Sensitivity analyses of carbon footprint measurement, comparative case studies

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Greenhouse gas emission is important as an aspect of contamination of the environment, and main accelerative force of global climate change. The 29% of global emissions of GHGs are from agriculture and food production (Vermeulen et al., 2012). Contribution of food production and food industry to the greenhouse gas emission and climate change gets more and more highlight among its environmental impacts nowadays. Carbon-footprint summarizes the greenhouse gas emission equal to carbon-dioxide amount of the production or manufacturing of a product or service. Definition of carbon footprint was given by several authors (Mujica et al., 2016, Rebolledo-Leiva et al., 2017). Carbon-footprint can be considered as a part of ecological footprint (Wiedmann and Minx, 2008), that measures the total amount of carbon-dioxide emitted directly or indirectly to the atmosphere by a certain activity or person or surface. The carbon-footprint is a sustainability indicator that gives numerically the amount of emitted greenhouse gases during the life cycle of the product. Life cycle assessment (LCA) is a methodology used to evaluate the environmental impacts of products and services by taking into account all the manufacturing and consumption stages, from the production of raw materials to the end of life, including all intermediate steps (Bicalho et al., 2017), therefore it has high data inquiry. The uncertainty of product information is a critical question to estimate product carbon footprint for product life cycle (He et al., 2018).

The methodologies used for the calculation of the carbon-footprint are not uniformed. There are many calculators, which give estimations often as a black box, but also software packages which have their inputs from different sources, so limitations in applications. In this paper we are following the directions of PAS 2070 (Publicly Available Specification 2070), and the ISO 14000 package standards, which help the calculations if we have all the detailed data available for certain products. When we think of the possible reduction of carbon footprint, it can be reached partly thanks to prevention, recycling, or using other ideas from the circular economy concept, but also with changing the usual practices. Every step is important, and reminding, that, many a little makes a mickle. The principle of the standards of the Intentional Organization of Standardization is what we need to follow: the Plan, Do, Check, Act/Adjust, Plan, … etc. cycle.

The World Business Council for Sustainable Development (wbcsd.org) has settled the crucial targets with indicators in its document Action2020; the most relevant mentioned in the current project are: sustainable farming (raw materials of food industry, agricultural source), less food waste (minimization, less transmission points in food value chains), sustainable value chain (footprint of food products), sustainable products and services (product lifetime), life cycle development (use of local sources, sustainable packaging, energy efficiency, product innovation).

In this research we are introducing cases of the carbon footprint calculations in different stages of the production process, based on in-depth interviews and manual data collection. With the in-depth interviews, we have measured the steps of the manufacturing process, while during the manual data collection we have developed a database of CO_2 emissions for the specific performance of the machines. Examples are given for "simple" (less processed) products like rice and frozen chestnut pure. First, we focus on the production of rice, based on calculations for the comparison of two technologies to produce raw material and in the manufacturing process of the rice product (Figure 1).

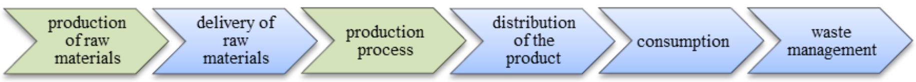

Figure 1. Simplified LCA model of food products, focusing on the first and the third stage

Rice can be produced with under water and overland technology. If produced with overland technology, the CO_2 emission can be reduced by 36,82% during the soil preparation and farming procedure, which means 24,23% less for the packaged rice product's carbon footprint. But production with the under-water technology has significant water footprint, 4000 l / 1 kg rice. We need to have a complex approach when thinking of the impact on the environment. The difference between brown and white rice is that producing white rice needs a polishing stage during the production process which increases the carbon footprint of the product. So brown rice is better for health and the environment at the same time. On the other hand, cooking of brown rice might need more energy than cooking white rice, but not if we soak it in water before cooking. There are calculations for different types of stoves too depending on the energy source they use, which is already a part of calculations for the fifth stage, consumption. Other consumption patterns can be also compared.

For the second stage (Figure 3), delivery of the raw materials, we use an example of the frozen chestnut pure produced by the company Prima Maroni Ltd. We have to mention that transportation is taking most of the environment in many cases. It is present in more steps of the life of products (see the example in Figure 2). Carbon footprint due to transportation comes from: delivery to the place of the production - which could be more for all the components depending on the product -, transporting from the place of manufacturing to the packaging place, delivery of the packaging materials to the place of packaging, from the packaging to the storage place, delivery from the storage to the retailers, etc.

