UNECE

UNECE Code of Good Practice for Reducing Food Loss in Handling Fruit and Vegetables

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INTRODUCTION

Fruit and vegetables are sold internationally, as well as locally, regionally and nationally. They are frequently traded over large distances and involve several actors. A continuous challenge is to reduce waste and losses, and this requires great care, attention and cooperation along the entire value chain.

The perishable nature of most fruits and vegetables means that loss and waste of products can be high. The problem of waste, in particular, has received much attention in recent years because of the impact on the environment.

Much can be gained, including economically, from taking measures to reduce the losses and waste. According to estimates, investments in measures to reduce losses and waste in food can give a 14-fold return.[1] A clear business case for the companies involved!

The Code of Good Practice supports the United Nations Sustainability Goal 12.3 on reducing food loss and waste: "By 2030, halve per capita global food waste at the retail and consumer level and reduce food losses along production and supply chains, including post-harvest losses."

The Code was endorsed by the Working Party on Agricultural Quality Standards (WP7) of the United Nations Economic Commission for Europe (UNECE) at its session in November 2019. For over 50 years, UNECE standards have been facilitating international trade in agricultural produce. The Code complements the standards and is intended to help maintain quality along supply chains. It is also aimed at strengthening the work on reducing food waste and associated costs that is already being done by many companies.

It sets out measures to be taken at the various stages before fruit and vegetables reach the consumer, i.e. from harvest to retail. It should support continued improvement, step by step. Real improvement, however, can only be achieved if actors along the distribution chain cooperate to improve their logistics, handling and planning, both inside countries and across borders. Communication will be a key factor. Measuring waste, which is the last point in each section of the Code, will give companies feedback on how well their work progresses.

[1] Hanson, C., and P. Mitchell. 2017. The Business Case for Reducing Food Loss and Waste. Washington, DC: Champions 12.3.

The Code consists of three distinct chapters which focus on the three major segments of the fruit and vegetable supply chain – producers, traders and retailers. The chapters can be used individually.

It is followed by two annexes and a selected list of reading matter that describe in detail the processes that regulate fruit and vegetable during growth, maturation, ripening and senescence and the best handling and storage practices.

1. PRODUCERS

Producers adhering to the Code of Good Practice undertake to do the following:

1.1 Follow the principles of Good Agricultural, Hygienic and Manufacturing practices

The following principles are designed to help reduce food loss and waste:

- **Good Agricultural Practices** – including dedicated farm techniques, such as conventional, organic or Integrated pest management principles that maximize yield and minimize food losses in the field. These are a collection of principles to apply for to-farm production and post-production processes, resulting in safe and healthy food and non-agricultural products, while taking into account economic, social and environmental sustainability.
- **Good Hygienic Practices** are a set of quality assurance practices to ensure that hygienic processes are rigorously set and monitored.
- **Good Manufacturing Practices** are a set of quality assurance practices to ensure that manufacturing processes are rigorously set and monitored.

It is highly recommended to proceed in accordance with these principles at all stages from harvest to retailer.

1.2 Ensure proper training of staff

Staff working with fresh fruit and vegetables at all stages of the distribution chain should be trained in how to handle the products and have a good knowledge of the consequences of shortcomings in handling and storing products. They should understand the impact of poor handling and storage practices on quality, shelf life and waste, and on loss of profit for the company.

1.3 Ensure that production is planned and adjusted to meet demand, in terms of both quantity and quality

Production should meet market demand. This means planning the produced volume to the expected demand, at different times, of a species, variety, size, colour and quality, as well as price level. It is also important to consider maturity stage at harvest, expected shelf life and type of product.

Some products may continue to develop added taste and aroma after harvest (climacteric fruit) whereas others do not (non-climacteric fruit).[2] Harvesting at the right stage of maturity is particularly important for tropical fruit (e.g. mangoes), as direct contact of immature fruit with more mature fruit can cause physical damage and quality losses. Harvesters should therefore be trained on how to harvest produce items at the right stage of maturity.

On local markets, direct communication between producer/seller and buyer will give the producer valuable information on the buyers' preferences and demands. In value chains stretching over country borders or even continents, good communication along the chain will help convey information on market demand to producers located far away from the final market.

Trade standards, which are drawn up with major input from the market, are commonly agreed descriptions of the quality expected of products sold as Class Extra, I or II and therefore provide valuable information on quality requirements. There may also be more detailed and often more stringent requirements in the specifications from the buyer.

By collecting information on market demand and planning production based on the quality standards and specifications, producers reduce the risk of products remaining unsold at the farm, of products being rejected upon arrival at wholesale level or of not being chosen by the consumer and therefore remaining unsold.

Collecting market information, using crop estimation tools as well as training in grading according to trade standards, can help to decrease losses.

1.4 Use the best possible harvest methods for product quality and shelf life

Unless products are carefully handled and the correct equipment is used properly, products can easily be damaged during harvest. All mechanical impact on products – cuts, bruises, tearing, breakages, etc. – will reduce their quality, shorten their storage and shelf life, and increase waste.

[2] A climacteric fruit is a fruit with a clear continuing ripening stage when many characteristics of the fruit change: for example, fruit texture, content of sugar and aroma substances, increased respiration rate and production of ethylene. Non-climacteric fruit lack this stage. A list of climacteric and non-climacteric fruit is provided in annex I.

For mechanical harvesting, it is very important to choose equipment that does not damage products. The quality of the harvested product will be influenced not only by the way the harvesting equipment is used but also by the experience and skill of the driver of a harvester. Raising awareness and training staff in correct use of the equipment will also help reduce losses.

If products are harvested manually, staff must be trained to handle products carefully. When products are cut, the use of sharp, disinfected knives or scissors that cut through a thin layer of cells will give a better result than blunt edges damaging a greater area in the cutting zone. And if boxes, bins and harvest bags are lined, potential damage to products will be minimized.

Soft-skinned fruit is particularly easy to damage. The careful handling at harvest and adherence of staff to personal hygiene is important. Studies have shown that even protruding fingernails can easily cause damage to soft-skinned fruit, reducing quality and increasing waste. The use of gloves when harvesting sensitive fruit can therefore help considerably.

1.5 Harvest products at the best appropriate conditions

Time of day and weather conditions at harvest can affect the post-harvest quality of products. An early harvest while products are still cool from the night and before the sun is high and temperatures have risen is likely to limit water losses and reduce the rate of senescence (i.e. the ageing of the fruit and vegetables). Leafy products and other products with a high surface to volume (e.g. broccoli) that easily lose water benefit most from this. The shorter the normal shelf life of a product, the greater the benefit. Higher temperatures will also speed up the ripening process.

Sunshine, high temperatures and wind will increase water losses and speed up the ageing of products. Products should therefore be taken to a storehouse as soon as possible using a means of transport that minimizes damage and maintains the quality of the products in the best possible way. While still in the field, products need to be protected from sun, wind, rain, dust and any other factors affecting their quality by, for example, being placed in covered containers or under a tree or in a shed. Humid weather makes fruit more water saturated (high turgor pressure), and this in turn makes fruit bruise more easily. For many fruits, harvesting in humid weather conditions should be avoided if possible.

1.6 Ensure that products that are not fit for long storage are delivered as soon after harvest as possible

Delivering harvested products without delay to warehouses or cooling facilities decreases waste throughout the distribution chain.

Harvested products that are normally not fit for long-term storage have a limited shelf life. The length of the shelf life depends on the climatic conditions in which they are harvested, transported, graded, packed, distributed, stored and displayed. Temperature has the greatest effect, but humidity and air circulation may also play a role.

The "age" of a product is largely determined by temperature and time. The shorter the time from harvest to retailer, the better the quality and the longer the shelf life.

Although a large share of food waste takes place at consumer level, part of this waste is caused by too short a shelf life remaining when products reach the consumer.

1.7 Cool products – where appropriate – to their correct temperature as soon as possible after harvest and keep them at this temperature until delivered

The single most important factor for retaining product quality after harvest is temperature.[3] Suboptimal cool or cold chain processes and management account for much food loss.

There is thus much to gain from rapid and efficient cooling of products after harvest. The higher the temperature at harvest and the more sensitive the products, the greater the benefit from cooling.

