Good Practices for Food Waste Reduction

Food Industry

Good Practices for Food Waste Reduction in Food Industry

Food Industry

The aim of this guide is to shed light on the reasons of food waste production in the food processing industry, and also to familiarize the reader with food waste categories and their economic and environmental effects. We would like to facilitate the work of employees in the food processing industry with already tested, concrete, good practices to prevent food waste and to decrease the amount of food waste.

Introduction

According to data from the Food and Agriculture Organization of the United Nations, FAO, (2011)[1], one third of the produced food goes to waste at some stage in the food chain worldwide. Food waste is not only a problem on the economy, but it has also severe damaging effects on the environment.

In order to find practical solutions to the issue of food waste, it is important to inspect the actors of the food chain from this point of view. Depending on the economic development of the countries, actors in the food chain are responsible for the generation of food waste to varying degrees. In developing countries, a significant amount of food waste is generated typically during cultivation, post-harvest treatment, and storage. Meanwhile in developed counties, the greatest amount is present mostly in the phases of production, processing, distribution, and consumption.

Considering the entire life cycle of a product from the food industry, the processing phase has the greatest effect on natural resources. At the same time, each phase has additional environmental effect. This means that the cost and the negative effect on the environment will increase the later we dispose of the food.[2]

According to the estimation of FUSIONS regarding 28 member states of the European Union in 2016, the most significant proportion of generated food waste 53% occurs in households. Based on their data, it can be stated that 19% of food waste is generated in the processing industry, 12% in food service and restaurants, 11% in the primary production sector, and 5% in trade (***Figure 1***).[3]

It is a fact that households are responsible for the largest proportion of food waste in developed countries. However, the presence of other sectors is not negligible; the responsibility is shared. Other actors of the food chain can have indirect effect on consumer behaviour: they can call attention to the importance of the issue with their exemplary attitude and awareness-raising campaigns.

[1] FAO (2011). Global Food Losses And Food Waste - Extent, Causes And Prevention. Rome, Italy.
[2] FAO (2013). Toolkit. Reducing the Food Wastage Footprint
[3] FUSIONS (2016). Estimates of European food waste levels

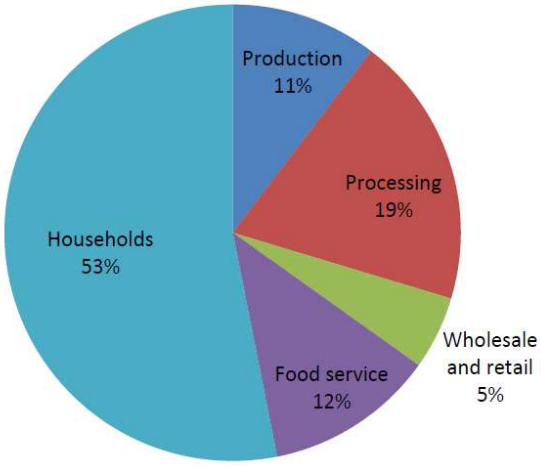

Figure 1. Sectors responsible for food waste (source:FUSIONS, 2016)

Primary data based on actual measurements was used only partially in order to prepare the estimate. In the case of the food processing industry, 19 member states provided data, however, only 4 sets of data were proven suitable for use among them. Moreover, another issue is that the estimated figures illustrate the total amount of food waste generated in the food chain, and it does not provide information on the result of actual wasting, called avoidable food waste.

The decrease of food loss and waste means a three-time advantage for every actor of the food chain: it alleviates the pressure on the climate, water and soil; it has positive economic effect on the producers, companies and households; and it allows that more people can be supplied with the food currently produced.

Food is the result of valuable resources' utilization, which has large ecological footprint considering energy that is invested in cultivation, harvesting, transportation, production, packaging, storage, trade and preparation. Through food waste, we also waste the invested energy.[4]

There are several solutions to eliminate this. Prevention of waste is the most effective and easiest solution among these, since the later in the procession we are, the more invested energy and value will be thrown out and used unnecessarily. Through prevention, less resources and labour for additional treatment of the wasted food will be required. Instead, this energy can be invested in value-creating processes.

WASTE PYRAMID

A communication of the European Commission published in 2015 presents EU action plan on circular economy.[5,6] In the statement's section regarding food waste, concrete commitments are made to decrease the amount of waste, which are the following:

- developing common EU methods for measuring food waste and identifying relevant indicators,

[4]Creedon, M., Hogan, J. (2010). Less Food Waste More Profit. A Guide to Minimising Food Waste in the Catering Sector

[5] FAO (2013). Toolkit. Reducing the Food Wastage Footprint

[6]https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52015DC0614&from=HU

- establishing a platform with the involvement of Member States and stakeholders to support the achievement of sustainable development goals for food waste and the sharing of best practices,
- clarifying EU legislation on waste, food and forage,
- facilitating the use of by-products in forage production without jeopardizing food and forage safety,
- conducting studies on the ways in which food chain operators can improve date labelling and the consumers' knowledge on it.

In its communication, the Commission emphasizes the importance of following the waste hierarchy, with priority being given to compliance with the principle of prevention.

According to directive 2008/98/EC:

"Waste policy should also aim at reducing the use of resources and favour the practical application of the waste hierarchy." (**Figure 2**)

Figure 2. Waste Hierarchy

Prevention

According to § 2 of Act CLXXXV of 2012 on waste (hereinafter Act CLXXXV of 2012):

is a measure taken before the substance or product has become waste, which can reduce

a) the amount of waste, through reusing products or extending the life of products, for instance,

b) the harmful effects of the waste on the environment and human health, or

c) content of hazardous substances in the materials and products

Through measures to prevent food waste, the use of necessary resources required for food production can be reduced, and the costs associated with the disposal of waste and environmental, economic and social impacts can be mitigated.

NOMENCLATURE

Waste: according to § 2 of Act CLXXXV of 2012, any substance or object which the holder discards or intends to or is required to discard.

Biowaste: according to § 2 of Act CLXXXV of 2012, biodegradable; park or garden waste; food or kitchen waste generated in households, restaurants, at caterers and establishments engaged in retailing activity, as well as similar waste generated in food processing plants.

It is important to emphasize that Act CLXXXV of 2012 does not define food waste.

