

WAGENINGEN

FOOD WASTE IN THE FRESH PRODUCE SUPPLY CHAIN



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1. Introduction

The world population estimated for 2050 will be around 9.1 billion people according to FAO (2009). With the growing population, several questions will arise. How to feed this amount of people? How about our ecological footprint? How do we produce the extra food for the growing population without increasing our ecological footprint? Hand in hand with these questions, lots of research is being done on more effective and sustainable ways to produce food. If these effective and sustainable ways of production can be met, less food will be wasted in the long run. So therefore, while talking about food security and the growing population, a critical look can be expected on food losses and food waste.

There are several definitions of food waste used along the literature of several articles. Food losses are the losses within the production supply chain. Mostly food waste is waste at consumer stage. In this context restaurants and consumers wasting food in the cooking process etc. Along this article, the definition of Stuart (2009) describe in Papargyropoulou, et al. (2014) is used. According to Stuart (2009) food waste is defined as the wholesome of edible material intended for human consumption but instead of consumption this food is discarded, lost, degraded or consumed by pest. Furthermore, the edible material that is meant for human consumption but instead is fed to animals or is a by-product of food processing diverted away from the human food chain, can also be food waste.

2. Research Questions

As mentioned in the introduction, food security is under pressure due to the growing population. The growing world population puts a lot of pressure on the production of food across the world. One of the questions that arises is; "Will there be enough land to produce the extra food consumption of the growing population?" This is only one of the uncertainties with huge effects. Hand in hand with the need for extra food production, to feed the increasing population, comes the efficiency of production. Due to the scarcity of production land, food waste is an undesirable outcome, so a critical look can be expected on the matter of food waste. A lot of food is wasted along supply chains. The supply chain of perishable products is no exception. When the amount of food that is wasted, is calculated you will find that a lot of value/money therefore is thrown away.

The importance of food waste will therefore be addressed in this article. The main research question will address the problem of food waste of perishable products. The main research question that will be answered is; **How to reduce food losses along the fresh produce supply chain?**

2.1 Sub-research Questions

The supply chain of fresh produce is an intensive and integrated chain. The fresh produce supply chain consists out of many shackles that are often scattered around the world. Recent articles by authors like Jones (2004,2006) and Lebersorger & Schneider (2014) illustrates that there are significant differences in the amount of food that is wasted in the different stages of the supply chain. The best way to create a clear image of the wastage in the supply chain of fresh produce is to split up the supply chain. The first sub-research question therefore will be; **What is the amount of food waste in the different stages of the supply chain of fresh produce?**

After the amounts of food waste in the different stages of the supply chain have been estimated it is time to analyse the losses. What are the reasons that these losses occur? The second sub-research question therefore will be; **What are the factors leading to food waste in the different stages of the fresh produce supply chain?**

Several factors will be mentioned and explained to identify the factors leading to food waste in the different stages of the fresh produce supply chain.

When the factors of food waste in the supply chain of fresh produce have been identified, the next step will be discussed. The search for potential solutions. The second sub-question will be about measures that could be implemented to reduce food waste in supply chain considering the factors that are mentioned by the first sub-research question. The third sub-research question will therefore be; **What measures can be implemented in the fresh produce supply chain, to reduce the food losses?**

Along this article, examples of various countries will be used to sketch a clear view of the size of food losses and how to reduce these losses.

3. General food loss overview

Food waste is a growing topic. Last decades an increase in research on food waste can be found. Food waste is becoming a more prominent topic at national and international politics. Due to this growing focus on food waste, food waste has already reduced. Nevertheless, there is still a lot of food losses and waste. The fresh produce supply chain is no exception.

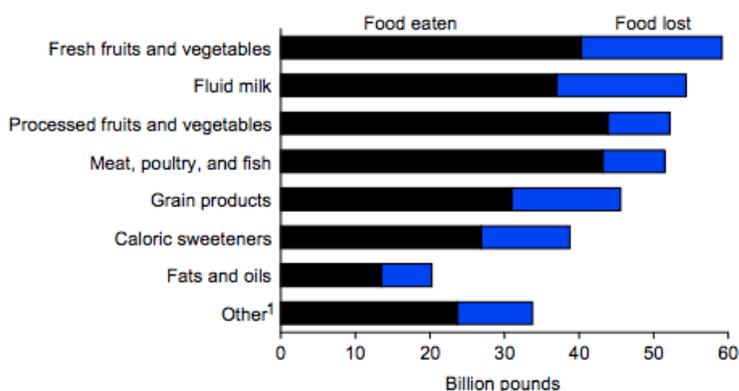
As starting point, for this general overview, the year of 1997 is chosen. This to conduct a clear image of food waste and its development towards the 21st century. Kantor et al. (1997) researched the food losses in the United States of America at the end of the 20th century. In total the USA food supply is 355.883 million pounds, 27% of this food supply is lost somewhere in the chain, when you calculate this to numeric values this will be around 96.088,41 million pounds that is lost. Kantor et al. (1997) did not only look at the USA. In the article distinction was also made in different food groups. In the fresh fruit chain, 22.389 million pounds is supplied and 32% is lost. Fresh vegetables are supplied by 36.830 million pounds and 32% is lost. The meat group is significantly more sustainable. According to Kantor et al (1997), for the products meat, poultry and fish 51.466 million pound is supplied, and only 16% is lost. The losses that Kantor et al. (1997) is describing are only retail, - and foodservice & consumer food losses.

Large Food Losses Occurred at the Retail, Foodservice, and Consumer Levels in 1995

Commodity	Edible food supply ¹	Losses from edible food supply					
		Retail food loss		Foodservice and consumer food loss		Total retail, foodservice, and consumer food loss	
		Million pounds	Percent	Million pounds	Percent	Million pounds	Percent
Grain products	45,606	912	2	13,682	30	14,594	32
Fruit	48,338	707	2	10,609	23	11,316	23
Fresh	22,389	448	2	6,717	30	7,165	32
Processed	25,949	259	1	3,892	15	4,152	16
Vegetables	63,077	999	2	14,947	24	15,946	25
Fresh	36,830	737	2	11,049	30	11,786	32
Processed	26,247	262	1	3,898	15	4,160	16
Dairy products	76,276	1,525	2	22,883	30	24,408	32
Fluid milk	54,474	1,089	2	16,342	30	17,431	32
Other dairy products	21,802	436	2	6,541	30	6,977	32
Meat, poultry, and fish	51,466	515	1	7,720	15	8,235	16
Red meat	30,350	303	1	4,552	15	4,856	16
Poultry	17,108	171	1	2,566	15	2,737	16
Fish and seafood	4,008	40	1	601	15	641	16

Figure 1. Kantor, et al. (1997) *United States of America*

Food Losses Vary by Commodity—Largest Losses Were in the Fresh Fruits and Vegetables, Fluid Milk, and Grain Products Sectors in 1995



Note: ¹Other includes eggs, peanuts, tree nuts, dry beans, peas, and lentils, and dairy products other than fluid milk. Source: Economic Research Service, U.S. Department of Agriculture.

Figure 2. Kantor, et al. (1997) *United States of America*

Where figure 1, only focusses on the amount of food that is lost, figure 2 illustrates the food that is lost compared to the amount of food that is eaten. Most of the times amounts of lost food due not appeal to imagination. To make it clearer how much of a certain food group is lost, it is in figure 2 related to the amount of food that is eaten from this food group.

To map the changes in food losses, of the United States, over the years, Gunders (2012) gives a good view. Gunders (2012) researched the food losses in the United States, Canada, Australia & New Zealand. Gunders (2012) made almost the same distinction in food groups as Kantor, et al. (1997). Which makes it

possible to already see some difference in food waste across a time span of +/- 15 years. Comparing to Kantor, et al. (1997), the food loss/ food consumed ratio has been change a lot. From roughly 1/3th of fresh produce loss in 1995 to a loss of 52% in 2011.

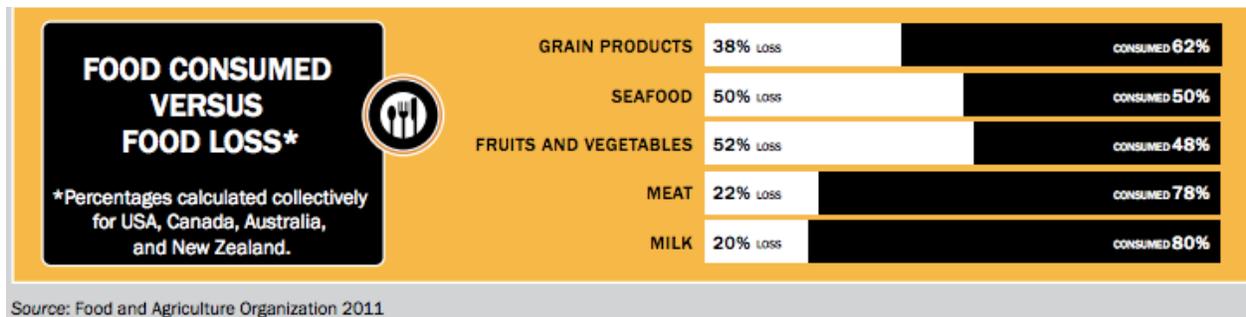


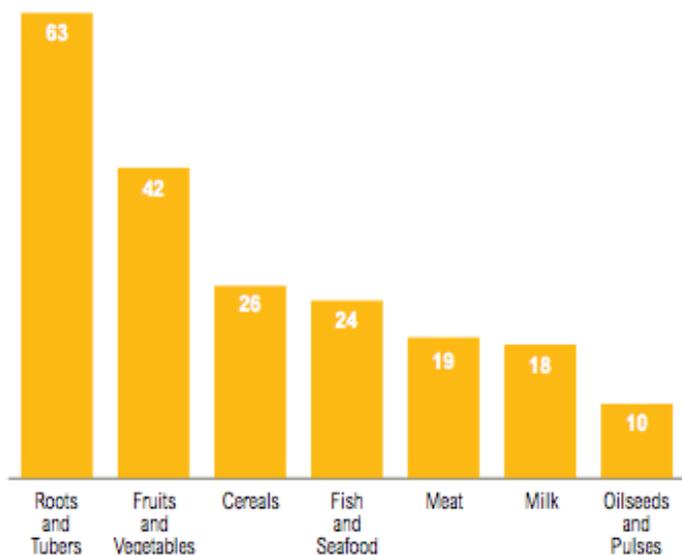
Figure 3. Gunders. (2012) USA, Canada, Australia & New Zealand

Kantor, et al. (1997) & Gunders (2012) mostly looked at the United States of America as indication of the food losses in the fresh produce supply chain. Are these numbers also representative towards other western countries like, for example, the United Kingdom? Quested & Parry (2011) researched the food losses in the United Kingdom. Quested & Parry (2011), included in their research on food waste in the United Kingdom, numbers from the Waste & Resource Action Programme. The WRAP estimated food waste of the United Kingdom. According to the research, 7.2 million tonnes of food and drink was wasted in the UK households alone. 5.8 million tonnes of the 7.2 million could be avoided. Totally unavoidable was the other 1.4 million tonnes.

