LCA case study of usual and prebaked industrial bread

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ABSTRACT
The consumer expectation to buy fresh bread even short before closing time lead to the use of prebaked bread that is crisped up in the shops on demand. Being aware, that the quick-freezing of prebaked bread as well as the maintaining of the cool chain need a lot of energy, JOWA AG wanted to know whether this prebaked bread conflicts their sustainability strategy from an environmental perspective. The goal of this study was to compare the environmental impact of usual industrial bread and prebaked industrial bread. Data for both the usual and prebaked bread were collected for every single process step from cradle to grave including bread losses (production, point of sale (POS), consumer stage). Different environmental impacts were analyzed. However, for the interpretation of the environmental impacts single score results of the ecological scarcity method 2013 and of the ILCD method were used. The agricultural production of the grains contributes most to the results (up to 85%). The environmental comparison of the whole chain leads to the conclusion that even though there is extra energy demand of the cool chain, the prebaked bread performs at least equally than usual bread due to more efficient production, lower bread losses at the POS and consumer stage (prebaked bread crisped up at the shop stays longer fresh at home). The use of prebaked bread meets the consumer expectation of fresh bread even short before closing time without conflicting the sustainability strategy of the retailer as the environmental impact of prebaked bread is not higher than of that of usual bread.

Keywords: bread, frozen, process chain, losses,

1. Introduction

JOWA AG, the industrial bakery of the Swiss retailer Migros plans an additional bread production factory design for prebaked bread in order to meet the consumer's expectation of buying fresh bread even short before closing time. It is expected that the energy demand is much higher due to the involved cooling chain of the prebaked bread. Stakeholder as well as consumer groups therefore suspect a possible conflict of this strategic alignment with the sustainability strategy of Migros. The JOWA management wanted to better understand the environmental hotspots and impacts of the prebaked bread production line compared to the usual production line of industrial bread.

2. Goal and Scope

Goal and Scope
The goals of the study at hand are:

- Detailed LCA analysis of the production of prebaked bread including also losses at the consumer stage.
- LCA comparison of prebaked bread with usual bread from industrial bakery on
  - Gate to gate: core processes only
  - Cradle to gate: processes up to point of sale
  - Cradle to grave: whole process chain including losses.

The functional unit was

- 500 g of bread (semi-white), at the point of sales (POS), for gate to gate and cradle to gate analysis
- 500 g of bread (semi-white), consumed, for the cradle to grave analysis

The compared breads are sold under the same name and have the same weight. But they have slightly different nutrient and energy contents, mainly because the prebaked bread has somewhat higher water content and some rye whey is used. Therefore, as a sensitivity analysis the nutrient density approach was used (Drewnowski, 2005) which considers different nutrients such as calories, proteins, fat, vitamins and trace elements. This approach allows to compare the breads based on equal nutritional value (see also Kägi et al. 2012).

Definition of bread variants:

Usual bread:
Bread that is baked by an industrial bakery at night or early in the morning and then distributed to the stores.

Prebaked bread:
Bread that is prebaked by an industrial bakery and shock-freezed immediately after baking. It is then stored in cold storage, distributed to the stores and crisped up in the stores on demand.

System boundary

All processes from cradle to grave were considered (figure 1) with a special focus on the in-house processes of the bakery and the losses at the point of sale (POS) and at home due to different storage life of the breads.