Apart from the fact that food waste is not defined on the level of policy currently, the concept is understood differently in scientific publications as well. Consequently, measurements concerning the quantity and quality of food waste are not compatible with each other. The following definitions were created as a result of the project FUSIONS in order to help the communication between each other, the unification, and the introduction of more efficient and successful solutions.

Based on the definition of FUSIONS, food waste is food removed from the food chain, so it is the total amount of food that has been thrown away. Both avoidable and unavoidable food waste belong to this category. FUSIONS does not consider food given to animals food waste, yet composted food parts belong to the category of food waste.

Avoidable food waste: raw material or meal originally intended for human consumption, which was thrown away. For example, expired yoghurt, shrunken whole fruit, thrown-out meal.

This type of food waste is in general the result of human negligence. This is the actual food waste, as its name suggests that its production could have been avoided.

Unavoidable food waste: food parts of animal or vegetable origin, which are not suitable for human consumption. For example, eggshell, bones, banana peel. Such waste inevitably arises in the food chain.

Potentially avoidable food waste: raw material or meal suitable for human consumption that was thrown away because of health reasons (such as the deterioration of chewing ability), or because of personal taste. For example, chicken skin, bread crust, apple peel.

It must be emphasised that there are no statutory definitions of concepts such as food waste, food loss, and prevention at the moment. Divergent standpoints are the result of overlapping concepts. At the same time, everyone agrees that the reduction of the generation of food waste is a necessary, shared task, regardless of the used conceptual system. The practices presented in this document help us to utilize most of our food products according to our possibilities, by taking sustainability considerations into account.

THE REASONS BEHIND FOOD WASTE IN FOOD INDUSTRY

Sustainability expectations in food industry have already appeared in the 20th century. The mechanical engineering of food industry and process engineering are constantly looking for the most efficient solutions due to energy and raw material costs, and the technology of companies is characterised by loss minimization from an organizational point of view.

This does not mean that the food industry will only deal with closed issues with regard to sustainability, they must continue to account for minimal losses as well.

Based on a study by the European Commission, the main reasons behind food waste in the food processing industry can be traced back to the following components (table 1). It can be stated based on the overview table that issues usually arise regarding the deficiency of packaging and other stringent quality requirements for products. Also, logistical disturbances and unexpected technical malfunctions often lead to waste.[7]

Table 1: The Reasons Behind Food Waste in Food Industry

The main reasons behind food waste	**Production, processing**
Awareness	
Knowledge	
Attitude	
Preferences	
Portion size	
Planning	
Socio-economic factors	
Labelling	
Packaging	x
Handling	
Logistics	x
Product quality requirements	x
Technical malfunctions	x

Inadequate packaging may result in food degradation. Damaged packaging can result in deterioration of quality, which also poses a food safety risk. In such cases, the products must be destroyed. Moreover, packaged food may also be waste if the product is although untouched, but its primary or secondary packaging is damaged in some form, since due to this, the product does not meet the trader's technical and the consumer's aesthetic expectations, or a part of the label becomes unreadable. In food industry, therefore, these aspects should be taken into account as well in the design and development of packaging materials.

[7] European Commission (2010). Preparatory Study on Food Waste Across EU 27

Technical malfunctions also play a role, including overproduction or inconsistencies of the manufacturing process that may result in the production of formless products or the damaging of products. This includes, for example, excessive heat treatment due to unexpected shutdown of continues flow of material (e.g., presence of foreign metal pieces in the system), or slightly pressed-in product due to congestion after a shutdown.

Problems encountered during the delivery of the stock may also result in food waste. Due to interruption of the refrigeration chain during transport, transshipment, and storage, foods may start deteriorating sooner. Rapidly deteriorating foods may even mean food safety risks, so special attention must be paid to sustain the refrigeration chain during logistic operations.

The minimum requirements for product quality (such as regulations, aesthetic factors, formal requirements that do not affect the safety of food or whether it can be consumed) often contribute to the disposal of foods that are still usable, especially if they are too strict. For example, in the case of the production of pickles, produceoutside the specified size limit cannot be processed and can therefore end up as food waste. In bakeries, the edge of the finished strudels is not aesthetically desirable, so the edges are cut off and not sold.

At the same time, it is worth noting that at the presently available technology level, most of the waste generated during the processing is a necessary source of food waste, that is to say, its generation cannot be avoided rationally according to our current knowledge. For example, a small amount of fruit pulp being cut off with the peel during the peeling of an apple, or the residual by-product of fruit juice production, the pomace. Along with the evolution of technology, these losses can be further reduced.

At the beginning of mass production, the easiest way to handle by-products was the disposal. Today, most of the food innovations are aimed at the alternative use of by-products. More and more initiatives use these by-products as the basis of new or existing food products, and from this point on, we can already talk about prevention. This document presents a number of existing practices that aim at the innovative use of by-products.

THE COST OF FOOD WASTE

Since the concept of food waste is understood differently, the studies with quantified data available have particularly different methods. For this reason, it is difficult to estimate the cost of food waste. When doing such calculations, it is important to have data from robust and comparable methods.[8]

As processing progresses, more and more resources are used, and this obviously shows in the price of the products.

Although the food production and processing sector is located at the beginning of the chain, the added value of a unit of food is relatively high. Of course, the price per unit of food consumed by the consumers is the highest, but the cost of waste for production and processing is nearly four times higher than the unit price of the waste of primary production. This means that the sector accounts for 465 000 Hungarian Forints per tonne of waste for the European Union per year, which, if the total amount is taken into account, amounts to approximately 7770 billion Hungarian Forints annually.

[8] FUSIONS (2016). Estimates of European food waste levels

According to the EUROSTAT report from 2006, Hungary's food production and processing industry produces 11.7 million tons of food, of which 10% is wasted, which is approximately 1.2 million tons.

