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# Carbon footprint associated with a cake factory

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## INTRODUCTION

Healthy products, that also present social and environmental responsibility, attract the interest of consumers.

This means that the concern with environmental impacts has already gone beyond the consumption of water and energy associated with activities or services, and begins to include food products.

This is evidenced by the success of alternative initiatives such as seals and eco-labels, for example, of organic foods, which confirm the interest of consumers in changing the way food is produced, processed, and sold.

Thus, labels help in the decision-making process of the consumer, contributing to a food production system with greater ethical and political values and capable of generating sustainable production systems, with lower levels of carbon emissions.

## OBJECTIVE

Calculate the carbon footprint associated with two flavors of cakes, produced in a small factory (monthly production 7580 cakes), in the city of João Pessoa (Northeast Brazil).

## MATERIALS AND METHODS

Quantification of the environmental impact generated during the production and distribution of cakes utilized the Life Cycle Assessment (LCA) methodology.

The LCA was developed with software SimaPro, utilizing two databases for the inventory: Ecoinvent 3 and Agri-footprint, and method IPCC 2013 GWP 100y for the environmental impact assessment (carbon footprint).

Direct consultation with the owner of the factory provided the required data for LCA, considering the production of English pound cakes and carrot cakes,

All inputs and outputs of the system were identified and quantified for the development of the LCA, considering the energy and materials necessary for the production and distribution of cakes. These monthly values were implemented in SimaPro and are shown in Table 1.

Table 1: Ingredients and processes associated with the monthly production of English pound and carrot cakes.

| Monthly ingredients | English pound cakes 468 cakes/month | Carrot cakes 196 cakes/month |
|---|---|---|
| Eggs | 1040 eggs | 196 eggs |
| White flour | 104 kg | 29.4 kg |
| Sugar | 78 kg | 29.4 kg |
| Sunflower oil ($\rho$ = 891 kg/m$^3$) | - | 15.72 kg |
| Margerine | 78 kg | - |
| Carrots | - | 31.36 kg |
| Milk ($\rho$ = 1027.7 kg/m$^3$) | 53.44 kg | - |
| Monthly processes | | |
| Electricity | 53.82 kWh | 22.54 kWh |
| Butane gas (99.20 MJ/m$^3$, 2.15 kg/m$^3$) | 294.93 MJ | 123.52 MJ |
| Packaging | 0.936 kg styrofoam, 0.585 kg plastic film | 0.392 kg styrofoam, 0.245 plastic foam |
| Transportation (10 km/l) | 110.59 km | 46.31 km |
| Water | 1852.25 kg | 775.73 kg |
| Nutritional value per cake | 1121.4kcal | 1071.0 kcal |

The process for butter was adapted to result in a representative process equivalent to margarine, which included vegetable oil, sodium chloride and milk.

## RESULTS AND DISCUSSION

Providing the environmental impact per unit of cake can provide the wrong impression that a carrot cake is directly comparable to an English pound cake (in which case labeling could influence the purchase option).

In the specific case of cakes, two functions have been identified: nutrition and pleasure. For the latter, further research is required to identify the best way to express the environmental impact. For the nutritional case, the carbon footprint is provided in terms of nutritional value (kg $CO_2$-eq/kcal) (Table 2).

Table 2: Carbon footprint associated with English pound and carrot cakes.

| Ingredients | English pound cake | Carrot cake |
|---|---|---|
| Eggs | 0.660 | 0.300 |
| White flour | 0.080 | 0.060 |
| Sugar | 0.240 | 0.210 |
| Sunflower oil | - | 0.120 |
| Margerine | 0.220 | - |
| Carrots | - | 0.070 |
| Milk | 0.180 | - |
| Processes | | |
| Electricity | 0.030 | 0.030 |
| Butane gas | 0.020 | 0.020 |
| Packaging | 0.010 | 0.010 |
| Transportation | 0.080 | 0.080 |
| Water | 0.003 | 0.003 |
| TOTAL (kg $CO_2$-eq/unit) | 1.523 | 0.903 |
| TOTAL (kg $CO_2$-eq/kcal) | $1.42 \cdot 10^{-3}$ | $0.81 \cdot 10^{-3}$ |

Eggs are responsible for the greatest share of the carbon footprint, followed by the sugar.

As aforementioned, the monthly consumptions of water, butane, electricity, packaging and transportation were allocated equally to the entire production of cakes. So the difference in the emissions associated with the different flavors was fundamentally due to the ingredients and their amounts.

## CONCLUSIONS

The carbon footprint of the English pound cake was higher ($1.42 \times 10^{-3}$ kg $CO_2$-eq/kcal) than the carbon footprint of the carrot cake ($0.81 \times 10^{-3}$ kg $CO_2$-eq/kcal). In both flavors, eggs were responsible for the greater share of emissions.

Further research is suggested on the development of sensitivity analyses for the substitution of ingredients: for example, eggs could be replaced by another product that is capable of performing the same nutritional or structural function. Considerations on the environmental impacts of food must be associated with nutrient density and health.

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