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Context

Human food is responsible for significant environmental impacts and the agricultural phase is recognized as a major contributor to these impacts. As a result, many studies have focused on the environmental impacts of agricultural food production and processing (Borges Soares et al., 2021), but to our knowledge, very few have focused on the environmental impacts of the food preparation process at home. In general, this stage is not taken into account in the literature, although what can happen at this scale can be significant. Therefore, in this study we sought to determine the impacts of these home practices on the environmental profiles of food products.

Objectives

The objectives of this study were to compare the environmental impacts of two pizzas processed in three scenarios of preparation modes (industrial, homemade by assembling industrial products, and homemade including pizza dough and tomato sauce preparations). The variability of the practices and equipments used by the panel were taken into account as well as their perceptions of the environmental impacts for each of the three scenarios.

Methodology

Pizza preparation scenarios

We compared the environmental performances of a ham-cheese pizza and a cheeses pizza produced in three different scenarios representative of the following situations.
1- Industrial pizza. The consumer buys an industrial pizza at the supermarket and bakes it at home.
2- Assembled pizza. The consumer buys at the supermarket an industrial pizza dough, an industrial tomato sauce, and all the toppings (cheeses, ham, vegetables). He/she assembles the pizza at home before baking it.
3- Homemade pizza. The consumer buys at the supermarket all the ingredients needed to make the pizza dough (flour, yeast, oil, salt), to make the tomato sauce (e.g., tomato puree, tomato concentrate, oil, salt, sugar, garlic, herbs of Provence, oregano), as well as all the toppings (cheeses, ham, vegetables). He/she prepares the dough and the tomato sauce at home and assembles the pizza before baking it.
The recipes of pizza prepared with scenarios 2 and 3 were formulated to be as similar as possible to the recipe of the industrial pizza. For each type of pizza, the nutritional profile and caloric density were similar across all scenarios.

Recruitment of participants

69 participants representative of the French population (in terms of gender, age, and socio-

professional categories) were recruited to prepare and eat the pizzas at home according to the different scenarios. The raw materials for pizzas were provided to all participants each week. Each participant prepared and consumed the 6 pizzas over three different weeks in a randomized order and filled in the associated questionnaires.

Questionnaires

The objectives of the questionnaires were mainly to collect the data needed to build the life cycle inventory, as well as the perceptions of consumers for each pizza.
Questionnaire 1: data on the equipment used by participants and their habits (e.g., model and brand of the fridge and oven, distance between their home and the supermarket).
Questionnaire 2: data on the preparation process of each of the 6 pizzas (e.g., cooking time, equipment used, cleaning method used to wash the dishes).
Questionnaire 3: data on the consumers' perceptions regarding the 6 pizzas.

Environmental impact - Life Cycle Assessment (LCA)

The system perimeter included all steps from the agricultural production of ingredients to the consumption of the pizzas at the consumer's home, including waste management. The functional unit (FU) used was 1 ready-to-eat-pizza. The inventory data were estimated from the responses of the 69 consumers to the different questionnaires. The main flows considered were materials (pizza ingredients and packaging materials), energy flows (electricity and gas), wastes (pizza packagings), water consumption related to equipment cleaning and transport. 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). LCAs were performed using a baseline scenario weighted by the actual situation of each households. For example, if X% of the participants reported using an electrical equipment for the dough making, a ponderation of X% was allocated to the electrical consumption linked to the equipment use. The average equipment power and use time reported by the participants were used to estimate this electrical consumption. 69 LCAs were also performed for each pizza in order to represent the 69 consumers and were then used for the comparison of the 6 pizzas including the variability of consumers' practices.

Results and discussion

Hotspots definition

For each of the 6 pizzas, baseline scenario was used to study the hotspots of pizza preparation and consumption. On average for all 6 pizzas, the main contributor to the environmental impacts of pizzas was the agricultural production of the ingredients for most environmental indicators. However, for the most electricity sensitive environmental indicators such as ozone depletion, ionising radiation, and resource use fossils, pizza oven cooking appears as the main hotspot. It could therefore be said that the choice of ingredients as well as the oven use time to bake the pizza are interesting levers to reduce the environmental impacts of pizzas for each of the 3 scenarios.

Influence of the consumers' practices on environmental impact of food products

First results showed that consumer practices can be very different from one to another. Therefore, we also studied the influence of consumer practices on the environmental impacts of the pizzas. The most impacting practices on the environmental impacts of pizzas are detailed below.

Cooking time. The oven use time (including oven pre-heating and pizza cooking) can vary greatly, from 10 to 50 minutes, depending on the participants. The reduction of oven use time from 50 to 10 min can reduce the environmental impacts of the pizza from 5% for less-energy sensitive indicators

such as land use to 60% for higher-energy sensitive indicators (ionising radiation, ozone depletion, resource use fossils). Therefore, oven use time including pre-heating is an important lever for reducing the environmental impacts of pizzas, especially on electricity sensitive indicators.