GOOD PRACTICES

PRELIMINARY ASSESSMENT

In order to assess the issue precisely, it is recommended to the food production units to store the generated food waste separately and to measure different waste types one by one. The measuring can only be conducted in units where it does not increase food safety risk and does not prevent the compliance to personal and occupational hygiene standards. It is advised to conduct the measuring at least once a year, and to aim for a one-week-long period. Naturally, more measuring per year and longer measuring intervals can result in a more precise picture. It is important to choose a week that is representative of the full year of operation. The measuring can be conducted in the most practical way with a scale set up for this reason, but in the case of liquids, volume measurement can be conducted as well. Volume and mass can be brought to common denominator on the basis of the density of liquids. We can use the density value of water, as itis ca. 0.98 kg/l (rounded to 1 kg/l) atroom temperature (further information: FAO/INFOODS Density Database Version 2.0 (2012)). If the weight of food waste generated in a week is extrapolated to the full year, we can get a clear picture of the actual amount of food wastes generated. It can also be a helpful feedback if the food waste is documented by type, so on the basis of the repeated measurements, we can statistically analyse which food types or ingredients are regularly thrown out. Experiences show that the measuring process itself and the knowledge of the annual volume of food waste generated improve the awareness of the employees.

It is worth organizing the measuring to pose no food safety risk and to mean no excessive burden on the employees, but at the same time, to provide sufficiently detailed results in order to successfully reduce waste. The simplest systems might be suitable to track the amount of food waste. If we do not have the necessary tools or space, we can keep track of the estimated quantities on paper as well. Such results can serve as guidelines to shape work processes in order to mitigate food waste.

The person responsible for carrying out the measurement and filling in the tables must be named and provided with all the necessary information. To design and conduct the assessment, the sample tables in the attachment can be used. Tables can be customized to fit the individual, the production facility; they can be modified and combined.

To collect and select waste and to measure its weight and volume, appropriate tools and clothing must be provided, such as weighing scale, rubber or work gloves, coat, apron, etc. Food safety aspects must be taken into account while using and storing these (spatial separation of wastes from storage of raw materials and food preparation areas, separation of tools in contact with waste from tools used to prepare food, dressing, personal hygiene measures).

Automated food waste tracking systems already exist, which can be used in food production facilities to reduce waste significantly. Their specialty is that they can be programmed to include the prices of raw materials, on the basis of which a more accurate analysis of economic losses can be realized.

STRATEGY DEVELOPMENT

When the preliminary assessment has been finished and evaluated, the process of developing the strategy might begin. The first step is to set such goals concerning the prevention of food waste that are realistic, but still make a real difference, and possibly means an economic advantage for the company/unit/factory as well.

Such goals might be:

"Reduce the amount of food waste generated by the company/unit/factory by 10% within 5 years."

"I am improving the awareness of my consumers and customers to reduce food waste, so that 5% less leftover is generated over a year."

After formulating the goals, the real planning can take place, the result of which is the assignment of tasks to the formulated aims. It is also favourable to determine the main intermediate steps and their deadlines (milestones). It provides motivation during the long term work, and also helps to track the progress.

The process of preparatory activities to reduce the amount of food waste consists of three steps, as illustrated in Figure 3. Based on the results of the preliminary assessment, we can determine realistic goals for our production unit, which is a prerequisite for developing the strategy.

Figure 3. Three steps of the process of preparatory activities

If possible, the action plan should be elaborated in a working group. Among the members of the working group, there must be people who, in their daily work, have a direct relationship with the process of generating food waste. Effective solutions can best be found on the basis of personal experience. When solving a problem, it is worth reconsidering the process of becoming abnormal and its reasons. This is accomplished by a series of answers to the question "Why?". As many questions can be asked as it is needed to find the main reason (Related chapter: Appendix I, tables for assisting the measurement of food waste).[9] Colleagues should also be aware that constructive criticism is helpful and allowed, as this is also a tool for effective development.

It is a highly important question to be motivated to achieve the goals. Motivations can range from moral factors through factors in performance measurement to direct financial benefits

[9]Martichenko, R. (2013). Everything I know about LEAN I learned in first grade

(for example, reinvesting part of the savings from less food waste after a closed period into personal payments). Only this is how it can be expected from the participants of the working group to form relevant ideas. For the whole organization, it is advantageous to have regular communication with team members, which can make a significant contribution to the personal commitment of the employees (Related chapter: Training and Development of Workers). Recommendations arising must be considered by the management of the company, in terms of enforceability and economic aspects, before the final decision is made. Efficiency can, however, be achieved if the plan that has been accepted is known by all employees and is committed to implementation in some way.

It is not enough to achieve the goals and to execute the planned optimization of the processes, the results must be sustained, so the changed must be controlled, measured, analysed, and in certain cases, intervention is required as well. This is a circular process that consists of planning, implementation, control, and intervention. The combination of the four processes is called the PDCA (plan, do check, act) cycles (Related chapter: Appendix I, tables for assisting the measurement of food waste).

PROCESS OPTIMIZATION[10]

Food producers are constantly trying to reduce their losses, including the generation of food waste, with regard to their economic interests. Different process optimization methods, such as the Lean system, can be the solution to this.

According to the Lean system, there are several groups of losses that can be distinguished, among which overproduction, inadequate size of inventory, repair, waiting, and unnecessary transport can lead to food waste.

Prevent overproduction! If a production plant does not comply with the demand and produces more products than the amount it is able to sell, the unsold products will be disposed of as waste.

Pay attention to excessive inventory accumulation! Most of the products that have a short shelf-life, and thus relatively rapidly deteriorating, are not sold and can also be food waste.

During repair, food waste is almost inevitable, especially if it is a not planned shutdown. A good maintenance plan also helps in waste prevention.

Eliminate the waiting time! If the sensitive raw material is not processed within the specified time period, it may be degraded before it could become a valuable finished product. One solution to this situation may be the use of the FIFO (First In First Out) principle, which means that the raw material received sooner is processed first.

Strive for less transfer! In this case, we should not only think about moving material between different rooms and spaces. The unreasonably high number of buffer tanks and temporary storage tanks used in the plant can cause more material sediment in both intermittent and continuous systems, so they cause more waste.

[10]Martichenko, R. (2013).Everything I know about LEAN I learned in first grade

GUIDING PRINCIPLES

Prevention

It is worth considering the consumption habits of different family models when determining packaging.It is a common problem that for single-person households, packages available in stores are too large and the bought food cannot be consumed, which deteriorates this way, and it has to be disposed of. Making small packages fit for one-person households could be a solution to the problem.

