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Code of Good Practice – reducing food loss and ensuring optimum handling of fresh fruit and vegetables along the value chain

Submitted by the Secretariat

The UNECE Code of Good Practice for reducing food loss in handling fresh fruit and vegetables was adopted by the Working Party on Agricultural Quality Standards in 2019. The following document contains the text of the second edition of the Code of Good Practice, submitted to the Working Party on Agricultural Quality Standards at its 2021 meeting. The document is presented for information purposes.

The Specialized Section is invited to take note of the second edition of the Code of Good Practice and to discuss the possibility of developing similar guidelines for nuts and dried fruit.

Code of Good Practice

– reducing food loss and ensuring optimum handling of fresh fruit and vegetables along the value chain

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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 its impact on the environment.

Much can be gained, including economically, from taking measures to reduce the losses and the waste. According to estimates, investments in measures to reduce losses and waste in food can give a 14-fold return.[1] (For further details, see the UNECE measuring methodology in annex V.)

The Code of Good Practice supports 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 has been drawn up by the United Nations Economic Commission for Europe (UNECE) to provide guidance to the sector on how to reduce losses and waste. Whereas the Voluntary Code of Conduct for Food Loss and Waste Reduction[2], prepared by the Food and Agriculture Organization of the United Nations (FAO), is a generic framework, the UNECE Code of Good Practice specifically addresses fresh fruit and vegetables. It contains actions and measures that public and private stakeholders are advised to take or put in place. It is aimed at strengthening the work already being done in this area by many food supply-chain actors.

The Code of Good Practice sets out measures to be taken at the stages in the value chain before the fruit and vegetables reach the consumer, i.e. from harvest to retail. It is intended to support continued improvement, step by step. Real improvement, however, can only be achieved if the food supply-chain actors cooperate to improve their logistics, handling and planning, both inside countries and across borders. Communication will be a key factor. Measuring loss and waste is essential; it gives the actors feedback on how well their work progresses.

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

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

[2] The FAO Code of Conduct can be found at https://www.fao.org/platform-food-loss-waste/news/detail/en/c/1413774.

It is complemented by five annexes and a select list of reading matter that describes in detail the processes that regulate fruit and vegetables during growth, maturation, ripening and senescence and the best handling and storage practices.

1. Primary 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, minimize losses in the field and lead to sound produce – are a collection of principles to apply for on-farm production and post-production processes including good post-harvest practices resulting in safe and healthy food and non-agricultural products, while considering 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 retail.

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 understand the consequences of shortcomings in handling and storing products. They should understand the impact of poor handling and storing practices on quality, shelf life and waste, and on loss of profit for the company.

Producers are therefore encouraged to provide training in proper product handling at harvest and post-harvest stages and to understand the

consequences on the environment, climate and profitability of not adhering to the recommendations.

For this purpose, it would be particularly useful to develop handling guides per product, taking into account the level of education and the high turnover of the labour force of harvesters. The guides should highlight appropriate practices and key parameters affecting quality.

1.3 Plan production to demand

Production should meet market demand in terms of both quantity and quality. 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 as some products may continue to develop added taste and aroma after harvest (climacteric fruit) whereas others do not (non-climacteric fruit).[3]

On local markets, direct communication between producer/seller and buyer will give the producer valuable information on the buyer's 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.

International trade standards, which are drawn up with major input from the market, are commonly agreed descriptions of the quality expected and therefore provide valuable information on quality requirements. There may also be more detailed and often more stringent requirements in the specifications from the commercial 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 bought by the consumer.

1.4 Use the best possible harvest methods

The best possible harvest methods need to be used for product quality and shelf life. Unless products are carefully handled and the proper equipment used correctly, products can easily be damaged. All mechanical impact on products – cuts, bruises, tearing, breakages – will reduce their quality, shorten their storage and shelf life, and increase waste.

[3] Climacteric fruits have a pronounced ripening stage where the fruit attains a softer texture and a change in taste and aroma. Non-climacteric fruits lack this pronounced ripening stage and there are no major changes in texture and taste after harvest.

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.

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. Careful handling and adherence of staff to personal hygiene is important. 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.

Harvesters should also be trained on how to harvest produce items at the right stage of maturity. Because tropical fruit ripens fast, harvesting at the right stage of maturity is essential. Direct contact of immature fruit with more mature fruit can cause damage and quality losses.

Raising awareness among staff and training them in the correct maintenance and use of equipment is important. For producers who do not own machines, wherever machinery is able to improve harvest results, it is recommended to consolidate among several producers.

1.5 Harvest products under the best conditions

Time of day and weather conditions at harvest can affect the post-harvest quality of products. It is scientifically proven that harvesting early in the day 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 ratio (e.g. broccoli) that easily lose water benefit most from this. This, however, does *not* apply for fruits when they still have condensed moisture on their surface. For fruits and for fruit vegetables[4], early harvesting should be done after the water droplets on the surface evaporate. In all cases, the shorter the normal shelf life of a product, the greater the benefit of harvesting early in the day. Higher temperatures will also speed up the ripening process.

Sunshine, high temperatures and wind will increase water losses and speed up the ageing process. 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.

[4] A “fruit vegetable”, also called “salad fruit” is a product that is botanically a fruit (a mature ovary with connected tissues, or more simply a seedbearing structure) but that is used as a vegetable.

While still in the field, products need to be protected from sun, wind, rain, dust and any other factors affecting their quality, such as by 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 rapid cooling

The single most important factor for retaining product quality after harvest is temperature. Suboptimal cool or cold chain processes and management account for much food loss. The higher the temperature at harvest and the more sensitive the products, the greater the benefit from cooling.

There is thus much to gain from rapid and efficient cooling of products after harvest. If cooling is available, products should be cooled to the recommended temperature as quickly as possible without harming the product. They should be cooled before transport, with the exception of short journeys to a storage facility or packhouse. The cooling equipment of transport vehicles does not have the power to lower product temperature, just maintain it.

When pre-cooling facilities are not available, it is even more important to harvest at the coolest time of the day and to transfer the produce to a shadowed area as soon as possible.

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.

Products with a large surface-to-volume ratio – for example, leafy vegetables and broccoli – easily 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 for many fruits and vegetables.)

1.7 Store products appropriately

Prior to dispatch, products should be stored at their appropriate, product-specific temperature to retain the visible quality, keeping quality and to

reduce food loss and waste. The longer the storage period, the greater the gain in storing products as close to their optimum storage temperature as possible. A low temperature reduces the ageing of products and the growth of plant pathogens.

When products have reached their optimum storage temperature, air circulation should be reduced to a minimum, just ensuring removal of respiration heat and gas exchange around products; excess air circulation will cause dehydration and loss of freshness.

Frequent changes in temperature also reduce produce shelf life. Taking products from cool storage and placing them back again should therefore be avoided.

The use of controlled atmosphere (CA) technology[5] during long-term storage can greatly extend the life of products and reduce losses. However, the conditions such as the level of oxygen and carbon dioxide need to be closely monitored for different crops and even varieties.

When refrigerated storage is not available, products should be kept at the best possible conditions and protected from sun, rain, wind and dust. If products are kept outside, a clean tarpaulin can provide some protection.

As freshness is an important quality parameter in most products, humidity needs to be considered. Leafy vegetables and other products with a large surface to volume ratio (e.g. broccoli) will quickly lose water in dry conditions, especially in combination with high-speed air circulation or wind. Lowering the temperature will increase relative humidity in the air, but may damage the produce due to dehydration if the water vapour content remains too low.

High-speed air circulation is important during cooling as it speeds up the cooling process, but must then be combined with high moisture. After products have reached their optimum temperature, air circulation should be low, but allow for the removal of respiration heat.

Relative humidity can be controlled by the temperature of the storing facility and/or controlling the moisture in the air of the facility (e.g. mists, spraying water and/or leaving water tins inside the storage facility are practical alternatives).

In addition, products producing ethylene (climacteric fruits, see annex I) and products that are sensitive to ethylene (see annex III) should not be transported together but in separate vehicles, trailers, containers or compartments to avoid damage or shortening the shelf life of the ethylene sensitive products.

[5] In controlled atmospheres, the level of oxygen in the storage room is reduced and the level of carbon dioxide is increased compared to normal air. As a result, product respiration and ethylene production decreases, which reduces ageing and loss of nutrients in the stored products.

1.8 Choose appropriate packaging and label correctly

To protect products during transport and distribution, appropriate packaging needs to be used. The cost and quantity of packaging material should be balanced against sufficient protection and 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 on a pallet.

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 such as leaves, sand or soil, 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 the transport and distribution can be minimized by using appropriate packaging as well 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.

Durable reusable crates which could be cleaned in a proper way could be used between actors with a long-term business relationship and if an exchange of full and empty crates is feasible. This would ensure the continuous use of suitable packaging.

It is important that boxes as well as consumer packages are labelled according to the requirements of the country of destination and of the buyer. Incorrect marking of consumer packages is one of the main causes for the rejection of produce by inspectors and can become the cause of loss and waste. Boxes may be re-labelled, at the expense of the sender, but the re-labelling of consumer packages is often considered too costly. When products are packed and labelled for a private label, in cases of returned or cancelled orders, it is difficult to sell the products to another buyer.

1.9 Stack boxes and crates appropriately

Cartons/cardboard boxes and crates of produce should be stacked correctly, not exceeding individual container stacking strength or be stacked too high on pallets.[6] Handling staff should adhere to the maximum height of

[6] Stacking strength indicates the container's resistance to crushing (and thus protection of its contents). It is built into carton sidewalls and influenced by the size and type of carton material used. The strength is sometimes printed on the carton.

unbroken pallet loads received from the wholesaler or exporter. Proper stacking includes following the lengthwise and crosswise method that aligns the carton vent holes in the correct direction to allow air circulation throughout the stacked containers.