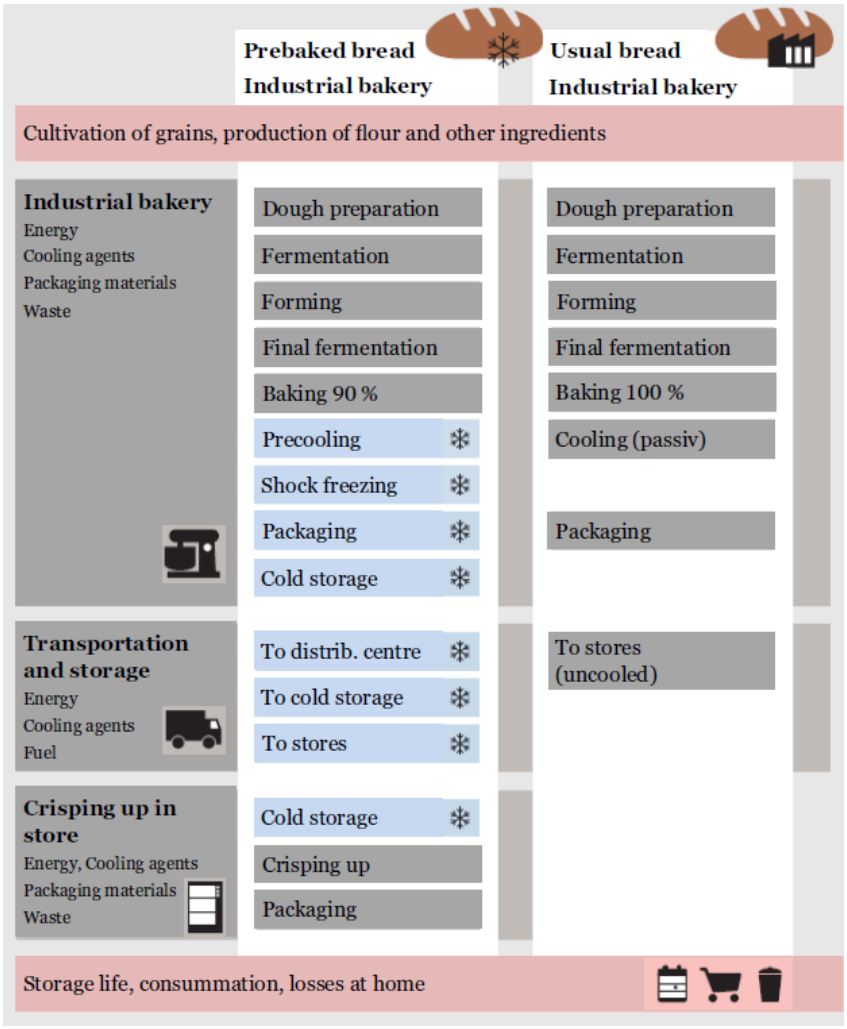

Figure 1: System boundary of prebaked and usual bread

Data / Inventory

Data for the production of the ingredients such as wheat grains, salt etc. was taken from the ecoinvent database v2.2 (ecoinvent 2010). Data for both the bread production were collected for every single process step for the year 2014. Data is based on real measurements at the production lines or yearly statistics of the Swiss bakery. Furthermore, distribution and storage data were collected as well

as data for crisping up at the store and bread losses during production, POS and consumer stage. Losses at the consumer stage were derived by a study of Englert and Dohner (2015).

Impact Assessment Method

Different environmental impacts were analyzed such as climate change, acidification, eutrophication, photochemical ozone formation, ecotoxicity, human toxicity, land use, water resource depletion and mineral, fossil & renewable resource depletion. However, for efficient decision support for the retailer's management (Kägi et al., 2016) single score results were used for the interpretation of the environmental impacts. We used the ecological scarcity method 2013 (Frischknecht & Büsser Knöpfel, 2013) and the ILCD method (JRC, 2011) with the weighting scheme proposes by Huppes and van Oers (2011).

Furthermore, an uncertainty analysis was performed in order to see whether there were significant differences.

3. Results

3.1 Analysis of core processes

In a first step, the management was very much interested in the analyses of the core processes only (gate to gate) neglecting the production of the ingredients and the losses at home.

This analysis (figure 2) shows that the prebaked bread has a factor 2 higher environmental footprint due to the electricity demand for the cooling chain and due to the secondary packaging for transportation. Whereas usual bread is transported in multipath containers, the frozen prebaked bread is transported in one-way cardboards (about 50 g of cardboard is used per 500 g bread). Heat for baking is much higher for the usual bread because the prebaked bread can be produced much more efficient on the production line without product changes during production time. The bread demand of several days or weeks can be produced in one batch whereas for the usual bread only the demand of one day can be produced at once.