According to an Australian study, knowledge of the environmental impacts associated with food packaging was low even among those who already thought that food-related activities are important for the environment, suggesting that extensive awareness-raising is needed.[11]

Some consumers believe that the packaging of food is more environmentally harmful than food waste, since the latter returns to the soil and thus into the food chain as well. However, this claim is not completely correct. On the one hand, unless we make compost from waste, it will never return to the soil. In addition, methane emission of food placed in landfills is significant, the greenhouse effect of which is twenty-five times stronger than carbon dioxide's. Methane emission associated with food waste accounts for 25% of total methane emission in most developed countries.[12]

Some people buy the larger package with the good intention that the fewer packaging materials mean less burden for the environment. Customers should be made aware that this can only be regarded as fully rational behaviour if the purchased products are consumed (freezing is an excellent preservation process, so this is also an option). If the excess is thrown out, the energy invested in the preparation of food is ultimately not utilized, which is also an environmentally harmful action.

As a result, it is of utmost importance to educate consumers and buyers and to raise their awareness in this area, since it is in the interest of all actors in the food chain, so in the interest of producers as well to prevent the production of excessive food. Food producers can also do a lot for our environment by taking advantage of the possibilities of packaging innovations and using environmentally-friendly materials to pack their products. In this document, we therefore present a wide range of packaging innovation ideas and initiatives, with the help of which we would like to facilitate orientation. Waste can be prevented.

AWARENESS RAISING

Raising Customer and Consumer Awareness

Raising the awareness of consumers should also be emphasised, since surveys show that consumer behaviour is responsible for food waste to a great extent. Strengthen the consumers' commitment to preventing food waste. In Hungary, more and more consumers recognize the importance of sustainability goals, so if the company credibly represents these values, the loyalty of our guests sensitive towards this cause can be enhanced.[13]

---

[11] Lea, E., Worsley, A. (2008). Australian consumers' food-related environmental beliefs and behaviours. Appetite. 50.(2-3) pp. 207-214.

[12] FAO (2013). Toolkit. Reducing the Food Wastage Footprint (Page 21)

[13] Bódi B., Kasza Gy. (2012). Fenntarthatóság az élelmiszerláncban. Minőség és megbízhatóság 45:(6) pp. 317-323.

Communicate that our company is making efforts to reduce food waste.

Inform the buyer that by purchasing the products, he can participate in this fight.

An excellent surface for information can be the label of a unique product and the involvement of the official website and social media.

Highlight why the aspirations of the manufacturer and the consumer's own personal involvement in the processes to reduce food waste are beneficial for him.

Awareness-raising campaigns with informational pamphlets can be launched. Inform the final consumer about what the concept of use-by and best-fore dates means, what the difference is between them. There is likely to be a lot of waste generated due to inappropriate knowledge of the concepts.

Awareness and Motivation of Employees

Raising the awareness of employees is of chief importance. Employees should be aware of the problem of food waste both on macro (regarding global economy, energy waste, and environmental effects) and micro level (factory, household) as well. Not only social benefits, but personal gains should also be highlighted. Strengthen the engagement of employees to prevent food waste.

They must be provided with the continuously available knowledge to maintain the level of knowledge achieved.
It is not enough to explain the problem of food waste just once. Success can be sustained if employees recognise that they have a direct, regular personal benefit, so they need to be helped regarding this. Employees should also be involved in the developments, because they can, through their direct contact, have relevant experience and ideas to help reduce waste.

Price reduction and donation

Products that are slightly damaged during the production process, such as dropped, therefore slightly pressed-in cans can be sold at a lower price, even among employees of the company. Products with such aesthetic defects are impeccable concerning food safety, so they can be donated to the Food Bank or to other charity organizations as well.

There are such foods that are also safe from the point of view of food safety, and the protective packaging of the product is not damaged but cannot be sold at retail. An example of this is the mixed-flavoured yoghurt produced during the change of aroma in large-scale yoghurt production. The two flavours are mixed and thus the finished product cannot be sold in the retail market but is fully suitable for charitable purposes.

Utilization of by-products in compost and animal feeding

Some by-products which are unsuitable for human consumption (such as corn husks and cob) can be used for composting and animal feeding. Although these are no longer considered

preventive practices, it is still a step in favour of waste management, as the resources used are reintroduced into the food chain.

Storage experiment

Producers often promise shorter shelf-life than what the product would actually require, as they try to take less risks. Based on the results of storage experiments, the shelf-life of a given product can be more accurately determined and thus food waste can be reduced.

Ensuring operational hygiene

During the regular operation of a food business, it is essential that food safety rules are respected in order to protect human health. At the same time, inadequate operational hygiene can indirectly lead to premature deterioration of food. For example, the product may become mouldy or start deteriorating before the delivery to department stores. Therefore, there is a close relationship between ensuring hygiene and reducing the amount of food waste, and this relationship should also be highlighted. Without ensuring the worker's awareness, neither the ensuring of hygiene nor the reduction of waste will be successful.

Extending the information content of barcodes

Distributing centres provide each batch with its own identifier (typically a barcode), which contains information about the best-before or use-by date, besides the price and product type information. However, the barcode on the unique product contains only the product type and the price. As a result, the barcode system does not follow the expiration date of products on the shelves of a retail unit. The IT system connected to the cash register usually assumes that the older products are first sold. This, however, does not reveal the reality because of the "date picking" of customers, which means that they prefer products that expire later. Of course, this behaviour is understandable, as the consumer likes to have the convenience of free choice at home, as opposed to having to consume a product only because its expiration date is approaching. However, it is often the case that older products simply stay on store shelves for this reason. Through joint development with trade, traceability of these products can be ensured later. Currently, they can only be tracked, sorted out, and in a lucky case utilised before expiration if decided that way by significant labour inputs.

OPPORTUNITIES OF PACKAGING INNOVATION

The global food supply chain requires the use of innovative, long-lasting packaging. In addition to preserving freshness, sustainability has emerged as a new aspect in recent decades, as the disposal of food packaging increasingly poses a burden on the environment. Packaging innovations detailed below can be the solution to this. Creative solutions listed include the application of smart label, or the use of industrial by-products – that would otherwisejust end up as waste – as a packaging material ingredient. Some of them (at the time of publication) are still in an experimental phase or their application is not yet economical. At the same time, the packaging material industry is developing dynamically, so the innovations presented may spread in practice within a few years.

(More information on their practical implementation can be found on the source of certain examples.)

