Exploring the carbon footprint of different vegetable choices in Aruba, a food import dependent island

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Rationale and objective

Aruba is an island in the Dutch Caribbean that is nearly import-dependent for their food supply. We aim to give insight into low-carbon vegetable import strategies for Aruba by modelling the carbon footprint of a selection of vegetables imported to Aruba. As islands are not situated on main maritime transport routes, we calculated the maritime transport phase with a high level of detail. We first made an overview of the carbon footprint of a selection of vegetables imported to Aruba. Then, we explored the carbon footprint of one package of tomatoes from Mexico more in-depth. We aim to give insight into the contribution of different life cycle stages, and the changes in the carbon footprint of Mexican tomatoes when more accurate data is used.

Approach and methodology

Selection of vegetables. Vegetables were selected by their weight contribution to the total vegetable category in Trademap import statistics from 2017 – 2019 (International Trade Center, 2020). Countries of origin were determined via Trademap and by visiting two large supermarkets in Aruba.

LCA methodology. The functional unit is one kg product at the supermarket in Aruba. The system boundaries are from farm in country of origin until arrival at the supermarket in Aruba. This includes agriculture (incl. land use change), processing, packaging, losses (post-harvest and distribution) and chilled road/sea/air transport. Greenhouse gas emissions (GHGs) were calculated using the characterization method IPCC 2013 (100a). We used three different LCA databases: the meta-analysis "LCA of food & drink products" from Poore (2018) as the basis, Agri-footprint version 4.0 for data on sea transport, and Ecoinvent version 3 for data on cooling during transport.

Agriculture. When data from a specific country of origin was not available in Poore (2018), all neighboring or the most nearby countries were selected as a proxy. For example, there was no data on tomatoes from Mexico and we selected the United States as a proxy. We did not consider differences in climate or agricultural practices. We used the proxy to calculate agriculture, processing, and packaging. Losses and transport were determined based on the country of origin.

Road transport. Road transport in the countries of origin was determined for each combination of vegetable and country of origin. The locations were determined by the geographic locations mentioned in Poore (2018). When no geographic location was mentioned, we assumed the location of other studies of the same product and country combination. When this was not possible, we assumed that the geographic location was similar to that of all other vegetables from the country of origin. Upon lack of data, we calculated the distance from the center of the country. Distances for road transport were determined with Google Maps, based on the fastest route. We assumed that all countries used cooled road transport. We multiplied the time needed for cooling with two to account for the driver's rest periods. Cooled road transport in Aruba was assumed to be 15 km.

Sea transport. Sea transport was mostly determined via the schedule of CMA CGM, one of the largest container shipping companies (AXSMarine, 2022). Their schedule shows duration, place(s) of transshipment, shipping lines, and vessel names (CMA CGM, 2022b). Data on distances between ports was obtained via the CMA CGM Eco Calculator (CMA CGM, 2022a). Data on the size of the ships was obtained via www.marinetraffic.com, expressed as summer deadweight tonnage (DWT). Often at least one transshipment was required to import products to Aruba. We assumed that larger container ships (> 13,000 DWT) were sailing at a load factor of 100% and smaller container ships used for the last transshipment to Aruba at a load factor of 80%. For these smaller ships we also assumed 'empty return', as Aruba has limited exports. The transport routes from Cartagena and Barranquilla in Colombia were based on a schedule from Caribbean Feeder Services (2022). GHGs were determined based on the DWT, load factor, distance sailed, and possible empty return.

Air transport. Distances were determined with www.airmilescalculator.com. No distinction was made between freight airplanes and freight transported by passenger airplanes. We assumed that no cooling was needed, according to the methodology of Poore (2018).

Losses. We assumed losses for post-harvest handling and for distribution. We assumed that post-harvest losses occurred at the farm, and that products were packaged afterwards. To determine the quantity of post-harvest losses we used an average of 2009-2011 from FAOSTAT, as provided in Poore (2018). For losses during distribution we used data from Gustavsson et al. (2013), as provided in (Poore, 2018). This data was based on FAO's Food Balance Sheets from 2007. We assumed that half of the losses during distribution occurred during road transport and half of the losses during sea or air transport. We accounted for the weight of the losses and of the packaging of the losses. We did not include the end-of-life treatment of losses.