Products that contain much air – for example, leafy vegetables – take a long time to cool. Certain cooling techniques such as forced air and vacuum cooling speed up the cooling process and reduce the risk that the interior of pallets remains uncooled after harvest cooling.

[3] Temperature has a direct effect on shelf life by affecting respiration rate, the rate with which carbohydrates in a product are converted into carbon dioxide and water. In asparagus, for example, respiration at 20 °C is around 10 times higher than at 2.5 °C. Temperature also has an indirect effect by affecting air humidity, ethylene production and the effect of existing ethylene.

Products with a large surface-to-volume ratio – for example, leafy vegetables and broccoli – quickly lose water during harvest cooling. Most products, but these in particular, benefit from high air humidity during cooling to prevent them from rapidly losing water.

Subtropical and tropical products develop chilling injuries when kept at lower, though non-freezing, temperatures. Attention should therefore be paid to ensuring appropriate storage temperatures so that products sensitive to chilling are not subjected to temperatures below those that may cause chilling injury (See annex II for recommended lowest storage temperatures).

1.8 Post-harvest treatments may also be considered in order to increase shelf life and reduce food loss and waste along the supply chain

Post-harvest treatments to increase shelf life and reduce loss and waste are available for both organic and conventional production of fruit and vegetables. When used, they must be authorized by the producing country and the country of destination.

Post-harvest treatments may have several beneficial effects, such as:

- Reducing water loss, and thereby delaying weight loss and loss of freshness
- Limiting the exchange of oxygen and carbon dioxide between the product and the surrounding air (creation of a modified atmosphere), which delays ripening and senescence and may delay loss of the nutritional value of products.

1.9 Choose packaging that protects products well during transport and distribution, while balancing the cost and quantity of packaging material and taking into account buyer requirements

Packaging is often chosen as the result of a dialogue between seller and buyer. The wish to fill packages and thereby use space in storage and transportation efficiently should be weighed against the risk of causing damage to the products when packages are put on top of each other in a pallet. Careless stacking of boxes during storage and transportation can easily lead to extra losses, especially when dealing with soft-skinned fruit.

Packages must be of a quality, strength and characteristic to protect the produce during transport and handling and maximize air circulation for effective cooling.

Clean materials should be used to protect the produce from foreign matter which could negatively affect the produce and its presentation. A visible lack of cleanliness in several packages could result in the goods being rejected. Bruising caused by vibration during transport and distribution can be minimized by using appropriate packaging as well as such simple things as properly inflated vehicle tyres.

For products that bruise easily, the use of trays should be considered. For many products, modified atmosphere may extend shelf life and reduce waste.

1.10 Find outlets for products that would not be harvested due to oversupply

Weather conditions may cause more products to be ready for harvest at the same time than was planned. These products meet buyer quality requirements but face a saturated market.

Alternatives that can be considered may include:

- Find alternative outlets, new markets or destinations
- Change the presentation
- Reduce the price. In some countries, electronic market places for unsold/surplus products are being developed
- Increase the amount of produce sold to the processing industry (if relevant for the product in question and if such an industry exists)
- Donate products to charity (e.g. EU Guidelines[4]).

1.11 Find alternative outlets for products not meeting buyer's quality requirements

Not meeting buyers´ requirements should of course be avoided. A continuing dialogue with buyers is therefore important to know clearly what the buyer expects but also to increase the buyer's knowledge and understanding regarding certain defects.

On many markets, especially with large retailers, buyers mainly demand Class I products. Class II products are however subject to the same requirements on

[4] The EU Food Donation Guidelines, for example, provide valuable advice: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:C:2017:361:FULL&from=EN

good eating quality as Class I products, but the allowance for defects is larger. Products that today are marketed as so-called ugly fruits/vegetables can largely be accommodated within the quality requirements and tolerances of Class II. If Class II products are going to be harvested and traded to a greater extent than today, they need to fetch a higher price than is now the case. If demand for Class II increases, and these products fetch a higher price, the share of products that can be sold for human consumption would increase.

The alternatives under 1.10 above can also be considered.

1.12 Measure the amount of produce that is wasted and specify the major causes of the waste

Companies in food production that understand the causes of food waste and measure it have a greater capacity to reduce waste at the source. This implies that most companies acknowledge there is a problem, measure the loss, identify hotspots and manage the food losses through targeted interventions. Companies that regularly measure waste can identify more easily the hotspots for this waste (where it happens) and review the results to start a learning process. This is an important tool for finding measures that lead to reduced waste.

The results can be used not only for future planning but also for the implementation of measures related to handling, temperatures, transport, logistics etc. Apart from the aspect of reducing waste, there is a strong business incentive to carry out this work since money spent on reducing waste is reported to give up to an estimated 14-fold return on the money spent.[5] (For further details, see the UNECE measuring methodology in Annex III.)

[5] Hanson, C., and P. Mitchell. 2017. *The Business Case for Reducing Food Loss and Waste.* Washington, DC: Champions 12.3.

2. TRADERS

Traders – buyers, wholesalers and sales departments of retail chains – adhering to the Code of Good Practice undertake to do the following:

2.1 Ensure proper training of staff

Your staff need to know how to handle products and to understand the impact of handling on quality, shelf life and waste, and possible loss of profit for the company. Staff working with fresh fruit and vegetables, at all stages of the distribution chain, need to be trained in how to handle the products and have a good knowledge of the consequences of shortcomings in handling and storing the products.

2.2 Ensure that ordered volumes of products are planned and adjusted to demand, in terms of both quantity and quality

Planning and adjusting ordered volumes to meet demand ensures that products can be delivered to retailers without unnecessary delay. Products that arrive at retail level with a larger part of their shelf life remaining will be fresher and thus have a better quality leading to reduced waste of these products at retail level and at consumer level.

Demand for products will vary according to the weather, season, holidays and celebrations. Some high-demand periods can easily be foreseen, whereas others are less predictable, thereby making planning more difficult. An efficient chain from harvest to retailer requires market knowledge and careful planning.

Planning involves estimating sales volumes of different products, but also for example trade types, varieties, sizes, quality categories, colour categories and level of maturity/stage of ripeness. Good communication along the distribution chain will help coordinate market demand with supply.

2.3 Improve logistics to shorten time from harvest or packing to retail

An efficient logistics chain that reduces the time from producer or packer to retailer is important for ensuring that a larger share of a perishable products' shelf life is retained for retail and consumer levels. Such efficiency reduces quality losses and waste.

An efficient logistics chain has no more stops and reloading points than necessary. Stops are short and reloading quick. At reloading points, a strict "first-in, first-out" principle is applied.

2.4 Cooperate to establish unbroken cool chains at the appropriate temperature for respective products

Suboptimal cold chain processes and management lead to considerable food losses. Lower temperatures are one of the most important factors for retaining product quality during distribution. These increase shelf life by reducing respiration rate and thereby the ageing of the fruit and vegetables. Shelf life is highly influenced by temperature deviations during transport and storage.

An appropriate temperature should be kept all the time from harvest to retail. The money and effort put into cooling products to the appropriate temperature is quickly lost if products are kept at too high a temperature later in the chain. Frequent change in temperature also reduces shelf life. A good dialogue along the distribution chain should therefore include discussions on how to establish an unbroken cool chain.

There is thus much to gain in terms of reduced waste and improved quality from keeping products in appropriate climate conditions throughout distribution and retail. The higher the temperature is and the more sensitive products are, the greater the gain from an unbroken cool chain. For example, lettuce has an estimated shelf life of up to 12 days at zero degrees Celsius but only 2 days at 20 degrees; leek and cauliflower may be stored over 40 days at zero degrees but only 2 days at 20 degrees. This only refers to products that are not chilling sensitive (see annex II).

Subtropical and tropical products develop chilling injuries when kept at low, though non-freezing, temperatures. Attention should therefore be paid to appropriate storage and transport temperatures to ensure that chilling sensitive products are not subjected to temperatures below those that may cause chilling injury (see annex II).

The cool chain should be established from harvest and retained all the way through retail, including, where possible, during display for the consumer.

