Food loss Solutions

Augustus 2024

Target-Measure-Act: Less Food Loss and Waste in Dutch blueberry supply chains

The growing recognition of the economic, social, and environmental consequences of Food Loss and Waste (FLW) has spurred a call to action among and in cooperation between stakeholders in the food system. The United Nations (through SDG 12.3) and the EU (through the Waste Framework Directive and the CSRD reporting directive) fully support reducing FLW. However, the question remains: Where should your company begin? This factsheet serves as a steppingstone in embracing the Target-Measure-Act approach. The information and statistics presented in this factsheet aim to empower you to target FLW in your food supply chain and formulate your objectives accordingly.

This factsheet presents the blueberry supply chain, the FLW percentages in the main supply chain stages, its destinations and impacts, and the causes and possible interventions to support FLW reduction through the Target-Measure-Act approach.

Blueberry market

The Netherlands produced 8.1 kiloton fresh blueberries in 2022 (*Vaccinium corymbosum*) [1], with a total of 780 hectares of land allocated to their production in 2023. The total acreage declined with 15% since 2020, after years of growth [2].

Dutch blueberries are mainly harvested and consumed between June and September [3]. However, the Netherlands does also import a large volume of blueberries. In 2021, the Netherlands imported 20.1 kiloton of blueberries [4] (see Figure 1). Imports of this group to the Netherlands come mainly from the continents of South-America (66% of total import volume), Europe (22%) and Africa (11%), and the main countries include Peru, Chile, South-Africa and Spain [5]. A significant portion – 82% of the blueberries produced in the Netherlands and imported to the Netherlands - is exported to neighbouring countries, especially within the European Union

Figure 1 Import and export of blueberries in the Netherlands (2021).[1] Source [4].

1 These numbers are the most recent national statistics published.

Table 1 Sample size, and FLW percentage + standard deviation for blueberries.

Supply chain stage (simplified)	**Primary production**	**Export** in-country handling	**Import** handling & distribution	**Retail**
SIFAV data 2022	4.4% ± 5.1% N = 8	3.1% ± 5.2% N = 3	7.1% ± 9.1% N = 5	Less than 3 datapoints
SIFAV data 2023	5.5% ± 4.5% N = 5	Less than 3 datapoints	2.7% ± 2.0% N = 3	Less than 3 datapoints
Literature	10.0% N = 2	5.2% N = 3	N/A	N/A

* This number includes default data, as provided by the Sustainability Initiative Fruit and Vegetables (SIFAV).

(mainly to Germany (40% of total volume), Belgium (7%) and Poland (5%)) [5]. This shows the pivotal role of the Netherlands in the distribution of fruits and vegetables to the rest of Europe. In comparison, the Netherlands imported 1.8 kiloton of currants, redcurrants and gooseberries in 2021, with a total value of 9.9 million euro, and exported 5.4 kiloton of those berries and currants with a total value of 45 million euro [4].

Blueberries are among the top 5 fruits and vegetables in terms of their import value in the Netherlands [6], accounting for around 0.9% of the total import value of fruits and vegetables [7]. In the context of global trade, the Netherlands is the second largest importer of blueberries, after the USA, and the Netherlands accounts for 11% of the total export weight worldwide [5, 8]. These substantial import and export volumes come with potentially significant Loss and Waste along the supply chain, underscoring the importance of addressing FLW.

FLW in the international blueberry supply chain

The blueberry supply chain consists of multiple actors that all add value to the product, for example by producing the blueberries, transporting, or providing storage. Every blueberries supply chain link differs, as individual companies are involved who all conduct different activities at their entity. In general, actors in the international blueberries supply chain include growers, exporters, importers and retailers. However, also different types of intermediaries can be active in the supply chain in the exporting countries, and actors can also perform multiple functions, such as being grower and exporter.

The FLW data collection process consisted of an inventory with quantitative templates with questions on produced or processed volumes and losses, its causes and destinations of lost products. The templates were distributed among SIFAV members (importers and retailers), who in turn shared them with their upstream partners. Partners included were growers, exporters and importers. Data collected at the primary production stage include the activities production and harvesting of blueberries, and post-harvest activities on-farm such as sorting and packing. Activities at the export stage include all activities performed after farm gate, prior to shipment, which can include for example packing, storage and transport. The import stage includes all activities from overseas and -land transport, arrival until delivery to the retail distribution centre and can include ripening, sorting, re-packing and delivering. Activities in the retail stage include the storage, transport and sales at the distribution centres and retail outlets. Table 1 shows the average FLW percentages[2] per supply chain stage as collected by SIFAV members[3], and the average FLW percentages found in literature. The blueberries production and export countries included in the sample of SIFAV (2022) were Chile, France, Germany, the Netherlands, Poland and Serbia. The production and export countries included in the sample of SIFAV (2023) were Germany, the Netherlands, Poland and Serbia.