In-depth analysis of Grape tomatoes from Mexico. During one of the supermarket visits we observed a package of Mexican Grape tomatoes from a brand from the United States, from now on referred to as brand A. The traceability code and information on the package allowed us to calculate the carbon footprint of this package in more detail, compared to the overview of the different vegetables. We will now describe how we adjusted the data from the overview. Proxies: In the overview we selected six data points from Poore (2018) for tomatoes grown in the United States. Now we only selected data points that reflected the production characteristics of these specific tomatoes: non-organic and open field. We also only used data points from California, as this state is situated adjacent to Mexico. We used two data points, from Brodt et al. (2013) and Nemecek et al. (2011). Road transport: We based the road transport on specific addresses. The tomatoes came from a farm in Sinaloa (Mexico) and were transported uncooled to the packaging facility in Sinaloa. At the packaging facility they were sorted, cleaned, packaged, and cooled. One or two days later the tomatoes were transported to the distribution center in Arizona (United States), this takes a bit less than one day (brand A, personal communication, June 7, 2022). The traceability code showed that the tomatoes were transported to the distribution center in a container, by a company from the United States. Therefore we assumed that the truck complied with fuel emission standards EURO6 of the United States (TransportPolicy.net, n.d.). Then, the tomatoes were transported for about three days to a consolidator in Florida (Consolidator, personal communication, June 7, 2022), and finally shipped to Aruba. Storage: The traceability code showed that the tomatoes were available to consumers in Aruba five weeks after packaging. We estimated that all cooled road transport took about one week. Sea transport also took approximately one week. Therefore, the tomatoes were stored in distribution centra in the United States for a duration of three weeks. We used the methodology as described in Asselin-Balençon et al. (2020) to take this into account.

Results and discussion

Selection of vegetables. We selected the following vegetables: potatoes (18% weight contribution), lettuce (10%), onions (10%), and tomatoes (8%). This is ~47 wt% of all vegetable imports to Aruba in 2017-2019. We also selected green beans as an interesting case study, as we noticed that they can be flown in from Kenya via the Netherlands or shipped to Aruba by sea from the United States. We identified 12 different countries of origins for all vegetables. Origins of selected products, proxies used, and carbon footprints are shown in Figure 1. We used proxies for eight out of 22 product-country combinations. Mostly, we used proxies for countries in Latin America. Although proxies were also used for green beans from the United States and onions from Canada.