Sensor phosphorescing at the presence of oxygen [14]

If, during a random check, it is noticed that the packaging of a pre-packaged product (typically cheese, cold cuts) is damaged, leaking, or pressed, it is common practice not only to dispose of the item but the entire batch. Thus, 2-10% of the total produced food is unnecessarily discarded.

Unnecessary discarding can be prevented if the packaging is provided with a sensor that clearly indicates if the product is in contact with oxygen, such as a phosphorescent patch indicating the presence of oxygen. The packaged products pass through a scan system, the software of which detects whether the oxygen level is below the acceptable value or has already exceeded. The technology can be used in the entire supply chain as cameras can be placed at the end of the packaging line, at the distribution centre, or at the place of sale.

"Smart" label[15]

The shelf-life of foods depends on the condition under which they are stored after the packaging was opened.The "smart" label indicates it with the change of colour when the ham is no longer consumable (yellow is the colour of the label if the product is fresh, which turns lilac over time). The colour of the label is affected by the time passed since the opening of the package and the storage temperature.

Image source: https://www.aol.co.uk/money/2017/07/03/sainsburys-smart-label-changes-colour-when-ham-goes-off/

Rougher label surface[16]

A similar solution to the above mentioned is to turn the surface of the label rougher once the product starts to deteriorate. A small triangular sticker is printed on the packaging of the food at the time of packing. If the label is smooth, the food is still fresh, but as soon as it starts to turn rougher, it is better if the food is thrown out to the garbage can. One layer of the four-layered label is gelatine, which responds to light, oxygen, and temperature just like food does, thus reflects the behaviour of the food inside the package. As the food begins to deteriorate, the gelatine will decompose and become liquid. The gelatine concentration of the label should be changed according to different foods.

[14] http://pac.ca/assets/pfw-project-11sensorspot-nov2015.pdf
[15] https://www.environmentalleader.com/2017/07/ham-gone-off-look-label-sainsburys-says/
[16] https://www.theguardian.com/technology/2014/dec/10/intelligent-food-expiry-label-waste-bump-mark

The advantage of this packaging is that it provides meaningful information to blind and visually impaired people as well about the usability of the product.

Food packaging from milk protein[17]

In a project which started in 2015 and will end in 2020, they are working on the development of a packaging product made from milk protein that can be used as a consumable coating as well (as an internal layer of the complete packaging). For its production, the dairy industry's protein-rich surpluses and by-products, such as fat-free milk powder or derivatives such as casein and whey are used. These packaging materials can improve the quality and functionality of food, protect food from deterioration and extend shelf-life, increase nutritional value, and last but not least reduce the amount of waste ending in landfills, since it can be consumed dissolved in liquid. The above mentioned surpluses and by-products are mixed with other consumable polymers, and then structurally modified by electro-spinning to create micro- and nanofibers that can form new food with high added value and non-food products.

Grain storage bags against weevils[18]

Certain strands of the grain storage bag contain insecticide, which is effective to destroy the insects typically present during storage, before they can contaminate the grain stored in the bag. This reduces grain loss,so fungus-related hazard or pesticide residues can be avoided, which may result from inappropriate insecticide application. The material is effective against moths, different types of weevils, and beetles. Through research, it has been proven that the residues of insecticide used does not appear to be present in the product to a risky amount.

Ethylene-absorbent strip for freshness[19]

Ethylene is a plant hormone produced by plants, which helps the ripening of the crops. There are also very sensitive and less sensitive plants for ethylene, and some plants produce lesser amounts of ethylene. For each variety, the ideal ethylene exposure is different, depending on the stage of ripening. Often, ethylene is used for the after-ripening of fruits, such as bananas, but after a certain degree of ripeness, the further presence of ethylene may result in overripening and subsequent rottening. By the application of this ethylene-absorbent strip in the package, the vegetables and fruits wrapped in it remain fresh for more days. This solution is beneficial for both producers, sellers, and consumers. It is estimated that this technology in Europe would save about 800 tons of tomatoes and 175 tons of avocados from ending as waste. This corresponds to almost 3,000 tons of carbon dioxide, or 33,000 cubic metres of water.

Real-time data on quality[20]

The main volatile metabolites occurring during the deterioration of freshly sliced fruit, ethanol, is sensed by the sensor built in the package. The signal can be wirelessly read by radio frequency identification (i.e. RFID), using a mobile device. With this technology, data

---

[17] https://www.ars.usda.gov/research/project/?accnNo=428714; Improving the Sustainability and Quality of Food and Dairy Products from Manufacturing to Consumption via Process Modeling and Edible Packaging, 2016 Annual Report.

[18] http://www.vestergaard.com/zerofly-storage-bags; http://www.vestergaard.com/images/ZeroFlyStorageBagBrochureApril2015.pdf

[19] http://www.fao.org/docrep/018/i3342e/i3342e.pdf (box18)

[20] http://www.foodengineeringmag.com/articles/93995-packaging-technology-sensor-communicates-food-spoilage-wirelessly

concerning freshness can be stored real-time in a cloud-based storage, so data on the quality of the food can be continuously compared to the previous values. The sensor can also be placed on a small sticker that can easily be attached to the packaging.

Spray for the inactivation of enzymes [21]

The hexanal originally produced by fruits slows down the deteriorating processes of the fruit: it inhibits the cell wall degrading enzyme, which causes the fruit to dry and rot. If the cell walls protect it, the cells remain intact, so the fruit itself as well, so it retains its freshness longer. The active ingredient of the spray is hexane extracted from fruits. The product is applied to the surface of the fruit one or two weeks before harvesting. Alternatively, the fruit can be immersed in the tincture, and then it has to be washed off. Using this technology can extend the shelf life of fruits by up to 50%. Its usage in the case of tomatoes or broccoli, it has also been researched, with encouraging results.

Patented plastic containers[22]

There are plastic containers that are not only recyclable, but they reduce mechanical damage due to their smooth internal structure, and through their temperature control, they reduce the shrivelling of fresh products, so that the ventilation helps to cool down faster and it also helps the withdrawal of heat of the soil. The containers are ergonomic, and their assembly is easy. The patented wavy bottom of the container aids the unloading, and its strong sidewalls enhance strength. Each container means a $1 saving. Due to ergonomic design, 20 to 40% less work is required;and as opposed to the paper-box design, 82% less solid waste is generated, the demand of total energy is 39% less, and the greenhouse gas emission is 29% lower.

