Food loss Solutions

Augustus 2024

Target-Measure-Act: Less Food Loss and Waste in Dutch banana 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 banana 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.

Banana market

Bananas ranked as the most popular fruit among Dutch consumers in the first half of 2021, closely followed by apples and oranges [1]. As this tropical fruit does not grow in the Netherlands, the market is totally dependent on its import.

Imported bananas by the Netherlands come mainly from America (70% of total import) and Europe (30% of total import), and the main countries include Costa Rica and Ecuador [2]. Not all of the imported bananas are actually consumed within the Netherlands. A significant portion – 74% of the total imported volume – is exported after ripening to neighbouring countries, especially within the European Union [2] (Figure 1).

Figure 1 Import and export of bananas in the Netherlands (2021).[1] Source [2].

This shows the pivotal role of the Netherlands in the distribution of fruits and vegetables to the rest of Europe. Bananas are among the top 5 fruits and vegetables in terms of their import value in the Netherlands, accounting for around 8% of the total import value of fruits and vegetables [3]. In the

1 These numbers are the most recent national statistics published.

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

Supply chain stage (simplified)	**Primary production**	**Export** in-country handling	**Import** handling & distribution	**Retail**
SIFAV data	3.8% ± 5.0% N = 11	10.2% ± 3.6%* N = 3	0.1% ± 0.1% N = 6	4.3% ± 5.0%* N = 3
Literature	2.2% N = 3	N/A	N/A	5.7% N = 3

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

context of global trade, the Netherlands accounts for 5% of the total volume of imported bananas worldwide and 4% of their total value [4]. 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 banana supply chain

The banana supply chain consists of multiple actors that all add value to the product, for example by producing the bananas, transporting, or performing ripening. Every banana supply chain link differs, as individual companies are involved who all conduct different activities at their entity. In general, actors in the international banana 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 bananas, and post-harvest activities on-farm such as washing, 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 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 banana production and export countries included in the SIFAV data were Ecuador, Peru, Colombia and Costa Rica.

The reported SIFAV data is in line with the data reported in literature. At the primary production stage, the reported percentage of 3.8% does not differ from the literature value of 2.2% due to the variation in the data [5,6,7]. Literature data for losses incurred at the export and import stage was not found. At the retail stage, the reported average of 4.3% is comparable to the average found in literature, which is 5.7% [5,7,8].

Destinations of FLW in the banana supply chain

Bananas 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 bananas as reported in the SIFAV inventory. In the primary production and export supply chain stages animal feed is used as destination for the banana side streams. However, part of their banana side streams are also used for land application, landfill and other. At the import and retail supply chain stages the banana side streams are only used for anaerobic digestion or landfill.

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 unless diverted to productive use. Productive use includes animal feed, industrial use, and other uses such as fertiliser and ground cover. Deviating from the FAO (2019) definition, animal feed and land application/ ploughed in are 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.