After seeing these specific numbers for the mostly the USA and the UK, Mena, et al. (2011) estimated the overall food losses of the western countries. Mena, et al. (2011) estimated that all the food that is produces an average between 25% to 50% is wasted along the supply chain in western countries.

So far, only has been looked to western countries of the world, particularly the United States of America. However, in 2013, Lipinski researched the global wastage of fresh produce. In figure 3, Lipinski (2013) is using the share of commodity lost or wasted in 2009, by the FAO. The share is calculated as percentage of kcal. In figure 3, the share of the fresh produce that is lost or wasted is 42%. When this is compared to Gunders (2012) it can be found that the 'global fresh produce loss' (42%) is less than the fresh produce loss of only western countries, which is 52%. Figure 4 shows the amount of global food waste, also divided in several food products, used in Lipinski (2013). In this figure, the waste of food groups is calculated as percentage of all the wastage. The first circle diagram, shows that fresh produce, is responsible for 13% of the global food waste, in terms of KCAL. However, while looking at the second diagram, it can be concluded that fresh produce has a greater impact. In terms of weights, fresh produce is responsible for 44% of the total global food waste. Thus, can be seen that in terms of Kcal, fresh produce takes a smaller share of the circle diagram. In contrast while looking at the weight that is wasted of food groups can be concluded that almost half is caused by fresh produce. Comparing both shares, Kcal and the weight, that is wasted, it can be concluded that the growth factor between both diagrams is more than 3.

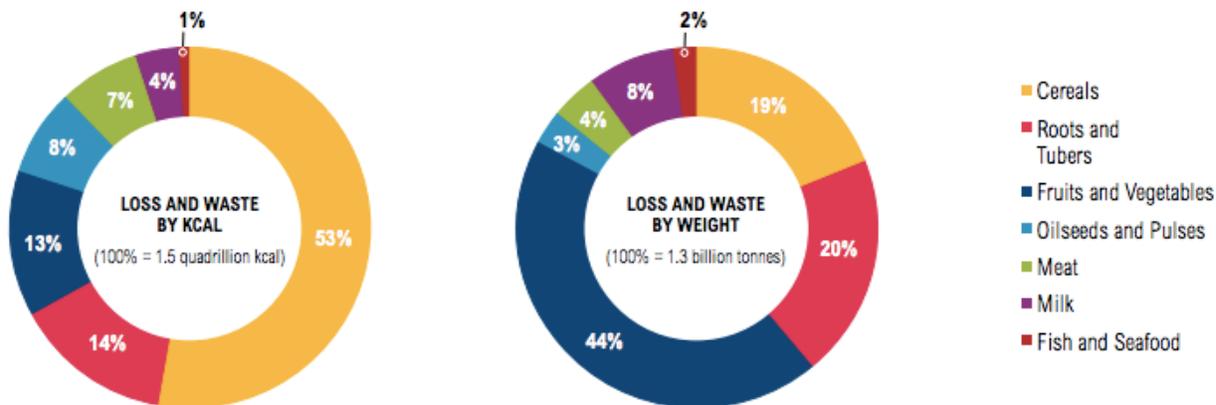
**Share of Commodity Lost or Wasted, 2009
(Percent of kcal)**



Note: Values displayed are of waste as a percent of food supply, defined here as the sum of the "Food" and "Processing" columns of the FAO Food Balance Sheet.

Figure 4. Lipinski (2013)

Share of Global Food Loss and Waste By Commodity, 2009



Source: WRI analysis based on FAO, 2011. *Global food losses and food waste—extent, causes and prevention*. Rome: UN FAO.

Figure 5. Lipinski. (2013)

The values discussed above are mostly numbers that are displaying the fresh produce supply chain as a whole. Figure 1 is an exception, since this figure displays numbers which are located for the retail level & household level. During research, Kantor et al (1997) and Jones (2004,2006) concluded that there are differences in wasting levels. Food waste percentages and values are not the same for every stage of the

supply chain or for every product. The differences in food waste between different food groups is also sketched by Lebersorger & Schneider (2014). Finally, Lundqvist, et al. (2008) concludes that as much of half of the food grown is lost or wasted before and after it reaches the consumer. While seeing these differences between food groups the question that arises is, how these differences are possible and how to reduce the losses in the perishable food group.

Further in this article the amounts of food waste in the different stages of the supply chain will be discussed. Afterwards the factors of food waste in the supply chain of fresh produce will be addressed and explained. In imitation of the addressing and explanation of the factors, several measures will be addressed that could reduce food waste in the future. Finally, out of these findings a conclusion and discussion will be drawn.

Several different literatures and factors will be researched. The stages that will be addressed to answer the main-, and sub-research questions are; (Post) Harvesting, Transport, Processing, Retail level and Consumer Behaviour.

4. The amount of food waste in different stages of the supply chain

Seeing the numbers of the general food loss overview, leads to the question where all these amounts of food are wasted. The supply chain of fresh produce is a supply chain that is a globally integrated chain. Therefore, the supply chain consists of several stages. The stages of the fresh produce supply chain that are addressed in this article are; (Post) Harvesting, Transport, Processing, Retail level and Consumer Behaviour. In every stage of the supply chain of fresh produce food waste occurs. What are the amounts in every stage of the supply chain for the fresh produce? This will be addressed below.

4.1 (Post) Harvesting

In 1997 Kantor, et al. (1997) researched the food losses in the United States. Kantor, et al. (1997) concluded that 7% of the food that is planted on the acres in the United States are not harvested. This was during 1994 and 1996. The 7% regarded all the food that was planted. More recently, Gunders (2012) did a summarily research regarding harvest losses. Gunders (2012) estimated the average losses especially for fresh produce. According to Gunders, at least 6% of fresh produce, in the United States, is unharvested. 6% of the fresh produce can be accounted for as 97.000 acres. That is about 6 million pounds. Mentioned by Gunders (2012) is that a great variety in losses can be seen while comparing different crops. Therefore, Gunders (2012) concluded, in line with Kantor, et al. (1997), that likely 7% of the fresh produce production will not be harvested, and therefore will be lost.

4.2 Transport

Nowadays products are transported all over the world to consumers everywhere. Transport can be done by several ways, plane, train, trucks and by ship. Not all the transported goods will in the end be purchased by consumers. Transport is a likely more difficult stage to find numbers about food waste. This, since the numbers of food waste in the transport stage are often bundled with other stages. In some cases, transport and harvest losses are combined, while in other cases transport is bundled with the retail level losses or even the processing stage.

4.2.1 Shipment Rejection

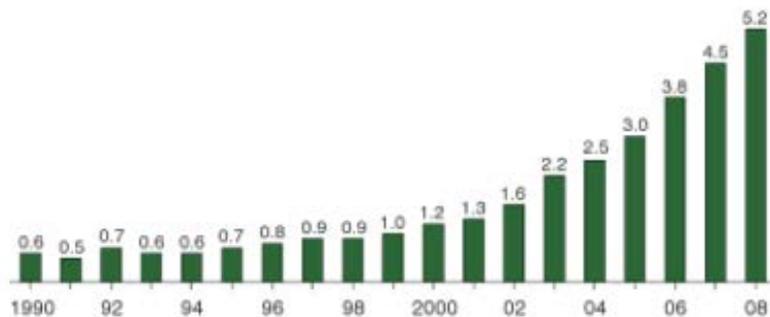
Millions of products each year are transported by ship. Some of the products, that are shipped, can be refused at the border. This mostly applies to transport by ship. Products are refused to avoid that condemned products enter the country. To determine which products cannot come into the country, routine inspections and samples are done at the borders. The U.S. FDA are responsible for these routine inspections and samples of food shipments into the U.S. According to Lupien, et al. (2005) about 33% of these food shipments, out of Central America, that want to enter the U.S. are rejected. Shipments can be rejected due to several reasons. The reasons that are used are; contamination with insects, rodent hairs, heavy metal contamination, illegal pesticide residues, contamination with pathogenic microorganisms, improper labelling, and other undesirable extraneous matter that indicates poor food hygiene and unacceptable production practices in the country of origin.

Not only shipments that want to come into United States are rejected, but also shipments to the European Union. According to Jaffee & Henson (2005) the numbers of incidence and number of notifications are rising in the European Union. Jaffee & Henson (2005) state that these numbers haven't been increased more than six-fold. The numbers of notifications and alerts have been increased more than six-fold in a time span of 4 years. In the 1998 (230 cases) and in 2002 (1,520 cases). A combination of factors reflects the increase of rejections. These factors, according to Jaffee & Henson (2005), are; tightening or harmonizing of standards, application of standards for formerly unregulated hazards, and the increased capacity for inspections and enforcement of standards.

The FDA is responsible for the routine inspections of cargo's that are imported by the United States. Gale & Buzby (2009) researched the shipment rejections of the United States. Gale & Buzby (2009) took a close look at the shipments that are imported from China. Due to the size of China and the rapid developing of the country, China has become a big and important player in the world market. Figure 6, displays the growth of China in the world market. In figure 6, the increase of U.S food imports from China is displayed.

Value of U.S. food imports from China, 1990-2008

\$ billion



Note: The definition of food items used here includes edible plant and animal items, foods, beverages, and animal feeds. It excludes live animals, live plants, seeds, straw, hair, animal guts and bladders, waxes, fuel alcohol, and plants for medicinal uses. The definition includes Harmonized System codes 02, 03, 04, and 07-23, except for 1209, 1211, 1520, 1521, 1522, 2207.

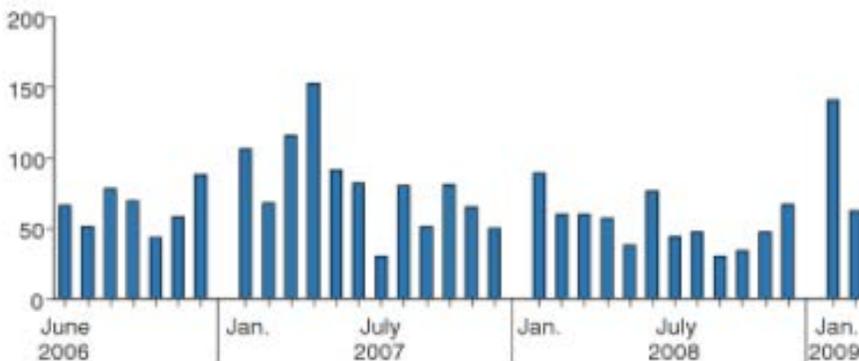
Source: Estimated by ERS from U.S. Customs statistics accessed through Global Trade Information Services.

Figure 6, Gale & Buzby. (2009)

As already mentioned. The FDA is responsible for the inspection of cargo that is imported at the border of the US. Figure 7, captures the monthly refusals by the FDA of shipments that have the origin of China over a time span of 2.5 years.

Monthly FDA import refusals of food shipments from China

Number



Source: ERS analysis of U.S. Food and Drug Administration import refusal data.

