation, livestock management techniques, processing and packaging. In the case of livestock farms, the analysis also took into account the biogenic emissions generated from the animals' enteric fermentation and manure. The data obtained were compared with similar conventionally produced foods, using data from the available literature.
The results obtained from the Life Cycle Assessment were striking. The carbon footprint values obtained for the analyzed Presidia products were in every case lower than those of similar conventional products:
- Beef: Making a 200-gram hamburger of Maremmana or Piedmontese beef produced emissions of greenhouse gases into the atmosphere of 3.2-3.4 kg CO_2 eq, 30% less than the average for a conventional farm (4.6 kg CO_2 eq)
- Pork: 100 grams of aged prosciutto from Mora Romagnola pigs produced emissions of 0.75 kg CO_2 eq, 16% less than conventional production using Large White pigs (0.9 kg CO_2 eq).
- Cow's and sheep's milk cheese: A 500-gram Vastedda cheese produced emissions of 2.13 kg CO2 eq, 64% less than the average produced on an intensive, conventional farm (6 kg CO_2 eq); a 2-kilo form of Macagn produced 3 kg CO_2 eq, 83% less (the average in the literature for similar cheeses is 17.7 kg CO_2 eq); while the emissions for a form of Caciocavallo from Podolica cows were 12% less (the average in the literature for cheeses produced in a similar way is 20.9 kg CO_2 eq).
- Eggs: The emissions to produce four eggs on the Cascina Santa Brera farm (0.52 kg CO2 eq) are around 37% less than conventional production (0.82 kg CO_2 eq).
- Produce: The emissions generated to produce 1 kilo of Presidium apples by Verner Andersen in Denmark are equal to 56 g CO_2 eq, compared to 300 g CO_2 eq for a similar product. The impact of his production of apple juice (300 g CO2 eq per liter in glass) is 75% less than a conventional product.
- Extra-virgin olive oil: Milenario oil production in Spain generates 1.51 kg CO_2 eq for every 0.5-liter bottle, 28% less than the average for industrial production (2.1 kg CO_2 eq).
- Chicken: The Alsatian Black chicken production chain generates emissions equal to 4.84 kg CO_2 eq per kilo of meat, 10% less than the European average (5.4 kg CO_2 eq).
- Milk: The value of emissions for 1 liter of hay milk produced on Kathrin and Martin Unterweger's dairy farm in Tscheltsch in Liesing, Lesachtal, Austria (1.07 kg CO_2 eq) is around 31% less than conventionally produced milk (1.54 kg CO_2 eq).
These results indicate a particularly careful and skilled management of livestock and crops (including those used for livestock feed) within the Slow Food Presidia. In all cases, the use of non-intensive cultivation and livestock-farming techniques (with animals kept in semi-wild conditions and a limited amount of time indoors) brings with it a series of good practices for the mitigation of impacts that contribute to further enhancing the quality of the products.
By now it is well known that products from livestock farms, particularly meat, have greater impacts on the environment than other food products. Limiting the consumption of these products within the daily diet is certainly the most obvious solution. However, foods from animals are a staple part of most people's diets, and the choice of quality products, such as those from the Presidia, which use natural practices, based on pasturing and feed grown on the farm (not industrially produced) ensures better animal welfare, positive effects for our health, improved flavor and, additionally, as shown by the results presented here, reduced pressure on the environment and natural resources.

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