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Life Cycle Assessment of apple and peach production, distribution and consumption in Mediterranean fruit sector

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ABSTRACT

Peach and apple are two important products in the Mediterranean fruit sector. The aim of this work is to analyse environmentally the entire life cycle stages of Mediterranean fruit production, from cradle to grave, considering agricultural, retail, consumption and disposal stages, using a multiyear approach with data from ten years of real production. The results of the study show that, for both fruits, the agricultural stage presents the highest contribution in 13 environmental impact categories, whereas the retail stage makes the highest contribution in 5 impact categories, and the consumption stage has the lowest values in all impact categories. The results related to the carbon footprint calculation show that the retail stage makes a contribution of 39%, the agricultural stage 36%, consumption 23% and disposal 2%. The study also quantified the emissions related to fruit losses during the different stages of the fruit production cycle. Results reveal that the total loss-related emissions are above 10%. This study contributes to completing the fruit LCA literature and provides new environmental information for fruit analysis, introducing the retail, consumption and disposal stages, in order to have a life cycle approach to detect the fruit production hot spots, and to obtain a multiyear perspective analysis to avoid the variability of results related to annual yield and climatic conditions.

1. Introduction

Agriculture is a strategic human activity that has been developing for many centuries. Several decades ago agricultural production was practiced in a natural way, using natural techniques and natural inputs The recent world globalization has generated big competence in all productive countries, to increase the productivity and international competitiveness of their agricultural and livestock production, in line with an economic growth model based on the quest for short-term profits (Naor and Girona, 2010).

As a response to the growing demand of an increasing population and worldwide economic interests, in last twenty years, the use of intensive farming practices have highly increased; so it has sponsored the influence of large companies to producing seeds and chemical fertilizers (Martínez-Blanco et al., 2011). The change from of traditional farming practices to intensive production has led important environmental problems as: soil erosion, water pollution, over-exploitation of water resources, and loss of biodiversity, pesticides damage and risk for human health. So the intensification of agricultural production has led to the degradation of ecosystems and serious ecological imbalances that accentuate acute environmental problems inherited from industrialization as over-exploitation of land, pollution of ground and surface water and the presence of excessive residues in food (Sanyé-Mengual et al., 2015).

Food production has an important contribution to the depletion of natural resources and generating and important environmental impact, and it contributes intensively to the existential threat of climate change (Cerutti et al., 2014). The IPCC 2007 report estimates that the direct impact of agriculture is about 10–12% of the global anthropogenic greenhouse gases emissions. Frey and Barrett (2007) reports that, fruit production is considered an agricultural sector with lower contribution to environmental impacts compared to other crops sectors. To satisfy their consumers food companies are increasingly more interested in reducing the environmental impact associated with their products, in order to provide their consumers with more sustainable. With the aim of promoting sustainable European development, European Commission is encouraging

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farmers to adopt integrated and organic production practices in order to develop sustainable agriculture (European Commission, 2012).

Apple and peach are two important fruit products in the Mediterranean area. According to FAO statistics (2014), Spain is the second (peach and apple) producer in the European Union, producing 1,057,596 tons/year of peach and 532,8174 tons/year for apple. Catalonia is the leading apple production region in Spain (it means 56% of total Spanish apple production) and the second region for peach production (37% of total Spanish peach) (MAGRAMA, 2013).

As report some authors (Milà i Canals, 2003; Vázquez-Rowe et al., 2012) Life Cycle Assessment (LCA) is one of the most commonly used methodologies to estimate the environmental burdens linked to fruit production. Many of the LCA studies are focused only in cultivation period, so the impacts are partially analysed. This studies do not present enough environmental information regarding to the entire cycle of fruit production excluding initial orchard stages, storing, retail, consumption and disposal (Vinyes et al., 2015). The reason that LCA fruit studies focuses only in cultivation period, is explained because many times there is a lack of inputs data (energy, resources, fuel, etc.) which were not taken in account by farmers years ago. Despite technological advances and innovations, agriculture is still subject to the soil, environmental and climatic conditions for development. Recently Mouron et al. (2006) demonstrated that the same apple cultivation in five European regions may have completely different protection requirements, leading to very different environmental impacts.