Figure 7, Gale & Buzby. (2009)

Figure 8, shows the amount of shipments out of China that are rejected by the FDA. This figure uses a time span of 10 years. The bar charts are divided in food groups. In the recent years of '07 & '08, 'fish and shellfish' are causing a huge amount of the shipment rejections. While in years before '07, 'fruit and vegetables' had a larger share of the rejections than 'fish and shellfish'.

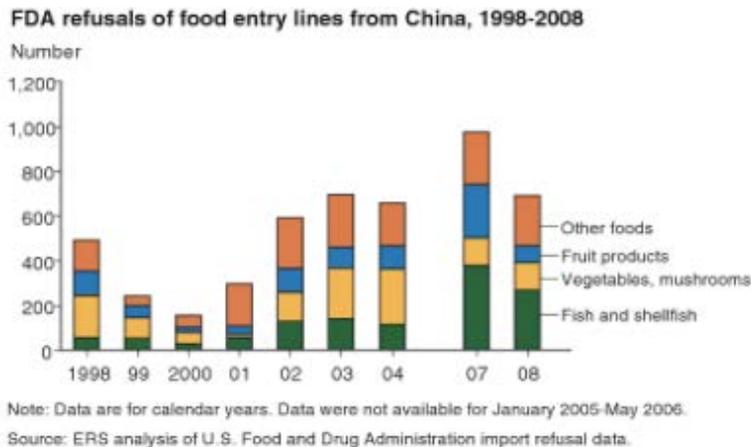


Figure 8, Gale & Buzby. (2009)

As for a great exporter and market player like China almost an average 80 shipments are rejected per month. Which are +/- 800 shipments per year. After seeing the figures 6, 7 & 8 it can be concluded that rejection of shipments has a great impact on food waste during the transport stage. Therefore, an important shackles to consider.

After seeing the figures and numbers about the rejection of shipments a new question arises. What happens to the shipments that are rejected at the border? Lupien (2007) and Gunders (2012) researched the rejection of shipments. Lupien (2007) concluded, same as Gale & Buzby (2009), that many exported foods do not meet the import requirements of the importing country. When this occurs, this leads to rejection, destruction or costly re-conditioning of shipments.

Gunders (2012) goes a bit more deeper and states, that the rejection of perishable shipments can lead to dumping when another buyer cannot be found in time. But when these shipments do make it to another buyer, the products have a shorter shelf life at arrival than other products of the same product group. Rejected shipments are sometimes brought to food banks. Even though food banks sometimes reject these shipments as well. Most of the times the food banks are not able to store the amounts due to a lack of capacity, and the products cannot be used in the quantities that are being shipped to the food banks. Gunders (2012) noticed that, food banks mostly do not have the transportation infrastructure to handle the huge quantities that are donated or reallocated to food banks. In the case that transportation infrastructure is present, and donations could be handled, another obstacle comes above water. The fact that food banks are mostly voluntary organizations. Therefore, food banks often do not have the resources to handle the quantities. Another factor that is limiting donations to food banks is that some products are not desired by the food banks. Products that are difficult to prepare decrease the donations usability.

4.3 Processing

The processing stage of the supply chain is an intensive stage. The products are washed, skimmed, trimmed etc. These processes cause food waste. To what extend is this stage causing food waste?

The first researcher that will be addressed is Monspart-Sényi (2006). According to the research of Monspart-Sényi (2006) the waste and by-products in food processing in Brazil, is 30%. These wastages are not always coming back to the market for human consumption. Monspart-Sényi (2006) states that only 2 to 3% of the by-products that are caused by the manufacturing will be back on the market for human usage. Most of the other by-products are used as animal feed.

After looking at a developing country, like Brazil, Parfitt, et al (2010) give insights in the processing waste at developed countries. According to Parfitt, et al. (2010). Approximately 20% of the food and drink waste in the United Kingdom, can be attributed to the processing stage, distribution and retail level. Parfitt, et al. (2010) mentions that the food and drink waste in the UK can be estimated at 14 mega tonnes. Recalculated the waste of food and drinks at the processing stage according to Parfitt, et al (2010) is around 2.8 mega tonnes. Total food waste that can be attributed to manufacturing and processing is 5 mega tonnes per annum. From these 5 mega tonnes around 2.6 mega tonnes is food waste. Parfitt et al. (2010) also concluded that of all the raw materials that are used approximately 16% is wasted during manufacturing.

A year later Mena, et al. (2011), estimates that the food waste, in the UK, in the stage of processing has a range that has a width from 3.5 mega tonnes to 6.6 mega tonnes. Gunders (2012), also researched the stage of processing within the fresh produce supply chain. In the study, several estimates about food waste at the processing stage are mentioned. Due to a lack of clarity, Gunders (2012) states two estimates about the processing losses. The first study that is mentioned by Gunders (2012), is conducted by the European Commission. The European Commission estimates that the losses during the processing stage, in the United Kingdom, are 39% of total food loss. The second estimate that is mentioned is based on a study conducted by, a U.K. based reduction and recycling organisation. This organisation estimates that 16% of the raw materials that are used in the processing stages, are lost.

Straight forward, the processing stage is the stage of turning a fresh product into preserved products. To do this, a selection of good products/elements, out of all products, needs to be made. The unsuitable elements will become by-products or waste. Nowadays supply chains are more designed to use by-products of other supply chains to make new products. When this is not possible and these by-products from other supply chains are refused, the by-products become waste. According to Monspart-Sényi (2006), about 60 till 65 percent of these so-called by-products in Hungary, becomes wastage.

4.4 Retail Level

Another important stage at which food is waste is at retail level. According to Eriksson (2012) the food waste in the retail sector of Germany is 3% of the whole food supply chain, and the food waste in the retail sector of Sweden is estimated to be even higher, 3.8%. Halloran, et al. (2014) did research on the food waste in Denmark. The food waste in the retail in Denmark is 45,676 tonnes per year. These losses are created by Danish warehouses, mini-markets, hypermarkets, discount stores and supermarkets. Most of these retail losses can be accounted to fruit/vegetables, bread and yoghurt.

Gunders (2012), estimated that the in-store/retail losses in the U.S. are 10% of the total amount of food waste in the supply chain. This can be recalculated as an amount of 43 billion pounds in 2008. Looking at supermarket level, fresh fruit waste is causing an 11,4 % wastage and 9,7% waste is regarding fresh vegetables.

In the article of Lebersorger & Schneider (2014) the rates of food loss were compared across different food groups. The rate of losses is presented for the Austrian retail level. The rate of loss of fruit & vegetables, dairy products and bread & pastry were considered. Fruit and vegetables had a loss range between 1.2% and 14.7%. Dairy products had a loss range between 0.2% and 8.4% and bread and pastry a loss range between 0.4% and 9.6%

4.5 Consumer

The consumer is the last stage of the fresh produce supply chain. At this stage, the food that is purchased at the retail level will be prepared for consumption in households. Several researches have been conducted to map the food losses at consumer level.

In 2003, the food loss at household level in the U.S. has been estimated at 14% by Jones et al. (2003, unpublished data). On yearly basis, this costs a household of four at least \$589,76 (Jones 2004). According to Jones (2004) the food loss in the USA was \$90-100 billion at yearly basis. Households were responsible for a food loss of \$48.3 billion (Jones 2006). In 2008, the US Environmental Protection Agency also researched the food waste. The agency estimated that 12.7% of the food is wasted at household level.

To expand the above numbers of Jones (2004 & 2006), can be looked at Gunders (2012). According to Gunders (2012), American households are estimated to throw away 25% of the food that is bought. Recalculated, this 25% of food waste, in an average American household of four, comes to an amount of \$1,365 to & \$2,275 that is wasted at household level (figure 9). To compare the US household food waste mentioned above, Gunders (2012) also researched the food waste in the households of the United Kingdom. Two third of the food waste in household of the U.K. is due to spoilage. Food that is not being prepared/used in time. The other 33% of the food that is wasted in the household of the U.K. is caused by cooking failures or by serving too much.