2.5 Place orders and/or change orders with enough time to allow for products to be carefully harvested, handled and cooled before dispatch

Producers need to be given enough time to be able to cool products to the appropriate temperature and to sort and pack according to specifications given. If orders are placed or changed shortly before time of dispatch, producers may have to send products that are not properly cooled. This will reduce the shelf life of the products. It may also lead to sorting and packing having to be done too quickly to allow for careful handling and for quality assurance to be carried out properly.

2.6 Avoid cancelling orders close to planned dispatch of products from packer/producer

When orders of perishable products are cancelled at short notice and close to dispatch, it is difficult to find a new buyer for these products and the products are often wasted.

The reason for late cancellations is often that market demand for a product, at a given time, is lower than when the buyer originally placed the order. Products may therefore still be wasted even if the order is kept. In these cases, the buyer should consider measures to promote the sale of these products.

The negative impact of a cancellation will be particularly severe if an order is cancelled for example after a producer has opened a cold store or a Controlled Atmosphere (CA) store and removed the products from the storage room. Once a CA store has been opened, the fruit has to go into the distribution chain.

2.7 Ensure that contracts include appropriate maturity requirements

Produce need to have reached an appropriate stage of development and/or maturity to have good eating quality and shelf life. This should be respected and developed by agreement and communication between producers, traders and retailers.

Consumers may be very eager to buy products when these first appear on the market at the beginning of the season. They may also be willing to pay a high price for these first products. It may therefore be tempting to sell products as early in their season as possible. If, however, products are marketed before they have reached the appropriate level of maturity, they may not be able to mature and

ripen into a product with good eating quality, but remain hard, lack the desired taste and deteriorate quickly. These immature products will then, most likely, be thrown away by the consumer and the (disappointed) consumer may avoid buying this product again for some time.

The different varieties of many fruits, for example apples and pears, mature and ripen at different times and should therefore be marketed at different times. It is important that each variety is placed on the market at the appropriate time with respect to harvest and storage period to avoid low eating quality and products being wasted. The best way to avoid this is to have good communication with producers and respect the advice given by them.

2.8 Define clear specifications that will prevent food loss and avoid interventions, by agreement and communication between producers, traders and retailers

Specifications should be clearly defined, in a dialogue with producers, in such a way that they avoid causing unnecessary waste. Trading parties should be mindful of specifications that might require trimming of produce to the same size or length to fit into a specific package. This type of intervention often leads to food waste.

2.9 Control the ordered products at arrival

- Apply an agreed inspection procedure
- Set up a control protocol specifying the defects and the percentage of non-conforming products
- Communicating complaints/ claims to the seller in a report format and within a reasonable time after products have arrived at the buyer's premises
- Establish, if possible, the likely reason for the non-conformity.

Rejection of products at wholesale level with reference to products not fulfilling the requirements of a quality standard or the requirements that have been agreed by buyer and seller constitutes a major cause of waste.

An added difficulty is that buyers and sellers do not always agree on whether products are in conformity. When the complaint is fair, and is justified by photos and additional supporting evidence, common agreement is facilitated.

In obvious cases, for example if all products are dirty or overripe, non-conformity is easy to establish and it may not be necessary to apply an agreed control method. Instead, photographs may suffice to communicate the extent of non-conformity to the seller. Products may be judged by the buyer to not be in conformity because the tolerances set out in the standards have been exceeded. When such non-conformity is not excessive and the complaint less easy to see from a photograph, a common control method needs to be agreed on and applied to give a replicable and objective control result. With an agreed control method, the buyer can establish the percentage of products with different defects and communicate the result to the seller. The communication of non-conformity is a difficult topic, as is the understanding between the two parties concerned. Using a commonly agreed control/inspection method can also avoid products being rejected erroneously.

To guarantee a reliable and repeatable inspection result, the Organisation for Economic Co-operation and Development (OECD) has developed an inspection method to be used for conformity controls of fresh fruits and vegetables.

The method defines the number of boxes in a sample – depending on the size of the lot – that need to be taken randomly and inspected as well as the method of inspection for products in consumer packages and for products loose in the package. (See OECD Guidelines on quality inspection.)

The buyer should use a control protocol format that identifies the percentage of products with different defects found in the sample that has been taken.

The control and the results should be communicated to the seller within a reasonable time. Depending on the sensitivity of the products and how they are kept and handled after arriving at the buyer's premises, their quality may diminish quickly.

Control results are therefore only a valid assessment of the quality of delivered products if made as soon as possible after the arrival of these products at the buyer's premises. What is judged to be "a reasonable time" will vary according to the product and how it is stored and handled after arrival.

Areas considered high risk and likely to cause problems should be defined in contracts in advance or otherwise by a common agreement between buyer and seller.

When products do not meet specifications, this should be communicated to the dispatcher immediately and the reason for the non-conformity should be clearly explained. This will help the actors involved to take measures to avoid this problem in the future. If, for example, products show symptoms of chilling injury and there has been a known deviation from the appropriate temperature during transport, this is important information to those involved. The buyer, in agreement with the seller, should always try to find ways to avoid returning products.

2.10 Find alternative outlets for products that cannot be sold on the intended market

Even with the most careful planning, there will invariably be products that cannot be sold to the intended buyer. Companies in the fruit and vegetable trade should therefore have in place alternative outlets and uses for products that cannot be placed on the intended market and/or sold to the intended buyer.

The following alternatives are examples that might be considered:

- Find alternative outlets, new markets or destinations
- Reduce price and sell as
  - Category II (if applicable)
  - "for home processing"
  - "for immediate consumption"
- Process (industrial)
- Donate to charity (e.g. EU Guidelines)[6]

2.11 Measure the amount of produce that is wasted and specify the major causes

Companies in food production that understand the causes of food waste and measure it have a greater capacity to reduce waste at the source. This implies most companies acknowledging there is a problem, measure the loss, identify hotspots and manage the food losses through targeted interventions. Companies that regularly measure waste can identify more easily the hotspots for this waste

[6] The EU Food Donation Guidelines, for example, provide valuable advice: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:C:2017:361:FULL&from=EN

(where it happens) and review the results to start a learning process. This is an important tool for finding measures that lead to reduced waste.

The results can be used not only for future planning but also for the implementation of measures related to handling, temperatures, transport, logistics etc. Apart from the aspect of reducing waste there is a strong business incentive to carry out this work since money spent on reducing waste is reported to give up to an estimated 14-fold return on the money spent.[7] (For further details, see the UNECE measuring methodology in Annex III.)

[7] Hanson, C., and P. Mitchell. 2017. The Business Case for Reducing Food Loss and Waste. Washington, DC: Champions 12.3.

3. RETAILERS

Retailers and retailer chains adhering to the Code of Good Practice undertake to do the following:

3.1 Ensure proper training of staff

Your staff need to know how to handle products and to understand the impact of handling on quality, shelf life and waste, and loss of profit for the company. Staff working with fresh fruit and vegetables need to be trained in how to handle the products and have a good knowledge of the consequences of shortcomings in handling and storing the products.

3.2 Ensure that ordered volumes are planned and adjusted to demand, in terms of both quantity and quality

If you plan and adjust your ordered volumes to meet demand, the products will not need to be kept in storage or on display longer than necessary, thus retaining their quality and lead to less waste.

Demand for products will vary according to the weather, season, holidays and celebrations. Some high-demand periods can easily be foreseen, whereas others are less predictable. To ensure a steady flow of products through your shop, you need to have good market knowledge and plan carefully.

Planning involves estimating not only the sales volumes of the various products but also types, varieties, sizes, quality categories, colour categories and stage of ripeness. Campaigns promoting the sale of one product may also influence the sales volumes of other, similar products. Good communication with the supplier or distribution centre should help coordinate demand and supply.

A "first-in, first-out" approach to stock will contribute to minimizing wastage.

3.3 Define clear specifications that will prevent food loss and avoid interventions, by agreement and communication with the producer and traders

Specifications should be clearly defined in a dialogue with producers, in such a way that they avoid causing unnecessary waste. Trading parties should be mindful of

specifications that might require trimming of produce to the same size or length to fit into a specific package. This type of intervention often leads to food waste.