The most common height for wholesale units is seven to eight layers high, whereas single layer boxes containing retail units can be stacked higher. Often products with large individual sizes such as melons, pumpkins and other such gourds are packed in pallet bins; while tubercule vegetables such as carrots, turnips, beets and onions are packed in mesh bags or loose in boxes. Irrespective of the container the appropriate stacking method should be applied.

All pallets can be both under-stacked and over-stacked in storage. Both practices have cost implications for the trader and retailer.

Under-stacking of pallets may result in:

- Less efficient use of the refrigerated storage/holding space.
- An increased risk of placing containers of other produce atop the stack and mixing non-compatible produce.
- Giving an incomplete tally of number of cartons/containers available (if only the number of pallets is counted) that can lead to inappropriate volumes being ordered.

Over-stacking of pallets may result in:

- Crushing of the packages at the lowest level and damaging the produce.
- Restricting efficient cold air circulation within the stack.
- Rougher handling by staff (manually and with equipment such as pallet jacks and forklifts).
- Posing direct threats to the safety of the workers who may have problems reaching the top layers or difficulty seeing around the stack (when using a forklift, for example).
- Inability to re-use cardboard boxes and plastic crates due to damage.

Placing packages on pallets and not directly on the floor in storage:

- enables the ease of handling through the use of machinery for loading and unloading,
- facilitates circulation of cool air throughout every produce container in the stack,
- contributes to sanitary conditions in storage and helps address consumer food safety concerns.

1.10 Post-harvest treatments may be considered

Post-harvest treatments to increase shelf life and reduce losses and waste are available for both organic and non-organic 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 positive 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.
- Restricting the presence and access of insects and other pests as much as possible in order to avoid immediate losses and future losses.

1.11 Ensure quick deliveries

Products that are not fit for long storage should be delivered as soon after harvest as possible to avoid 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 by the time products reach the consumer.

1.12 Record parameters affecting quality

Parameters that affect quality include temperature, humidity, harvest time, transport to packing house, grading, packaging and storage. These should be monitored and recorded for easier traceability and implementation of corrective measures. They should be recorded per handling stage and for every shipment.

1.13 Report outbound quality

Reducing waste in the global food chain starts by supplying the appropriate quality into the system. It is recommended that producers create "outbound quality-control reports" that mirror the quality reports of their clients – i.e. know what critical quality parameters the client monitors and check the same (with photographs) when the product is ready for dispatch. This allows for corrective measures to be taken prior to departure or warning the client to know what to expect and avoid rejections.

1.14 Find alternative outlets

(a) Oversupply products

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. Producers 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. However, accessing the alternative markets may require an adjustment of price.

The following alternatives are examples that might be considered:

- Find alternative outlets, new markets or destinations, e.g. in the hospitality industry (HORECA sector). To facilitate these alternatives, electronic marketplaces for unsold/surplus products are being developed in some countries.
- Change presentation to address new market segments.
- Find buyers that can process (industrially) for food purposes.
- Find buyers that can process into fresh-cut fruits and vegetables or other novelty products.
- Process products on-site, e.g. drying, fermentation, to make them durable and to address new market segments.
- Donate to charity, respecting applicable guidelines.[7]
- Use surpluses for economic uses such as animal feed, energy generation, or fertilizers.

If no alternative outlet can be found, products should be treated in a way that limits the negative effects on the environment.

[7] The EU guidelines on food donation are one example
https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:C:2017:361:FULL&from=EN

(b) Products not meeting buyer specifications

In all production, part of the crop will not meet the requirements specified by the buyers that the products are normally sold to. Good communication with buyers is therefore important in order to know clearly what the buyer expects but also to increase the buyer's knowledge and understanding regarding certain defects. It can raise an interest in the buyer for selling products with exterior defects as for example "rescued produce" in order to contribute to reducing losses and waste. If products are sold in quality categories, a lower category will often accommodate most of the products with exterior defects thanks to the higher tolerances in lower categories.

If products cannot be sold to the "normal" buyer in a lower category or as "rescued produce" or equivalent, the alternatives set out above can also be considered.

1.15 Measure the losses

Primary producers and others involved 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 acknowledge the problem, measure the loss, identify hotspots and manage the food losses through targeted interventions. Those 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 a valuable tool for finding measures that lead to reduced waste.

The results can be used not only for future planning but also for implementing measures related, for instance, to cultivation, handling, temperatures, transport and logistics. Apart from the aspect of reducing waste, there is a strong business incentive to carry out this work.

1.16 Support local government interaction

Communicate waste data to the local government or agricultural office.

This information opens opportunities for public measures (e.g. redistribution of surpluses into shortage areas). The UNECE digital food loss management system named FeedUP@UN allows the collection of data and may facilitate redistribution of products.

2. Traders

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

The term “traders” here covers a wide range of actors along the value chain. They can be cooperative or producer organizations collecting and marketing their members’ production as well as storing, sorting and packing their produce. They can also be private companies buying products and selling them to buyers locally, domestically or abroad. And they can be wholesalers connected to retailer chains, supplying their retail stores.

As many of these operators handle large volumes of products, introducing small changes in their handling practices can greatly contribute to reducing losses and waste at the retail level.

2.1 Ensure proper training of staff

Warehouse and quality-control staff working with fresh fruit and vegetables should be trained in how to handle the products and understand the consequences of shortcomings in handling and storing products. They should understand the impact of poor handling and storing practices on quality, shelf life and waste, and on loss of profit.

Traders are therefore encouraged to provide staff with training in proper product handling and in the consequences on the environment, climate and profitability of not adhering to the recommendations.

For this purpose, it would be particularly useful to develop handling guides per product, taking into account the level of education and the high turnover of the labour force. The guides should highlight appropriate practices and key parameters affecting quality. Special attention must be paid to sorting and grading, as this affects food losses and waste throughout the chain.

In addition, sales personnel need to be trained on the urgency of selling products within shelf-life limits so as to avoid food losses and waste.

2.2 Plan ordered volumes to demand

Planning and adjusting ordered volumes to market demand via careful product planning is necessary to ensure that products ordered can be delivered to retailers without unnecessary delay and thus with minimal losses. Careful product planning also includes harvesting at market maturity and having logistical arrangements that facilitate product arrival at retail stage with a longer shelf life remaining, i.e. fresher and better quality leading to reduced loss and waste at both retail and consumer levels. Products delivered to clients must meet quality specifications, including maturity, so as to avoid rejections or disputes that can lead to waste.

Demand for products depends on the weather, the season, holidays and celebrations. For some products, demand periods are well established, whereas for others they are less predictable, thereby making planning more

difficult. Procurement staff should employ demand-planning strategies and tools to minimize this kind of uncertainty.

An efficient chain from harvest to retailer requires market knowledge and careful planning and plan implementation. Planning involves pre-guaranteeing sales volumes of different products, but also for example trade types, varieties, sizes, quality classes/grades, colour requirements and maturity level/stage of ripeness. Good communication with clients and suppliers is important to coordinate market supply and demand.

2.3 Ensure efficient logistics

An efficient logistics chain that reduces the time from producer or packer to retailer ensures an appropriate shelf life of perishable products and reduces quality losses and waste along the chain.

An efficient logistics chain should have a minimum of stops and reloading points. Stops should be short and reloading conducted effectively and efficiently. A strict "first-in, first-out" principle must be followed, as long as the quality of the produce is also aligned. But if a later delivery has more sensitive products (shorter shelf life), these should be prioritized.

Quality-control staff are encouraged to frequently monitor the quality of the products in the warehouse. In the absence of automatic systems, environmental conditions should also be monitored.

2.4 Place and change orders in a timely manner

Orders should be placed early so as to give the producers enough time to harvest products at the appropriate time of day, cool products to the appropriate temperature, sort/grade and pack according to the specifications. If orders are placed or changed shortly before time of dispatch, producers may have to send products that are not properly cooled – resulting in reduced shelf life and increased food loss and 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. In cases where orders are placed in foreign countries requiring several days or weeks of sea travel, last-minute ordering is often not feasible.

2.5 Avoid late cancellations[8]

Orders of perishable products that are cancelled at short notice close to dispatch makes finding a new buyer difficult, often leading to food loss. This problem is more severe when the product is packed in specific branded packaging of the retailer which cannot be sold to another retailer without costly repackaging and additional risk of damages by handling.

[8] Some countries or regions have adopted legislation addressing this problem. One example is the European Union, which has adopted a regulation directive on Unfair Trading Practices which includes a section on cancellation of orders (EU /2019/633).

In the case of orders placed in foreign countries requiring several days or weeks of sea travel to destination markets, cancellations may not be feasible, or can result in high rates of food loss in producing countries, particularly if the product is not part of the country's diet.

The frequent cause of late cancellations is often that market demand for a product has become lower than when the buyer originally placed the order. In some cases when it is impossible to change the order (product is located at the shipping port, or already loaded on the means of transport), the products may therefore still be wasted upon arrival at the destination market. In such 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 must be moved into the distribution chain.

Note that when products are packed and labelled for a private label, in cases of returned or cancelled orders, it is difficult to sell the products to another buyer.

2.6 Define clear specifications

Retailers' specifications – including quality requirements, correct maturity for the intended purpose and labelling – should be clearly defined in advance and in good communication with and/or purchase agreements with producers, in such a way that unnecessary waste is avoided.

Retailers' specifications on quality should ideally be identical to the marketing standards[9] for trading fresh fruits and vegetables. Additional quality requirements, added to the requirements in the trade standards, should be kept to a minimum in order to reduce transaction costs, losses and waste. An increased acceptance and therefore sale of products with exterior defects not affecting the eating quality will reduce losses at primary production.

Trading parties should pay attention to specifications that might require grading, sorting or trimming of produce that might lead to avoidable food waste (e.g. trimming to the same size or length to fit into a specific package, refusing specific sizes or varieties as not being part of the goods accounting).

Trading parties should also take note that some products such as tropical root crops (e.g. yams and ginger) must be trimmed during harvest. This knowledge is very important to avoid food wastage.

[9] Such as, for example, the international marketing standards developed by UNECE or CODEX.