Figure 9, Gunders, et al (2012). *United States*

Overview

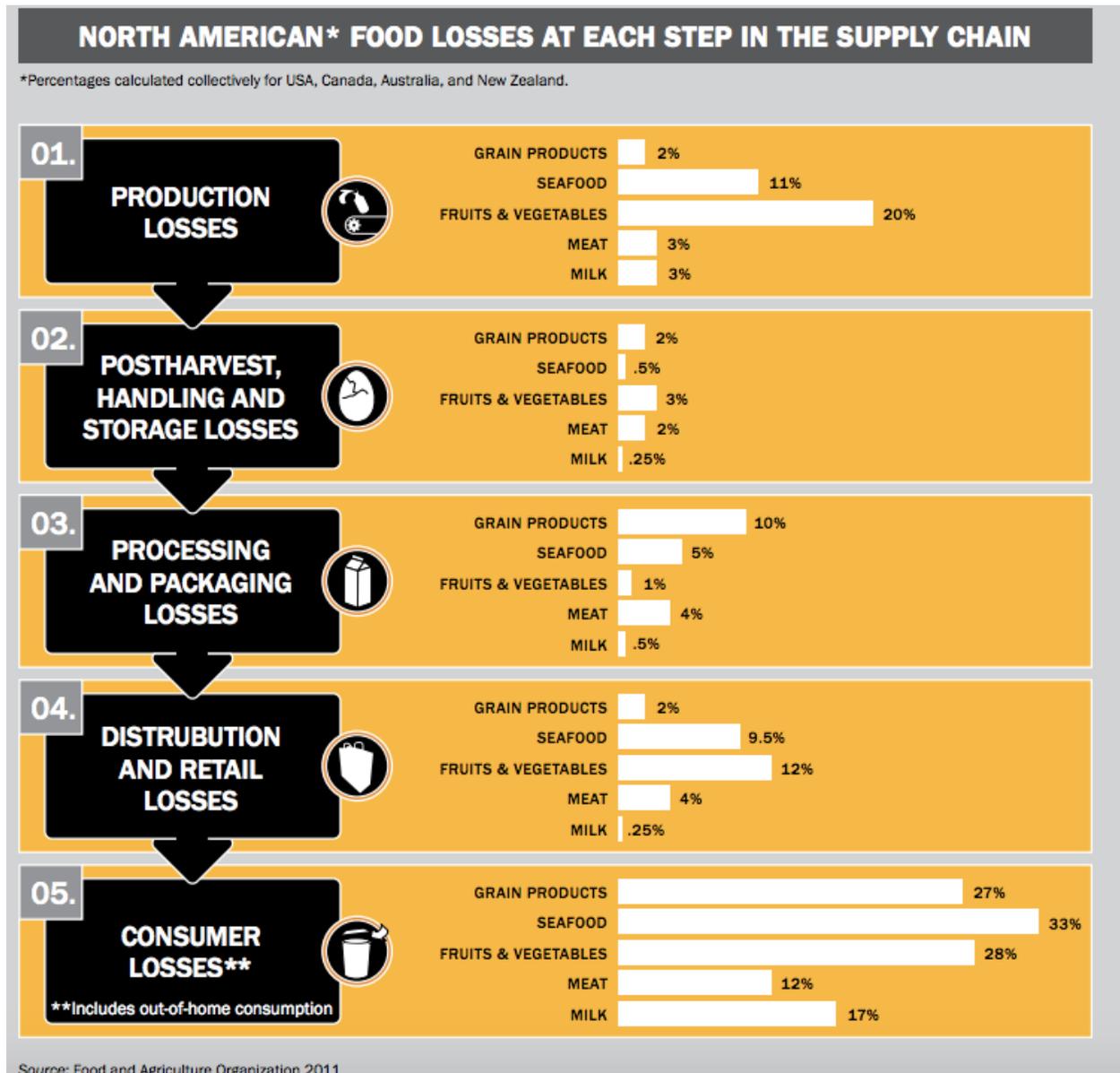
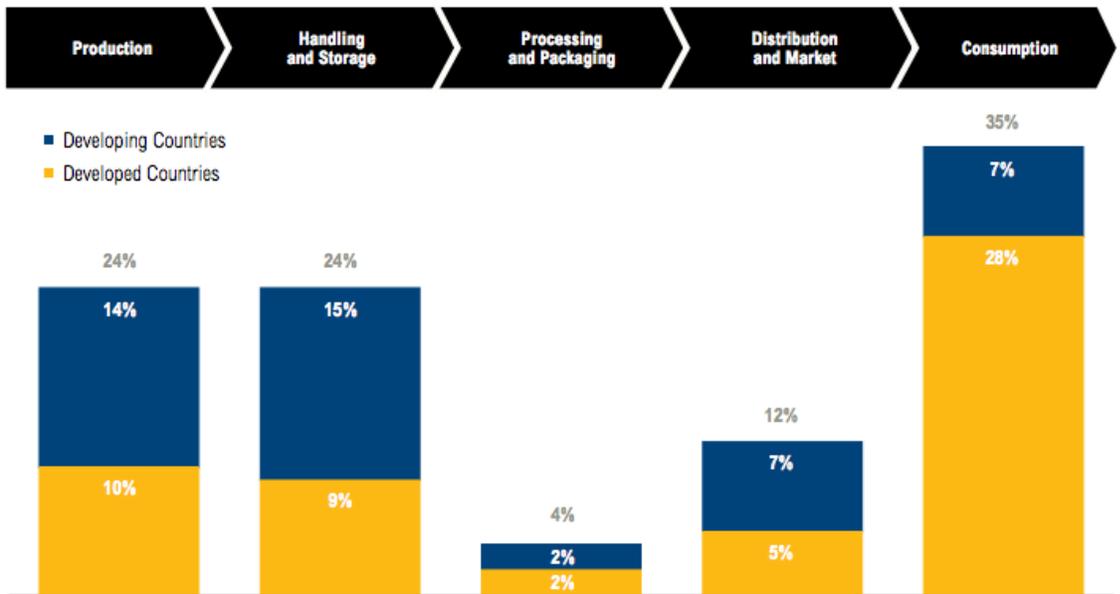


Figure 10, Gunders, et al. (2012) *United States, Canada, Australia & New Zealand*

Share of Total Food Loss and Waste by Stage in the Value Chain, 2009
(100% = 1.5 quadrillion kcal)



Note: Number may not sum to 100 due to rounding.

Source: WRI analysis based on FAO, 2011. *Global food losses and food waste—extent, causes and prevention*. Rome: UN FAO.

Figure 11, Lipinski, et al. (2013) *Global*

The differences in food waste at every stage of the agricultural supply chain are illustrated by figure 10 & 11. Where Figure 10 focusses on the fresh produce supply chain of the United States of America, figure 11 focusses on the average agricultural food waste per stage of the supply chain. While comparing these figures it can be noticed that fresh produce ‘production losses’ (figure 10, 20%) are significantly higher than the average global ‘production loss’ (Figure 11, 10%). At the stage of ‘Handling and storages’, the American food losses are 3 times as low (3%), then the average global losses (9%). Also at the stage of ‘distribution and retail, the American food losses (12%), are significantly higher than the average global losses (5%).

Table 1.

	Waste
(Post) Harvesting	7%, USA (Kantor, et al 1997) 7%, USA (Gunders, 2012)
Transport	No specific known numbers.
Shipment rejections	33% of shipments from <i>Central America into USA</i> (Lupien et al. 2005)

Processing	<p>30%, <i>Brazil</i> (Monspart-Sényi, 2006)</p> <p>3.5 mt – 6.6 mt, <i>UK</i> (Mena et al. 2011)</p> <p>39% of total food loss, <i>USA</i> (Gunders 2012)</p> <p>16% of raw materials, <i>USA</i> (Gunders 2012)</p>
Retail Level	<p>3% (<i>Germany</i>) 3.8% (<i>Sweden</i>) of whole supply chain (Erikson 2012)</p> <p>45,676 tonnes per year, <i>Denmark</i> (Halloran, et al. 2014)</p> <p>10% of whole chain, <i>USA</i> (Gunders 2012)</p>
Consumer	<p>14%, <i>USA</i> (Jones et al. 2003)</p> <p>12.7%, <i>USA</i> (US Environmental Protection Agency)</p> <p>25% of bought products, <i>USA</i> (Gunders 2012)</p>

Table 1 concludes all the numbers of food waste per stage in the fresh produce supply chain, as discussed in the previous paragraph above. Many differences can be concluded out of this table. It seems like the stages of (Post) Harvesting and Retail level have the lowest numbers of wastage. (Post) Harvesting is a solid stage. (Post) Harvesting has been stable over a timespan of 15 years, and is accountable for 7% of the food waste in the United States of America. At the processing stage a bigger range of food waste is stated, which means that this stage is harder to get a clear insight in the numbers of food waste. While talking about stages that are hard to interpret, a look must be made to the stage of Transport. The stage of transport does not even have specific numbers. Which makes it even more hard to sketch a view of the food waste at that stage. Since transport is often taken together with the retail or processing stage little information about the exact numbers is available. However, while looking at the Shipment Rejections, more than one third is rejected. The question that arises here is, are these Brazilian shipment rejection rates representative for other shipments that are imported from developing countries. Finally, the Consumer stage. The Consumer stage can be evaluated as a stage that is responsible for a huge amount of food waste. The wastage of this stage will be in the range of +/- 13% till 25%.

5. Factors leading to food waste in the fresh produce supply chain

Nowadays the world is connected more than ever before. This has impact on almost everything in the world. Supply chains are no exception for that. Supply chains exist of several companies in different countries due to globalization. Supply chains have become long, complex and consisting of many links. The globalization has impact on the supply chains and some factors that are causing losses. This means that there are many links that could lead to food waste. Food waste along the supply chain is caused by several factors. In this paragraph, several factors leading to food waste in the different stages, will be discussed. Such factor could be consumer behaviour. Gustavsson et al, (2011) concluded that in developed countries food waste during the consumption stage accounts for 40% of the total food waste in the supply chain. A second factor of food waste is the unartful handling of products. In early years, Hardenburg et al. (1986) and Appleman & Arthur (1919) did research to the declining quality of products directly after the first harvest to the warehouse. These and other factors that are causing losses in the different stages of the fresh produce supply chain will be addressed in the sections below.

5.1 (Post) Harvesting Quality

Sargent et al. (2000) did research about maintaining postharvest quality. During the research Sargent, et al. (2000) mentions the factor, 'harvesting at the incorrect maturity stage'. Which means that some fresh produce is not harvested at the stage of highest quality and will therefore lose quality at a higher level than when it is harvested at the highest quality. Secondly there is the careless handling at harvest. In several cases, directly after harvesting, fresh produce is not handled carefully enough. This will lead to bruises on fresh produce, these bruises will spoil in an earlier stage and therefore will lead to food waste in the long run. Sargent et al. (2000) also mentions the distance to the first warehouse. Often the distance to the first warehouse for storage is too big. Due to this the fresh produce often lies too long in the burning sun at the field or in the trucks, which leads to quality decline.

Several other researchers claim that not all the biological & environmental factors are known by farmers. Kader (2004) is one of them. Since these conditions are not known by farmers, food is wasted due to lack of knowledge.

More recently, Gunders (2012) researched the food waste regarding harvesting. Gunders (2012) discovered another factor, which is not discussed yet, that is leading towards unharvested fresh produce. Gunders (2012), addresses this factor as 'food safety scares'. For example, in 2008, 32% percent of the tomatoes in the United States were not harvested. In advance of the harvest, there was a warning by the Food and Drug Administration of the U.S. The warning was about Salmonella contamination. There was a chance that some tomatoes could have a Salmonella contamination. The warning led to a risk averse attitude of consumers regarding tomato consumption. The change in attitude led to a decrease in total demand for tomatoes. Therefore, not all tomatoes needed to be harvested to equal the demand of the consumers. Of course, this example was extreme, but in this case it led to a 32% loss of food.

5.2 Transport

The distance that products cover these days to get to the consumer is huge. There are many intermediate stations before the products that are harvested on the fields arrive at the consumers. This long distance comes with a lot of different sizes and length in time of transport. Due to these differences

in transport and different parties that arrange these transports along the supply chain, problems occur which lead to food losses.

Hardenberg et al. (1986), Appleman and Arthur (1919) did research to the quality of perishable products directly after harvesting. Concluded was that one of the key transports in the supply chain is the first transport. This means the first transport, directly after harvesting, to the first warehouse. In the first warehouse the fresh produce is for the first time cooled to a certain temperature that prevents the decline of quality. Both two articles, Hardenberg et al. (1986), Appleman and Arthur (1919), concluded that the loss of quality and value is at the highest rate direct after harvesting. In a society where consumers aim to consume products at the highest quality, the conclusion can be drawn that the first transport therefore is an important factor.

According to Sargent et al. (2000), along the fresh products supply chain, products are not always handled with the same carefulness as it should be. During, transport and transshipments along the supply chain, fresh produce gets damaged. The products often get bruises. The bruises will spoil in an earlier stage than fresh produce without these bruises which were handled more carefully. So, in the long run these fresh produces will lead to waste due to careless handling during transport.

Another important factor that is addressed by Sargent et al. (2000) is the temperature of products. To maintain the quality of fresh produce it is important that, during transport and shipment, the products are held at an optimal temperature. To achieve this there are several parts that need to work optimally. In the case of transport for fresh produce, the right equipment is needed. This kind of equipment needs to be equipped with a good cooling system. The cooling systems are there to keep the temperature during transport at the right level to maintain product quality. A second important part of the factor is temperature during transshipment. During transshipment, the focus is shifted towards transshipping the products. In some occasions the shift towards transshipping leads to decrease in attention to the quality of fresh produce. The optimal temperature of fresh products is not considered anymore and transshipment from one transport to the other transport is not in tune. This leads to fresh produce that is not held at the optimal temperature for amounts of minutes till hours. Which causes decline in product quality and spoilage in an earlier stage of the supply chain.