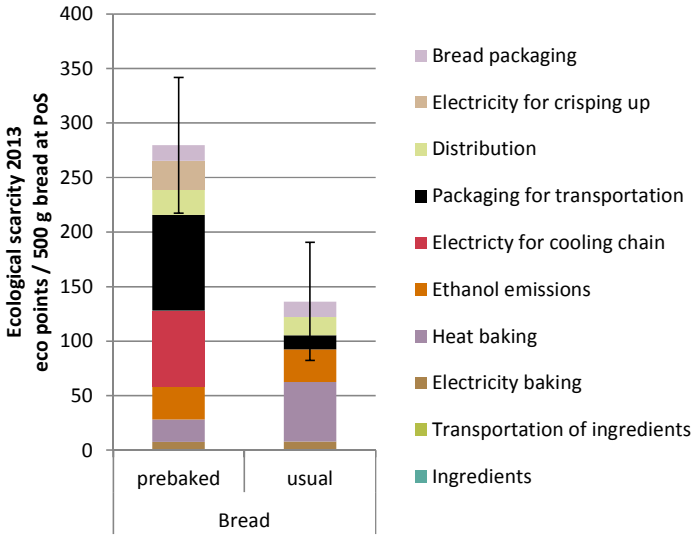

Figure 2: environmental footprint of bread at the point of sale but core processes only (gate to gate).

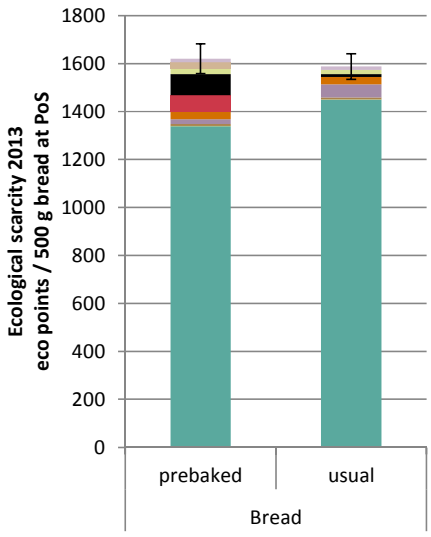

Figure 3: environmental footprint of bread at the point of sale (cradle to gate).

3.2 Comparison at the point of sale (POS)

The comparison at the POS (cradle to gate) shows the relevance of the ingredient production (figure 3). The agricultural production of the grains contributes most to the results (up to 85%). The two bread variants do not show any significant differences anymore. Even though the core processes of the prebaked bread have a twice as high footprint , it needs slightly less ingredients per 500 g bread at

the POS because it has slightly higher water content due to less water evaporation during baking (it is only baked to 90 % and then shock-freezed. During the crisping up the evaporation is less relevant).

3.3 Comparison per consumed bread, at home

The environmental comparison of the whole chain (cradle to grave) shows that even though there is extra energy demand for the cool chain, the prebaked bread performs slightly better than usual bread due to lower bread losses at the POS and consumer stage (figure 4 and 5). At the POS the bread losses are lower because the prebaked breads can be crisped up on demand whereas the amount of usual bread has to be preordered daily by the stores from the industrial bakery. In order to fulfill the consumer's expectation of fresh bread even short before closing time with usual bread only, rather too much than too little bread is ordered leading to quite high losses[1]. At home, prebaked bread crisped up at the shop stays longer fresh and less bread is lost in average. This fact was also proven by a blind degustation study (Englert and Dohner 2015).

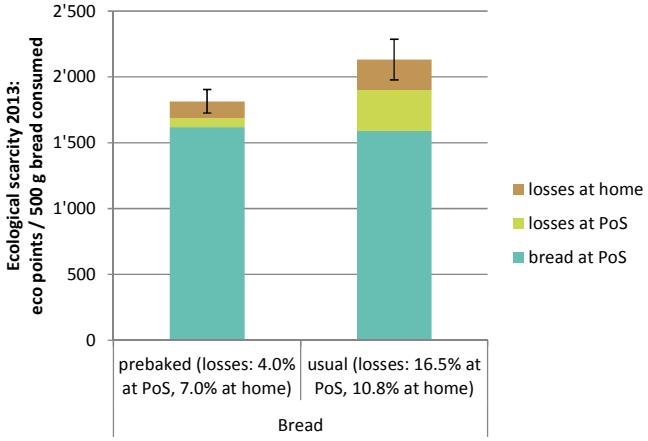

Figure 4: Environmental footprint of bread consumed at home using the ecological scarcity method 2013.