The data of FLW in the blueberry supply chain is limited. For primary production, the data from SIFAV (2023) is in line with the literature. The data reported in SIFAV (2022) is slightly lower. Beausang et al. (2017) reported a berry loss of 5%, while Neff et al. (2018) reported berry losses of 15%. The latter also included unharvested berries [9, 10]. At the export stage, the reported percentage of 3.1% is in line with the data found in literature (5%) [11, 12]. Literature data for FLW incurred at the import- and retail supply chain stages are absent.

2 This factsheet uses the FLW definition of FAO (2019). FLW refers to the decrease in quantity or quality of the edible portion of raw, semi-processed or processed food intended for human consumption that is redirected to other non-food uses or productive use. Productive use includes animal feed, industrial use, and other uses. Deviating from the FAO (2019) definition, feed is reported as being FLW in the SIFAV data.

3 Please be aware that the reliability of the SIFAV data presented in this factsheet is constrained by the sample size at each supply chain stage.

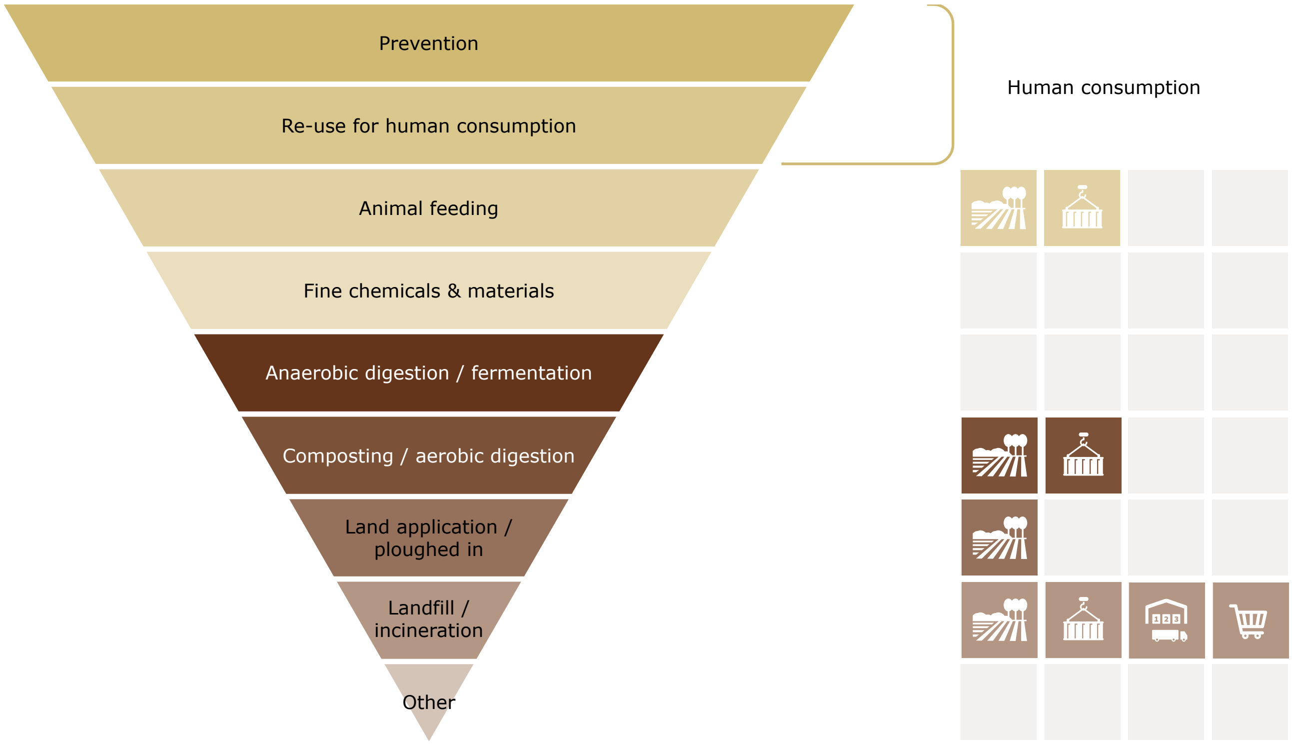

Figure 2 Destinations of discarded blueberries. The visualisation is based on 'Moerman's Ladder', which ranks the value of valorisation options from high to low. The icons correspond with the supply chain stages, and the presence of an icon indicates that at least one actor mentioned this category as a destination of discarded blueberries. Source SIFAV (2022).