In addition to Sargent, et al. (2000), Estrada-Flores, et al (2002) mentions that several trails have been started that are related to temperature control. Concluded during this research are that several factors during transport are causing food waste. Estrada-Flores, et al. (2002) highlighted that there are differences in refrigerating equipment. In many refrigerating transport equipment is spatial variation in product temperatures significant. Additional to the spatial variation in product temperature other environmental conditions have impact on the fresh produce. Not only spatial variation but also, relative humidity and air velocity are important factors, which if are not fine tuned to the fresh produce can lead to food waste.

Watkins (2016) is in line with the researchers above and recognizes the factors that are mentioned above. Transport losses during the transport stage of the supply chain are related to unartful handling during harvest and transport. But also, due to; delay in cooling, excessive vibration and refrigeration equipment failure.

5.2.1 Shipment rejection

In the previous paragraph about transport, the numbers of rejected shipments have been indicated. However, what are the factors that are leading to the rejection of shipments? In figure 12, the shipments from China that are rejected to enter the USA, are compared to the shipments from 'all countries'. The factors that are leading to the rejection of shipments by the FDA are displayed. The factors are shown as a percentage of the rejections. In the years 2002 till 2004 significantly more shipments from China are rejected by the factor 'Filthy', then shipments from 'all countries'. The factors that are increasingly causing more rejection of shipments from China, are the factors 'Unsafe additives' & 'Labelling'. The factor 'Labeling' is an interesting factor. At first, in the years 2002 till 2004, less shipments are rejected than in comparison of the shipments of 'all countries'. However, in years 2007 till 2008 more shipments were rejected due to the factor 'Labelling', in comparison to the earlier years and to 'all countries'. What is causing this increase in rejections?

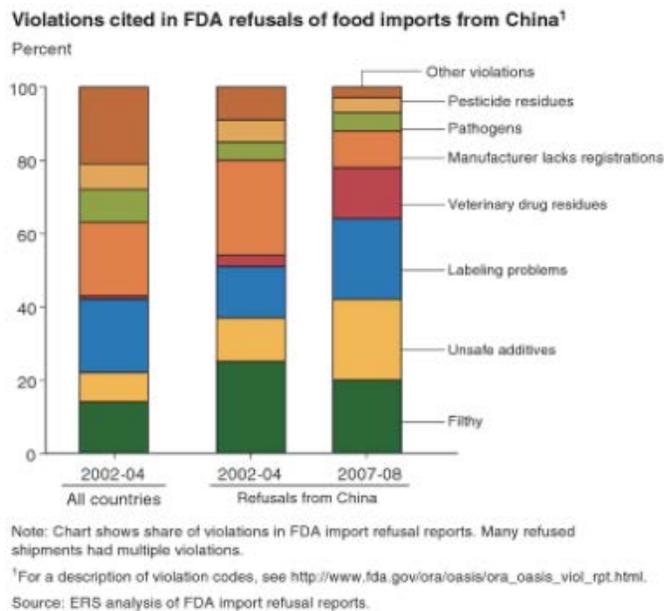


Figure 12, Gale & Buzby. (2009)

In nowadays society, consumers in developed countries pay high-level attention to what food is consumed. Food safety is of great concern for consumers. Large food safety scandals of last decades have led to concerns. Not only by consumers but also by governments. Products that do not meet the standards, will be refused at the border.

Trienekens & Zuurbier (2008) researched these regulations regarding food safety. Trienekens & Zuurbier (2008) found several factors that are causing the different levels of regulations. One of these factors is the proliferation of standards in developed countries. Secondly an important factor is the lack of an enabling environment. In many developing countries, the institutional and infrastructure facilities are not optimal or not even present. Often there is a lack of skilled personnel and laboratories in developing countries. This makes the companies in developing countries often do not know if the products that are exported are meeting the standards of the importing countries. When the products do not meet the standards, it will lead to food waste, since the products than will be refused by the importing country.

Below in figure 13 are the differences stated between three regions and their situation towards food safety regulation according to Trienekens & Zuurbier (2008). The regions researched are the European Union, the Mercosur countries and the ACP countries. The European Union speaks for itself. Mercosur countries are the emerging economy countries and ACP are the African Caribbean Pacific countries.

The European Union mainly focusses on consumer-related topics. Developed countries mostly pay attention to traceability and labelling systems. Together comes that communication about food safety and quality should be increased and improved. The supply chains in European Union therefore are focused on both private- and public demand. This leads to multiple audits. These factors lead to incentives for innovation.

In contradiction to the countries in the European Union, the Mercosur countries are more focused on the markets. Mercosur countries want to develop new markets. Both national-and international markets. Still behind the Mercosur countries are the ACP countries. The ACP countries did not pay attention to the issue of food safety before and therefore need to start from the beginning now. ACP countries are discovering the field of food safety. The concluded that these factors are of great importance considering international trade.

Bottlenecks and opportunities regarding application of food quality and safety standards in three regions

Bottlenecks	Opportunities
<ul style="list-style-type: none"> ● EU <ul style="list-style-type: none"> ○ lacking consumer knowledge ○ insufficient risk communication ○ low dissemination R&D knowledge ● Mercosur <ul style="list-style-type: none"> ○ uneven income distribution ○ harmonization of standards ○ lack of coordination (horizontal and vertical) ● ACP <ul style="list-style-type: none"> ○ no or too few laboratories ○ low investments in transportation and storage ○ lack of legal framework 	<ul style="list-style-type: none"> ● EU <ul style="list-style-type: none"> ○ provision of product information ○ monitoring safety and quality of food ○ innovative products and packagings and niche markets ● Mercosur <ul style="list-style-type: none"> ○ design of coordinated subsystems ○ standards harmonization (PP) within and between Mercosur countries ○ improvement of inspections and enforcements ● ACP <ul style="list-style-type: none"> ○ investments in infrastructures ○ improvements in feed and feeding system ○ PP development of standards

Figure 13, Trienekens & Zuurbier (2008)

In the developing countries addressed by Trienekens & Zuurbier (2008), small-and medium size companies are struggling. In the Mercosur and ACP countries companies have difficulty reaching the high standards of food safety regulations that are required in the European Union.

Several factors are causing the fact that companies in developing countries are not able to meet the food safety standards that are set by developed countries. The first factor is that in these developing countries there mostly is a lack of awareness and information about the regulations and demands of the markets in developed countries. Often exporting companies assume that their products meet the food regulations of western countries, while in fact the products do not meet the standards. Secondly, the standards and regulations of regions are different. Third factor that is causing the fact that companies in developing countries cannot meet the food safety standards is because of the lack of harmonization of national norms. However, companies often find out about these regulations when products are already exported. The products are then refused at the borders and often are leading to food waste. Food safety comes together with costs. So, called costs of certification. Costs of certification are costs that come with regulation of food safety. These costs mostly cannot be met by the companies.

5.3 Processing

According to Gunders (2012), food waste caused during the process is mostly done by removing uneatable parts. Losses are caused by trimming. Trimming is the process of when the eatable and uneatable parts of products are removed. Because these trimmings are done by machines makes it less accurate than when it is done by hand. Therefore, the trimming process is causing most losses. Secondly, there are the factors of overproduction, product and packaging damage and technical malfunctions, but according to Gunders (2012) these last factors are harder to reduce.

Even before entering the processes at all, several fresh produces do not fit the size constraints demanded by the manufacturers. This means that some of the fresh produce is not suitable for the industrial processing stage. According to Halloran, et al. (2014), these demand sizes are caused by retailers and by marketing mechanisms. There is a regulation (Commission Regulation N1221/2008), regarding quality standards which is causing this phenomenon. The regulation is not for food safety, but for quality standards. The matters that are discussed in this regulation are; the size, shape and looks of fresh produce. This causes the fact that under- and oversized fresh produce cannot. Most of the fresh produce that do not meet the required demand size, due to under- or oversized fresh produce, and are often not reaching the market at all and food is that could have been eaten is wasted.

5.4 Retail level

Lebersorger & Schneider (2014) has an explanation for the losses at the retail level. One of these factors is the confusion caused by dates that are stated on the products. The so called, best before/use-by/sell-by dates. Many consumers do not understand the differences between these three types of date. Often this leads to consumers thinking that products are perished or not suitable for usage anymore while in fact this is not. Consumers are mistaken in the sell-by/ best before date and the use-by data. This leads to an even higher degree of food waste at the consumer level.

Several other factors causing food waste at the retail level, discussed by Lebersorger & Schneider (2014), are 'apparent flaws of the product', 'part of the product is lacking', 'damaged packaging' and 'breakage'. Due to apparent flaws, lacking parts of the products or damage the consumer is less interested to purchase the products. This will lead automatically to more wastage.

Another factor in the retail level leading to food wastage are the discounts that are offered by retailers. There are several different forms of discounts. Discounts like 'buy one get one free' or the 'economy size' packages are frequently used discounts. These discounts can mainly lead to food waste in the single households because the consumers buy these larger quantities. This can be related to the fact of consumer behaviour. Meanwhile the consumers do not have enough time to consume these larger quantities of products. The products will expire the expiration date and food will be thrown away. In Denmark, therefore 60% of the single household demands smaller packages to avoid this kind of spoilage. According to Halloran, et al. (2014) this is mainly related to meat, fruit & vegetables and sandwich foods.

Gunders (2012) comes with another factor regarding food waste at the retail level. Retailers assume that consumers like full shelves. Full shelves give the consumer the chance to choose which product of the shelf is of highest quality and fits them. Retailers therefore stack the shelves as full as possible. When this is done by fresh produce it could lead to wastage. Since the bottom products are carrying the weight of all the products on top of them. The bottom products will bruise/damage more easily and in the long run spoil at a higher rate than the other products.

Nowadays consumers in developed countries, expect to have the choice out of every product of the world at any time of the year. Since consumers want to be able to choose every product that is available on the world market, the retail level is necessitated, to have all of these products. These expectations are leading to the fact that in the supermarkets there are more than the daily average nutritional needs per person available. Papargyropoulou, et al (2014) noticed this. According to Papargyropoulou, et al (2014), comparing the average daily nutritional needs per person against the actual food available at the retail level in high income countries highlights the growing gap between food production and consumption.

5.5 Consumer

One of the stages that is causing huge losses in the fresh fruit/vegetable supply chain are the consumers. Consumers are mainly not acquainted with the amount of food they are wasting at their own homes. According to Lundqvist et al. (2008), most consumers do not have a clue how much they are wasting. "The very majority of people in the UK describe the amount of food they throw away as "some, a little, hardly any or none" as compared to the actual through always that are equivalent to about a third of the food bought". Sanne (2002) researched the behaviour of consumers related to consumption. Sanne (2002) concluded that even if consumers are willing to make sustainable choices, the consumer does find themselves often trapped into unsustainable user practices and infrastructures. So even though consumers will realize the amount of food that is wasted, they do often not know how to change their behaviour.