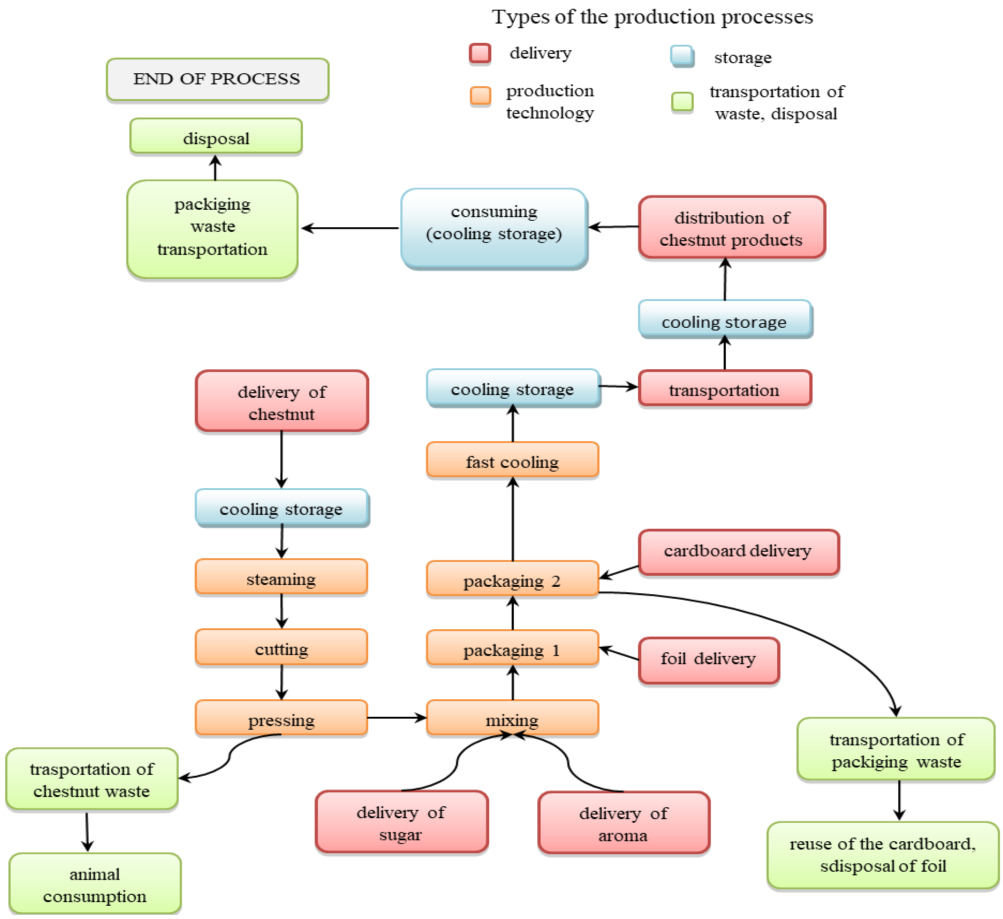

Figure 2. Process map: Flowchart of the frozen chestnut pure product

Calculations given here are only for the delivery of raw materials. This company is using chestnuts delivered both from Italy and Portugal. Comparison of these two suppliers show in calculating the CO2 footprint of the delivery of raw materials, that transporting from Italy can reduce the carbon footprint in this stage by 55,65% compared to Portugal, so the footprint measurement is very sensitive on the original of the chestnuts.

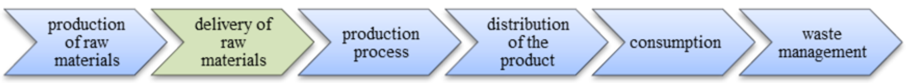

Figure 3. Simplified LCA model of food products, focusing on the second stage

The calculation method is building bottom-up the value of the carbon footprint for the selected part of the manufacturing process of certain products and follows the guidelines of the life cycle assessment. Since it is always related to a specific product it helps the stakeholders to understand the environmental impacts of different strategies and helps decision making. The most serious limitation of the method is that unfortunately the willingness of providing data suitable for such calculation is still poor in the stakeholders of the whole production chain.

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