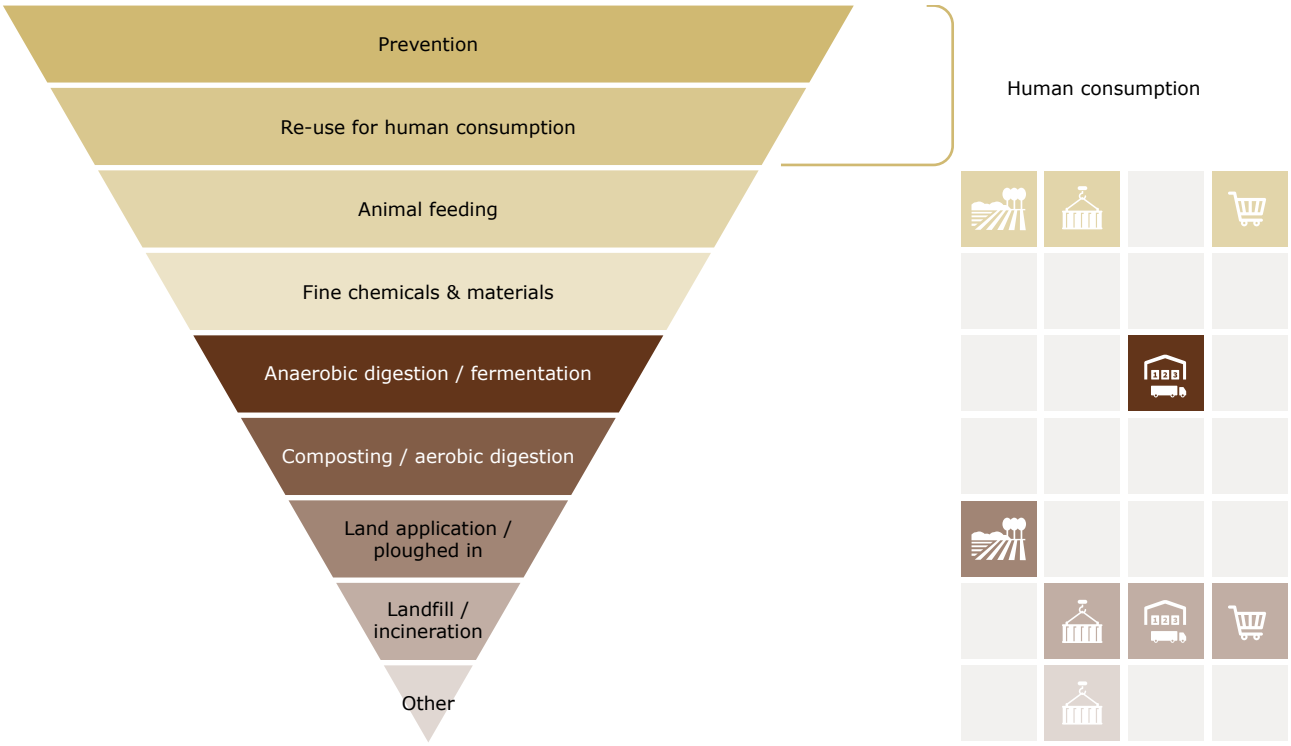

Figure 2 Destinations of discarded bananas. The visualisation is based on 'Moerman's Ladder', which ranks the value of valorisation options from high to low. The icons correspond with the supply chain stages, and the presence of an icon indicates that at least one actor mentioned this category as a destination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

Greenhouse gas impact of banana 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 banana 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 banana 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 bananas 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 bananas along the banana 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 bananas	0.31	0.52	0.67	0.82

The FLW percentages from Table 1 are applied to the banana volumes of the Netherlands. Converted to impact, the chain stage division in CO_2 footprint as in Figure 3 results. With the highest FLW % in the export chain stage, discarded bananas in this stage of the supply chain contribute the most to the GHG emissions along the chain.

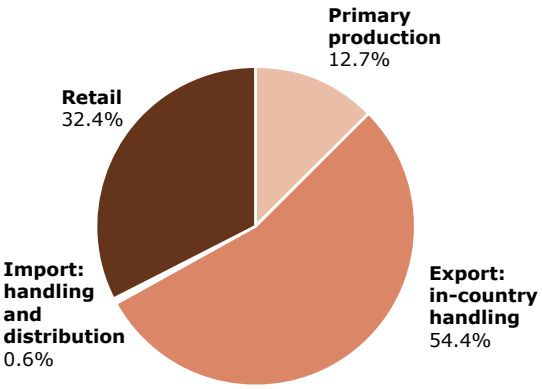

Figure 3 Division of FLW associated GHG emissions along the supply chain for the Dutch banana import volume.

Causes of FLW in each supply chain link

Table 3 shows the causes of FLW for bananas in the international supply chain, per supply chain stage. As bananas are a perishable food item, most causes are generic and also applicable to a variety of other perishable food items. In the primary production stage, the main root causes of FLW for bananas include pest damage, damage from weather events, cosmetic defects and inappropriate use of packaging. Main root causes of banana waste further up in the supply chain include rejection due to maturation.

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

Supply Chain Link	Causes of FLW
Primary production	• Planting distance to avoid mutual shading and overlapping of root zones, and use of water and fertilization (poor production practice leading to suboptimal product starting quality at harvest) • Selection of limited export varieties (limited harvest windows, leading to over- supply during peaks) • Bruises due to rough handling (poor harvesting and post-harvest practices [9]) • Bruises due to bumpy roads (Lack of infrastructure for efficient logistics) • Black Sigatoka (pest damage or disease infections [9])
Export: in-country handling	• Scuffing of bananas (damage due to inadequate packaging) • Mixed loads with suboptimal conditions (temperature and relative humidity) • Too large or too small sizes (non-conformance with export standards)
Import: handling and distribution	• Yellow bananas due to inadequate maturity stage at harvest or wrong temperature settings during shipment (quality rejection at arrival) • Too high concentrations of ethylene causing overripening (inadequate conditioning during transit)
Retail	• Overstocking or suboptimal storage conditions (inventory management [9]) • Oddly shaped or overripe yellow-brownish bananas (consumer preferences [9])

Interventions to prevent and reduce FLW

Potential interventions for FLW reduction for bananas, 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 fresh fruit supply chains. Main interventions to tackle the root causes of FLW for bananas include pest-preventing measures and appropriate packaging in the country of origin, and a careful controlled ripening process to avoid over-ripening at the import stage of 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, bananas 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.

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

	Hardware	Software	Orgware
Primary production: harvest & post-harvest	• Cable system/bins/crates/foam protection to reduce bumping	• Post-harvest Standard Operation Procedure (SOP) maintain the quality of the product • Trained staff to maintain quality during handling • Knife- and cutting wire disinfection protocol to reduce risks of diseases • Data registration software to improve transparency in the supply chain, so other actors can act when a low-quality batch arrives	• Deploy outlets or utilization pathways for harvested products not fit for export to match supply and demand volumes
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 • Air humidification and bananavac liners to maintain relative humidity and therefore the quality of the product • Forced-air precooling to maintain the quality of the product • 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 • Chlorine (dump tank water) and post-harvest (temperature and relative humidity) measurements to correct settings and maintain the quality	• Timeslots for packhouse delivery to decrease waiting time at arrival
Importer	• 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	• A careful controlled ripening process to avoid over-ripening • 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

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 [10].