During a normal day, a consumer makes more than a hundred of small decisions. If a consumer would use an intensive decision making process for these decisions, it would take a lot of effort and time. Time a normal consumer does not have during daily decisions. Lindblom (1959) and Simon (1997) therefore concluded that if a consumer needed to make more than hundreds of decisions, the decisions would not all be made rational. According to their view, consumers have no alternative but to take heuristic shortcuts when making the hundred small, often mundane decisions that occur during daily life.

Ajzen (1991), agrees with Lindblom (1959) and developed the theory of planned behaviour. From the perspective of the theory of planned behaviour, consumer decisions are made under volitional control, and intentions are a function of attitudes and subjective norms. The theory of planned behaviour describes a consumer that maximizes its utility. When applying this theory, a consumer maximizes its utility and therefore is a happy consumer. Happy consumers do not always choose the best and most sustainable options. Therefore, for example consumers choose product that are at sale that often are not consumed and are wasted.

With the given information above, it can be concluded that habits of consumers are difficult to change. This is because habits are routines, and routines are difficult to interrupt. It is in the nature of man to hold on to tradition. People do not like to change. In the eyes of many people change is scary. Change brings a certain unknown outcome and people do not like the “unknown”, which makes people frightened to change.

Gunders (2012), did not only look at specific habits or behaviour of consumers, like the researchers mentioned above. Gunders (2012) also looked at other factors that are causing food losses at household level. According to Gunders (2012) are products that are promoted at sale leading to unusual purchases. Promotions are causing bulk purchases or purchases of products that usually are not used by the consumer. Due to the promotions consumers are buying products that do not fit in their regular eating pattern and habits and therefore leads to food waste.

During grocery shopping a consumer is easily distracted by sale promotions. Gunders (2012), is therefore of opinion that lack planning is a factor that indirectly leads to food waste. Consumers that go shopping without proper planning of their meal are wasting more in the long run. Shopping without shopping list/meal preparation makes it for consumers harder to estimate the amount of food that is needed for their meals. This leads to fact that consumers buy more products than are needed for their meals/misjudge food needs, which leads to spoilage.

Gunders (2012) also recognizes the factor of improper storage. Consumers often do not store meal leftovers the proper way. Gunders (2012) does not only mentions improper storage but also mentions factors like refrigerators that are stacked to the limit and ingredients that are not used as a whole. The ‘over stacked refrigerator’ causes poor visibility. Therefore, partially ingredients will remain and spoil after time. Another in house factor that is causing food wasted mentioned by Gunders (2012) is the over preparation of food. Often consumers do not know exactly how much food intake is normal/average. Therefore, many consumers cook more food than can be consumed. If the remainders are not saved and consumed in time, the over preparation of food in households will lead to food waste.

Last but not least, dinner plates play an important role in food waste at household level. Gunders (2012), mentioned that the average dinner plates have increased by size. Between 1960 and 2007 the size of a regular dinner plate has increased by 36%. Wansink & Van Ittersum (2006), researched the intake of food coherent with the size of dinner plates. Wansink & Van Ittersum (2006), concluded that bigger dinner plates lead to bigger amount of food on the plates. Therefore, consumers are dishing up their plates. While consumer cannot take in these amounts of food. So, the behaviour of consumers dishing up their plates when using bigger dinner plates, leads to food waste.

Overview

Table 2.

	Waste	Factors
(Post) Harvesting	7%, <i>USA</i> (Kantor, et al 1997) 7%, <i>USA</i> (Gunders, 2012)	<ul style="list-style-type: none"> - Incorrect harvesting time - Uncarefull handling - Distance to warehouse - Temperature in warehouse
Transport	No specific known numbers.	<ul style="list-style-type: none"> - Uncarefull handling - Temperature during transport & transhipment - Vibration - Equipment failure
Shipment rejections	33% of shipments from <i>Central America into USA</i> (Lupien et al. 2005)	<ul style="list-style-type: none"> - Different food safety standards - Lack of enabling environment - Lack of skilled personnel & laboratories - Focus on different parts on the chain - Costs of certification
Processing	30%, <i>Brazil</i> (Monspart-Sényi, 2006) 3.5 mt – 6.6 mt, <i>UK</i> (Mena et al. 2011) 39% of total food loss, <i>USA</i> (Gunders 2012)	<ul style="list-style-type: none"> - Processing processes - Packaging damage - Technical malfunctions - Demand sizes

	16% of raw materials, USA (Gunders 2012)	
Retail Level	3% (Germany) 3.8% (Sweden) of whole supply chain (Erikson 2012) 45,676 tonnes per year, Denmark (Halloran, et al. 2014) 10% of whole chain, USA (Gunders 2012)	<ul style="list-style-type: none"> - Labelling - Flaws of products - Discounts - Overfull shelves
Consumer	14%, USA (Jones et al. 2003) 12.7%, USA (US Environmental Protection Agency) 25% of bought products, USA (Gunders 2012)	<ul style="list-style-type: none"> - Utility maximizers - Discounts - Lack of planning - Improper storage - Big dinner plates - Over preparation

Table 2 contains the numbers of wastages of the different stages and the factors that are causing these wastages. Several of these factors that are mentioned are similar or are related to one another. At both (Post) Harvesting and at the Transport stage, the factor of 'Uncarefull handling' can be found. Products are damaged at both stages due to uncarefull handling which leads eventually to food waste. Secondly at both stages factors about 'temperature' are mentioned. The temperature in the first warehouses and the temperature during transport and transhipment. Temperature at both stages are not optimal which leads to food waste. 'Flaws of products' is a factor that can be found also at two stages. These stages are; Processing and Retail Level. At processing this factor is mentioned as 'Packaging damage'. Damages at products and packaging often lead to early spoilage of the products. Besides that, damaged packaging is a significant reason for consumers to not buy the product at Retail level. The last factors that can be related are the 'Discounts' at the retail level, and the factors 'Utility maximizers' & 'Lack of planning' at the consumer stage. Since, consumers are utility maximizers, and often do not prepare the shopping list before shopping, discounts are very effective. These discounts in the end lead to more purchases of the consumers. The consumer is not able to prepare/eat the extra purchased products before expiration and products are wasted.

6. Measures leading to lower food waste in the supply chain

In previous paragraph of this article factors that are causing food waste in the supply chain are recognized and set put. While discussing factors that can cause losses along the supply chain, the question that automatically comes up is, how to tackle these factors? What measures can be

implemented? This paragraph will discuss the potential measures that could reduce food waste along the different stages of the fresh produce supply chain.

Buzby et al. (2009) is one of the articles that addresses some of the factors that were addressed in the previous section and comes up with several measures. Buzby et al. (2009) concluded that for many products and commodities several measures have led to a decline in loss over time. The measures that are mentioned are the improvement of packaging, improvement of ordering systems, more frequent deliveries, and increased product handling training for in-store personnel, improvement temperature-control tracking and the introduction of produce varieties with improved shelf life. Some of these measures will be discussed further in the article when applied to the factors discussed in the previous paragraph of this article which are causing food waste.

6.1 (Post) Harvesting

Blakburn & Scudder (2009) say that by managing the process from picking through cooling, growers can maximize product value in the responsive segment of the chain by implementing optimal transfer batch sizes. By doing this the exponentially declining value can be stabilized for perishable products.

By managing the process from picking through cooling, growers can maximize product value in the responsive segment of the chain by implementing optimal transfer batch sizes.

To reduce the wastage at post harvesting, Kader (2004) named two important measures that could lead to the desired outcome. Kader (2004) noticed that many farmers do not have the appropriate knowledge about their crops and their harvesting techniques. Farmers often do not know what the best time is to harvest their crops, what impacts pesticides and fertilizers have on the crops and on the production land. Therefore, the first measure that needs to be done is proper education for farmers. This to understand the biological and environmental factors that are involved in postharvest deterioration. Secondly the proper techniques and procedures should be implemented. When these postharvest techniques are implemented the quality of the products will be maintained at a higher level. Since appropriate technology and procedures will lead to a slowdown of deterioration and more safety of the commodities.

Sargent et al. (2000) discussed the matter of mechanical injury and managing temperature. According to Sargent et al. (2000) these two are two of the most important means to ensure the quality of perishable products during postharvest handling. "Proper handling and temperature management will significantly reduce losses due to decay and accelerated senescence. With vegetables, typically being handled several times from harvest to retail level, it is critical that personnel at each step be properly trained and supervised."

Gunders (2012) puts forward another measure that could reduce post-harvest quality food losses. Farmer's markets could be a solution. Farmer's markets are physic markets that allow farmers to sell their products that are still of high quality but do not meet the requirements of retailers. For example, the products that do not meet size, shelf life etc. demanded by the retailers.

6.2 Transport

Food losses that can be allocated to transport could be reduced by information transparency across the supply. Nowadays not much information is shared along the supply chain. This leads to unreliable

forecasts of the number of products and batch sizes (capacity planning and managing yield uncertainty). Information that include the optimal knowledge about the product and therefore the perfect transportation conditions are not always discussed properly along the supply chain. This leads to truck drivers and other personnel that do not check the products and the conditions that need to be met while loading the products from one way of transport to another. Wilson (1996) states that “The most transparent chains will give the most feedback to the producer so, in the increasingly complex and competitive market, with worldwide oversupply of produce, chains need to position themselves strategically in relation to others to maximize potential benefits.”

The factors sketched, in the previous paragraph, by Watkins (2016); delay in cooling, packing equipment damage, excessive vibration, refrigeration equipment failure and other factors are causing food waste. To reduce this kind of food waste, attention and understanding of the crop physiology is necessary. In addition, also all aspects of transportation are required to produce and bring products with high quality to the consumers.

Estrada-Flores, et al. (2002) highlighted in the previous paragraph the importance of spatial variation, relative humidity and air velocity concerning fresh produce transport. Estrada-Flores, et al. (2002) made up some measures that could help preventing food waste during transportation. According to the research done specific guidelines need to be set to optimize the transportation of fresh produce. The guidelines that need to be set an involve that the fresh produce should be pre-cooled prior to loading on transport. To achieve this onshore quality assurance, need to be applied. By doing this the temperature of the products can be accessed during loading time. Another guideline mentioned is that the warmest products should be furthest from the air delivery system during transport. This is because these products would most likely have a higher opportunity of perishability. Which means that these products have the shortest shelf time so these products need to be managed first through the inventory into the retail stores.

6.2.1 Shipment rejection

Addressed in the previous section of the article are the factors causing the rejection of shipments at the borders of importing countries. Differences between levels of food safety standards need to be addressed at several fronts. One of the fronts that need to be addressed is at the level of the early producer. The gap between quality of the early producer and the demanded quality need to be bridged. This could be managed by educating farmers about usage of fertilizer/pesticides and the optimal time and way to harvest the products.