This study wants to complete the previous publication (Vinyes et al., 2015), which presented the concept of the multiyear approach and use local data for peach cultivation analysis (only for the cultivation stage). As a novelty, the present study includes an analysis of the remaining stages to complete the entire cycle of peach production: retail, consumption and disposal. This work also includes the analysis of apple cycle production not only for peach as did the previous work.

The study will also present the carbon footprint values related to fruit production. The fact that it analyses the entire fruit production cycle will provide us with a global vision of this product and detect all the hot spots related to the environmental impact, and enable us to know which parts of the production process it is possible to change in order to promote more sustainable fruit production. The analysis of entire fruit production cycle (orchard establishment, cultivation, retail, consumption, food waste and final disposal), has been possible with the coordination between IRTA, distribution and retail companies as well as other actors involved in fruit sector, which has allowed to work with real and experimental data over a period of 10 years.

2. Materials and methods

The environmental analysis of the apple and peach production will be performed using LCA methodology according to ISO Standard 14040:2006, with a multiyear approach described in a previous work by Vinyes et al. (2015), where the quantifications are done since the average of 10 years production.

2.1. Life Cycle Assessment approach

According to ISO 14040:2006, LCA analysis evaluates the potential environmental impacts throughout a product's life cycle from cradle-to-grave, including raw material acquisition to production, use and disposal. The characterisation factors used to perform this LCA study are mid-point factors, and the calculation method used is Recipe Midpoint (H). Calculations were performed using Simapro 8 Software, and the ecoinvent database 3.0.

The environmental impact indicators considered in the study were selected according to ISO 14040, fruit and nuts Product Category Rules (PRC) recommendations, system boundaries, and the data available. The following environmental impact indicators were considered in the study: Climate Change (CCH), Ozone Depletion (ODP), Terrestrial Acidification (TAC), Freshwater Eutrophication (FEU), Marine eutrophication (MEU), Human toxicity (HTX), Photochemical oxidant formation (PHO), Particulate matter formation (PMT), Terrestrial ecotoxicity (TEC), Freshwater ecotoxicity (FEC), Marine ecotoxicity (MEC), Ionising radiation (IOR), Agricultural land occupation (ALO), Urban land occupation (ULO), Natural land transformation (NLT), Water depletion (WDP), Metal depletion (MDP), Fossil depletion (FDP), Demand for non-renewable energy resources (NRE), Demand Renewable energy (RE).

Fruit and nuts PCR fruit is a documents guide published by Environdec (2012) that provides specifications for the assessment of the environmental performance of UN CPC 21494 (Jams, fruit jellies, marmalades, fruit or nut purée and fruit or nut paste) and the declaration of this performance by an Environmental Product Declaration (EPD). PCR are specified for specified information modules "gate-to-gate", called core modules. PCR also provides rules for which methodology and data to use in the full LCA, i.e. life cycle parts up-streams and down-streams the core module.

2.2. Functional unit

ISO 14040:2006 describes the functional unit (FU) as a measure of the function of the system studied and provides a reference to which the inputs and outputs can be related. In this study, in order to compare the results obtained according to yield a variations over the years, a mass-based functional unit was chosen, so the FU for this study is defined as the production of one kg of fruit considering the stages of the whole production cycle: cultivation, distribution, consumption, and final disposal.

2.3. Orchard design

Both orchards (apple and peach) studied in this work apply integrated fruit production, and are located in the North West Catalonia region, located in North East Spain. . The apple specie cultivated is *Malus Dometica* with average yield of 48.81 tons/ha. The peach specie cultivated is (Prunus persica L) with average yield of the orchard is 36.78 tons/ha.

2.4. System boundaries

Fig. 1 shows the boundaries of the system analysed and the stages considered. The study considered the entire production cycle, including the following stages: agricultural, retail, consumption and disposal.

2.4.1. Agricultural stage

Agricultural stage includes the following tasks: soil preparation and plantation, fertilisation plus irrigation (fertigation), pest management, weed mowing, pruning, and harvest. The nursery stage was excluded, mainly due to the lack of reliable data regarding this phase of fruit-growing. For all these tasks, the following inputs were considered: production of fertilisers and their application to the field, pest management substances manufacture and their application (fungicides and insecticides), machinery manufacture and implements used with their transport to the orchard, water use, energy use (from irrigation pumps and input manufacturing).