Fruit and vegetables need to have reached an appropriate stage or degree of development when harvested to have sufficient shelf life and appropriate quality for the intended purpose. This stage is called horticultural maturity.[10]

Horticultural maturity is any stage from a seedling (sprouts), a tender spring carrot, a shoot (asparagus), undeveloped flowers (broccoli) and all the way to ripe and fully developed fruits (apples, peaches etc.) Climacteric fruit such as apples, pears and peaches must attain an appropriate degree of development to ensure proper completion of the ripening process and develop the expected taste, aroma and texture – i.e. physiological maturity.[11]

The correct maturity is also important for products to be able to withstand transportation and handling and have a sufficient shelf life for retail and at consumer level.

The trading parties should fully understand and have the same interpretation of the terms "maturity" (in fruits[12]) and "sufficiently developed" (in vegetables and root crops).

Consumers may be very eager to buy early season products at a premium price. However, if these early season products are marketed before they have reached the appropriate maturity, they may not ripen properly to reach the desired quality. Consumers may then discard these products and avoid buying such products again, either in the near future or permanently – even when better qualities are available. This will have a negative impact on price and demand of such products for an extended period of time, as well as the reputation of the supplier/producer.

The trader should be aware that the different varieties of many fruits from the same region or country – for example, apples and pears – mature and ripen at different times, and should therefore be marketed at different times. Each variety should be placed on the market at the correct time. One of the best ways to ensure this is to have good communication with producers and to seek and respect their advice.

The best way to avoid losses and waste connected to maturity is to follow the guidelines as set out in the OECD brochures for fresh fruit and vegetables[13] and for producers and traders to adhere to the international

[10] Horticultural maturity: The stage of development when a plant part possesses the necessary characteristics for use by consumers

[11] Physiological maturity: The stage of development when a plant part will continue development even if detached.

[12] Including fruit vegetables such as tomatoes, cucumbers, aubergines, zucchini.

[13] https://www.oecd.org/agriculture/fruit-vegetables/.

standards on maturity requirements and to respect the advice of given by producers and traders.

The OECD brochures are acknowledged worldwide as a prime reference to interpret international standards. Their adoption should be agreed on between producers and buyers (wholesalers and importers) and between sellers (wholesalers and importers) and retailers.

2.7 Control ordered products at arrival

The buyer (wholesaler or importer) should inform the supplier of the inspection protocol that produce undergoes upon arrival. This is important because in many cases produce undergoes food safety and plant health inspections before quality/conformity assessment. Additionally, it is prudent for both parties to:

- Apply an agreed inspection procedure
- Set up a control protocol specifying the defects and the percentage of non-conforming products
- Communicate complaints/claims to the supplier in preferably a written report format such as the inspection report and in a timely manner after the products are inspected and/or have arrived at the buyer's premises
- Establish, if possible, the likely reason for the non-conformity and possible actions that can be undertaken to reduce food loss and waste (e.g. reconditioning, downgrading, processing, feed).

Rejection of products at wholesale level due to products not fulfilling the requirements of a quality standard or the requirements that have been agreed by buyer and supplier is a major cause of waste.

An added difficulty is that buyers and suppliers do not always agree on whether products are in conformity. However, when the complaint is fair, and is justified by photos and additional supporting evidence, common agreement can easily be reached.

When evidence is clear – for example if all products are dirty or overripe – non-conformity is easy to establish and applying an agreed control method may not be necessary. Photographs may sufficiently communicate the extent of non-conformity to the seller.

Products may also be judged by the buyer as not to be in conformity because the tolerances set out in the standards have been exceeded. However, at times when such non-conformity is not excessive and the complaint is less visible from photographs, applying a common control method will 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 supplier.

The communication of non-conformity is difficult without having an agreement to use international standards and control methods for conformity assessment. Having a commonly agreed control/inspection method can also avoid products being rejected erroneously.

One example of quality inspection guidelines for fruit and vegetables are those developed by OECD.[14] The OECD inspection method defines the number of boxes in the primary sample – depending on the size of the lot – that should be taken randomly and inspected. It also defines the method of inspection for products in consumer packages and for products in different sizes of consumer packages and for products loose in the package.

The perishable nature of fresh fruits and vegetables demands that quality-control results are communicated to the supplier within a reasonable time depending on the sensitivity of the products, thus allowing for consideration of any necessary alternative actions, including price adjustments. This also 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 known deviation from the appropriate temperature during transport, this is an important piece of information to those involved. The buyer, in agreement with the supplier, should always try to find ways to avoid returning or rejecting products.

The control protocol should preferably specify the percentage of products with different defects as found in the control that has been made. 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 judgement of the quality of delivered products at a point in time immediately after their arrival at the buyer's premises. What is judged to be "a reasonable time" will vary according to the product and how it is stored, transported and handled after arrival.

Areas considered high risk and likely to cause problems should be defined in the 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 sought. This will help the parties involved to take measures to avoid the problem in the future.

[14] https://www.oecd.org/agriculture/fruit-vegetables/.

2.8 Choose appropriate packaging and label correctly

To protect products during transport and distribution, appropriate packaging needs to be used. The cost and quantity of packaging material should be balanced against sufficient protection and 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 on a pallet.

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 such as leaves, sand or soil, 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 the transport and distribution can be minimized by using appropriate packaging as well 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.

Durable reusable crates which could be cleaned in a proper way, could be used between actors with a long-term business relationship and if an exchange of full and empty crates is feasible. This would ensure the continuous use of suitable packaging.

It is important that boxes as well as consumer packages are labelled according to the requirements of the country of destination and of the buyer. Incorrect marking of consumer packages is one of the main causes for the rejection of produce by inspectors and can become the cause of loss and waste. Boxes may be re-labelled, at the expense of the sender, but the re-labelling of consumer packages is often considered too costly. When products are packed and labelled for a private label, in cases of returned or cancelled orders, it is difficult to sell the products to another buyer.

2.9 Stack boxes and crates appropriately

Cartons/cardboard boxes and crates of produce should be stacked correctly, not exceeding individual container stacking strength or be stacked too high

on pallets.[15] Handling staff should adhere to the maximum height of unbroken pallet loads received from the wholesaler or exporter. Proper stacking includes following the lengthwise and crosswise method that aligns the carton vent holes in the correct direction to allow air circulation throughout the stacked containers.

The most common height for wholesale units is seven to eight layers high, whereas single layer boxes containing retail units can be stacked higher. Often products with large individual sizes such as melons, pumpkins and other such gourds are packed in pallet bins; while tubercule vegetables such as carrots, turnips, beets and onions are packed in mesh bags or loose in boxes. Irrespective of the container the appropriate stacking method applied.

All pallets can be both under-stacked and over-stacked in storage. Both practices have cost implications for the trader and retailer.

Under-stacking of pallets may result in:

- Less efficient use of the refrigerated storage/holding space
- An increased risk of placing containers of other produce atop the stack and mixing non-compatible produce
- Giving an incomplete tally of number of cartons/containers available (if only the number of pallets is counted) that can lead to inappropriate volumes being ordered.

Over-stacking of pallets may result in:

- Crushing of the packages at the lowest level and damaging the produce
- Restricting efficient cold air circulation within the stack
- Rougher handling by staff (manually and with equipment such as pallet jacks and forklifts)
- Posing direct threats to the safety of the workers who may have problems reaching the top layers or difficulty seeing around the stack (when using a forklift, for example).
- Inability to re-use cardboard boxes and plastic crates due to damage.

Placing packages on pallets and not directly on the floor in storage:

- enables the ease of handling through the use of machinery for loading and unloading,
- facilitates circulation of cool air throughout every produce container in the stack,

[15] Stacking strength indicates the container's resistance to crushing (and thus protection of its contents). It is built into carton sidewalls and influenced by the size and type of carton material used. The strength is sometimes printed on the carton.

- contributes to sanitary conditions in storage and helps address consumer food safety concerns.

2.10 Store products appropriately

Temperature is a vital factor in retaining product quality during distribution. It increases shelf life by affecting respiration rate and thereby reduce the ageing of the fruit and vegetables. Shelf life is highly influenced by deviations in temperature during storage. As a result, inadequate cool-chain processes and management cause a large percentage of food losses and waste.

During distribution, products should be stored at their appropriate, product-specific temperature to retain the visible quality and keeping quality and to reduce food loss and waste. Therefore if products are kept at incorrect temperatures, at any time along the chain, the money and resources spent on all activities at every previous stage including production, harvest and post-harvest is quickly wasted.

For example, lettuce has an estimated shelf life of up to 12 days at zero degrees Celsius but only 2 days at 20 degrees; leeks and cauliflower may be stored over 20 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).

Frequent changes in temperature also reduce shelf life. Taking products from cool storage and placing them back again should therefore be avoided. The resources invested into pre-cooling and cooling products to the appropriate temperature is quickly lost if these products are kept at inappropriate temperatures later in the chain. Collaboration and discussions along the value chain should be conducted to establish an unbroken cool chain.

Subtropical and tropical products develop chilling injuries when kept at low temperatures. Attention should therefore be paid to ensuring that chilling-sensitive products are not subjected to temperatures below those that may cause such injury (see annex II). When possible, there should be different temperature zones in the storage facilities to accommodate the different temperature requirements of products.

In addition to temperature, traders should take into consideration all other aspects, including humidity and ethylene, that are important to retain the quality of the products (visible quality, keeping quality, taste, smell, appearance and touch) and that would reduce waste.

Relative humidity can be controlled by the temperature of the storing facility: setting the dew point and/or controlling the moisture in the air of the facility (e.g. mists, spraying water and/or leaving water tins inside the storage facility are practical alternatives). Products that easily lose water should not be placed next to a fan or air outlet. Products producing ethylene (climacteric fruits, see annex I) and products that are sensitive to ethylene (see annex III) should be stored separately.

2.11 Record parameters affecting quality

Parameters such as temperature or humidity that affect quality should be monitored throughout the distribution chain and recorded for easier identification of points for implementing corrective measures. They should be recorded per handling stage and for every shipment.