Destinations of FLW in the blueberry supply chain

Blueberries not suitable for human consumption are rejected, become part of the FLW side stream, and need a new destination other than human consumption. Figure 2 shows the destinations of these rejected blueberries as reported by SIFAV (2022). In the primary production and export supply chain stages animal feed is used as destination for the blueberry side streams. Besides the destination animal feed, other destinations for the blueberry side streams are reported, such as composting, land application/ ploughed in and landfill/incineration. At the import and retail supply chain stages only the destination landfill/incineration is reported. The reported destinations are based on a limited number of data entries, so the results below might not present a complete overview of destinations for blueberry side streams.

Greenhouse gas impact of blueberry FLW

FLW does not only have a negative effect on economic factors, but also on social and environmental factors such as food security and climate change. As an example of environmental impact, the FLW associated greenhouse gas (GHG) emissions for the Dutch blueberries import and distribution are presented here, covering the activities primary production, transportation (from the country of origin to retail), and packaging. The primary production and transportation related emission factors are origin-dependent. Therefore, the FAO detailed trade matrix was used to determine the countries of origin, including a correction for re-export among European countries, for the blueberries imports to the Netherlands. From this import profile, an average emission factor for the primary production, export and import stages result. For distribution towards retail the volume for domestic consumption and the export volumes to various countries are used as input for the average emission factor for the retail chain stage. The packaging emission factors were derived from literature.

The resulting FLW attributed GHG emission factors for the blueberries imported to the Netherlands based on SIFAV data are given in Table 2. The emissions per kg product increase to the end of the supply chain. In other words, one kg product wasted at the retail sector contributes to a larger extend to GHG emissions compared to one kg product lost at primary production.

Table 2 Impact factors in kg CO_2-equivalents per kg blueberries along the blueberries supply chain for the Netherlands.

Supply chain stage (simplified)	Primary production	Export: in-country handling	Import: handling and distribution	Retail
FLW associated kg CO_2-equivalents per kg of blueberries	0.54	0.97	1.02	1.19

The average SIFAV FLW percentages from Table 1 for the chain stages primary production and import and the SIFAV FLW percentage from Table 1 for the export stage are applied to the import and domestic production volumes of the Netherlands. Converted to impact, the chain stage division in CO_2 footprint as in Figure 3 results for the first three chain stages. Since there is no estimate of the discarded blueberries at the retail available the impact of these losses could not be determined. With the highest FLW % in the import chain stage, discarded blueberries in this stage of the supply chain contribute the most to the GHG emissions along the upstream chain.

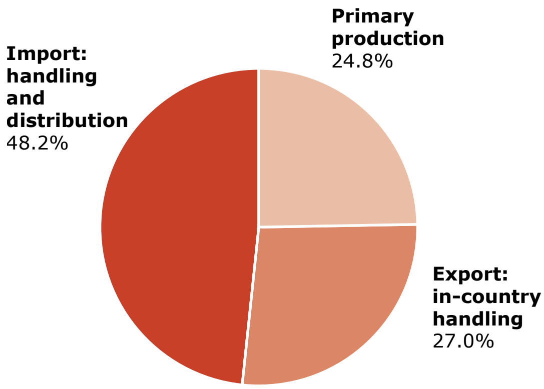

Figure 3 Division of FLW associated GHG emissions along the supply chain for the Dutch blueberries import volume.

Causes of FLW in each supply chain link

Table 3 shows the causes of FLW for blueberries in the international and national supply chain, per supply chain stage. As blueberries are a perishable food item, most causes are generic and also applicable to a variety of other perishable food items. In the country of origin, the main root causes of food losses for blueberries include lack of pre-cooling, uncareful handling and interruptions in the cold chain. The root causes of blueberry discards at import and retail include rejection due to moisture loss, and pathogens and rots.

Table 3 Causes of FLW in each supply chain link. Cause categories are provided in brackets.