Micro-perforated packaging[23][24]

Each product has different natural gas exchange characteristics, and the controlled atmosphere packaging is adjusted to this, so the packaging will be product-specific. Micro-perforated, controlled atmosphere packaging extends the life of the product, and improves or maintains its quality without having to be aesthetically corrected. The tray is sealed with a polymer-based film on which micro-perforations control the flow of oxygen and carbon dioxide according to the respiration of the product. An average tomato can be consumed for 14 days after harvest, but with micro-perforated packaging, it can be increased to 23 days. For some designs, ethylene gas absorption and dehumidifying function are two additional features that can be incorporated into the packaging.

[21] http://www.cbc.ca/news/canada/kitchener-waterloo/guelph-fruit-spray-extends-shelf-life-1.3647271
[22] http://pac.ca/assets/pfw-casestudy1-feb2015.pdf
[23] http://pac.ca/assets/pfw-project-17sunset-dec2015.pdf
[24] http://pac.ca/assets/pfw-project-16tempo-dec2015.pdf

INNOVATIVE SOLUTIONS BY INDUSTRY

There are many initiatives to utilize food parts, by-products of the food industry that are basically not consumed, but can be used, through their other valuable component, as a raw material for new products with other technological processes. There are some examples below that others have tried and successfully applied.

Meat, egg, and dairy industry

Blood proteins[25]

Blood is the first by-product of animal meat processing, and blood protein (immunoglobulin, haemoglobin, globin, plasma) is widely used as food additive. Plasma is used in sausages for meat binding and emulsification. Haemoglobin is an additive of pet foods, but it is commonly used for colouring puddings to black. Immunoglobulin is also used for emulsification in meat products. Globin protein improves the texture of minced meat (e.g. burger meat) and helps to connect components to some extent. The pharmaceutical industry also produces blood protein isolate, such as creatine, which is also used as a nutraceutical*.

Blood proteins could be utilized by freezing or spray drying, solvent precipitation, or chromatographic methods.

Nutraceuticals: a food or food part that has positive health effects such as the prevention and/or treatment of diseases.[26]

Utilization of egg shell powder as raw material of dietary supplement[27]

Egg shell powder is a biologically very well-utilized source of calcium and can be made suitable for human consumption after proper treatment. Low lead, aluminium, cadmium, and mercury content can be listed as the advantages of egg shell powder, because other natural calcium sources may be contaminated with these elements.

Fish chips[28]

According to a Danish initiative, from parts of fish that are otherwise not consumed, fish chips rich in omega-3 fatty acids can be produced.

Distillery industry

Grape pomace[29]

Grape pomace that is generated in a large amount (20% of the grape's weight) during the production of wine is a high-nutrientby-product rich in and bio-active components, and therefore, it can be used in a number of ways. The consumption of it can help diet with low level of antioxidants, fibres, and minerals. Innovations of this type are not only curiosities but can have positive health effects as well.

---

[25] Handbook of Waste Management and Co-product Recovery in Food Processing (Page 314)

[26] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1369156/

[27] Schaafsma, A., Pakan, I., Hofstede, G.J.H., et al., 2000. Mineral, Amino Acid, and Hormonal Composition of Chicken Eggshell Powder and the Evaluation of its Use in Human Nutrition. Poultry Science 79:1833-1838. https://myplasticfreelife.com/wp-content/uploads/2014/01/poultrysci79-1833.pdf

[28] European Commission(2010). Preparatory Study on Food Waste Across EU 27

[29] http://onlinelibrary.wiley.com/doi/10.1111/1541-4337.12238/pdf

Flour made of pomace is the ingredients of mainly cereal-based products, such as breads and biscuits. The consumption of freeze-dried fruit-enriched bread may reduce cholesterol levels. When consuming white bread made with the addition of grape seed extract, the post-meal glycaemic response eases, and the feeling of fullness increases. It is a growing trend that grape pomace is also used in extruded snacks, since the glycaemic response will be lower due to its high fibre content. Different pomace-based products are also added to dairy products, but in such medium the phenols become unstable and their complexes with proteins can cause turbidity in the product. Options to its usage are unlimited: ice cream enriched with grape seed extract, sausage enriched with pomace flour, steak prepared with grape seed oil, infusion or powder used as an ingredient of an extract added to seafood. Anthocyanin-type compound obtained from grape pomace, enocyanine is a great colouring agent, but the expression of colour is naturally PH- and medium-dependent, and the colour of red cabbage has more favourable properties, therefore the use of enocyanine of the grape pomace is limited.

Cereal bar from brewers' grain[30]

In earlier periods, breweries were located close to agricultural production, and it was obvious that the grain used for brewing was used for feeding animals. However, craft breweries are increasingly widespread in the city centre as well, and at best they only compost the grain, but typically they only transport it to the landfill.

The brewers' grain, so the grain left after brewing can be utilized to produce cereal bars, granola bars, and the product palette can be expanded by adding other grains and seeds. This solution is close to the implementation of cycle economy.

Fuel from whisky[31]

In the case of whisky production, not only composting, but biofuel production is also an option in the utilization of the accumulated barley and distillation residues.

Drink industry

The increasing of nutritional value of snacks with carrot pomace[32]

Carrot pomace is a by-product of vegetable and fruit juice production that is generated in a large amount. Applying a suitable ratio, carrot pomace improved the nutritional value and expansion of the extruded corn flakes based snack.

Various utilization of apple pomace[33]

Apple pomace is often used as raw material of dietary supplements, because its fibre content is extremely high. When pressing apples, pectin-rich cell walls remain, so it can be used to produce pectin as well.[34]

---

[30] http://makezine.com/2017/04/06/eat-beer/

[31] http://www.celtic-renewables.com/

[32] Kaisangsri, N., Kowalski, R.J., Wijesekara, I. 2016. Carrot pomace enhances the expansion and nutritional quality of corn starch extrudates. LWT – Food Science and Technology, 68, 391-399.

[33] Szilágyi, A. (2013). Almalégyártási melléktermék hasznosításának vizsgálata. Budapest.

[34] Schieber, A., Stintzing, F., & Carle, R. (2001). By-products of plant food processing as a source of functional compounds — recent developments. Trends in Food Science & Technology, 12(11), 401–413.