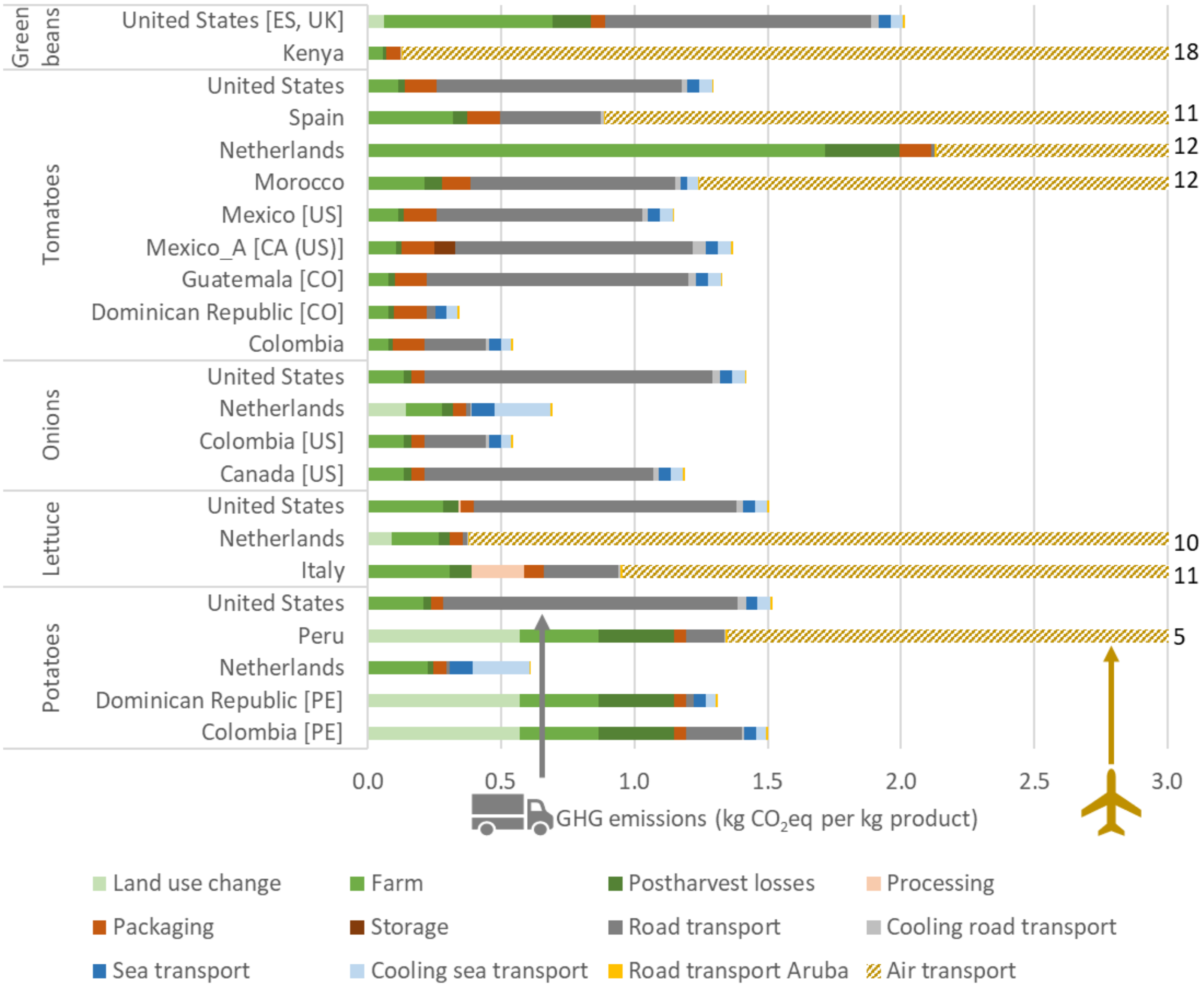

Figure 1 Greenhouse gas emissions of products from different countries of origin imported to Aruba. Losses during distribution and packaging of losses are included in the respective life cycle phases. All results from flown-in products did not fit on the y-axis and are depicted by a number. Mexico_A depicts results from the in-depth analysis of Mexican tomatoes from brand A. The 2 letter codes represent the proxies: California [CA, (US)], Colombia [CO], Spain [ES], Peru [PE], United Kingdom [UK], and the United States [US].

GHGs. Products imported by air transport had significantly higher GHGs (4.8 – 18.1 kg CO_2eq per kg) than products imported by sea (0.3 – 2.0 kg CO_2eq per kg), due to the relatively high GHGs emitted during airfreight. This was also found by Frankowska et al. (2019) who conducted an LCA on imported vegetables to the United Kingdom. Sim et al. (2007) found that air transport contributed for 89% to the carbon footprint of importing French beans from Kenya to England. In our study the air transport of green beans from Kenya contributed for 99% to the total GHGs. Although sea transport was calculated with detailed information on maritime transport routes and ship characteristics, it usually was not one of the life cycle stages that contributed most to the overall GHGs. Except for onions and potatoes from the Netherlands, which were shipped in chilled reefer containers for about one month. For most products that were not flown in, the road transport contributed mostly to the GHGs. Except when GHGs from agriculture were relatively high, such as for potatoes from Peru, the Dominican Republic, and Colombia. GHGs due to road transport were especially high for products from the United States, Morocco, Mexico, Guatemala, and Canada. For vegetables from these countries the fastest shipping route to Aruba was via Port Everglades in Miami, which resulted in a long road transport.

Lessons learned from the in-depth analysis of Grape tomatoes from Mexico. We drafted three lessons learned from the in-depth analysis of Grape tomatoes from Mexico. First, calculating actual road transport routes did not significantly increase the carbon footprint due to road transport for these tomatoes, even when the road transport increased with about 1400 km. However, it is still important to calculate road transport as accurately as possible for vegetable imports to Aruba, as this life cycle stage contributes a lot to the carbon footprint. Globally, transport was estimated to contribute for 9% to the carbon footprint of tomatoes (Poore & Nemecek, 2018). While for Mexican tomatoes from brand A transport contributed for 78%. Second, it is important to consider cooled storage, even when storage contributed only for 6% to the carbon footprint of Mexican tomatoes from brand A, which were stored for about three weeks. GHGs due to storage can increase a lot for products which are stored for a longer time, such as potatoes and onions. This might be even more important for cooled storage in Latin American countries due to the warmer outside temperature. Finally, for the tomatoes from brand A, the GHGs in the agricultural phase did not change a lot upon more accurate information. However, we need to see how this would affect the in-depth analysis of other product and country combinations to know how significant this step is.

Planning future research. To give insight into low-carbon vegetable import strategies for Aruba we have the following recommendation in terms of scope and methodology. We recommend broadening the scope by assessing several impact indicators and by extending the countries of origin included in the research, if applicable. We expect that by visiting more supermarkets more frequently, more countries of origin can be observed. Pictures of products should be taken to gain more information about production methods, brands and related locations, and possible traceability codes. We envisage to improve the methodology by including the following aspects: 1. Make a distinction between the use of passenger airplanes and freight airplanes. As nearly all foods imported to Aruba are imported by passenger airplanes. 2. Gaining more insight into GHGs emitted in the agricultural stage by finding more recent articles and by gaining insight in land use change per country and when possible, per region. Current articles used in this analysis ranged from 2006 – 2015. These also did not include the seasonality of the carbon footprint which is especially important for products produced in heated greenhouses. 3. Introduce Data Quality Indicators to compare the reliability of different results. 4. Add cooled storage for all products.

Conclusion

Vegetables that were imported to Aruba by sea rather than air have the lowest carbon footprint, due to the relatively high GHGs of airfreight. The carbon footprint was even lower when significantly less road transport was required. To give insight into low-carbon vegetable import strategies for Aruba we plan to further expand the scope and methodology of this research.

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