2.12 Report outbound quality

Reducing loss and waste in the global food chain starts by supplying the appropriate quality into the system. It is recommended that producers create "outbound quality-control reports". These should mirror the quality reports from the buyer's arrival control – to convey what critical quality parameters the client monitors and check these parameters when the product is ready for dispatch from the supplier. This allows for the supplier to take corrective measures before dispatch and inform the client of the quality of the consignment in order to avoid rejections.[16]

2.13 Find alternative outlets

Even with the most careful planning, there will invariably be products that cannot be sold to the intended buyer. Parties in the 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. However, accessing the alternative markets may require an adjustment of price.

The following alternatives are examples that might be considered:

- Find alternative outlets, new markets or destinations, e.g. in the hospitality industry (HORECA sector). To facilitate these alternatives, electronic marketplaces for unsold/surplus products are being developed in some countries.
- Change presentation to address new market segments.
- Find buyers that can process (industrially) for food purposes.
- Find buyers that can process into fresh-cut fruits and vegetables or other novelty products.

[16] https://www.oecd.org/agriculture/fruit-vegetables/

- Donate to charity, respecting applicable guidelines.[17]
- Use surpluses for non-food economic uses, such as animal feed, energy generation or fertilizers.

If no alternative outlet can be found, products should be treated in a way that limits the negative effects on the environment.

2.14 Measure the losses

Traders that are aware of their food loss volume and that understand the causes and have the means to measure it should have a greater capacity to reduce the loss than those that do not. This implies that traders acknowledge the problem, measure the loss, identify hotspots and manage the food waste through targeted interventions. This enables them to start a learning process that serves as an important tool for finding remedial measures that lead to reduced losses.

The results can be used not only for future planning but also for introducing measures related, for example, to handling, temperatures, transport and logistics. Apart from the aspect of reducing waste, there is a strong business incentive to carry out this work.

2.15 Support local government interaction

Communicate data on waste to the local government or agricultural office.

This information opens opportunities for public measures (e.g. redistribution of surpluses into shortage areas). The UNECE digital food loss management system named FeedUP@UN allows the collection of data and may facilitate redistribution of products.

3. Transporters

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

Transportation services are essential in the produce industry at every stage from harvest through the distribution channel and eventually to the retailer or, in e-commerce, directly to the consumer. Therefore, according to the type of product, its age and the duration of the transport, transporters must determine the most appropriate means of transport (ground, sea or air) and transport package (refrigerated containers, rail carloads, break

[17] The EU guidelines on food donation are one example https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:C:2017:361:FULL&from=EN

bulk, palletized, and bulk). The means of transport should be cost effective and protect and deliver the produce to its destination in marketable condition with the least possible impact on its quality and shelf life.

As road is the most common means of transport, this chapter mainly focuses on recommendations for that mode, but the ideas are applicable to other means of transport.

Transporters that also provide storage facilities for fresh fruit and vegetables should adhere to the recommendations in this chapter as well as to those set out for traders.

3.1 Ensure proper training of staff

Transportation staff need to be knowledgeable on the storage, handling and distribution of perishable products as well as the impact of careless/poor handling on safety, quality and shelf life that results in losses and waste and reduced profitability. Transporters are encouraged to provide training for truck drivers, dock workers as well as workers at other unloading/reloading points to ensure that handling and transportation are done carefully, thereby providing the best conditions for products during transport.

Transporters are encouraged to train and give their staff basic knowledge of the different temperature requirements of products. Training should also include the importance of transporting ethylene-producing and ethylene-sensitive products separately. It is recommended to make available to the staff detailed information on products, including quick referencing literature, such as individual product optimum temperature charts and container product mixture charts for storage and transportation purposes.

3.2. Ensure proper planning of transport

Transport should be planned to minimize time and optimize conditions.

The longer the transportation period, the more important it is to provide optimal climatic conditions for the transported perishable products and their packing material in the vehicle.

If products will be unloaded at more than one point, they should be loaded onto the vehicle/container in reverse unloading order, to avoid unnecessary loading and reloading. In cold climates, measures should be taken to avoid products from getting freezing damage.

In vehicles and/or containers with regulated temperatures, careful planning is required to ensure that products with similar temperature requirements are stored in the same compartment/container. Careful planning should also avoid putting products emitting ethylene in the same space as products that are sensitive to ethylene (see annex III).

3.3 Ensure optimum conditions during transport

Transporters should provide the best possible conditions in terms of temperature, humidity, compatibility between products, and protection against direct sun, rain, wind and dust. If cooling is available, products should be cooled to the recommended temperature as quickly as possible without harming the product. Products should be cooled before transport, with the exception of short journeys to a storage facility or packhouse. The cooling equipment of transport vehicles does not have the power to lower product temperature, just maintain it.

Humidity is another major factor to consider as freshness is an important quality parameter in most products. Leafy vegetables and other products with a large surface to volume ratio (e.g. broccoli) will quickly lose water in dry conditions, especially in combination with high-speed air circulation or wind. Lowering the temperature will increase relative humidity in the air, but may damage the produce due to dehydration if the water vapour content remains too low. Product water loss during transport may be reduced by packed ice in the cargo, plastic, and/or pre-cooling the cargo.

In addition, products producing ethylene (climacteric fruits, see annex I) and products that are sensitive to ethylene (see annex III) should not be transported together but in separate vehicles, trailers, containers or compartments to avoid damage or shortening of the shelf life of the ethylene-sensitive products. Annex IV contains information on which products can be transported together.

3.3.1. Non-refrigerated transport

Products transported in non-refrigerated vehicles should be loaded in the shade. In open vehicles, the products should be completely and adequately covered – for example, with a tarpaulin or any other suitable material to protect them against direct sunlight, the elements, dirt and temperature variations. Tarpaulins must be clean and undamaged with sufficient measures in place so as to ensure that they are adequately secured. Thermal insulation tarpaulin may provide some protection against heat.

Proper ventilation should be provided to avoid dehydration of the produce.

Stops and reloading should be kept to a minimum. Care must be taken during loading and unloading to avoid temperature abuse and physical injuries.

3.3.2. Refrigerated transport

The shelf life of perishable products is highly influenced by temperature deviations during transport, handling and storage. Optimum product temperature is one of the major factors in retaining product quality and condition during the storage, handling and distribution in the value chain. Products exposed to inappropriately high temperatures get a reduced shelf

life due to increased respiration rates and thereby enhancing the ripening process, ageing and loss of turgidity of the perishable product. Inappropriately low temperatures on the other hand cause chilling injuries and therefore shorten shelf life and increase losses and waste in all the following stages, including at consumer level.

There is much to gain from keeping an unbroken cool chain at the optimum product temperature. For example, lettuce has an estimated shelf life of up to 12 days at zero degrees Celsius but only 2 days at 20 degrees; leeks and cauliflower may be stored around 20 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 quickly develop chilling injuries when kept at temperatures below ambient/inappropriately low, though non-freezing, temperatures. Therefore, attention must be paid to appropriate storage and transport temperatures to ensure that chilling-sensitive products are not subjected to temperatures that could cause chilling injury (see annex II).

Frequent changes in temperature as well as shipping and/or storing of fresh fruit and vegetables with different optimum product temperature in the same shipping container or cold storage also reduces shelf life. Having good communication and collaboration along the value chain should therefore include discussions on how to establish and maintain an uninterrupted cool chain.

If possible, products should be transported with regulated and monitored temperature vehicles and/or containers. Uniform temperature should be maintained through distribution. Small deviations may be tolerated by some of the less perishable products, but typically temperatures should be maintained within small deviations of the targeted temperature to avoid loss of quality.

3.3.3. Monitor temperatures during transport

Keeping track of the temperature in the vehicle during the entire duration of the transport will raise awareness of the importance of proper temperature management. Therefore, transporters are reminded to use the temperature chart on shipping containers and/or ground transportation vehicles. These charts are very useful in recording the transportation temperature history and help identify the possible route when and where the temperature chain was broken or failed, and if product quality at the destination point is not of the appropriate standard.

3.4 Use proper vehicles, packaging and unitizing

Vehicles should have a good suspension system to avoid excessive shocks, or alternatively, a good means of cushioning products during ground transportation.

Proper temperature management demands proper air circulation through airflow management, proper packaging and unitization and cargo space management.

Proper packaging and unitization is necessary to avoid physical injuries due to compression and vibration of the cargo. Packaging material should be suitable and fit for the transport and its conditions. Usage of low-quality packing material (e.g. boxes) might lead, especially when transport takes place under humid transport conditions, to collapsing of boxes and damage of the products in the packaging material. Therefore, transporters should inform the sender of potential risks when inappropriate packaging for the transport is identified.

3.5. Stack boxes and crates appropriately

Cartons/cardboard boxes and crates of produce should be stacked correctly, not exceeding individual container stacking strength or be stacked too high on pallets.[18] Handling staff should adhere to the maximum height of unbroken pallet loads received from the wholesaler or exporter. Proper stacking includes following the lengthwise and crosswise method that aligns the carton vent holes in the correct direction to allow air circulation throughout the stacked containers.

The most common height for wholesale units is seven to eight layers high, whereas single layer boxes containing retail units can be stacked higher. Often products with large individual sizes such as melons, pumpkins and other such gourds are packed in pallet bins; while tubercule vegetables such as carrots, turnips, beets and onions are packed in mesh bags or loose in boxes. Irrespective of the container there is an appropriate stacking method applied.

All pallets can be both under-stacked and over-stacked in storage. Both practices have cost implications for the trader and retailer.

Under-stacking of pallets may result in:

- Less efficient use of the refrigerated storage/holding space

[18] Stacking strength indicates the container's resistance to crushing (and thus protection of its contents). It is built into carton sidewalls and influenced by the size and type of carton material used. The strength is sometimes printed on the carton.