3.4 Ensure that contracts include appropriate maturity requirements

Produce needs to have reached an appropriate stage of development and maturity to have good eating quality and shelf life, and this should be respected.

Consumers may be very eager to buy products when these first appear on the market at the beginning of the season. They may also be willing to pay a high price for these first products. You may therefore be tempted to sell products as early in their season as possible. If, however, products are marketed before they have reached the appropriate maturity, they may not be able to ripen properly and will remain hard and tasteless. The consumer will then probably throw these products away and avoid buying such products again in the near future.

As the different varieties of many fruits, for example apples and pears, mature and ripen at different times, they should be also marketed at different times. Each variety should be placed on the market at the correct time to avoid low eating quality that leads to products being wasted. The best way to avoid this is to have good communication with producers, and seek and respect their advice.

3.5 Control products and make complaints/claims within a reasonable time after products have arrived at the buyer´s premises (buyer and seller should have a common agreement on criteria and method for controls and claims)

Rejection of products at wholesale level because they fail to fulfil the requirements of a quality standard or the requirements agreed to by buyer and seller is a major cause of waste.

The added difficulty is that buyers and sellers do not always agree on whether products are in conformity with standards. When the complaint is fair, and is justified by photos and additional supporting evidence, common agreement is facilitated.

In obvious cases – for example, if products are dirty or overripe – non-conformity is easy to establish. Photographs usually suffice to communicate the extent of non-conformity to the seller. In less obvious cases, there may be a need for a more thorough check. Buyer and seller should have a common agreement on

methods for controls and claims and also on how claims are communicated and what documentation they should be based on.

The checking and the results should be communicated to the seller within a reasonable period of time. Depending on how sensitive products are and how they are kept and handled after arriving at the buyer's premises, they may quickly lose quality.

The results of the checking are therefore only a valid judgement of the quality of delivered products if made in connection with the arrival of these products at the buyer's premises. What is judged to be "a reasonable time" will vary depending on which product it is and how it is stored and handled after arrival. Areas considered high risk and likely to cause problems should be defined in contracts in advance or otherwise by a common agreement between buyer and seller.

When products are found not to meet specifications, this should be communicated to the dispatcher immediately and the reason for the non-conformity should be identified. This will help those involved to take measures to avoid this problem in the future. If, for example, products show symptoms of chilling injury and there has been a known deviation from the appropriate temperature during transport, this is important information for those involved. The buyer, in agreement with the seller, should always try to find ways to avoid returning the product.

3.6 Store and display products in shops at the appropriate, product-specific temperature

Inadequate cold-chain processes and management cause a considerable share of food losses. Temperature is a vital factor in retaining product quality during distribution. It increases shelf life by affecting respiration rate and thereby the ageing of the fruit and vegetables. Shelf life is highly influenced by deviations in temperature during transport and storage.

An appropriate temperature must be kept all the time from harvest to retail. If products are kept at too high temperatures later in the chain, the money and effort put into cooling products to the appropriate temperature is quickly lost.

Frequent change in temperature also reduces shelf life. A good dialogue along the distribution chain shall therefore include discussions on how to establish an unbroken cold chain.

The higher the temperature and the more sensitive the products, the greater the gain from an unbroken cool chain. For example, lettuce has an estimated shelf life of up to 12 days at zero degrees Celsius but only 2 days at 20 degrees; leek and cauliflower may be stored over 40 days at zero degrees but only 2 days at 20 degrees. This, however, only refers to products that are not sensitive to chilling (see annex II).

Subtropical and tropical products develop chilling injuries when kept at low, though non-freezing, temperatures. Attention should therefore be paid to ensuring that chilling-sensitive products are not subjected to temperatures below those that may cause chilling injury. (See Annex II).

Products must be stored and displayed at their appropriate, product-specific temperature to retain the visible quality, keeping quality and the nutritional quality, and to reduce waste. When possible, there should be different temperature zones to accommodate the different temperature requirements of products. The volume of products displayed at unfavourable temperatures should be limited to avoid shortening shelf life.

Taking products from cool storage and back should be avoided as frequent changes in temperature reduces shelf life. When products are offered for sale in the open, measures should be taken to protect them from unfavourable weather conditions.

Retailers who have no cooling facilities may prolong shelf life by covering their fresh produce overnight with wet cloth or tissue.

3.7 Handle products carefully and take measures to reduce the risk of products getting bruised

Bruising causes damage, reduces quality and often leads to products being wasted. Products may become bruised not only when being transferred from boxes into display areas but also when consumers handle and squeeze them.

Products that are packed individually on trays in the packages (boxes) will be less bruised if displayed for sale in these boxes.

Products should be handled as carefully as possible when transferred into display. Your staff should be well instructed and fully understand the consequences of not handling products carefully.

Consider taking measures that limit the damage caused by careless consumers, such as limiting the volume displayed at any given time and thereby the number of times each product is scrutinized by a consumer until finally chosen.

3.8 Store and display products appropriately

Products should be stored and displayed appropriately, taking into account their specificities and the facilities available. In addition to temperature, you should take into consideration any other aspects of the presentation of the produce that are important to retain the visible quality, the keeping quality, the nutritional quality and that would reduce waste.

You should present the products in such a way as to:

- minimize a negative impact of fruit with a clear ripening stage (climacteric fruit,[8] such as bananas) on other produce
- maintain adequate humidity.

3.9 Avoid campaigns encouraging consumers to buy more than they can eat

Promotional campaigns such as "buy three, pay for two" encourage consumers to buy more products than they may be able to consume, thus causing a waste of food. Although there may be good intentions behind such campaigns – such as increasing consumption for health reasons or helping producers sell an unexpected overproduction due to a period of hot weather – it is, however, better to decrease the price instead.

Consider, also, that when you encourage consumers to buy more of a certain product, they may quite likely buy less of other similar products: for instance, a campaign to promote pears may lead to decreased sales of apples, thus leading to possible waste of apples.

Therefore, in the long run, a stable volume and price decreases waste.

[8] A climacteric fruit is a fruit with a clear continuing ripening stage when many characteristics of the fruit change, for example fruit texture which becomes softer, content of sugar and aroma substances, increased respiration rate and production of ethylene. Non-climacteric fruit lack this stage. A list of climacteric and non-climacteric fruit is found in annex I.

3.10 Find ways to use or sell damaged or suboptimal products

Even with the most careful planning, storage and handling, you will find that some of your products cannot be sold as you originally intended. You should therefore have some alternative solutions for selling or giving away these products:

- Reduce price and sell as
  - Category II (if applicable)
  - "for home processing" (if applicable)
  - "for immediate consumption"
- Highlight for the consumer alternative uses of products (at point of sale)
- Process to juices, jams, smoothies, etc.
- Give to charity (e.g. see EU Guidelines)[9]

3.11 Measure the amount of produce that is wasted and specify the major causes of the waste

Companies that understand the causes of food waste and measure it have a greater capacity to reduce waste than companies not making this effort. Companies that regularly measure waste, identify the specific causes for this waste and hold discussions on the results start a learning process that is an important tool for finding measures that reduces waste. The results can be used for future planning but also for measures related to handling, temperatures, transport, logistics etc. Apart from the aspect of reducing waste there is a strong economic incentive to carry out this work since money spent on reducing waste is reported to give up to an estimated 14-fold 10 return on the money spent. (For further details, see the UNECE measuring methodology in Annex III.)

[9] The EU Food Donation Guidelines provide valuable advice: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:C:2017:361:FULL&from=EN

Retailers buying directly from producers should also undertake the following:

3.12 Improve logistics to shorten time from harvest or packing to retail

As fresh fruit and vegetables have a limited shelf life, the time that elapses from harvest to retail, or for long-term stored products from packing to retail, should be as short as possible. A strict "first-in, first-out" principle should be applied.

3.13 Cooperate to establish unbroken cool chains, at the appropriate temperature for respective products

An appropriate temperature shall be kept at all times from harvest to retail. The money and effort put into cooling products to the appropriate temperature is quickly lost if products are exposed to unfavourable and/or fluctuating temperatures later in the chain. Therefore, a good dialogue by all participants along the distribution chain shall include discussions on how to establish an unbroken cool chain.