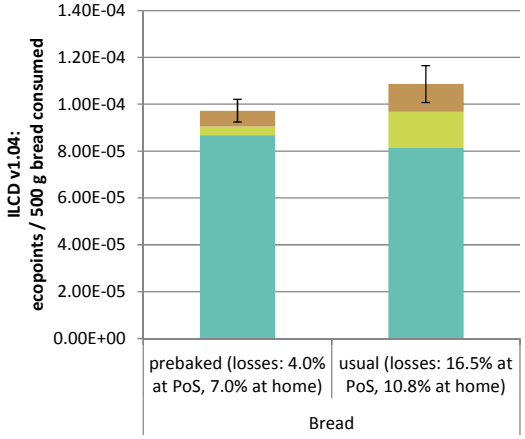

Figure 5. Environmental footprint of bread, consumed at home using the ILCD v1.04 method with the weighting scheme of Huppes and van Oers (2011).

3.4 Sensitivity analysis per equal nutrient density

As a sensitivity analysis the results of the two breads were adjusted to their nutrient density allowing a comparison per equal nutritional value. Figure 6 shows that the results do not change compared to the comparison per equal weight. The reason is that even though the two bread are sold identically with the same product name the prebaked bread contains some rye flour whereas the usual bread contains only wheat flour (due to the differences in the process chain). Rye flour has a higher nutrient density than wheat flour. So the prebaked bread shows an almost equal nutrient density per 500 g even though it has higher water content.

[1] The goal of this study was to compare usual with prebaked bread. However, nowadays most stores already use a combination of usual bread during the day and frozen prebaked bread in the afternoon in order to reduce losses. This combination leads to equally high losses as using prebaked bread only.

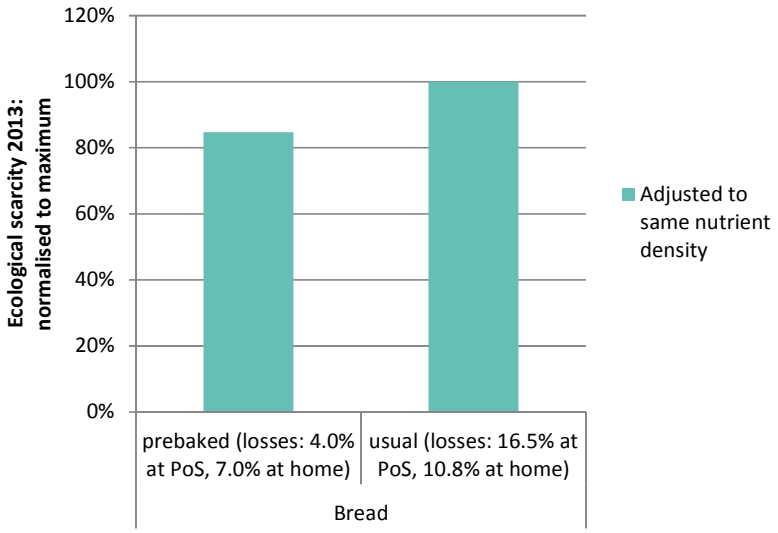

Figure 6: Environmental footprint of bread, consumed at home, adjusted to the same nutrient density value.

4. Discussion

The hypothesis that the additional energy use for the cooling chain may show a higher environmental burden is only true for the gate to gate analysis of the core processes. If the whole process chain is included, this disadvantage disappears as other processes such as the cultivation of wheat show a much higher contribution to the environmental footprint than the core processes and the prebake bread contains slightly less flour and more water.

It should be kept in mind, that in this case study the prebaked bread can be produced more efficient than the usual bread. Furthermore, the results show how important it is to include even the losses at the consumer stage, as this significantly influences the results. A very important aspect is the storage life of the bread at home.

The sensitivity analysis showed that even though prebaked bread has slightly higher water content and therefore lower flour content, the nutrient density does not differ. This is because the prebaked bread contains a small fraction of rye flour which has a higher nutrient value than wheat flour.

The sensitivity analysis with the single score of the ILCD method showed very similar results to the ecological scarcity results leading to the same outcomes and conclusions.

5. Conclusions

The use of prebaked bread meets the consumer's expectation of fresh bread even short before closing time without conflicting the sustainability strategy of the retailer as the environmental impact of prebaked bread is not higher than that of usual bread. However, if the same bread variety is produced with prebaked bread, its production would not be as efficient anymore due to shorter batches. Furthermore, the stores already combine usual bread during the day with prebaked bread during the afternoon till closing time. With this strategy the consumer's expectation is met without too much losses at the POS and still having a broad assortment of breads during the day. To use only prebaked bread would not further reduce the losses at the POS but it would lead to a loss of bread variety in the stores.

6. References

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