- An increased risk of placing containers of other produce atop the stack and mixing non-compatible produce.
- Giving an incomplete tally of number of cartons/containers available (if only the number of pallets is counted) that can lead to inappropriate volumes being ordered.

Over-stacking of pallets may result in:

- Crushing of the packages at the lowest level and damaging the produce.
- Restricting efficient cold air circulation within the stack.
- Rougher handling by staff (manually and with equipment such as pallet jacks and forklifts).
- Posing direct threats to the safety of the workers who may have problems reaching the top layers or difficulty seeing around the stack (when using a forklift, for example).
- Inability to re-use cardboard boxes and plastic crates due to damage.

Placing packages on pallets and not directly on the floor in vehicles:

- enables the ease of handling through the use of machinery for loading and unloading,
- facilitates circulation of cool air throughout every produce container in the stack,
- contributes to sanitary conditions in storage and helps address consumer food safety concerns.

3.6 Ensure clean transport

Vehicles and containers should be kept clean to ensure proper air circulation around the load, to reduce produce contamination by plant pathogens, food-borne pathogens, chemicals, dirt and dust, as well as strong smells and chemical contamination. The container should be free of any evidence, including taint, of previous cargo. The substances for cleaning should be appropriate in connection to food.

3.7. Clarify responsibility of damages

As products may be damaged during loading, unloading and transportation, the responsibility of each party or service provider at each point and stage must be clear. Such clarity leads to improvement in handling, transportation and storage, which improves or maintains quality, reduces damage and decreases economic losses.

4. Retailers

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

In this final stage of the value chain all measures taken to produce high-quality products, cool them to preserve quality and nutritional value, sort, grade and pack them for nice presentation and transport and distribute them to the store will be seen in the performance of products on display for the consumer.

The result will determine the price consumers are willing to pay for the produce, the share of products wasted and in end the profitability for the store.

It is therefore important that all the measures invested in production and along the value chain are properly attended to at this last stage. Products should be carefully handled and stored and then displayed in appropriate conditions.

4.1 Ensure proper training of staff

Retail staff need to know fresh produce storage, handling, product placement and display practices and to understand the impact of poor handling on safety and quality, shelf life and waste, consumer purchases and eventually the retailer's profitability. They also need to know the urgency of selling products within their shelf-life limits and therefore the importance of applying the principle of "first in, first out." Staff should therefore be trained in best practices, enabling them to acquire a good knowledge of the consequences of inappropriate handling and storing of products.

Handling guides per product, with guidance on appropriate temperatures, ethylene sensitivity, mixture charts and common problems may be a useful tool for this. The guides should highlight quality affecting key parameters and appropriate practices.

4.2 Ensure ordered volumes match demand

The best retailer practice is to adjust produce volumes ordered to demand. In this way products will not be required to be kept in storage or on display longer than necessary, thereby retaining their quality/marketability and reducing food loss and waste. A strict "first-in, first-out" approach to stocking/storage also significantly contributes to minimizing food loss and

waste and economic losses, unless the condition of received consignments of products should motivate a change in order.

Demand for products varies due to the weather, seasons, holidays and celebrations. Some high-demand periods are easily predictable, but others are less so. To ensure a steady flow of the appropriate products based on consumer demands, the retailer's shop needs good market knowledge; and a marketing/sales and supply plan is essential. Procurement staff are required to speculate less and employ demand-planning strategies and tools, to minimize the uncertainty.

Plan carefully in order to avoid oversupply. Planning involves more than estimates of only sales volume of the various products but also types, varieties, sizes, quality categories, colour categories, and the stage of ripeness. Promotion campaigns promoting the sale of one product may also influence the sales volumes of other, similar products. Therefore, good communication with the supplier or distribution centre should help coordinate supplies to meet market demand.

4.3 Define clear specifications

Retailers' specifications – including quality requirements, correct maturity for the intended purpose and labelling – should be clearly defined in advance and in good communication with and/or purchase agreements with producers, so that unnecessary waste is avoided.

Retailers' specifications on quality should, as far as possible, be identical to the marketing standards[19] developed for trading fresh fruits and vegetables. Additional quality requirements, added to the requirements in the trade standards, should be kept to a minimum so as to reduce transaction costs, losses and waste. An increased acceptance and therefore sale of products with exterior defects not affecting the eating quality will reduce losses at primary production.

Trading parties should pay attention to specifications that might require grading, sorting or trimming of produce that might lead to avoidable food waste (e.g. trimming to the same size or length to fit into a specific package, refusing specific sizes or varieties as not being part of the goods accounting. Trading parties should also specially note that some products such as tropical root crops (e.g. yams and ginger) must be trimmed during harvest. This knowledge is very important to avoid food wastage.

[19] Such as, for example, the international marketing standards developed by UNECE or CODEX.

Fruit and vegetables need to have reached an appropriate stage or degree of development when harvested to have sufficient shelf life and appropriate quality for the intended purpose. This stage is called horticultural maturity.[20]

Horticultural maturity is any stage from a seedling (sprouts), a tender spring carrot, a shoot (asparagus), undeveloped flowers (broccoli) and all the way to ripe and fully developed fruits (apples, peaches, etc.) Climacteric fruit such as apples, pears and peaches must attain an appropriate degree of development to ensure proper completion of the ripening process and develop the expected taste, aroma and texture – i.e. physiological maturity.[21]

The correct maturity is also important for products to be able to withstand transportation and handling and have a sufficient shelf life for retail and at consumer level.

The trading parties should fully understand and have the same interpretation of the terms "maturity" (in fruits[22]) and "sufficiently developed" (in vegetables and root crops).

Consumers may be very eager to buy early season products at a premium price. However, if these early season products are marketed before they have reached the appropriate maturity they may not be able to ripen properly and reach the desired quality. Consumers may then discard these products and avoid buying such products again, either in the near future or permanently – even when better qualities are available. This will have a negative impact on price and demand of such products for an extended period of time, as well as the reputation of the supplier/producer.

The retailer should be aware that the different varieties of many fruits from the same region or country – for example, apples and pears – mature and ripen at different times, and should therefore be marketed at different times. Each variety should be placed on the market at the correct time. One of the best ways to ensure this is to have good communication with producers and to seek and respect their advice.

4.4 Control ordered products at arrival

Buyer and seller should have a common agreement on criteria and method for ensuring conformity with agreed quality requirements and the process for handling non-conformities. Non-conformity of buyers' specifications, as well as non-valid claims are major causes of food loss and waste. However, areas considered high risk and likely to cause

[20] Horticultural maturity: The stage of development when a plant part possesses the necessary characteristics for use by consumers

[21] Physiological maturity: The stage of development when a plant part will continue development even if detached; will continue development even if detached

[22] Including fruit vegetables such as tomatoes, cucumbers, aubergines, zucchini.

problems should be defined clearly in contracts in advance or otherwise by a common agreement between buyer and seller. Effective communication between buyer and seller is the best way to address the problem and reduce losses and waste.

It is very difficult when buyers and sellers do not agree on whether products are in conformity with agreed quality standards. In cases of dirty or overripe products, non-conformity is easily established; photographs usually suffice to communicate the extent of non-conformity to the seller. In less obvious cases, a more thorough quality inspection of the product is required. When a complaint of poor quality produce is supported by a legal inspection report (based on transparent sampling, tolerances, photos and additional supporting evidence), common agreement is facilitated.

A precondition for the acceptance of a complaint is a prompt incoming inspection and prompt feedback to the seller /supplier. The quality inspections should be carried out directly after arrival of the produce in order to clearly reflect the condition at arrival. The results (non-conformities) should be communicated to the seller as quickly as possible in order to avoid the impression that the defects might have developed due to unfavourable conditions at the buyer's premises. The results of the quality inspection 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. Depending on how sensitive products are and how they are kept and handled after arriving at the buyer's premises, they may quickly deteriorate in quality.

If possible, the reasons for non-conformities must be identified. This communication will assist those involved to take necessary 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 optimum temperature during transport, this deviation is important information for those involved.

The buyer, in agreement with the seller, should always try to find ways to avoid returning the product. Possible remedies are accepting the legal tolerances, downgrading the produce, correcting the labelling.

4.5 Store products appropriately

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

When products are stored prior to display, they should be stored at their appropriate, product-specific temperature to retain the visible quality, keeping quality and to reduce food loss and waste. Therefore if products are kept at incorrect temperatures, at any time along the chain, the money and resources spent on all activities at every previous stage including production, harvest and post-harvest is quickly lost and/ or wasted. For example, lettuce has an estimated shelf life of up to 12 days at zero degrees Celsius but only 2 days at 20 degrees; leeks and cauliflower may be stored over 20 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).]

Frequent changes in temperature also reduce produce shelf life. Taking products from cool storage and back should therefore be avoided. Collaboration and discussions along the value chain should be conducted to establish an unbroken cool chain.

Subtropical and tropical products develop chilling injuries when kept at low 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). When possible, there should be different temperature zones in the storage facilities to accommodate the different temperature requirements of products.

In addition to temperature, retailers should take into consideration all other aspects of produce presentation that are important to retain the quality (visible quality, keeping quality, taste, smell, appearance and touch) and that would reduce waste, such as humidity and ethylene.

Relative humidity can be controlled by the temperature of the storing facility: setting the dew point and/or controlling the moisture in the air of the facility (e.g., mists, spraying water and/or leaving water tins inside the storage facility are practical alternatives). Products that easily lose water should not be placed next to a fan or air outlet. Products producing ethylene (climacteric fruits, see annex I) and products that are sensitive to ethylene (see annex III) should be stored separately.

4.6 Stack boxes and crates appropriately

Cartons/cardboard boxes and crates of produce should be stacked correctly, not exceeding individual container stacking strength or be stacked too high on pallets.[23] Handling staff should adhere to the maximum height of unbroken pallet loads received from the wholesaler or exporter. Proper

[23] Stacking strength indicates the container's resistance to crushing (and thus protection of its contents). It is built into carton sidewalls and influenced by the size and type of carton material used. The strength is sometimes printed on the carton.

stacking includes following the lengthwise and crosswise method that aligns the carton vent holes in the correct direction to allow air circulation throughout the stacked containers.