The cool chain should be established from harvest and retained all the way through retail, including, where possible, during display for the consumer.

3.14 Place orders and/or change orders with enough time to allow for products to be carefully harvested, handled and cooled before dispatch

Producers need to be given enough time to be able to cool products to the appropriate temperature and to sort and pack according to specifications given. If orders are placed or changed shortly before time of dispatch producers may have to send products that are not properly cooled. This will reduce the shelf life of the products and increase waste. It may also lead to sorting and packing having to be done too quickly to allow for careful handling and for quality assurance to be carried out properly.

3.15 Avoid cancelling orders close to planned dispatch of products from packer/producer

When orders of perishable products are cancelled at short notice and close to dispatch, it is difficult to find a new buyer for these products and the products are often wasted.

The reason behind late cancellations is often that market demand for a product, at a given time, is lower than when the buyer originally placed the order. Products may therefore still be wasted even if the order is kept. In these cases, the buyer should consider measures to promote the sale of these products.

The negative impact of a late cancellation will be particularly severe if an order is cancelled for example after a producer has opened a cold store or a Controlled Atmosphere (CA) store and removed the products from the storage room. Once a CA store has been opened, the fruit has to go into the distribution chain.

Further reading

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ANNEX I

Classification of fruit, based on their respiratory behaviour, into climacteric and non-climacteric fruit

Climacteric fruit		Non-climacteric fruit	
Apple	*Malus domestica*	Blackberry	*Rubus fruticosus*
Apricot	*Prunus armeniaca*	Cacao	*Theobroma cacao*
Avocado	*Persea americana*	Carambola	*Averrhoa carambola*
Atemoya	*Annona squamosa*	Cashew apple	*Anacardium occidentale*
Banana	*Musa paradisiaca*	Cherry	*Prunus avium, Prunus cerasus*
Biriba	*Rollinia deliciosa*	Coconut	*Cocos nucifera*
Blueberry	*Vaccinium cyanococcus*	Cranberry	*Vaccimium occycoccos*
Bitter melon	*Momordica charantia*	Cucumber	*Cucumis sativus*
Breadfruit	*Artocarpus altilis*	Date	*Phoenix dactylifera*
Cantaloupe	*Cucumis melo*	Dragon fruit	*Hylocereus undatus*
Cape gooseberry		Eggplant	*Solanum melongena*
Cherimoya	*Annona cherimola*	Grape	*Vitis vinifera*
		Grapefruit	*Citrus x paradisi*
		Java plum	*Syzygium cumini*
Durian	*Durio zibethinus*	Jujube	*Ziziphus jujuba*
Feioja	*Feijoa sellowiana*	Langsat	*Aglaia spp*
Fig	*Ficus carica*	Lemon	*Citrus limon*
Guava	*Psidium guajava*	Lime	*Citrus aurantifolia; Citrus latifolia*
Honeydew melon	*Cucumis melo*	Longan	*Dimocarpus longan*
Jackfruit	*Artocarpus heterophyllus*	Loquat	*Eriobotrya japonica*

Climacteric fruit		Non-climacteric fruit	
Japanese pear		Lychee	*Litchi chinensis*
Jujube	*Zizyphus jujuba*	Okra	*Abelmoschus esculentus*
Kiwifruit	*Actinidia deliciosa*	Olive	*Olea europea*
Mammee apple		Orange	*Citrus sinensis*
Mango	*Mingifera indica*	Pea	*Pisum sativum*
Mangosteen	*Garcinia mangostana*	Pepino, melon pear	*Solanum muricatum*
Muskmelon	*Cucumis melo*	Pepper	*Capsicum annuum*
Nectarin	*Prunus persica*	Pineapple	*Ananas comosus*
Papaw		Pitaya	*Stenocereus ssp.*
Papaya	*Carica papaya*	Pomegranate	*Punica granatum*
Passion fruit	*Passiflora spp.*	Prickly pear	*Opuntia stricta*
Peach	*Prunus persica*	Rambutan	*Nephelium lappaceum*
Pear	*Pyrus communis*	Raspberry	*Rubus idaeus*
Persimmon	*Diospyros kaki*	Rose apple	*Syzygium ssp.*
Plantain	*Musa paradisiaca*	Star apple	*Chrysophyllum cainito*
Plum	*Prunus domestica*	Strawberry	*Fragaria ananssa*
Quince	*Cydonia oblonga*	Summer squash	*Cucurbita pepo*
Rambutan	*Nephelium lappaceum*	Surinam cherry	*Eugenia uniflora*
Sapodilla, chiku	*Achras sapota*	Tamarillo, Tree tomato	*Cyphomandra betacea*
Soursop	*Annona muricata*	Tangerine and mandarin	*Citrus reticulata*
Sweetsop	*Annona squamosa*	Watermelon	*Citrullus vulgaris*
Tomato	*Lycopersicon esculentum*		

Sources: Kader, A.A. 2002. *Postharvest Technology of Horticultural Crops*. University of California, Publication 3311; Kays, S.J. and Paull, R.E. 2004. Postharvest Biology. Exon Press, Athens, GA, USA.

ANNEX II

Classification of fruit and vegetables, based on their sensitivity to chilling injury, i.e. injuries caused by low but non-freezing temperatures, and recommended lowest storage temperature

Chilling-sensitive fruits	Lowest storage temperature	
	°C	°F
Annona, Cherimoya, Atemoya *Annona ssp.*	13	55
Avocado, var. Hass, *Persea americana*	3-7	37-45
Banana, *Musa paradisiaca*	13-15	56-59
Breadfruit, *Artocarpus altilis*	13-15	55-59
Carambola, *Averrhoa carambola*	9-10	48-50
Cranberry, *Vaccinium macrocarpon*	2-5	35-41
Cucumber, *Cucumis sativus*	10-13	50-55
Dragon fruit, *Hylocereus undatus*	10	50
Durian, *Durio zibethinus*	4-6	39-42
Feijoa, *Feijoa sellowiana*	5-10	41-50
Grapefruit, *Citrus paradisi*	10-15	50-60
Guava, *Psidium guajava*	5-10	41-50
Jackfruit, *Artocarpus heterophyllus*	13	55
Jujube, *Zizyphus jujuba*	2.5-10	36-50
Lemon, *Citrus limon*	10-13	50-55
Lime, *Citrus latifolia, Citrus aurantiifolia, Citrus limettioides*	9-10	48-50
Longan, *Dimocarpus longan*	4-7	39-45
Lychee, *Litchi chinensis*	1-2	34-36

Chilling-sensitive fruits	Lowest storage temperature	
	°C	°F
Mandarin, *Citrus reticulata, Citrus unshiu, Citrus clementina, Citrus deliciosa, Citrus tangerina*	4-7	40-45
Mango, *Mangifera indica*	13	55
Mangosteen, *Garcinia mangostana*	13	55
Melon, **Canary**, *Cucumis melo*	10	50
Melon, **cantaloupe**, *Cucumis melo*	2-5	36-41
Melon, **casaba**, *Cucumis melo*	7-10	45-50
Melon, **Crenshaw**, *Cucumis melo*	7-10	45-50
Melon, **honey dew**, *Cucumis melo*	5-10	41-50
Melon, *Persian, Cucumis melo*	7-10	45-50
Olive, *Olea europea*	5-10	41-50
Orange, *Citrus sinensis*	3-9 (dry areas) 0-2 (humid regions)	38-48 (dry areas) 32-36 (humid regions)
Papaya, *Carica papaya*	7-13	45-55
Passion fruit, *Passiflora spp.*	10	50
Pepino, *Solanum muricatum*	5-10	41-50
Pepper, **sweet**, *Capsicum annuum*	7-10 (sweet) 5-10 (hot)	45-50 (sweet) 41-50 (hot)
Pineapple, *Ananas comosus*	7-13	45-55
Plantain, *Musa paradisiaca*	13-15	56-59
Pomegranate, *Punica granatum*	5-7.2	41-45
Prickly pear, *Opuntia stricta*	5	41
Pomelo [also **Pummello**], *Citrus maxima*	7-9	45-48
Rambutan, *Nephelium lappaceum*	12	54
Sapodilla, *Achras sapota*	15-20	59-68

