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Context: Cheese is a widely consumed product worldwide and it is particularly appreciated in France (La filière laitière française, 2013). A large number of cheeses varieties exist and they are known to have significant environmental impacts as animal products (Borges Soares, 2021). Most of the time, studies focus on the environmental evaluation of a single cheese. Yet the environmental impacts of the studied cheeses vary from one to another: for instance, hard cheeses seem to have a higher environmental impact than soft cheeses (Finnegan et al., 2018). Nevertheless, since these different cheeses were not studied in a same study, the variability observed in the literature can be the result of differences in the implemented models.

Objective: We wanted to study the variability of environmental impacts between a wide range of cheeses along three objectives: (i) To define the environmental hotspots of each of them; (ii) To determine the specificities of these hotspots relative to the characteristics of these cheeses; (iii) to make recommendations on what to focus on in order to improve their environmental profiles. We also wanted to identify the main factors responsible for the variations of environmental impacts between cheeses in order to make recommendations on what to focus on in order to reduce them.

Methodology: In order to study the environmental impacts of different cheeses, the LCA approach was followed.
      Scope and goal
We have chosen to study the 45 French PDO (Protected Designation of Origin) cheeses. This allows us to compare cheeses produced by different technologies and from different milks (highland cow, lowland cow, goat and sheep). This choice has also a practical advantage since PDO cheeses must be produced according to very precise specifications available in free access, which allowed us to find a certain amount of information easily. The scope of the system we studied goes from the agricultural production of milk to the ripening step (included). The functional unit used is 1 kg of cheese after ripening. PDO cheeses can be produced in an artisanal or industrialized way. In this study, we focused only on artisanal production. Nevertheless, in order to study the influence of the ripening room on the environmental impacts of cheeses, two ripening room scenarios were explored: a small room scenario (commonly used in artisanal productions) and a large mutualized ripening room scenario.
      Inventory analyses
The inventory data needed for the LCA were collected in different ways: information from the specifications, on-site measures (from previous INRAE projects), data from equipment technical sheets and expert estimates. From these documents the masses of co-products were also estimated for each cheese and impact allocation was assigned relative to the masses in dry basis between products and co-products.
      Impact assessment

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LCAs were conducted on SimaPro 9.1.0.11 software using the "EF 3.0 Method (adapted) V1.00 / EF 3.0 Normalization and Weighting Set" (Fazio et al., 2018).

Interpretation of the results

The results showed that the environmental impacts of cheeses vary widely between the studied cheeses, mainly due to differences related to milk and to ripening scenarios, while the cheese technology used doesn't. For example, the impact of the cheese with the highest impact on climate change is more than 3 times higher than the one of the cheese with the lowest impact.

Milk. For both scenarios, the agricultural production of milk is a major hotspot. The amount of milk needed to produce one kilogram of cheese is positively correlated to the global environmental impact of cheeses, and this correlation is much stronger for the large mutualized ripening room scenario than for the small ripening room scenario. The origin of the milk (cow (lowland or highland), goat or sheep) also has an influence on the magnitude of the cheese environmental impacts.

Ripening. The environmental impacts are higher for the small ripening room scenario than for the large shared room scenario, despite the increase in transport that the shared room scenario implies. In the small ripening room scenario, the ripening stage is a major hotspot for some environmental indicators. This poor performance of small ripening rooms is due to the electricity consumption, more optimized in large than in small rooms. The energy consumption is also strongly positively correlated to the time of maturation of the cheese.

Discussion/Conclusion: The results show that the environmental impacts of cheeses can be variable meaning that the consumption of these cheeses cannot be considered as similar from an environmental point of view. They also show that particular attention must be paid to the quantity of milk used. Therefore, reducing milk losses during processing, as well as reducing environmental impact of milk farming could be interesting levers for reducing the environmental impact of cheeses. Particular attention must also be paid to the cheese ripening step. Reducing the ripening time as well as optimizing the ripening room (by both improving the energetic performance of its equipment and its filling rate) are therefore interesting levers for reducing the environmental impact of cheeses. Nevertheless, the electrical consumption data used for the small ripening room scenario come from experimental rooms that are not necessarily as optimized as real ripening rooms. In any case, the huge diversity of existing ripening rooms is not represented in this study and we believe that a real effort should be made to measure the electrical consumption of a large number of ripening rooms in order to be able to refine the calculations of the environmental impacts of cheeses. Nevertheless, attempts to improve the environmental performance of the cheeses by improving the ripening rooms could be considered for further research, particularly for long-ripening cheeses.

These results may be of interest to cheese makers wishing to reduce the environmental impact of their products and to consumers wishing to learn about the impacts of their consumption choices.

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