The most common height for wholesale units is seven to eight layers high, whereas single layer boxes containing retail units can be stacked higher. Often products with large individual sizes such as melons, pumpkins and other such gourds are packed in pallet bins; while tubercule vegetables such as carrots, turnips, beets and onions are packed in mesh bags or loose in boxes. Irrespective of the container there is an appropriate stacking method applied.

All pallets can be both under-stacked and over-stacked in storage. Both practices have cost implications for the trader and retailer.

Under-stacking of pallets may result in:

- Less efficient use of the refrigerated storage/holding space
- An increased risk of placing containers of other produce atop the stack and mixing non-compatible produce.
- Giving an incomplete tally of number of cartons/containers available (if only the number of pallets is counted) that can lead to inappropriate volumes being ordered.

Over-stacking of pallets may result in:

- Crushing of the packages at the lowest level and damaging the produce.
- Restricting efficient cold air circulation within the stack.
- Rougher handling by staff (manually and with equipment such as pallet jacks and forklifts).
- Posing direct threats to the safety of the workers who may have problems reaching the top layers or difficulty seeing around the stack (when using a forklift, for example).
- Inability to re-use cardboard boxes and plastic crates due to damage.

Placing packages on pallets and not directly on the floor in storage:

- enable the ease of handling through the use of machinery for loading and unloading,
- facilitate circulation of cool air throughout every produce container in the stack,
- contributes to sanitary conditions in storage and helps address consumer food safety concerns.

4.7 Handle products carefully

Poor handling is manifested by bruising and other damages. Damages reduce quality and can lead to rot resulting in products being wasted. Products may be damaged not only when being transferred from boxes into display areas but also by consumers who handle and squeeze them.

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

Products should be handled as carefully as possible when being transferred to retailer displays. As such, retail staff should be well trained and fully understand the consequences of improper handling of products. Any wasted produce reduces the profit of the retailer, has an impact on sustainability and disregards all efforts of producers and other partners along the chain.

Retailers should consider taking measures that limit the damage of products caused by improper consumer handling. Possible measures include restricting the volume displayed at any given time and thereby the number of times each product is scrutinized by a consumer until finally chosen and providing point of sale information. For products that are easily damaged such as peaches, apricots, ripe pears and ripe avocados, sale in pre-packages can reduce waste but this measure has to be weighed against the increased use of packaging material.

4.8 Display products appropriately

Products should be displayed appropriately, taking into consideration their specific characteristics and the facilities available. In addition to temperature, 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. The appropriate temperature should be kept all the way to the point of display as frequent changes in temperature at retail points reduces produce shelf life.

Good communication along the distribution chain on how to establish an unbroken cold chain, product placement in retail outlets (near doors, near other types of food – cheese, butter, frozen meat and fish), retail method (pallet bins, smaller retail containers of only one fruit variety or mixture of different fruits) is essential.

To avoid shortening shelf life, the quantity on display should be adjusted to possible sales so as to limit the volume of products displayed at inappropriate temperatures. This is particularly important in open-air markets.

When products are offered for sale in the open, measures should be taken to protect them from direct sunshine, wind, dust, dirt and contamination by other sources. Products that dehydrate easily, such as leafy vegetables, may be sprayed with potable water. Small retailers with no cooling facilities may prolong shelf life by covering their fresh produce overnight with cloth, tissue or any other suitable material dipped in or moistened with potable water.

Products should be presented in such a way as to minimize a negative impact of fruit with high ethylene production with ethylene sensitive products (see annex III)

4.9 Choose responsible promotional campaigns

Promotional campaigns such as "Buy one, get one free" and other enticements to large volume purchases encourage consumers to buy more products than they, or their household, may be able to consume. Such purchases often result in food waste. Although there may be good intentions behind many promotion campaigns – such as increasing consumption of produce for health reasons or providing economic help to domestic producers to sell an unexpected overproduction due to favourable weather conditions – it may, from a waste perspective, be better to reduce the price instead.

It is important to consider the side effects of promotional campaigns. For instance, when consumers are encouraged to buy more of a targeted product, they may likely buy less of other similar products – for example, 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 will reduce losses and waste.

4.10 Find solutions for unsold products

Even with the most careful planning, there will invariably be products that cannot be sold to the intended buyer. Therefore, retailers should have alternative solutions for selling or disposing of the products to reduce food waste. However, accessing the alternative markets may require an adjustment of price.

The following alternatives are examples that might be considered:

- Sell as
  - lower category produce (if applicable)
  - "for home processing" (if applicable)
  - "for immediate consumption"
- Promote interesting recipes or new preparations to increase interest of consumers (at point of sale), including tastings
- Process to juices, jams, smoothies, etc.
- Donate to charity, respecting applicable guidelines[24]
- Include saved products.

[24] The EU guidelines on food donation are one example
https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:C:2017:361:FULL&from=EN

If no alternative outlet can be found, products should be treated in a way that limits the negative effects on the environment.

4.11 Measure waste

Retailers that are aware of their food waste volume and that understand the causes and have the means to measure it should have a greater capacity to reduce the waste than those that do not. This implies that retailers acknowledge the problem, measure the loss, identify hotspots and manage the food waste through targeted interventions. This enables them to start a learning process that serves as an important tool for finding remedial measures that lead to reduced waste.

The results can be used not only for future planning but also for implementing measures related, for example, to handling, temperatures, transport and logistics. Apart from the aspect of reducing waste, there is a strong business incentive to carry out this work.

Retailers buying directly from producers should also undertake the following:

4.13 Improve logistics

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.

An efficient logistics chain that reduces the time from producer or packer to retailer is therefore important for ensuring an appropriate shelf life of perishable products for retail and consumer stages. Such efficiency reduces quality losses and waste along the chain.

An efficient logistics chain has no more stops and reloading points than necessary. Stops should be short and reloading conducted effectively and efficiently. A “first-in, first-out” principle must be followed, as long as the quality of the produce is also aligned. But if a later delivery has more sensitive products (shorter shelf life), these must be prioritized.

4.14 Ensure unbroken cool chains

Products should be kept at an appropriate temperature from harvest to retail. The investments (money and effort) put into production, post-harvest handling and cooling products to the appropriate temperature is quickly lost if products are exposed to inappropriate and/or fluctuating temperatures

later in the value/ distribution chain. Therefore, good communication among all participants along the distribution chain should include discussions on how to establish an unbroken cool chain. The cool chain should be established and maintained from harvest to retail stage – which includes point of sale display.

4.15 Place and change orders in a timely manner

Orders should be placed early so as to give the producers enough time to harvest products at the appropriate time of day, cool products to the appropriate temperature, sort/grade 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 food loss and 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. In cases where orders are placed in foreign countries requiring several days or weeks of sea travel, last-minute orders are often not feasible.

4.16 Avoid late cancellations

Orders of perishable products that are cancelled at short notice close to dispatch makes finding a new buyer difficult, often leading to food loss. This problem is more severe when the product is packed in specific branded packaging of the retailer which cannot be sold to another retailer without costly repackaging and additional risk of damages by handling.

In cases of orders placed in foreign countries requiring several days or weeks of sea travel to destination markets, order cancellations may not be feasible, or can result in high rates of food loss in producing countries; particularly if the product is not part of the country's diet.

A frequent cause of late cancellations is that market demand for a product, at a given time, is lower than when the buyer originally placed the order. In some cases when it is impossible to change the order (product is located at the shipping port, or already loaded on the means of transport), the products may therefore still be wasted upon arrival at the destination market. In such 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 must be moved into the distribution chain.

Note that when products are packed and labelled for a private label, in cases of returned or cancelled orders, it is difficult to sell the products to another buyer.

Further reading

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Annex I. Classification of fruit, based on 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 cherimola Mill x Annona squamosa, L.	**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	*Physalis peruviana*	**Eggplant**	*Solanum melongena*
Cherimoya	*Annona cherimola*	**Grape**	*Vitis vinifera*
Custard apple, fruta do conde	*Annona squamosa, L.*	**Grapefruit**	*Citrus x paradisi*
Durian	*Durio zibethinus*	**Java plum**	*Syzygium cumini*
Feioja	*Feijoa sellowiana*	**Jujube**	*Ziziphus jujuba*
Fig	*Ficus carica*	**Langsat**	*Aglaia spp*
Guava	*Psidium guajava*	**Lemon**	*Citrus limon*
Honeydew melon	*Cucumis melo*	**Lime**	*Citrus aurantifolia; Citrus latifolia*
Jackfruit	*Artocarpus heterophyllus*	**Longan**	*Dimocarpus longan*
Japanese pear	*Pyrus serotina*	**Loquat**	*Eriobotrya japonica*
Jujube	*Zizyphus jujuba*	**Lychee**	*Litchi chinensis*
Kiwifruit	*Actinidia deliciosa*	**Okra**	*Abelmoschus esculentus*
Mammee apple	*Mammea americana*	**Olive**	*Olea europea*
Mango	*Mingifera indica*	**Orange**	*Citrus sinensis*

Mangosteen	*Garcinia mangostana*	**Pea**	*Pisum sativum*
Muskmelon	*Cucumis melo*	**Pepino, melon pear**	*Solanum muricatum*
Nectarin	*Prunus persica*	**Pepper**	*Capsicum annuum*
Papaw	*Asimina triloba*	**Pineapple**	*Ananas comosus*
Papaya	*Carica papaya*	**Pitaya**	*Stenocereus ssp.*
Passion fruit	*Passiflora spp.*	**Pomegranate**	*Punica granatum*
Peach	*Prunus persica*	**Prickly pear**	*Opuntia stricta*
Pear	*Pyrus communis*	**Pumpkins and winter squash**	*Cucurbita moschata* and *Cucurbita maxima*
Persimmon	*Diospyros kaki*	**Rambutan**	*Nephelium lappaceum*
Plantain	*Musa paradisiaca*	**Raspberry**	*Rubus idaeus*
Plum	*Prunus domestica*	**Rose apple**	*Syzygium ssp.*
Quince	*Cydonia oblonga*	**Star apple**	*Chrysophyllum cainito*
Rambutan	*Nephelium lappaceum*	**Strawberry**	*Fragaria ananssa*
Sapodilla, chiku	*Achras sapota*	**Summer squash**	*Cucurbita pepo*
Soursop	*Annona muricata*	**Surinam cherry**	*Eugenia uniflora*
Sweetsop	*Annona squamosa*	**Tamarind fruit**	*Tamarindus indica* L.; synonyms T. *occidentalis Gaertn*., *T. officinalis* Hook.
Tomato	*Lycopersicon esculentum*	**Tamarillo, Tree tomato**	*Cyphomandra betacea*
		Tangerine and mandarin	*Citrus reticulata*
		Watermelon	*Citrullus vulgaris*

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*;* Gross, Kenneth C., Chien Yi Wang, and Mikal Saltveit, eds. 2016. *The Commercial Storage of Fruits, Vegetables, and Florist and Nursery Stocks.* Agriculture Handbook 66, U.S. Department of Agriculture, Agricultural Research Service, Washington, DC.

