Life-cycle assessment of chestnut produced in the north of Portugal

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Abstract

This article compares the environmental impacts of fresh and frozen chestnut produced in Portugal (for exports and national consumption). A life-cycle model and inventory was implemented for chestnut cultivation, processing and packaging, distribution, retail and final preparation for consumption. Climate change (CC), terrestrial acidification (TA), freshwater eutrophication (FEW) and marine eutrophication (ME) were analyzed. The cultivation stage presented the most significant contribution to the environmental impacts of both fresh and frozen chestnut (from 43% in CC to 98% in ME). The results showed the importance of improving resource management practices at the cultivation stage, namely an efficient use of fertilizers and fossil fuels, together with increasing chestnut yields, reducing the environmental impacts of both fresh and frozen chestnut.

1. Introduction

Portugal was the third largest producer of chestnut in Europe and the seventh worldwide in 2013, with an annual production of 24.7 thousand tons, and an orchard area of 35 thousand hectares [1, 2]. The north of the country represented 84% of production and 88% of the chestnut orchard area [2]. Roughly 70-75% of Portuguese chestnuts are intended for exports, essentially to Italy, Spain and traditional markets of Portuguese emigration (France and Brazil) [3].

The Life-Cycle Assessment (LCA) methodology has been applied to multiple agricultural products; however, as far as the authors are aware, only a few LCA studies have been done for chestnuts [4, 5, 6].

2. Life-cycle model and inventory

The functional unit chosen for this study was 1 kg of chestnut kernel at consumer (including storage and final preparation at household). A cradle-to-plate analysis was performed. The system boundaries are presented in Figure 1. Two producers from northern Portugal were analysed: P1 (881 kg ha^{-1}, 92 ha, year 2011) and P2 (1048 kg ha^{-1}, 7 ha, 2010 to 2012). The main agricultural processes were soil management, fertilization, pruning, pesticide treatments and harvesting.

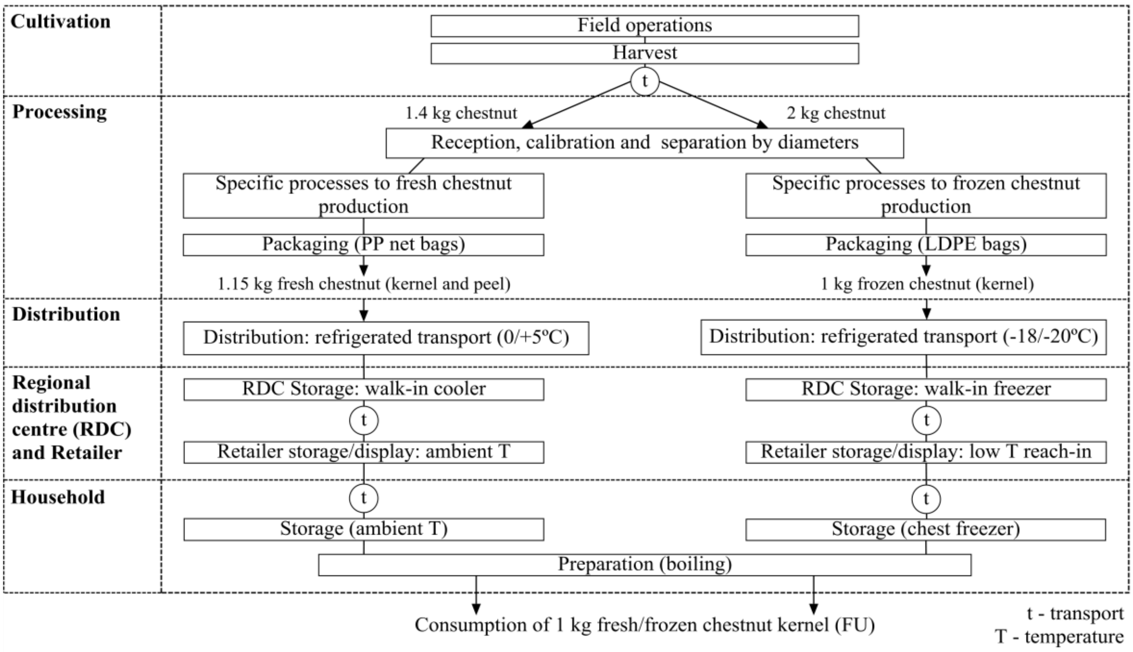

Figure 1 – Fresh and frozen chestnut production chain.

Fresh and frozen processing lines were studied. Data was collected from an industrial unit in Portugal. Processing starts with reception, calibration and separation of chestnuts by size. Frozen chestnuts were peeled, sorted, frozen and packed; while fresh chestnuts were sterilized, sorted and packed. Two kg of harvested chestnut were required to produce 1 kg of frozen chestnut (kernel) while 1.4 kg of harvested chestnut were required to produce 1.15 kg of fresh chestnut (kernel and peel). Frozen chestnut was packed in 1 kg LDPE (low density polyethylene) bags and fresh in PP (polypropylene) mesh bags.

It was assumed that the main national distribution (refrigerated) was to Lisbon (truck) and exports were to France, Italy (truck) and Brazil (ship). Transport from the factory to a distribution center (RDC) and to the supermarket was included, as well as energy requirements with refrigeration. As for the household stage, consumer transport from the supermarket to the household, energy consumption with storage and cooking were considered. Secondary data was also collected or calculated, namely emissions from fertilization [7, 8], ancillary material and energy production [9, 10], agricultural operations [11], combustion of propane [12], production of packaging materials [13, 14] and transportation [15].