Supply Chain Link	Causes of FLW
Primary production	• Quality of blueberries depend on cultivation practices, such as irrigation, fertilization and crop protection measures (poor production practices leading to suboptimal starting quality for the product at harvest) • Harvest frequency too low while blueberries need to be picked when at a near to full ripe stage (limited harvest window) [13, 14] • Harvesting and post-harvest handling cause loss of bloom wax on blueberries (poor harvesting and post-harvest practices) [15] • Insufficient pre-cooling directly after harvest (lack of infrastructure for efficient logistics) [15] • Fungus, insects, bacteria and birds (pest damage or disease infections) [16]
Export: in-country handling	• Handling, such as grading, sorting and packaging must be done carefully to avoid bruising and other damage to the blueberries, including the use of clean and suitable materials at all times (damage due to inadequate packaging) • Poorly managed temperature settings and variations in temperature along the cold chain can cause condensation resulting in the growth of microorganisms and pathogen (temperature and relative humidity) [12, 15] • Product not meeting specifications due non-uniform appearance/size, over-maturity, rot or bruises (non-conformance with export standards)
Import: handling and distribution	• Moisture loss (shrivelling) which downgrades pallets being underweight on arrival at the destination (moisture loss) (quality rejection at arrival) [15] • Moisture loss in itself may result in substantial weight loss/ food loss • Temperature and relative humidity setting resulting in diseased fruit and pathogens (inadequate conditions during transit)
Retail	• Progressive defects; shrivelling and rot (inventory management) • Lower product turnover during parts of the year (prize, seasonality) (consumer preferences)

Interventions to prevent and reduce FLW

Potential interventions for FLW reduction for blueberries, per supply chain stage, are provided in Table 4. The interventions are classified into three categories: hardware, software and orgware[4]. Addressing all three categories ensures a comprehensive approach to developing strategies to decrease FLW. Most potential interventions presented can be implemented in all type of international and national fresh fruit supply chains. Main interventions to tackle the root causes of FLW for blueberries include harvesting frequency, pre-cooling and careful handling in the country of origin, and using the right temperature settings at the import stage of

4 Hardware, software and orgware interventions = Hardware interventions refer to the physical assets that are needed to adequately handle and preserve the product throughout the chain. Software interventions are related to the skills, knowledge and communication that guide daily operations and decision-making. Orgware interventions relate to the organisational aspect, being about the roles and responsibilities throughout the chain [17].

Table 4 Potential interventions for FLW reduction per supply chain link. Source: Literature and expert consultation.

	Hardware	Software	Orgware
Primary production: growth	• Spray with sufficient air support to protect all crops against pests and diseases	• Good Agricultural Practices (GAP) to increase the growth and quality of the product. • Farm management software based on real-time data to assure optimal growth • Plant blueberry plants at the proper depth	• Timely supply farm input to assure optimal growth and quality
Primary production: harvest & post-harvest	• Use of stackable, intact and clean field crates • Use of good, clean and sufficient materials (gloves, shaded harvest trolleys, harvest brushes (to facilitate harvest) • Shaded collection at pathways and sufficient capacity to collect the harvested fruit with limited intervals (30 minutes) to bring to packhouse and start cooling	• SOP) to maintain the quality of the product • Trained staff to maintain quality during harvesting and handling • Hand-picking of blueberries to offer the highest quality and the lowest occurrence of bruising or mechanical injury • Data registration software to improve transparency in the supply chain, so other actors can act when a low-quality batch arrives • Harvest blueberries at a near to full ripe stage • Pre-cooling as quick as possible after harvest • Stack and tighten the pallets/field crates during transport	• Deploy outlets or utilization pathways for harvested products not fit for export to match supply and demand volumes • Harvests should take place every 3 to 9 days for a few weeks to increase homogeneous quality and reach higher berry firmness
Export: in-country handling	• Trucks for transport to packhouse to minimize bumping and manage the capacity • Cleanable packhouse with hygienic conditions (hand washing) to reduce risks of pests and diseases • Forced-air precooling and cooling in packhouse to reduce quality decay • Cooled handling space (5C) to avoid condensation on the product and warm clothes for workers • Air humidification and liners to maintain relative humidity and therefore the quality of the product • Grading and sorting machines equipped with vision systems to automatically detects and remove quality issues • Transit settings following system to monitor and adapt settings during oversea transport	• Post-harvest handling Standard Operation Procedure (SOP) to maintain the quality of the product • Training of staff to maintain quality during handling • Hygiene- and cleaning protocol to reduce risks of pests and diseases • Temperature and relative humidity measurement in cold storage and packhouse to correct settings and maintain the quality of the product • Use of climate-controlled loading dock via cold tunnels into the reefer to prevent ambient air entering the pre-cooled reefer container to avoid condensation.	• Timeslots for packhouse delivery to decrease waiting time at arrival
Import: handling and distribution	• Demand and forecasting technology to match supply and demand • Automatic side-stream monitor system to understand the causes and act upon it the next time • Modified Atmosphere package (MAP)	• Compatibility, temperature and ethylene management in the warehouse to avoid over-ripening • Efficient and quick quality checks to reduce delay and therefore quality decay after reefer delivery	• First-expired-first-out warehouse management system to minimize time in the warehouse for all products • Delivery based on weekly programs with clients to match supply and demand
Retailer	• Quality-based pricing system to sell also the low-quality products • Automatic side-stream monitor system to understand the causes and act upon it the next time	• Compatibility, temperature and ethylene management in the shelfs to avoid over-ripening • Dynamically lower the price when supply exceeds demand to increase the demand	• Revision of the aesthetic standards to lower the rejection of edible food on cosmetic grounds in preceding supply chain links • Promotion of imperfect fruits and vegetables, and products made from ingredients that otherwise would be wasted to increase the demand