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 and "fruit vegetables"[25]	Lowest storage temperature	
	°C	°F
Annona, **Cherimoya**, Atemoya *Annona ssp.*	13	55
Atemoya, *Annona cherimola Mill x Annona squamosa,* L.	12-14	53-57
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	50
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
Mandarin, *Citrus reticulata*, *Citrus unshiu, Citrus clementina*, *Citrus deliciosa*, *Citrus tangerina*	4-7	40-45
Mango, *Mangifera indica*	13	55

[25] A "fruit vegetable", also called "salad fruit" is a product that is botanically a fruit (a mature ovary with connected tissues, or more simply a seedbearing structure) but that is used as a vegetable.

Chilling-sensitive fruits and "fruit vegetables"[25]	Lowest storage temperature	
	°C	°F
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
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
Chayote, *Sechium edule*	7-10	45-50
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
Jicama, *Pachyrhizus erosus* [L.] Urban	12.5-15	
Luffa gourd, *Luffa spp.*	10-12	50-54
Okra, *Abelmoschus esculentus*	7-10	45-50
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		
Apple, *Malus domestica*	-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
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		
Artichoke, *Cynara cardunculus*	0	32
Asparagus, *Asparagus officinalis*	2.5	36
Bean sprouts	0	32
Beetroot, *Beta vulgaris* L. subsp. *vulgaris*	0	32

Bok choy, *Brassica campestris* **L. ssp.** *chinensis*	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
Chicory, Belgian Endive or Witloof Chicory, *Cichorium intybus* **L.**	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
Ginseng, *Panax ginseng*	0	32
Horseradish, *Armoracia rusticana*	-1-0	30-32
Jerusalem Artichoke, *Helianthus tuberosus* L.	0	32
Kale, *Brassica oleracea var. acephala*	0	32
Kohlrabi, *Brassica olearacea* var. *gongylodes*	0	32
Leek, *Allium ampeloprasum*	0	32
Lettuce, *Lactuca sativa*	0	32
Mustard greens, *Brassica juncea* L.	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
Radicchio, Chicorium intybus L	0	32
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
Swiss chard, *Beta vulgaris* L. var. *cycla*	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*;* Gross, Kenneth C., Chien Yi Wang, and Mikal Saltveit, eds. 2016*. The Commercial Storage of Fruits, Vegetables, and Florist and Nursery Stocks.* Agriculture Handbook 66, U.S. Department of Agriculture, Agricultural Research Service, Washington, DC.

Annex III. Classification of selected fruits and vegetables according to ethylene production at 20℃ and ethylene sensitivity

Product	Ethylene production (µl C_2H_4/kg-hr)	Ethylene sensitivity	Ethylene effect
Apple, *Malus sylvestris*	High 10-100	High	Ripening
Apricot, *Prunus armeniaca*	High 10-100	Medium	Ripening
Artichoke	Very low	Not sensitive	
Atemoya	High, up to 100 to 300 µL kg-1 h-1 at 20 ºC	Sensitive	Ripening
Asparagus			Stringy texture
Avocado, *Persea americana*	Very high >100	High	Ripening
Banana, *Musa spp.*	Moderate 1-10	High	Ripening
Beet	Very low	Low	
Blackberry, *Rubus macropetalus*	Low 0.1-1	Low	
Blueberry, *Vaccinium corymbosum, V. angustifolium, V. ashei*	Moderate 1-10	Low	
Brocolli	Very low <0.1	High	Yellowing
Breadfruit, *Artocarpus altilis*	Moderate 1-10	Medium	
Cantaloupe, *Cucumis melo*	High 10-100	Medium	
Carambola, *Averrhoa carrambola*	Moderate 1-10	Low	
Carrots	Very low <0.1	High	Bitterness
Casaba melon, *Cucumis melo*	Low 1-10	Low	
Cabbage, headed			Chlorophyll breakdown, detached leaves
Cauliflower, *Brassica oleracia var. botrytis*	Very low <0.1	High	Yellowing, loss of leaves
Cherimoya, *Annona cherimola*	Very high >100	High	Ripening
Cherry, *Prunus avium, P. cerasus*	Very low <0.1	Low	
Cranberry, *Vaccinium macrocarpon*	Low 0.1-1	Low	
Cucumber, *Cucumis sativus*	Low 0.1-1	High	Yellowing
Eggplant, *Solanum melongena*	Low 0.1-1	Medium	Texture change
Fig, *Ficus carica*	Moderate 1-10	Low	
Fejioa, *Feijoa sellowiana*	High 10-100	Low	
Grape, *Vitis vinifera*	Very low <0.1	Low	
Grapefruit, Citrus x paradisi	Very low <0.1	Medium	Colour change
Guava, *Psidium guajava*	Moderate 1-10	Medium	Ripening
Honeydew melon, *Cucumis melo*	Very low <0.1	High	
Jujube, *Zizyphus spina-christi*	Very low <0.1	Medium	
Kiwifruit, *Actinidia chinensis*	High 10-100	High	Ripening
Leafy vegetables	Very low <0.1	High	Yellowing, detached leaves
Lemon, *Citrus limon*	Very low <0.1	Medium	Colour change
Lime, *Citrus aurantifolia*	Very low <0.1	Medium	Colour change
Loganberry, *Rubus loganobaccus*	Low 0.1-1	Low	
Lychee (litchi), *Litchi chinensis*	Very low <0.1	Medium	
Mammee apple, *Mammea americana*	Very high >100		
Mandarin,	Very low <0.1	Medium	Colour change, skin defects
Mango, *Mangifera indica*	Moderate 1-10	Medium	Ripening
Nectarine, *Prunus persica var. nucipersica*	High 10-100	Medium	Ripening

Product	Ethylene production (µl C_2H_4/kg-hr)	Ethylene sensitivity	Ethylene effect
Netted melon, *Cucumis melo*	High 10-100	Medium	
Olive, *Olea europaea*	Very low <0.1	Medium	
Onion, green with leaves	Low 0.1-1	High	Yellowing
Onion, mature	Very low<0.1	Low	
Orange, *Citrus chinensis*	Low 0.1-1	Medium	Colour change
Papaya, *Carica papaya*	Moderate 1-10	Medium	Ripening
Passion fruit, *Passiflora edulis*	Very high >100	Medium	Ripening
Parsnip, *Pastinaca sativa*	Very low < 0.1	High	Bitterness
Peach, *Prunus persica*	High 10-100	Medium	Ripening
Pear, *Prunus communis*	High 10-100	High	Ripening
Pepper, *Capsicum annuum*	Low 0.1-1	Low	
Persimmon, *Diospyros kaki*	Low 0.1-1	High	
Pineapple, *Ananas comosus*	Low 0.1-1	Low	
Plantain, Musa spp.	Moderate 1-10	High	Ripening
Plum, *Prunus domestica, P. americana*	High 10-100	Medium	Ripening
Pomegranate, *Punica granatum*	Very low < 0.1	Low	
Potato, *Solanum tuberosum*	Very low <0.1	Medium	Sprouting
Pumpkin, *Cucurbita spp.*	Low 1-10	Medium	
Raspberry, Rubus idaeus	Low 0.1-1	Low	
Rutabaga	Very low <0.1	Low	
Sapota, *Mauilkara zapota*	Very high >100		
Squash, Cucurbita spp.	Low 0.1-1	Medium	Yellowing
Star apple, *Chrysophyllum cainito*	Low 0.1-1		
Strawberry, *Fragaria x ananassa*	Very low <0.1	Low	
Tamarillo, *Cyphomandra betacea*	Low 0.1-1	Medium	
Tomato, *Lycopersicon esculentum*	Moderate 1-10	Low	Ripening
Watermelon, *Citrullus lanatus*	Very low <0.1	High	Tissue softening, colour change

Source : Gross, Kenneth C., Chien Yi Wang, and Mikal Saltveit, eds. 2016. *The Commercial Storage of Fruits, Vegetables, and Florist and Nursery Stocks.* Agriculture Handbook 66, U.S. Department of Agriculture, Agricultural Research Service, Washington, DC.

Annex IV: Compatibility chart for fruits and vegetables in short-term transport or storage

The table below shows which fruits and vegetables can be stored and transported together based on optimal temperature, relative humidity, and ethylene production and sensitivity.