Further readings

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

- Fresh Knowledge: Become a postharvest expert. https://www.freshknowledge.eu/en/knowledge-database/crops/banana.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/
- Broeze, J. (2019). Agro-chain greenhouse gas emissions (ACE) calculator. Wageningen, the Netherlands: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Agro-Chain Greenhouse Gas Emissions (ACE) calculator (cgiar.org)
- Guo, X., Broeze, J., Groot, J. J., Axmann, H., & Vollebregt, M. (2020). A worldwide hotspot analysis on food loss and waste, associated greenhouse gas emissions, and protein losses. Sustainability, 12(18), 7488.
- Oostewechel, R. J. A., Verschoor, J. A., da Silva, F. P., Hetterscheid, S., & Castelein, R. B. (2022). Postharvest Assessment Methodology: conceptual framework for a methodology to assess food systems and value chains in the postharvest handling of perishables as a basis for effective interventions (No. 2359). Wageningen Food & Biobased Research. Concept note for a Postharvest Assessment Methodology (wur.nl)
- Soethoudt, J. M., Pedrotti, M., Bos-Brouwer, H. E. J., & Castelein, R. B. (2021). Adoption of food loss and waste-reducing interventions in Low-and Middle-Income Countries (No. 2196). Wageningen Food & Biobased Research. Adoption of food loss and waste-reducing interventions in Low- and Middle-Income Countries — Research@WUR

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, Fisheries, Food Security and Nature, 2022-2024.

Take-home message

Facts and figures

- The percentage of Food Loss and Waste (FLW) in the international supply chain of bananas to the Netherlands from primary production till and including retail is 17.4% in total, with the highest percentage of FLW occurring in the exporting country. Estimated FLW associated greenhouse gas emissions increase from 0.31 kg CO_2-equivalents per kg bananas at primary production to 0.82 at retail for Dutch imports of bananas.
- The main root causes of FLW for bananas include pest damage, damage from weather events, inappropriate packaging and loss due to maturation.
- The main interventions for FLW reduction for bananas include pest-preventing measures, appropriate packaging, and carefully controlled ripening processes.

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.

References

1 Vakblad Voedingsindustrie. (2021, August 3). Nederlanders blijven meer groenten en fruit kopen. https://vakbladvoedingsindustrie.nl/nl/artikel/nederlanders-blijven-meer-groenten-en-fruit-kopen

2 Centraal Bureau voor de Statistiek (2022, December 19). Goederensoorten naar land; natuur, voeding en tabak, 2008-2021 [Dataset]. Retrieved from https://opendata.cbs.nl/#/CBS/nl/dataset/81267ned/table?ts=1691399037474

3 Ministerie van Landbouw, Natuur en Voedselkwaliteit (2022). In 2021 blijvend sterke rol Nederlands handel groenten en fruit. Accessed 07-08-2023. https://www.agroberichtenbuitenland.nl/actueel/nieuws/2022/01/13/in-2021-blijvend-sterke-rol-nederlandse-handel-groenten-en-fruit

4 FAOSTAT (2021). Trade – Crops and livestock products. Retrieved from FAOSTAT https://www.fao.org/faostat/en/#data/TCL

5 Coltro, L., & Karaski, T. U. (2019). Environmental indicators of banana production in Brazil: Cavendish and Prata varieties. Journal of Cleaner Production, 207, 363-378.

6 Macheka, L., Ngadze, R. T., Manditsera, F. A., Mubaiwa, J., & Musundire, R. (2013). Identifying causes of mechanical defects and critical control points in fruit supply chains: an overview of a banana supply chain. International Journal of Postharvest Technology and Innovation, 3(2), 109-122.

7 Kamalakkannan, S., Wasala, W. M. C. B., Kulatunga, A. K., Gunawardena, C. R., Bandara, D. M. S. P., Jayawardana, J., ... & Chandrakumar, C. (2022). Life cycle assessment of food loss impacts: case of banana postharvest losses in Sri Lanka. Procedia CIRP, 105, 859-864.

8 Svanes, E., & Aronsson, A. K. (2013). Carbon footprint of a Cavendish banana supply chain. The International Journal of Life Cycle Assessment, 18, 1450-1464.

9 Rezaei, M., & Liu, B. (2017). Food loss and waste in the food supply chain. International Nut and Dried Fruit Council: Reus, Spain, 26-27.

10 Kok, M. G., Vernooij, D. M., & Castelein, R. B. (2023). Roadmap approach for improving food value chain efficiencies: How to identify and implement interventions for reducing Food Loss and Waste in Dhaka's food system? (No. 2435). Wageningen Food & Biobased Research. Roadmap approach for improving food value chain efficiencies: How to identify and implement interventions for reducing Food Loss and Waste in Dhaka's food system? — Research@WUR

Contact

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

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

Project Website FLW Toolbox URL
www.foodloss-solutions.com