the supply chain. Root causes cannot always be tackled by simply investing in one intervention. Often losses found in one part of the supply chain are already caused further upwards in the supply chain. For example, blueberries sorted out at arrival at the importer due to bruises received the bruises due to transport or the packaging that was used in the producing country. Therefore, it is needed to collaborate with other actors in the supply chain to efficiently reduce FLW.

Further readings

Interesting material for further readings for companies, branch organisations, policymakers and other interested stakeholders include:

- Fresh Knowledge: Become a postharvest expert. https://www.freshknowledge.eu/en/knowledge-database/crops/blueberry.htm
- EFFICIENT protocol. Take the "Target, Measure, Act" approach to reduce food waste? Yes, but be pragmatic about it. https://www.wur.nl/en/research-results/research-institutes/food-biobased-research/show-fbr/take-the-target-measure-act-approach-to-reduce-food-waste-yes-but-be-pragmatic-about-it.htm
- The FLW cause and intervention tool. https://the-efficient-protocol.azurewebsites.net/
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Take-home message

Facts and figures

- The percentage of Food Loss and Waste (FLW) in the supply chain of blueberries to the Netherlands from primary production till and including retail cannot be calculated, as the FLW% of blueberry in the retail supply chain stage is lacking. When excluding retail, the total percentage of FLW is 13.4%, with the highest percentage of FLW occurring in the import supply chain stage. Estimated FLW associated greenhouse gas emissions increase from 0.54 kg CO_2-equivalents per kg blueberries at primary production to 1.19 at retail for Dutch imports and domestic production of blueberries.
- The main root causes of FLW for blueberries include lack of pre-cooling, uncareful handling, interruptions in the cold chain, and rejection due to moisture loss, pathogens and rots.
- The main interventions for FLW reduction for blueberries include harvesting frequency, pre-cooling, careful handling, and using the right temperature settings.

Where to begin?

- Implement the target-measure-act strategy and make use of the tools of the FLW toolbox at www.foodloss-solutions.com.

Concrete actions and targets

- Actions: Set targets for your own organisation and monitor FLW volumes, discuss the causes of FLW, determine reduction strategies, allocate capacity, formulate a business case, discuss challenges with chain partners, and evaluate the results.
- Targets: Connect your targets with the SDGs. Achieving targets is feasible when tackled jointly in the supply chain with support of a wider network of stakeholders.

Acknowledgements

This factsheet is part of the KoM project "Synthesising Food Loss Research Results into Applied Food Loss Reduction Tools", project number BO-43-000-044, financed by the Ministry of Agriculture, Nature and Food Quality, 2022-2024.

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Contact

Do you want to start with the Target-Measure-Act approach to monitor and reduce your Losses and Waste in the Dutch blueberry supply chain? Please do not hesitate to contact us.

Authors: Melanie Kok, Charlotte Harbers, Rene Oostewechel, Martijntje Vollebregt, Wageningen Food & Biobased Research

Project Website FLW Toolbox URL
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