Transport from the supermarket to the consumer home. The average transportation of the pizza from the supermarket to the consumer's home did not have a large contribution to the environmental impacts of pizzas, except for the indicator resource use, minerals and metals. However, some parameters can increase the influence of this step such as the distance between the consumer home and the supermarket, the transportation means, and the frequency of grocery shopping. For exemple the pizza impact on the resource use minerals and metal indicator is decreased by almost 80% when the distance consumer home–supermarket is 1 km instead of 16 km and by more than 30% when using a small gasoline car instead of a large diesel one (for an average distance home–supermarket). However, the parameter that seems to have the highest influence on the environmental impacts of pizza linked to its transport is the frequency of grocery shopping. Indeed, the environmental impacts of the pizza bought as part of a grocery basket for half a week is from 15% to more than 80% lower than when the pizza is bought alone depending on the indicator. This is due to the allocation factor to distribute the environmental impacts between the different items bought at the same time in the case that pizza is not bought alone. Therfore, it can be said that optimizing the trip to the supermarket by buying not only one food product is a good way to reduce its environmental impacts.

Pizzas leftovers management. After consuming the pizza, some participants had leftovers. Keeping the leftovers in order to consume them later avoid consuming some other food. On the opposite, throwing leftovers away implies that some other food will be needed for the next meal of the participant which would have been avoided by saving the leftovers. Therefore, the daily environmental impacts of the participant food consumption will be increased when leftovers are thrown away and the calories they could have provided replaced by some other food. However, the reheating of pizza leftovers can increase significantly the impacts of the pizza on environmental indicators sensitive to electricity consumption when the oven use time is high. Therefore, from an environmental point of view, keeping leftovers is better than throwing them away but the consumer has to be careful with the oven use time, or use a microwave for which the electrical consumption is lower due to a lower use time.

Comparison of the 6 pizzas environmental impacts

Differences of environmental impacts were observed between the 6 pizzas prepared and consumed by the 69 consumers. Some environmental indicators seem to be especially impacted by the pizza family (ham-cheese/cheeses). This is the case for climate change and land use, which are known to be sensitive to the agricultural production. For these two indicators, cheeses pizzas have higer environmental impacts than ham-cheese pizzas independently of the scenario. However, the scenario can have an influence on environmental indicators sensitive to the electricity consumption such as ionising radiation and resource use fossils. Indeed, for these two indicators the homemade pizzas have higer impacts than other pizzas because they require more electricity to prepare. Nevertheless, no pizza had higher environmental impacts than others on all indicators and therefore there is no one best option in terms of environmental performance according to our results.

Consumer perception

The consumer perception regarding the environmental impacts of the 6 pizzas they consumed were assessed. To do so, the consumers had to rank the different pizzas from the one they thought had the lowest environmental impacts to the one they thought had the highest. Figure 1 shows the average ranking of each pizza.

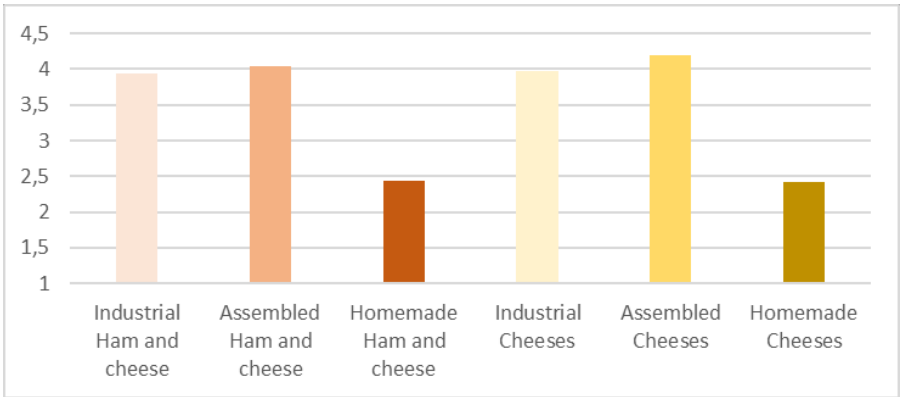

Figure 1. Average ranking of the pizzas by the 69 consumers to the question "Rank the 6 pizzas from the one with the lowest impact on the environment to the one with the highest impact on the environment". The lower the ranking number, the lowest the environmental impact is perceived.

The homemade pizzas were perceived as the ones with the lowest environmental impacts for both ham-cheese and cheeses pizzas. The consumers also had to rank the 6 pizzas according to their preferences. It appeared that homemade pizzas were the preferred ones. This shows that the perception of the pizzas' environmental impacts by participants is correlated to their preferences. This also shows that consumers tend to have erroneous perception of the environmental impacts of the pizzas they consumed because LCA results did not highlight that homemade pizzas had lower environmental impact than others, they even tend to have more impacts on electricity sensitive indicators.

Conclusion

These results gave us a first insight into the effect of the difference in food preparation modes on the environmental impacts of products. The consumers practices are very variable from one consumer to another and this can have high influence on the food products environmental impacts. However, this is never included in food LCAs which can lead to miss a large proportion of the environmental impacts of the food product. Similar studies on a wide choice of products and with more details on the reality of the consumer stage (e.g. with on-site measurements) would be helpful in order to deepen knowledge on the impact of production scenario of food on its environmental impacts. This would allow recommendations to be made to consumers for more sustainable food choices and home practices. In any case, our results showed that the use stage should not be neglected in food products LCA studies and that further research in this area is needed.

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