Chilling-sensitive fruits	Lowest storage temperature	
	°C	°F
Squash, *Cucurbita pepo*	7-10 (summer) 12-15 (winter)	45-50 (summer) 54-59 (winter)
Tamarillo, *Cyphomandra betacea*	3-4	37-40
Tamarind, *Tamarindus indica*	2-7	36-45
Tomato, *Solanum lycopersicum*	10-13 (mature-green), 8-10 (firm-ripe)	50-55 (mature-green) 46-50 (firm-ripe)
Watermelon, *Citrullus lanatus*	10-15	50-59

Chilling-sensitive vegetables	Lowest storage temperature	
	°C	°F
Basil, *Ocimum basilicum*	12	54
Beans, **green**, *Phaseolus vulgaris*	4-7	40-45
Beans, **lima**, *Phaseolus lunatus*	5-6	41-43
Bitter gourd, *Momordica charantia*	10-12	50-54
Cassava, *Manihot esculenta*	0-5	32-41
Chilli peppers, *Capsicum annuum, C. baccatum, C. chinense, C. frutescens and C. pubescens*	5-10	41-50
Courgettes, *Cucurbita pepo* , Zucchini Group	7-10	45-50
Cucumber, *Cucumis sativus*	10-12	50-55
Eggplant, **aubergine**, *Solanum melongena*	10-12	50-54
Ginger, *Zingiber officinalis*	13	55
Luffa gourd, *Luffa spp.*	10-12	50-54
Okra, *Abelmoschus esculentus*	7-10	45-50

Chilling-sensitive vegetables	Lowest storage temperature	
	°C	°F
Peppers, *Capsicum annuum*	7-10	45-50
Potato, *Solanum tuberosum*	10-15 (early crop) 4-12 (late crop)	50-59 (early crop) 40-54 (late crop)
Pumpkin, *Cucurbita maxima*	12-15	54-59
Sweet potato, **yam**, *Ipomea batatas*	13-15	55-59
Tomato, *Solanum lycopersicum*	10-13 (mature-green), 8-10 (firm-ripe)	50-55 (mature-green) 46-50 (firm-ripe)

Non-chilling-sensitive fruits	Lowest storage temperature	
	°C	°F
Apple, *Malus domestica*	-1.1-1	30.0
Apricot, *Prunus armeniaca*	-0.5-0	31-32
Bilberries, *Vaccinium myrtillus*	-0.5-0	31-32
Blackberry, *Rubus sect. Rubus*	-0.5-0	31-32
Blueberry, *Vaccinium corymbosum, Vaccinium formosum, Vaccinium angustifolium, Vaccinium virgatum*	-0.5-0	31-32
Cloudberry, *Rubus chamaemorus*	0	32
Cherry, *Prunus cerasus, Prunus avium*	0 (sour) -1-0 (sweet)	32 (sour) 30-32 (sweet)
Coconut, *Cocos nucifera*	0-2	32-36
Cowberries, **lingonberries**, *Vaccinium vitis-idaea*	-0.5-0	31-32
Cranberry, *Vaccinium macrocarpon, Vaccinium oxycoccos*	2-5	35-41
Currant, **black**, *Ribes nigrum*	-0.5-0	31-32

Non-chilling-sensitive fruits	Lowest storage temperature	
	°C	°F
Currant, **red**, **white**, *Ribes rubrum*	-0.5-0	31-32
Date, *Phoenix dactylifera*	-18-0	0-32
Dewberry, *Rubus spp*	-0.5-0	31-32
Elderberry, *Rubus spp*	-0.5-0	31-32
Fig, *Ficus carica*	-0.5-0	31-32
Gooseberry, *Ribes uva-crispa*	-0.5-0	31-32
Grape, *Vitis vinifera*	-0.5-0	31-32
Kiwifruit, *Actinidia chinensis, Actinidia deliciosa*	0	32
Loganberry, *Rubus loganobaccus*	-0.5-0	31-32
Loquat, *Eriobotrya japonica*	0	32
Nectarine, *Prunus persica*	-0.5-0	31-32
Peach, *Prunus persica*	-0.5-0	31-32
Pear, *Pyrus communis*	-1.5-0.5 (European)	29-31 (European)
Persimmon, *Diospyros kaki*	0	32
Plum, *Prunus domestica, Prunus salicina*	-0.5-0	31-32
Quince, *Cydonia oblonga*	-0.5-0	31-32
Raspberry, *Rubus idaeus*	-0.5-0	31-32
Strawberry, *Fragaria spp*	0	32

Non-chilling-sensitive vegetables	Lowest storage temperature	
	°C	°F
Artichoke, *Cynara cardunculus*	0	32
Asparagus, *Asparagus officinalis*	2.5	36
Bean sprouts	0	32
Beetroot, *Beta vulgaris* L. subsp. *vulgaris*	0	32
Broccoli, *Brassica oleracea var. italica*	0	32
Brussels sprouts, *Brassica oleracea* var. *gemmifera*	0	32
Cabbage, *Brassica oleracea* var. *capitata*	0	32
Carrot, *Daucus carota*	0	32
Cauliflower, *Brassica oleracea* var. *botrytis*	0	32
Celeriac, *Apium graveolens* var. *rapaceum*	0	32
Celery, *Apium graveolens* var. *dulce*	0	32
Chinese cabbage, *Brassica rapa* subsp. *Pekinensis*	0	32
Cilantro, *Coriandrum sativum*	0-1	32-34
Corn, **sweet**, *Zea mays*	0	32
Dandelion, *Taraxacum officinale*	0-2	32-36
Dill, *Anethus graveolens*	0	32
Endive, *Cichorium intybus, Foliosum Group*	0	32
Fennel, *Foeniculum vulgare* var. *azoricum*	0-2	32-36
Garlic, *Allium sativum* var. *sativum*	0	32
Ginger, *Zingiber officinalis*	13	55
Ginseng, *Panax ginseng*	0	32
Horseradish, *Armoracia rusticana*	-1-0	30-32
Kale, *Brassica oleracea* var. *acephala*	0	32

Non-chilling-sensitive vegetables	Lowest storage temperature	
	°C	°F
Kohlrabi, *Brassica oleracea* var. *gongylodes*	0	32
Leek, *Allium ampeloprasum*	0	32
Lettuce, *Lactuca sativa*	0	32
Onion, *Allium cepa*	0	32
Parsley, *Petroselium crispum*	0	32
Parsnip, *Pastinaca sativa* L. subsp. *sativa*	0	32
Peas, *Pisum sativum*	0-1	32-34
Radish, *Raphanus sativus, Radicula Group*	0	32
Rhubarb, *Rheum rhabarbarum*	0	32
Rutabaga, *Brassica napus* var. *napobrassica*	0	32
Salsify, *Tragopogon porrifolius,* subsp. *porrifolius*	0	32
Scorzonera, *Scorzonera hispanica*	0	32
Shallots, *Allium cepa,* Aggregatum Group*, Allium oschaninii*	0	32
Spinach, *Spinacia oleracea*	0	32
Swede, *Brassica napus*	0	32
Turnip, *Brassica rapa*	0	32
Watercress, *Nasturtium officinale*	0	32

Sources: Kader, A.A. 2002. *Postharvest Technology of Horticultural Crops*. University of California, Publication 3311; Kays, S.J. and Paull, R.E. 2004. Postharvest Biology. Exon Press, Athens, GA, USA.

ANNEX III

Simply Measuring - Quantifying Food Loss and Waste: UNECE food loss and waste measuring methodology for fresh produce supply chains

1. INTRODUCTION

BACKGROUND

According to the FAO, approximately 33 per cent of all the food for consumption produced globally is either wasted or lost. This percentage amounts to a total produce weight of 1.3 billion metric tons (FAO, 2019).

Food loss and waste is no longer a negligible nuisance, it has become a sizeable and growing problem in the context of a rapidly increasing population with food and energy needs; environmental degradation, climate change, fluctuating prices and production pressures.