Secondly there is no overarching organization or government institution for food safety regulations. Since there is no overarching organization that analyses and sets the regulations, confusion about regulations consists. The lack of an overarching organization leads to the fact that every companies in these countries can set to some extend own regulations. So, the lack of an overarching organization is leading to an increase of all kinds of different food safety regulations, different in every country. All the regulations of different countries are leading to a lack of awareness and information, causing confusions for companies that are willing to export, about all the regulations and which apply where. Since companies can set to some extend their own regulations, companies now often think that their regulations also fit regulations abroad. Therefore, often products do not meet the regulations of other the companies abroad and the shipments of these products are refused at the border.

An overarching institution which monitors and set all regulations regarding food safety could be the solution for the problem. The overarching institution makes the playing field of food safety regulations more equal, fair and transparent. This will lead to a reduction of regulations across countries and therefore a better playing field for all companies. In addition to that, Martinez & Poole (2004) on financial support. According to Martinez & Poole (2004), an overarching institution should also provide financial support to companies to help them meeting the quality constraints of other countries.

An advantage of centralizing these regulations of food safety, is that the costs of certification will drop. The concentration of certifying bodies will lead to economies of scale, which in their turn will lead to reduction of costs. Due to higher efficiency, caused by standardization of the certification system or technological innovation, the costs of certification will be lowered. Standardization could lead to a more efficient process of defining protocols for the quality data on industry level companies. Halloran et al. (2014) is agreeing to the fact that abolition of several food quality rules could lead to a reduce in food waste.

Not only an adjustment to the already existing safety regulations for food could be a measure to reduce the rejection of shipments. Even if these measures will be applied in the future, shipments will be rejected. When this happens, it is important that these 'rejected' shipments can be allocated to a new country/market. Gunders (2012) came up with an idea to increase the efficiency in the process of shipment rejections. Rejected products can faster be allocated to a new market by Online exchanges. These online exchanges can lead to less food waste due to rejection and faster delivery to a new market.

6.3 Processing

In previous section of the article about the processing stage, has been illustrated that losses of food are significant in the processing stage. To reduce the waste in the processing stage of the supply chain several measures can be implemented.

In nowadays society many fruits and vegetables are pre-cut for consumer. This, so that consumers do not need extra time in their cooking process for cutting the fresh produce. During the cutting process done by the manufacturer. Food is wasted. A measure to reduce this, according to Gunders (2012), is to reduce the pre-cut fresh produce in supermarkets. This would lead to less food waste in the processing stage. In contrast to whole products, trimmed products do not lay loose in the shelves of the retail shops. Therefore, pre-cut products have a bigger environmental impact due to the extra packaging and the disposal afterwards. After opening the pre-cuts, spoilage will set in earlier than it will do for whole products, thus Gunders (2012).

The measure of limiting pre-cuts discussed above, does not only affect this factor at processing level. It also leads to another affect. Limiting the pre-cut fresh produce leads to more whole products. These whole products do not have printed sell-by or use-by dates on them. Which leaves more flexibility for consumers and retail stores to evaluate the quality of the fresh produce thus Gunders (2012), and therefore to less food waste due to use-by dates.

A different measure to reduce the food losses at the processing stage is to increase the re-use of the by-products. The by-products that are caused during the processing stage can be re-allocated to another supply chain to become a new, finished product. According to Monspart-Sényi (2006), several

techniques need to be implemented before a by-product can become a finished product. To reduce the waste of by-products and the reallocation of the by-products, among other things, precooling techniques, solid-state production, gas chromatographic evaluation of residues, etc. must be implemented. Gunders (2012) agrees with Monspart-Sényi (2006), more attention should be paid to the re-use of by-products. Gunders (2012) recognizes that by-products still have value, which are often not noticed. Therefore, higher effort must be done to re-use these by-products to the highest value. The desired outcome would be that these by-products become new products, if not, these by-products can be used as animal feed, compost or energy feedstock.

For example; composting is a usable measure to reduce these processing wastages. Composting is a method that has been used for ages. According to Monspart-Sényi (2006), "Its principle is that wastes containing organic materials are decomposed in the presence of microorganisms and oxygen besides appropriate environmental conditions". When this has been done, the result is an organic compound and inorganic mineral substances which can be used as fertilizer. Along the article of Monspart-Sényi (2006) several products that could be reduced from processing waste are: candied peel, oils, pectin, re-formed fruit pieces, enzymes, wine/vinegar, etc.

During the paragraph about factors that are causing food waste in the processing stage, Halloran, et al (2014) addressed the quality standards that are used at the retail level. These quality standards were causing food waste since products are not entering the processing stage because these products do not meet these quality standards. By reducing or even abolishing these quality standards food losses can be reduced. According to Halloran, et al (2014) the European Union already reduced these quality standards. A reduction from 36 to 10 products for which these standards apply for.

Overall the processing stages need to be improved and evaluated all the time. Gunders (2012) recognizes that the focus needs to be on reengineering the processing stages. Gunders (2012) sees that some of the processing losses are unavoidable but still the processing stage can still be improved. Gunders (2012) claims that by redesigning, not only the processes, but also, the products and researching & adopting new technologies, more efficient processes can arise. These new processes could lead to a reduce of food waste.

6.4 Retail Level

Lebersorger & Schneider (2014) researched the rate of food waste at the retail level. For reducing the food waste at the retail level several measures are mentioned by Lebersorger & Schneider (2014). Food waste at the retail level could be reduced by shifting the responsibility of food waste to the retail companies. Lebersorger & Schneider (2014) say that this shift would provide an incentive for the retail stores to reduce waste. According to Lebersorger & Schneider this can be done by optimizing demand planning and ordering and providing specific information to the consumers.

In the process of making the retail level more sustainable and less wasting, Lebersorger & Schneider (2014) advised that the differences between retail stores are useful to optimize work routines. In this way, less efficient retail stores can identify the best way processes within their stores and the appropriate training and instructions for the employees working at the retail stores. Buzby, et al (2009) is an advocate for improving the ordering system. By optimizing the ordering system wastage can be reduced.

Halloran, et al. (2014) concluded during the research, reducing food waste needs a high level of coordination. In addition to Lebersorger & Schneider (2014) and Buzby, et al. (2009), Halloran et al. (2014) sees the importance of sharing information. For Halloran, et al. (2014) this implies insight of production and logistics of both the producers and retailers. According to Halloran, et al. (2014) the best way to achieve this is a horticultural knowledge sharing towards marketing and selling.

Above the measures concerning information sharing are discussed. Another factor of food waste at retail level are the damaged produces. Due to damages and lacking parts of products, consumers are not willing to buy these products and therefore food is waste. Packaging can be a part of the solution for this factor. If packaging can be made and designed in a better and smarter way, less food is wasted. These new packages can lead to the fact that food can be held fresh and damage free for a longer time. The products can be protected for damaging and packages can be accommodated to consumer demands concerning portion size and variety.

Not only because of the food waste, the retail level is interesting. Also, because the retail sector can be seen as 'the link between producers and consumers' (Eriksson, et al (2012)). Retail level is the level/market where the producers and consumers meet. Therefore, the retail level is an interrelated network. At the retail level, retailers can communicate with the consumers. Within this communication, the environmental awareness of the consumers can be increased. The awareness of the consumer's food waste can be triggered. By using awareness campaigns at the retail level, consumers can be made aware of the amounts of food waste and their own behaviour toward food waste. The other way around, the retail level can acquire information about food waste at the retail level and consumer behaviour. This information can be linked back to the producers which could lead to preventive measures at production level.

In the previous paragraph food date confusion was mentioned as a factor leading to food waste. According to Gunders (2012), the food date confusion could be reduced by measures that are implemented by governments. If governments would be able to implement policies or provide manufacturers and retailers guidance regarding what dates should be printed on the packaging of products. When these guidelines are clear for everybody this will also be clear to the consumer and will reduce food waste. Lipinski, et al. (2013) elaborates on the measures about what manufacturers and retailers could change to reduce the food date confusion. Manufacturers and retailers could provide the consumers with additional information about the dates on the packaging. This could give more clarity to the consumer. Secondly manufacturers could move to a code that can replace the sell-by date on packaging. These codes can only be scanned by manufacturers and retailers and therefore not been read by consumer. Such a "closed date" system could reduce food date confusion even more.

Gunders (2012) also mentioned the increase of large portions. Sometimes smaller retail stores want a lower amount of a product than bigger retail stores. But packing sizes of these products are sometimes so big that retail stores need to buy extra products. Gunders (2012) uses the following example; "if a grocer wants 50 grapefruit but they come in cases of 80, the store is then stuck with 30 extras".

6.5 Consumer

Reducing the food loss at consumer level could be one of the most difficult factors. Already mentioned that consumers underestimate the amount, one third, of food that is wasted in households. Due to this

lack of insight it will be hard to change behaviour. Behaviour can be changed if the 'bad' behaviour is recognized and there is willingness to change. To achieve this change in behaviour, information needs to be provided. This information can lead to the awareness of the problem at consumer level. An opportunity to create awareness for the problem can be forms of information sessions for consumers.

Another factor that makes it difficult to raise awareness and change behaviour is that consumers are often 'locked in'. Eivind et al. (2007) concluded that consumers are sometimes locked in in decision making structures, social norms and habits. Since consumers are locked in by these factors lead to the problem that consumers are not able to make sustainable choices. Consumer behaviour change can only be accomplished by informative instruments and campaigns. According to Eivind et al (2007) this can only be done when three components are addressed at the same time. These components are, motivation/intent, ability and opportunity.

Tukker et al (2010), elaborated to the measures mentioned by Eivind et al (2007). The measures that Tukker et al (2010) noticed come out of the fact that consumers are 'locked in'. The measures of changing consumers' habits and routines and creating opportunity. Creating a window of opportunity for behavioural/attitude change by offering alternatives to fulfil the same needs as before. Other measures mentioned by Tukker et al. (2010) is increasing the consumers' knowledge. Increase the knowledge about products and processes with labelling and other information-oriented measures. Additionally, comes the shift of consumer attitudes through awareness campaigns. Papargyropoulou et al (2014), concluded that by raising the awareness on food waste and the impact that it has on the environment, could potentially reduce food waste by generations. By raising awareness, ultimately the goal is to change behaviour and attitudes. Often behaviour and attitudes are passed on from parent to child. Therefore, it could, as Papargyropoulou (2014) states it, potentially reduce food waste by generations.

Tukker et al (2010) also comes up with changing the symbolic meanings of consumption. For example, making sustainability values such as equity, human rights, and care for nature part of values carried by certain consumer goods.

Improved food labelling is an important measure to reduce food waste (Papargyropoulou et al 2014). Improved labels can give additional information about the product and about the proper way of usage. On the improved labels, descriptions can be added how to use and store the product to maintain the highest quality and the longest usage time. The improved labels will enhance consumer behaviour which will lead to a reduction of food waste in the long run. Papargyropoulou et al. (2014) also concludes that planning and preparation before shopping is an important measure. When consumer go shopping with a shopping list, consumers have a lesser intent to buy random products. Since, these random products are not stated on their shopping lists. This lesser intent to buy random products will lead to a lower amount impulse purchase that do not fit with the consumers' regular diet. Therefore, shopping lists and the preparation of shopping leads to a reduce of food waste. When looking at the preparation of food the improved labels could help by buying the right products and prepare the food in a correct way with least food waste. Improved food labels can be a useful instrument to reduce the confusing regarding the best-before, sell-by and use-by date.