Apple pomace is also widely used in mushroom cultivation: it is easy to use as a culture medium;it does not require preparation.[35]

Orange peel for water purification[36]

Even grapefruit and orange peel generated during the production of fruit juice do not have to be completely waste. A material made from peels of citrus can be used to cleanse water which is contaminated with heavy metal and organic substances. With a new process, the peel is invested with absorption properties, greater porosity, and surface. Due to this treatment, the material acts selectively. It can also be installed in fixed bedcolumns where the sewage can flow continuously through it. The material is vying with the advantageous properties of commercial activated carbon, and also reduces the degree of environmental impact.

Yarn from citrus peel[37]

One million tonnes of citrus peel are generated annually only in Italy, and although biodegradable, their proper destruction costs a lot. By treating the peels, the cellulose is extracted, from which the yarn is spun. Its useful properties include that due to nanotechnology, the material includes – even after treatment – essential oils and vitamin C, which is absorbed by the skin and can therefore be considered a wearable hydrating moisturizer. Despite its oil content, it does not give a greasy feel while wearing it. It is guaranteed that the oil lasts for at least 20 washings, but they work on developing "refill" methods.

Canning industry

Subtraction of lycopene and β-carotene content of tomato pomace[38]

Due to the high carotenoid content of tomato pomace, it is extremely suitable for animal feeding. However, its use can be limited by its high fibre and water content, partly due to the limited portions that can be given to animals, and partly because of its perishability. By extracting carotenoids (lycopene and β-carotene), such feed supplement can be developed that can provide an adequate amount of these minerals throughout the year.

Less sauce and packaging waste[39]

In the production technology of sauces (e.g. ketchup, mayonnaise), intermediate storage tanks are often used, which are immediately placed to a landfill as soon as they are emptied. So, their recyclability cannot be solved, but they still have a considerable amount of sauce, which cannot be recovered. By eliminating intermediate storage tanks and direct container filling, both product and packaging losses can be reduced.

Utilization of tomato edges

The top and bottom of tomatoes are not included in hamburgers in fast-food restaurants. Researchers at Wageningen gather these tomatoes that are still perfectly suitable for

---

[35] Kennedy, M., List, D., Lu, Y., Newman, R. H., Sims, I. M., & Bain, P. J. S. (1999). Apple pomace and products derived from apple pomace: uses, composition and analysis (Vol. 20, pp. 75–119). Berlin: Springer-Verlag.

[36] Romero-Cano, L.A., Gonzalez-Gutierrez, L.V., Baldenegro-Perez, L.A. 2016. Biosorbents prepared from orange peels using Instant Controlled Pressure Drop for Cu(II) and phenol removal. Industrial Crops and Products, 84, 344-349.

[37] https://materia.nl/article/fabric-orange-peel-orange-fiber/

[38] https://www.delifarm.hu/informacio/gop-111-09-1-2009-0002

[39] http://pac.ca/assets/pfw-casestudy2-feb2015.pdf

consumption and produce food after pureeing and powdering. Previously considered unnecessary tomatoes are then consumed in soups or do end up in hamburgers as tomato sauce.

Vegetable oil production

Microalga from olive oil[40]

By combining different filtration techniques, marketable soil improvers and crop-enhancing products can be produced of wastewater generated during the production of olive oil. The extracted organic fertilizer and clean water can be returned to the farmland, implementing the principle of circular economy. Inorganic nutrients can contribute to the production of Spirulina microalga. Spirulina is widely used in the food industry due to its special nutritional characteristics: high protein content (55-70%, based on dry matter content) and essential fatty acid content, as well as rich in certain vitamins and minerals.[41]

Confectionery Industry

Cone: 100% fruit[42]

The non-saleable, but fruits that are consumable and impeccable regarding food safety was used to produce such sugar-free ice cream alternatives, the cone of which is made of dried fruit. Distribution is carried out with a special ice cream cart, running on methane produced by rotting food waste.

Mushroom for coffee[43]

Based on an initiative in Rotterdam, we can grow even mushrooms on coffee beans. Coffee ground generated in the catering unit is collected and transported to a mushroom farm to serve as a culture medium for the oyster mushrooms grown there. The ripe oyster mushrooms are then returned to the catering units, where they are offered as delicacy for guests.

Coffee from coffee[44]

During the processing of coffee crops, 30-50% of beans harvested (the crop's grain and flesh) are wasted. An existing solution is to use coffee beans to create a cup that has the same characteristics as our usual traditional coffee cups: they keep our drinks warm, and they can also be placed in a microwave and dishwasher.

---

[40] https://www.eip-water.eu/projects/respira-olive-oil-wastewater-reuse-production-and-commercialisation-spirulina-alga

[41] FAO (2008). A review on culture, production and use of spirulina as food for humans and feeds for domestic animals. Rome.

[42] http://www.fao.org/docrep/018/i3342e/i3342e.pdf (box44)

[43] https://www.rotterzwam.nl/page/homepage

[44] https://www.huskee.co/

Sugar industry

Various uses of the by-products of sugar beet[45][46]

One hundred and forty kg of sugar can be obtained from one tonne of sugar beet, so 86% of the raw material is wasted. In the European Union, more than 100 million tonnes of solid waste and 0.5 m^3 wastewater per tonne are generated during sugar production. These are usually returned to the land, but the generated by-products may also be used for other purposes.

Leaves, weeds, beet tails, and soil removed from the root at 100 kg waste for a tonne of raw material, which is traditionally used for animal feeding and composting. The beets are sliced and pressed, resulting in the sugar beet pulp (50 kg). This pulp contains large quantities of valuable substances, such as protein, prebiotics, cellulose, pectin, or hemicellulose. Ferulic acid can be extracted from the pulp and then bioconverted to vanillin. The pressed juice is purified by the addition of calcium hydroxide (milk of lime) and carbon dioxide. The generated by-product, carbonation lime (60 kg), can be used to repair sour, lime-deficient sand soils and as absorbent materials. Lastly, the sugar is separated from the molasses (38 kg) during crystallization and the latter is used for animal feeding, pharmaceutical extraction (betaine, vitamins, etc.) or as a carbon source for fermentation processes (e.g. ethanol and citric acid production).