The reasons for food loss and waste throughout supply chains are multifaceted and occur at all nodes of the supply chain from production to consumption. They include: Shortage of access to data on production, price, requirements, storage facilities; logistic issues that arise due to freight, local transportation, including storage at destination; last-minute order cancellation; improper planning production and distribution without knowing the market demands, quality requirements; production without knowing the demands and pricing; stringent buyer requirements; rate fluctuations that impact produced goods supply and resulting in heavy food loss; "natural overproduction" due to favourable growing conditions; or climate and climate change.

While a topic with wide-reaching social, demographic and environmental impact – food loss and waste are also business opportunities lost – engendering economic effects to all parts of the supply chain.

Therefore, the question arises of what needs to be put into place to address this complex subject towards reducing food waste and loss.

In this context and recognizing the need for and the power of data to devise, repurpose and redistribute available but currently lost food, UNECE has developed this methodology.

While a stand-alone tool, the simple UNECE methodology, which records losses and waste from production to wholesale levels, can also be integrated into an IT-based smart food loss management system to help trace and make food visible which would otherwise be lost or wasted and create opportunities to re-distribute food through or to alternative food chains. The systematic measurement and quantification of the loss or waste by actors in the food supply chain will help the public and private sectors contribute to finding viable and sustainable solutions to the food and environmental challenges of today.

A brief introduction sets the background of the food loss and waste topic. Section 2 shows the relevant fresh produce supply chain stages and actors that the quantification methodology is designed for. Section 3 includes the food loss and waste quantification method, followed by a food loss and waste hotspot analysis method in section 4. Section 5 indicates the financial loss related to the lost or wasted food. Ultimately, a food loss and waste measurement unit is suggested in section 6.

FOOD LOSS AND WASTE DEFINITION

According to the latest report of the Food and Agriculture Organization of the United Nations (FAO), the definitions of food loss and waste reads as follows:

"**Food loss** is the decrease in the quantity or quality of food resulting from decisions and actions by food suppliers in the chain, excluding retail, food service providers and consumers." (FAO, 2019)

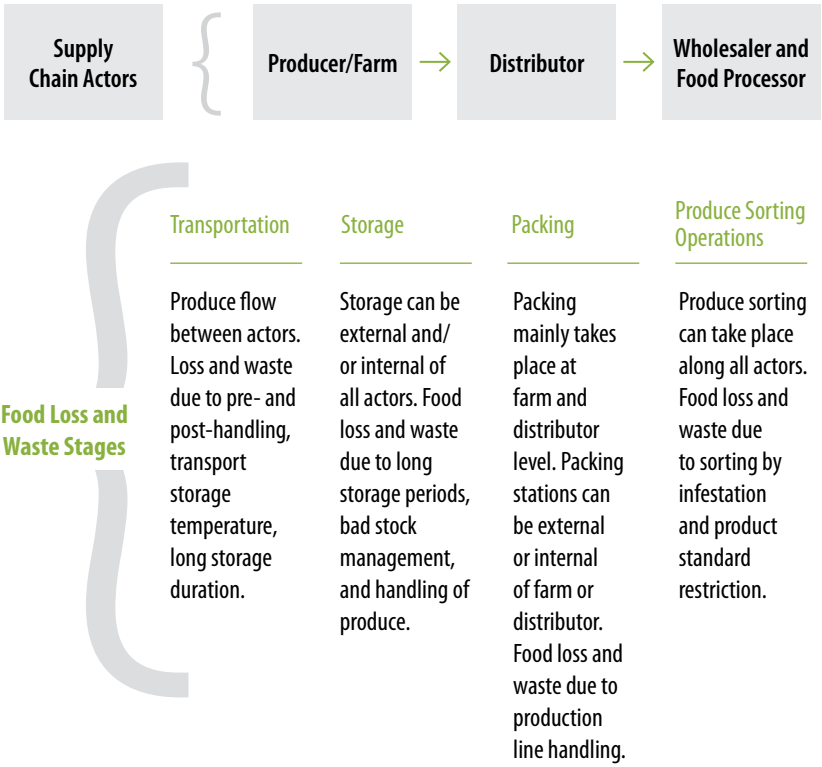
"**Food waste** is the decrease in the quantity or quality of food resulting from decisions and actions by retailers, food services and consumers." (FAO, 2019)

In line with the FAO definitions and for the purpose of this work, only food losses will be measured. However, food loss and waste may be used as a concept in some texts.

2. FRESH PRODUCE SUPPLY CHAIN STAGES AND ACTORS

For the simple food loss quantification methodology, this approach solely looks at the fresh produce (fruits and vegetables) supply chain stages and actors from "production" to "wholesale" level. Essentially, it can be established that the main relevant stages and actors from production to wholesale are as shown in figure 1.

FIGURE 1
Supply Chain Actors and Waste Stages of Concern for Methodology



ACTORS:

Farms/ Harvest areas
The production level of fruits and vegetables.

Distributors
Close business relationship with the farmers. The distributor is the farmer's direct point of contact for prospective buyers for the fresh produce. Nonetheless, distributors basically do not sell the fresh produce directly to the consumers.

Wholesalers
In general, wholesalers purchase large fresh produce volumes from distributors.

Food Processors
Companies that are capable to further process the fresh produce, e.g. a fresh orange juice factory. Food processors usually buy their produce from distributors as well as from wholesalers.

Packing Stations
A place where the fresh produce can be packed as desired by the various business customers. Packing stations can be at the farm or integrated in the distributor's facility as well as external in form of a third-party company that provides the packing service.

STAGES:

Transportation
Includes the fresh produce transfer between the supply chain actors.

Storage
Includes all places where the fresh produce is put into stock. Also includes the storage during transportation.

Packing
Involves the process of fresh produce packing at a packing station.

Produce Sorting Operations
Involves the process of fresh produce selection. This can be due to partial infested produce, cosmetic standard distinction, or ripening stage.

3. THE FOOD WASTE AND LOSS QUANTIFICATION METHOD

The purpose is to display a simple food loss quantification methodology for the fresh produce supply chain actors and stages from production to wholesale levels.

The formulas for quantifying lost food in the fresh produce supply chain are set on the following assumption.

- **Lost food entails removal of fruits and vegetables from the fresh produce supply chain meant for consumption by the end consumer. Therefore, it can be established:**

  Food Lost = Food Removed from the Fresh Produce Supply Chain

- **The moments of produce transitioning to a different place are the key points in the process of fresh produce trade to look at the occurrence of any amount variances.**
- **Any *processing* of fresh produce trade basically involves fresh produce packing for the intended customer at a packing house as well as any sorting operation that is undertaken. Packing and sorting operations are key points to look at lost or wasted food.**

Regarding the supply chain stages and actors of Farm/Harvest, Distributor, Wholesaler, Transportation, Storage, Packing and Sorting Operations, the following formulas are established.

(0)	X (Kg) Expected Harvest	–	X (Kg) Actually Harvested	=	Food Loss I (Kg)

> **Applicable at Harvest Level**

(1)	X (Kg) Harvested	–	X (Kg) Transported Harvest to a Next Place	=	Food Loss II (Kg)

Test formula: Food Loss II ≈ (X Kg lost through pre- and post- loading handling + X Kg lost through long storage + X Kg lost during packing + X Kg lost due to damage during transportation + X Kg lost through wrong storage temperature).

> **Applicable at Harvest Level**

(2)	X (Kg) Harvested	–	X (Kg) Out Sorted, Edible & Unsaleable Produce Due to "Standard" Restriction	=	Food Loss III (Kg)

Test formula: Food Loss III ≈ X Kg Unsalable Class II + III Fresh Produce

> **Applicable at Harvest Level**

(3)	X (Kg) Transported Produce to Storage	–	X (Kg) Received at Storage	=	Food Loss IV (Kg)

Test formula: Food Loss IV ≈ (X Kg lost through pre-and post - loading handling + X Kg lost through long transportation storage, X Kg lost through wrong storage temperature)

> **Applicable at Distributor, Wholesaler, and Food Processor Level**

(4)	X (Kg) Produce Set and Intended for Packing	–	X (Kg) Actually Packed Produce	=	Food Loss V (Kg)

Test formula: Food loss V ≈ X kg lost through produce handling at packing-production line

> **Applicable at any packing station entity**

(5)	X (Kg) Out Sorted Infested Produce (after Produce Sortation by Infestation)	=	Food Loss VI (Kg)

> **Applicable at any entity that undertakes infestation sortation**

(6)	X (Kg) Unsaleable/Not Requested Product Calibers + (Class II + III Produce)	=	Food Loss VII (Kg)

Test formula: Food Loss VII ≈ Distributor Produce Purchase % of not requested product calibers as well as class II+III produce, which the distributor is obliged to purchase.