3. Results and discussion

Climate change (CC), terrestrial acidification (TA), freshwater eutrophication (FEW) and marine eutrophication (ME) were analysed (ReCiPe V1.07/Midpoint-H method) as these are tipical impact categories in fruit LCA [16]. The cultivation stage presented the most significant contribution for the environmental impacts of both fresh and frozen chestnut (from 43% in CC to 98% in ME). Cultivation impacts derived mostly from diesel requirements (41% for P1) and fertilizer use (58% for P2). Frozen chestnut presented higher environmental impacts than fresh, in all impact categories (from 24% for TA to 36% in CC), mainly due to higher losses of frozen chestnut at the processing stage and higher energy requirements due to frozen storage (factory, retailer and household).

Chestnut distribution to Rome by truck presented the highest life-cycle impacts in three impact categories, not only because of the distribution itself (truck had higher impacts than ship), but also because the electricity mix in Italy had higher environmental impacts, except for FWE, in which the highest impacts were calculated for Lisbon, mainly due to electricity consumption in household stage (the Portuguese mix had a higher impact on this category).

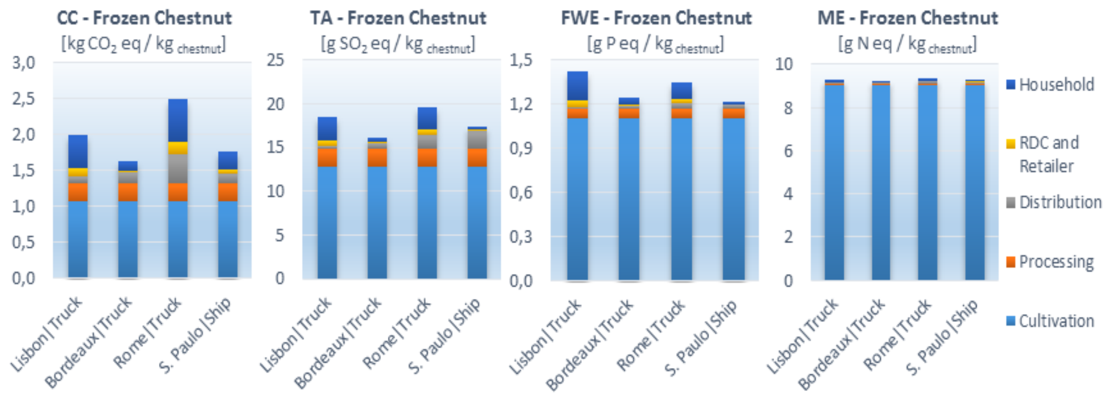

Figure 2: Life-cycle environmental impacts of frozen chestnut.

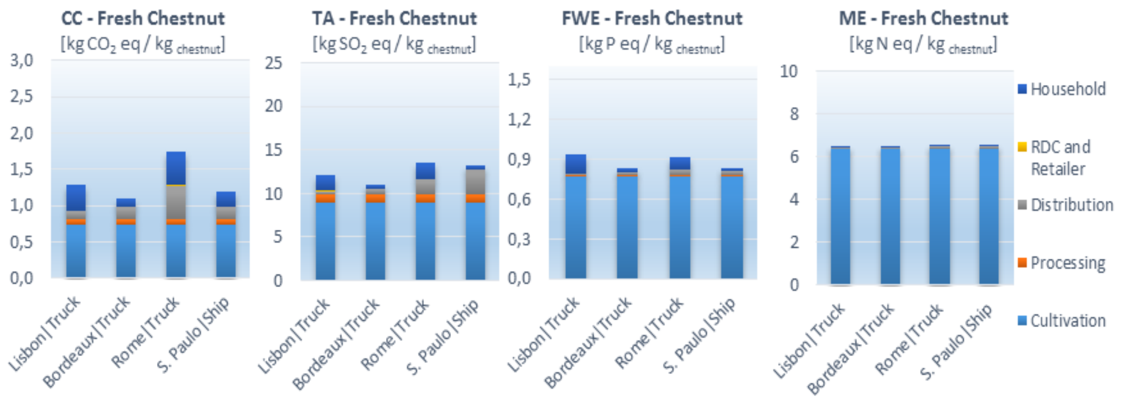

Figure 3: Life-cycle environmental impacts of fresh chestnut.

4. Conclusions

This paper assessed the life-cycle environmental impacts of fresh and frozen chestnut produced in the north of Portugal and distributed for consumption in and outside Portugal. The cultivation stage presented the most significant contribution to the environmental impacts of both fresh and frozen chestnut (mostly due to diesel requirements and fertilizer use). Frozen chestnut presented higher impacts than fresh, in all impact categories, mainly because of higher losses of the processing of frozen chestnut as well as the additional energy requirements with refrigeration (factory, retailer and household). The results showed the importance of improving resource management practices at the cultivation stage, namely an efficient use of fertilizers and fossil fuels. Additionally, increasing chestnut yield is critical to reduce the overall impacts, followed by the minimization of chestnut losses in the processing of harvested chestnut to fresh and frozen chestnut.

5. References

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