Bakery and pasta industry

Optimizing bread portions[47]

Former, standard, one-kilogram and half-kilogram breads were in many cases too large, especially for single-person households, and therefore, a large amount of them ended up in the garbage can. To prevent this, the introduction of selling smaller (e.g. 3-400 g) fresh breads, the size and shape of which were optimized. The portions are suitable for one-person households to consume the purchased product without waste, but the expanding assortment is also beneficial for larger families, as they can put together their meals from a variety of breads, providing a balanced diet. The great advantage of sliced packaged bread is that the packaging helps to keep the bread fresh when the indicated storage conditions are respected.

Horticultural products

Value from surplus food[48]

In the kitchen of an NGO called Alameda Point Collaborative based in Alameda, California, such vegetables and fruits are processed that would otherwise not be consumed. They provide affordable meals for the low-income population.

In connection with this, a number of social purpose enterprises have begun to operate that offer value-added products with some profits. Such initiative is, for example, Barnana, which produces snacks from bananas which are unsuitable for export or import. Misfit Juicery produces juices made of not aesthetic fruits and vegetables.

---

[45] https://thecitywasteproject.files.wordpress.com/2013/03/handbook_of_waste_management_and_co-product-recovery-in-food-processing.pdf (Page 420)

[46] http://www.biokontroll.hu/cms/index.php?option=com_content&view=article&id=515%3Atalajjavitas-szakszeren&catid=402%3Atapanyag-utanpotlas&Itemid=127&lang=hu

[47] https://bakeryinfo.co.uk/news/fullstory.php/aid/13858/Bread_tops_food_waste_list,_finds_study.html

[48] http://www.refed.com/solutions/value-added-processing ; https://misfitjuicery.co/ ; https://barnana.com/

Drying, grinding, and subsequent use of vegetables and fruits[49]

Such vegetables and fruits are collected that otherwise would not be consumed by humans (because they are too ugly, irregular, or overripened) and converted into dried powder, extending their shelf-life from two to seven years. This method preserves not only 90% of nutrients, but there is also no logistical problem with the product. The grains are later used as supplements and ingredients of foods. Another initiative, for example, produces biscuits and fruit leather made of the dried ground powder.[50]

Drying, grinding, and subsequent use of various industrial by-products[51]

Okara is the by-product of the production of soy milk, which can be used to produce gluten-free flour rich in nutrients after drying and grinding. By grinding the shell of pistachio, we get to the so-called mulch, which helps to drain plants and to smoke meat during grilling in the garden. Extract made of olive pomace is used as an ingredient of cosmetic products.

Vanillin from agricultural waste[52]

Low-cost vanillin can be produced naturally from waste generated in agriculture, which may replace the chemically synthetic aroma.

CHECKLIST

Using the Food Waste Prevention Checklist can help the production facility to prevent and reduce the generation of food waste connected to its operation. Example can be found in Appendix II.

[49] http://www.hellofopo.com/
[50] WasteBusters, Thought For Food Challenge, Global Summit, 2017.
[51] http://www.renewalmill.com/#renewal-mill-1
[52] LignoFlava, Thought For Food Challenge, Global Summit, 2017.

APPENDIX I.

TABLES FOR ASSISTING THE MEASUREMENT OF FOOD WASTE

Table for recording the mass of food waste for a period of one week:

Day	Date	Expired, spoiled raw materials, processing aids(kg)	Waste arising from malfunction(kg)	Damaged packaging (kg)	Total weight (kg)
1					
2					
3					
4					
5					
6					
7					
Total (kg)					

APPENDIX II.

FOOD WASTE PREVENTION CHECKLIST

Please mark the cells describing the current state clearly.

	FOOD WASTE PREVENTION CHECKLIST	**Yes**	**No**	**N.A.**
1.	Do the company conduct a survey of the amount of food waste generated at least once a year for a week?			
2.	Do the company conduct a survey of the composition of food waste generated at least once a year for a week?			
3.	Do the company conduct a survey of the reason of the generation of food waste at least once a year for a week?			
4.	Are there adequate tools to measure the amount of food waste produced by the production facility?			
5.	Does the production facility have adequate storage facilities to store tools used to measure food waste?			
6.	Is an automated food waste tracking system used in the production facility?			
7.	Do you use a paper-based food waste tracking system in the production facility?			
8.	Do you calculate the amount of material loss food waste mean for the production facility per year?			
9.	Do you calculate the annual environmental impact of food waste that can be linked to the operation of the production facility?			
10.	Is the knowledge of the prevention of food waste included in the training of new workers?			
11.	Is the knowledge of the prevention of food waste included in the regularly repeated education and training of workers?			
12.	Are there good practices available in the production facility to reduce food waste?			
13.	Does the production facility have a procurement and logistics system that contributes to the prevention and reduction of food waste generation?			
14.	Does raw material expire often due to excessive inventory accumulation?			
15.	Does the production facility apply the FIFO and FEFO principle while using raw materials and processing aids?			
16.	Does the production facility apply the FIFO or FEFO principle when removing finished products?			
17.	Do you conduct a storage experiment to determine the exact shelf-life of the finished product?			
18.	Does the production facility provide for animal feeding the			

	suitable by-products generated during production?			
19.	Does the production facility provide for composting the suitable by-products generated during production?			
20.	Does the production facility use the by-product generated during production to produce other food products?			
21.	Is the production facility conducting innovation activities to utilize the generated by-products as food?			
22.	Does it occur often that food waste is generated due to malfunction of equipment?			
23.	Does the production facility donate finished products to the Food Bank or to other charity organizations (such as consumable food with deformed packaging)?			
24.	Does the company make finished products that are non-tradable for some reason, but still suitable for consumption available on a lower price?			
25.	Are containers available in the dining area of employees to collect food waste selectively? (Purpose: to raise the awareness of employees.)			
26.	Do you consider it important to raise the awareness of suppliers, customers and final consumers regarding the issue of food waste?			
27.	Do you have a ready-made program to raise the awareness of the parties concerned regarding the issue of food waste?			

Date: ……..

Checking carried out by: ……

Edited by
Working Group for Food Industry of the *Wasteless* programme

Published by
National Food Chain Safety Office
H-1024 Budapest, Keleti Károly utca 24.
portal.nebih.gov.hu

www.maradeknelkul.hu/en
maradeknelkul@nebih.gov.hu

Photos
Fotolia

The Wasteless program is co-funded by European Union's LIFE Program.