> **Applicable for Distributors**

(7)	X (Kg) Unsaleable Produce Returned to Distributor or Farmer	=	Food Loss (Kg) (Harvest, Distributor)

> **Applicable at Harvest and Distributor Level**

4. FOOD WASTE AND LOSS HOTSPOT ANALYSIS METHOD

Food loss and waste occurs at every stage along food supply chains. However, globally there is a distinctive difference of lost and wasted food that occurs between low- and high-income countries. Contrary to low income countries – that show more food loss concentrations within the beginning of the supply chain (grower/ harvest level) due to inefficient storage capabilities and lack of adequate cooling systems, bad infrastructure and transport – high income countries generate more food waste within the latter part of the supply chain (retail-, consumer level). Here, the waste can result from various sources including retail (supermarkets) rejection of the produce due to quality insufficiencies, infestations such as mould etc., processing towards a product that reduced features of the initial resource, inadequate temperature conditions in warehouses or supermarkets, inadequate handling, overordering and subsequent cancellation, communication issues between involved parties, or unawareness by consumers, discarding products too soon (Gustavsson, Cederberg, & Sonesson, 2011).

To reply to the key question on where the critical waste generation points are that are related to the fresh produce supply chain stages and actors of this methodology, it can be argued that this is essentially a question of how efficient the fresh produce throughput is along all related processes. The more efficient the produce throughput of a stage, the less of a critical food loss or waste hotspot it becomes. The calculations explained in chapter 3 do not explain how efficient the throughput of the related stages is. Hence, a calculated food waste amount of e.g. 100,000 Kg can be subject to a more efficient throughput stage than a calculated food waste amount of 1,000 kg of a different throughput stage.

Thereon based, the calculations of chapter 3 can be rearranged in order to show the fresh produce throughput efficiency in all cases.

For example, if 1, 500 Kg of harvest is intended for transportation but, for various reasons, 1000 Kg of produce is actually transported to the next supply chain entity, one can establish the ratio of:

$$\frac{1{,}000\ \text{Kg}}{1{,}500\ \text{Kg}} = 0{,}66 = \text{Harvest to Transportation Throughput Ratio}$$

The ratio can be translated into a percentage when multiplied by 100 in order to show the throughput efficiency in percent. Hence, in the case of the example the "Harvest to Transportation Throughput Efficiency" is 66 %.

Hence, the calculations read as follows:

(0)	X (Kg) Actually Harvested / (Kg) Expected Harvest	(x100) =	Harvest Yield Efficiency (%)
(1)	X (Kg) Transported Harvest / X (Kg) Harvested	(x100) =	Harvest to Transportation Efficiency (%)
(2)	X (Kg) Out Sorted, Edible & Unsaleable Produce Due to "Standard" Restrictions / X (Kg)Harvested	(x100) =	Produce Standard Output Efficiency (%)
(3)	X (Kg) Stored Produce / X (Kg) Transported Produce	(x100) =	Transported to Stored Produce Efficiency (%)
(4)	X (Kg) Actually Packed Produce / X (Kg) Produce Set and Intended for Packing	(x100) =	Produce Packing Efficiency (%)
(5)	X (Kg) Infested Produce / X (Kg) Produce Set for Sortation by Infestation	(x100) =	Edible Produce Efficiency (%)
(6)	X (Kg) Unsaleable Produce Returned from One Entity to Another / X (Kg) Produce Sold by One Entity to Another	(x100) =	Successful Produce Trade Efficiency (%)

In principle, any produce throughput efficiency rate of 100% suggests a fully efficient produce throughput. The throughput efficiency rate shows the food loss or waste generation potential of the related supply chain stages.

5. FINANCIAL LOSS RELATED TO FOOD LOSS AND WASTE

The financial loss related to lost or wasted food can be a topic of concern and, simultaneously, a topic of opportunities for the related supply chain actor. For a research project in 2018 of the fresh produce wastes of one leading distributor of organic fruits and vegetables considerable financial losses have been made visible as shown in table 1.

In table 1, the financial loss related to lost and wasted food can be essentially established with the help of two components.

Component I: The lost monetary purchase value (for the farm level, lost monetary sales value) of the related fresh produce. The rationale is that the entity that purchases a certain amount of produce from another supply chain actor cannot valorize what has been disposed, and therefore completely loses the amount of money that has been paid for the produce. This loss is certain as opposed to the "imaginary loss" that would occur if the produce could have been sold with a profit margin added to the purchase price (which, for instance, is the essential purpose of every produce reseller before the produce reaches the end consumer).

For the fresh produce farmer in the supply chain, a certain financial loss can be expressed through the price the distributor agreed to pay for the farmer's produce, which cannot be realized through the food that is lost.

Component II: The disposal costs that one supply chain actor must pay a disposal company. (This component may or may not be applicable for a supply chain actor depending on what the regulations on food disposal state in the specific country or area.)

Therefore, it can be established:

For Distributors, Wholesalers, and Food Processors:

Price Paid for Produce in Currency × Food Lost = Lost Monetary Purchase Value

For the harvest level:

Price Offered for Produce in Currency × Food Lost = Missed Sales Value

In both cases and if applicable with the addition of disposal service cost.

6. TRUCK UNIT MEASUREMENT SUGGESTION

In order to exemplify the data on lost and wasted fresh produce amounts, a "Truck Unit Quantification" can be used, especially for the supply chain levels downward the harvest/farm level. It is commercial practice to refer to the amount of shipped produce by talking about the number of pallets that have been transported, sold, and purchased. The dimensions and the "picture" of fully loaded pallets and trucks seem to be more comprehensible among actors of fresh produce trade as opposed to amounts only expressed in metric units. Further, a fully loaded common truck trailer seems to be more positively associated with efficient.

In fresh produce trade, the "industrial pallet" is a widely used exchange pallet throughout the world. The pallet measures a length of one meter, a width of 1.5 meters and it can be loaded with up to 1,500 kilograms for safe working (European Pallet Association, 2017). A common truck trailer can be loaded with 26 industrial pallets.

Therefore, data on lost or wasted food could be translated as shown in the example of table 2.

TABLE 2
Example for Truck Unit Conversion of Lost or Wasted Food Amounts

Year (or month, or period of time)	Total lost food in a common fully loaded truck
2018	1,300,000,000,000Kg / (26 pallets x 1500kg) = 33.33 Million Trucks (Annual Global Food Lost)

Hence, the conversion reads as follows:

$$\frac{\text{X Kilogram Lost Fresh Produce}}{\text{39,000 Kilogram}} = \text{"Fully Loaded Truck with Lost Food"}$$

The food loss record sheet can be used to record and compare loss at various stages in the supply chain and the actors involved.

TABLE 3

Food loss record sheet (can be used daily, weekly, or monthly)

Actor	Harvest Expected (Kg)	Harvested (Kg)	Sales Price in Currency for Harvest / Kg	Harvest Trans-ported to Next Entity (Kg)	Out Sorted, Edible and Unsaleable Produce Due to Standard Restriction (Kg)	Trans-ported Produce to Storage (Kg)	Received Produce at Storage (Kg)	Produce Set for Packing (Kg)	Packed Produce (Kg)	Sorted Due to Infes-tation (Kg)	Unsalea-ble/ Not Requested Product Calibres (Kg)	Unsaleable Produce Returned from One Actor to Another (Kg)	Paid Purchase Value in Currency / KG
Producer / Harvest Level													
Distributor													
Wholesaler / Food Processor													
Packing Station													
Storage													
Sorting Operation Entity													

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