Compatible fresh fruit and vegetables during 10-day storage

Group 1A: 0°C - 2°C – (32°F - 36°F) and 90-98 % relative humidity				
VEGETABLES				
alfalfa sprouts	Brussels sprouts*	daikon*	leek*	scorzonera
amaranth*	cabbage*	endive*, chicory	lettuce*	shallot*
anise*	carrot*	escarole*	mint*	snow pea*
asparagus	cauliflower*	fennel*	mushroom	spinach*
artichoke*	celeriac	garlic	mustard greens*	sweet pea*
beans: fava, lima	celery*	green onion*	parsley*	Swiss chard*
bean sprouts	chard*	herbs* (not basil)	parsnip	turnip
beet	Chinese cabbage*	horseradish	radicchio*	turnip greens*
Belgian endive*	Chinese turnip	Jerusalem artichoke	radish	waterchestnut
bok choy*	collard	kailon	rutabaga	watercress*
broccoflower*	corn: sweet, baby	kale*	rhubarb	
broccoli*	cut vegetables	kohlrabi	salsify	
Group 1B: 0°C - 2°C – (32°F - 36°F) and 85-95 % relative humidity				
FRUITS AND MELONS				
apple	cantaloupe	elderberry	lychee	prune
apricot	cashew apple	fig	nectarine	quince
avocado, ripe	cherry	gooseberry	peach	raspberry
Barbados cherry	coconut	grape	pear: Asian, European	strawberry
Blackberry	currant	kiwifruit	persimmon*	
Blueberry	cut fruits	loganberry	plum	
Boysenberry	date	longan	plumcot	
Caimito	dewberry	loquat	pomegranate	
Group 2: 7°C - 10°C – (45°F - 50°F) and 85-95 % relative humidity				
VEGETABLES		**FRUITS AND MELONS**		
basil*	okra	avocado, unripe	guava	pineapple
beans: snap. green, wax	pepper: bell, chili	babaco	Juan Canary melon	pummelo
cactus leaves (nopales)*	squash: summer (soft-rind)	cactus pear, tuna	kumquat	sugar apple

calabaza	tomatillo	calamondin	lemon*	tamarillo
chayote*		carambola	lime*	tamarind
Cowpea (Southern pea)	Winged bean	Cranberry	Limequat	tangelo
cucumber*		custard apple	mandarin	tangerine
eggplant*		durian	olive	ugli fruit
kiwano (horned melon)		feijoa	orange	watermelon
long bean		granadilla	passion fruit	
malanga*		grapefruit*	pepino	
Group 3: 13°C - 18°C – (55°F - 65°F) and 85-95 % relative humidity				
VEGETABLES		**FRUITS AND MELONS**		
bitter melon	squash: winter (hard rind)*	atemoya	jaboticaba	rambuntan
boniato*	sweet potato*	banana	jackfruit	sapodila
cassava	taro (dasheen)	breadfruit	mamey sapote	sapote
dry onion	tomato: ripe, partially ripe and mature green	canistel	mango	soursop
ginger		casaba melon	mangosteen	
jicama		crenshaw melon	papaya	
potato		honeydew melon	Persian melon	
pumpkin	yam		plantain	

Notes:

Ethylene level should be kept below 1 ppm in storage areas.

*Indicates products sensitive to ethylene damage.

Source: Kader, A. A. (ed.). *Postharvest technology of horticultural crops.* Oakland: University of California, Agriculture and Natural Resources, 2002. 553 pages, Table from page 115.

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

Introduction

According to the Food and Agriculture Organization of the United Nations (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, creating economic effects on all parts of the supply chain.

Therefore, the question arises as to what needs to be put in place to address the complex subject of 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 simple methodology.

While a stand-alone tool, the 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.

Chapter 2 shows the relevant fresh produce supply chain stages and actors that the quantification methodology is designed for. Chapter 3 includes the food loss and waste quantification method, followed by a food loss and waste hotspot analysis method in chapter 4. Chapter 5 indicates the

financial loss related to the lost or wasted food. Ultimately, a food loss and waste measurement unit is suggested in chapter 6.

DEFINITIONS

The Food and Agriculture Organization of the United Nations (FAO) defines food loss and waste 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)

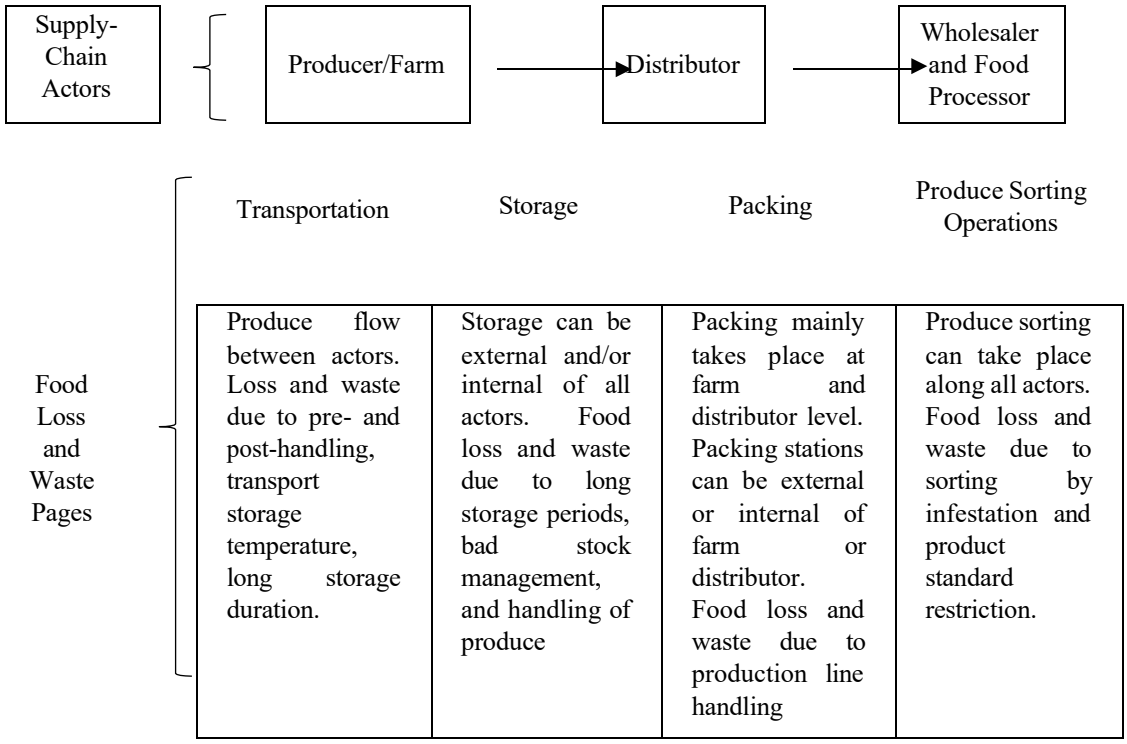
In line with the FAO definitions and for the purpose of this work, only food losses will be measured. However, food loss and waste may be used as a concept in some texts.

2. FRESH PRODUCE SUPPLY-CHAIN STAGES AND ACTORS

For the simple food loss quantification methodology, this work solely looks at the fresh produce (fruits and vegetables) supply-chain stages and actors from "production" to "wholesale" level. The main stages and actors from production to wholesale are set out 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 of this publication 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 Calibres + (Class II + III Produce)	=	Food Loss VII (Kg)

Test formula: Food Loss VII ≈ Distributor Produce Purchase % of not requested product calibres 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 occur 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.

Low-income countries 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, 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 set out 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.

The calculations of chapter 3 can therefore be rearranged 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) $\frac{\text{X (Kg) Actually Harvested}}{\text{(Kg) Expected Harvest}}$ (x100) = Harvest Yield Efficiency (%)

(1) $\frac{\text{X (Kg) Transported Harvest}}{\text{X (Kg) Harvested}}$ (x100) = Harvest to Transportation Efficiency (%)

(2) $\frac{\text{X (Kg) Out Sorted, Edible \& Unsaleable Produce Due to "Standard" Restrictions}}{\text{X (Kg)Harvested}}$ (x100) = Produce Standard Output Efficiency (%)

(3) $\frac{\text{X (Kg) Stored Produce}}{\text{X (Kg) Transported Produce}}$ (x100) = Transported to Stored Produce Efficiency (%)

(4) $\frac{\text{X (Kg) Actually Packed Produce}}{\text{X (Kg) Produce Set and Intended for Packing}}$ (x100) = Produce Packing Efficiency (%)

(5) $\frac{\text{X (Kg) Non-Infested Produce}}{\text{X (Kg) Produce Set for Sortation by Infestation}}$ (x100) = Edible Produce Efficiency (%)

(6) $\frac{\text{X (Kg) Produce Actually Sold by One Entity to Another}}{\text{X (Kg) Saleable/ Requested Caliber Produce}}$ (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.

Table 1

Financial loss related to lost and wasted food of a fresh produce distributor in the Netherlands (2015-2017)

Year	*Total food lost and wasted in metric tons*	*Disposal costs paid in €*	*Lost monetary purchase value in € (millions)*
2015	*635.09*	*47,631.75*	*2.07*
2016	*1,213.28*	*90,996*	*4.3*
2017	2,031.11	*152,333.25*	7.9

In table 1, the financial loss related to lost and wasted food can be essentially established with the help of three 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: During the time produce is unsold, it generates storage and handling costs - whether the storage facility is owned or furnished via a warehousing service provider. These costs usually refer to the occupied space and moving pallets within the warehouse.

Component III: 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

Including, in both cases, storage and handling costs and, if applicable, disposal service costs.

6. TRUCK UNIT MEASUREMENT SUGGESTION

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 efficiency.

In fresh produce trade, the "industrial pallet" is a widely used exchange pallet throughout the world. The pallet measures a length of one metre, a width of 1.5 metres 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 in table 2.

Table 2

Example of 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	1,300,000,000,000 Kg / (26 pallets x 1500 Kg) = 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 Transported to Next Entity (Kg)*	*Out Sorted, Edible and Unsaleable Produce Due to Standard Restriction (Kg)*	*Transported Produce to Storage (Kg)*	*Received Produce at Storage (Kg)*	*Produce Set for Packing (Kg)*	*Packed Produce (Kg)*	*Sorted Due to Infestation (Kg)*	*Unsaleable/ 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													