Several factors causing food waste are mentioned by Gunder (2012). One of these factors is the over preparation of food. According to Gunders (2012), the household which do not often consume the leftovers need to be informed. The information will lead to behavioural insight and consumers are willing to prepare smaller dinner portions. Another measure piece of information could be to inform the consumers about the average dinner food intake.

The average dinner plate factor has also been discussed by Gunders (2012). The surface of an average dinner plate has increased by 36%. A simple measure to reduce food waste is to belittle the average dinner plate said Gunders (2012). This measure will not only lead to less food waste but also to health benefits according to Gunders (2012).

7. Conclusion

Table 3.

	Waste	Factors	Measures
(Post) Harvesting	7%, <i>USA</i> (Kantor, et al 1997) 7%, <i>USA</i> (Gunders, 2012)	<ul style="list-style-type: none"> - Incorrect harvesting time - Uncarefull handling - Distance to warehouse - Temperature in warehouse 	<ul style="list-style-type: none"> -Optimal transfer batch sizes - Farmer Education - Implementation of proper techniques & procedures - Farmer's Markets
Transport	No specific known numbers.	<ul style="list-style-type: none"> - Uncarefull handling - Temperature during transport & transhipment - Vibration - Equipment failure 	<ul style="list-style-type: none"> - Information Sharing - Crop physiology understanding - Implementing of transport guidelines
Shipment rejections	33% of shipments from <i>Central America into USA</i> (Lupien et al. 2005)	<ul style="list-style-type: none"> - Different food safety standards - Lack of enabling environment - Lack of skilled personnel & laboratories - Focus on different parts on the chain - Costs of certification 	<ul style="list-style-type: none"> - Concentration of certifying bodies - Overarching institution - Wider regulations - Increase efficiency in rejection processes
Processing	30%, <i>Brazil</i> (Monspart-Sényi, 2006) 3.5 mt – 6.6 mt, <i>UK</i> (Mena et al. 2011)	<ul style="list-style-type: none"> - Processing processes - Packaging damage 	<ul style="list-style-type: none"> - Re-use of by-products - Reengineering - Limit pre-cuts

	39% of total food loss, USA (Gunders 2012) 16% of raw materials, USA (Gunders 2012)	<ul style="list-style-type: none"> - Technical malfunctions - Demand sizes 	<ul style="list-style-type: none"> - Abolish demand sizes
Retail Level	3% (Germany) 3.8% (Sweden) of whole supply chain (Erikson 2012) 45,676 tonnes per year, Denmark (Halloran, et al. 2014) 10% of whole chain, USA (Gunders 2012)	<ul style="list-style-type: none"> - Labelling - Flaws of products - Discounts - Overfull shelves 	<ul style="list-style-type: none"> - Shifting waste responsibility - Optimizing ordering system - Improved packaging - Raising consumer awareness - Policies regarding labelling
Consumer	14%, USA (Jones et al. 2003) 12.7%, USA (US Environmental Protection Agency) 25% of bought products, USA (Gunders 2012)	<ul style="list-style-type: none"> - Utility maximizers - Discounts - Lack of planning - Improper storage - Big dinner plates - Over preparation 	<ul style="list-style-type: none"> - Awareness campaigns - Increase knowledge about labels - Planning - Reduce dinner plates - Smaller portions

Table 3 again contains, the numbers about food waste per stage of the fresh produce supply chain and the factors causing these wastages. However, in addition to the previous table, table 3 also contains the measures which could lead to a decrease in wastage. The first measure that can be found in various variates is 'knowledge'. At (Post) Harvesting, the measure of 'farmer education' is mentioned, at transport stage knowledge about 'crop physiology' and at the consumer stage, knowledge about 'Labels' is important.

A second measure that can be found in various variates is 'guidelines'. At (Post) Harvesting, the implementation of 'proper harvesting guidelines'. At Transport, the implementation of transport guidelines. For Shipment rejections, the implementation of guidelines can be found in the measure of an 'Overarching institution' which needs to make it clearer what regulations are applicable at what region. Also, guidelines need to be implemented at retail level. 'Policies regarding labelling' need to be implemented to reduce food waste due to sell-by and use-by dates.

The third measure that can be found across the table is, 'optimization'. Several stages, or parts of these stages need more optimization. This measure can be found at shipment rejection in the form of 'increase efficiency in rejection processes'. The processing stage needs to be constantly analysed, optimized and as mentioned 'reengineered'. The last shackle in the supply chain that needs to be optimized is the retail level. At the retail level, optimization of the ordering system could lead to a reduce in food waste.

The fourth and last measure that can be found is the raise in 'awareness'. Both at retail level and at the consumer, raising the awareness is an important measure which needs to be taken seriously.

In previous paragraphs and the tables, the factors and measures concerning food waste in the supply chain of fresh produce have been discussed. The overall conclusion that can be drawn is also drawn by Papargyropoulou, et al. (2014) is that the movement towards a more sustainable production and consumption approach need to increase. The food surpluses and food waste in at the western markets need to be tackled. Focus needs to be on the entire supply chain and not on several sectors to make a real difference. Which measures are the best to reduce fresh produce food waste?

An overall measure that needs to be implemented is the information sharing. Information and knowledge need to be shared across the whole supply chain of fresh produce. Buzby, et al (2009) and Lebersorger & Schneider (2014) are one of many who support the information sharing. Via this way, the whole supply chain is more connected and more depending on different stages. With more information sharing, stages can communicate and able to adjust and influence each other. The sharing of information will cause benefits for every stage along the supply chain. For example, farmers will have access towards better farmer equipment/knowledge, retail stores can share forecast information to manufacturers which leads to a better adjustment of the stocks at retail level. Another advantage of information sharing across the supply chain is that fact that rejected shipments can be allocated more easily to a different/new market. Gunders (2012) mentions that via an online system, a platform can be created to ease the sale or donation of rejected shipments.

To reduce loss rates at the process level it is important to keep evaluating and improving the processes. Research must be continued on how to improve the processes and how to improve the usage of by-products that are created during the processes. Gunders (2012) mentioned this as reengineering of the processing stage. To make sure that this reengineering is been done, it is important that there are incentives for manufacturers to improve their processes. Incentives can be created in several ways. For example, it is possible that the government has a close look at the fresh produce industries and maybe use sanctions to facilities that are not sustainable enough. Another option could be that research on improving these processes are encouraged by the government. So, the government could give order to conduct these researches or give companies financial compensation to conduct these researches.

Confusion about sell-by and use-by dates has been a factor that has led to significant food waste at retail & household level. This factor is discussed by Gunders (2012) and Lipinski, et al. (2013). Food date confusion could easily be reduced by the measure of the improved labelling. Improved labelling is also easily implementable. Manufactures are already mentioning the dates on the labels. According to Lipinski, et al. (2013), a small adjustment to existing labels could be enough. Replacing the sell-by date by a code that can only be read by the retailers will reduce the confusion for consumers.

The most important factor at consumer level is consumer behaviour. Lots of research have shown that behavioural change is difficult to achieve. Quested, et al. (2013) have illustrated this in figure 14. Behaviour consists out of 'attitudes & values', 'motivation', 'habits' etc. To achieve behavioural change, it is important to change as many aspects of this figure as possible. When this is achieved, it is most likely to change the behaviour of consumers and reducing food waste. Awareness campaigns could be a tool to change these consumers' behaviours. A good awareness campaigns, motivates, educates, creates awareness of the issue and takes as many aspect of figure 14 in consideration. Which in the end leads to a reduction of food waste.

Several ideas for awareness campaigns are mentioned below. The awareness campaigns could be started by retailers, and create awareness in retail stores. Another idea could be to start a national awareness campaign. Governments will be involved which makes it possible to reach more consumers. Think about 'food waste programmes' on schools, TV-spots etc. Via this way, a greater number of consumers are involved for a longer time, than only their shopping time in a local retail store.

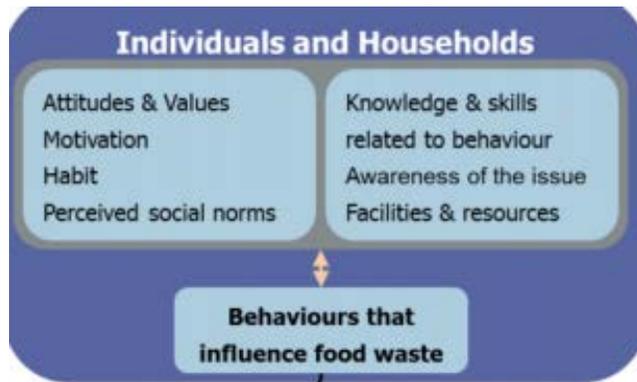


Figure 14, Quedsted et al (2013)

Gunders (2012), is upon these days the most complete framework that consists all the stages in the fresh produces supply chain. Gunders (2012) states many factors and measures that need to be addressed in the future to reduce food waste along the supply chain. Things that could be added to the research Gunders (2012) conducted are; Improving farmer knowledge, transport guidelines regarding cooling systems, optimization of the ordering system at retail level and raising the consumer awareness.

8. Discussion

Pre-cutting fresh produce may cause waste at the processing level. Which maybe makes sense to limit the pre-cut of fresh produce. While doing this, a consumer must cut all the fresh produce itself. Which gives a new dilemma. It is possible that consumers are not more sustainable than the processors and make during the trimming stage, more waste than the manufacturers would when pre-cutting it. The second thing Gunders (2012) mentions, is that pre-cuts must be packed and whole products do not. Which makes whole products more sustainable. Gunders (2012) also mentions the opposite part of the story. The pre-cuts will be more protected during transport than whole products. So, while pre-cuts maybe are 'less' sustainable for being packed, the pre-cuts have a lower rate of food loss during transport because it is protected in contrast to whole products.

Another discussion point is a combination of consumer behaviour and the processing stage. Pre-cut fresh produce have become a part of our fast moving and energetic society. Limiting pre-cuts could be an option but in the end economy is supply and demand. So, if behaviour of the consumers cannot be changed, there will be demand for pre-cuts and companies will supply to these demands.

While mentioning all these measure that could reduce food waste in the fresh produce supply, there is tendency to forget something. Since supply chains are mostly global, there are also poorer countries and companies which are supplying fresh produce. Measures such as reengineering the processing stages, by

research and investing in new technologies, and making sure that transport facilities have proper cooling systems are not always the easiest. Dealing with poorer countries means that these countries just do not always have the capital to arrange these facilities.

'The consumer' is a huge concept. There is a lot of variety in consumers and in the way consumers behave. Which makes the way to approach consumers different in every, country and continent. Not only the way of behaving is different in every country, also, the food consumption patterns of consumer's variate. According to Katajajuuri, et al (2014) this variates from countries, cultural differences and cultural explanations. This should be considered when the change of consumer behaviour is mentioned.

9. References

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