Food Packaging Sustainability

A guide for packaging manufacturers, food processors, retailers, political institutions & NGOs

Based on the results of the
project "STOP waste – SAVE food"
Vienna, February 2020

This guide is based on the results of the research project "STOP waste – SAVE food" (2016 - 2020)

Co-funded by the Austrian Research Promotion Agency (FFG)

Coordinated by the Food Cluster of Lower Austria and the Plastics Cluster

food cluster of lower austria

plastics cluster in lower austria

Co-financed by the Austrian producer responsibility organisations (PROs) for packaging

Abfallvermeidungs-Förderung der österreichischen Sammel- & Verwertungssysteme für Verpackungen

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Suggested citation: ecoplus, BOKU, denkstatt, OFI (2020): Food Packaging Sustainability: A guide for packaging manufacturers, food processors, retailers, political institutions & NGOs. Based on the results of the research project "STOP waste – SAVE food". Vienna, February 2020

Imprint:
Responsible for the content:
ecoplus. The Business Agency of Lower Austria
3100 St.Pölten
Plastics Cluster, Food Cluster of Lower Austria
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Partners who supported the "STOP waste – SAVE food" project:

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Abkürzungsverzeichnis

ADP	Abiotic Depletion Potential
BBD	Best Before Date
CO_2e	Carbon Dioxide Equivalents
EPS	Expanded Polystyrene
EVOH	Ethylene Vinyl Alcohol Copolymer (Barrier Material)
FAO	Food and Agriculture Organization of the United Nations
GHG	Greenhouse Gas(es)
GWP	Global Warming Potential
LCA	Life Cycle Assessment
MAP	Modified Atmosphere Package
PBT	Polybutylene Terephthalate
PE	Polyethylene
PEF	Polyethylene Furanoate
PET	Polyethylene Terephthalat
PLA	Polylactic acid
PP	Polypropylene
PS	Polystyrene
Skin	Vacuum skin packaging (the filling material is fully sealed by a special skin film on a dimensionally stable film or on a tray)

Carbon Footprint: Environmental impact of all greenhouse gas emissions over the entire life cycle of products (Product Carbon Footprint)

Superscript numbers "[1]" refer to literature sources or footnotes, see page 43

About this guide

This guide "Food Packaging Sustainability" is aimed at professionals in the fields of packaging production, food processing, retailers, political institutions and NGOs concerned with the reduction of food waste and the sustainability of packaging.

The guide focuses on the question of whether and how optimised packaging can contribute to the reduction of food waste. Within the framework of the research project "STOP waste – SAVE food" (2016 - 2020), large quantities of data were generated. The findings are made available in this guide.

The project results will form part of a general overview of the state of food waste generation in Austria, as well as additional suggestions for food waste avoidance beyond packaging optimisation.

With this guide, the authors want to contribute to an objective and diverse discussion about the advantages and disadvantages of different packaging options. We would be pleased if this guide also stimulates cooperative projects along the supply chain in order to reduce food waste and optimise packaging in terms of sustainability.

To make global food systems more sustainable and thus fit for the future, complex systems must be analysed and optimised. We hope that this guide will inspire you to dive a little deeper into this complex subject.

Contents

Summary:
'STOP waste – SAVE food' in 16 steps

1. Approximately 30% of global greenhouse gas emissions are related to food. [9,17,26] One third of all food produced is lost. [5] VAvoiding food waste can reduce our overall carbon footprint by up to 8%. [6]

2. Packaging should be avoided unless it is absolutely necessary for product protection or other requirements, and when omission of such packaging no longer produces food waste.

3. Due to its protective function, packaging often helps to reduce food waste. If this is the case, the environmental benefit of avoided waste is usually 5 to 10 times higher than the environmental cost of the packaging. Product protection pays off especially for food products with resource-intensive production (e.g. meat, cheese).

4. Optimised packaging provides the required product protection, uses as little material as possible and is recyclable or reusable wherever possible.

5. Sustainable packaging solutions can be slightly more expensive. However, the additional costs are often offset by reduced waste and other benefits.

6. There is no packaging material that is good or bad in itself. When choosing the material, necessary packaging functions and low environmental impacts should be harmonised.

7. 'Design for Recycling' or for 'Re-Use' and the use of recyclable material should lead to improved environmental effects throughout the life cycle.

8. The development of optimised packaging and the further reduction of food waste is particularly successful if the players concerned cooperate along the supply chain.

9. In the process of transforming food packaging, all relevant packaging and waste data should be documented and evaluated whenever possible, in order to provide more quantitative examples of the link between food waste and packaging in the retail environment.

10. Holistic assessments (technical – environmental – economic) help to find solutions that are actually sustainable. Typical clichés often do not correspond to the quantitative findings of the assessments.

11. Food producers can – partly through cooperation with the retail market – transform today's waste into valuable by-products.

12. Consumers should be increasingly informed about the benefits and function of packaging.

13. Portion sizes and quantities purchased should consider household size and needs. Where consumption is low, portion packs can help to reduce food waste.

14. Consumers should know the correct meaning of the 'best before' date. Many products can be consumed long after this date. "Look, smell and taste" first – instead of throwing anything away hastily.

15. Consumers should receive and observe information on the recommended handling of packaging and temperatures during storage.

16. Leaving packaging behind in the environment as litter is an absolute no-go. However, as long as permanent littering levels measured in Austria (see page 28) remain in the per thousand range, this should not be a significant factor in the overall assessment of packaging in this country.

1. Food in focus

Food is a precious commodity. However we still lose a third of all food produced and 30% of all greenhouse gas emissions are related to the food industry. In order to reduce both the use of resources and waste, we need to understand the main influences: Which foods have a particularly high emissions footprint and how much waste is produced? What role does packaging play and can it help to reduce waste?

- 1.1. **Food is precious – therefore food waste should be minimised**
- 1.2. **Stages along the value chain of food – and how they contribute to LCA results**
- 1.3. **Comparison of environmental impacts of packaging vs. packaged food**
- 1.4. **Environmental benefits of the protective function of packaging**

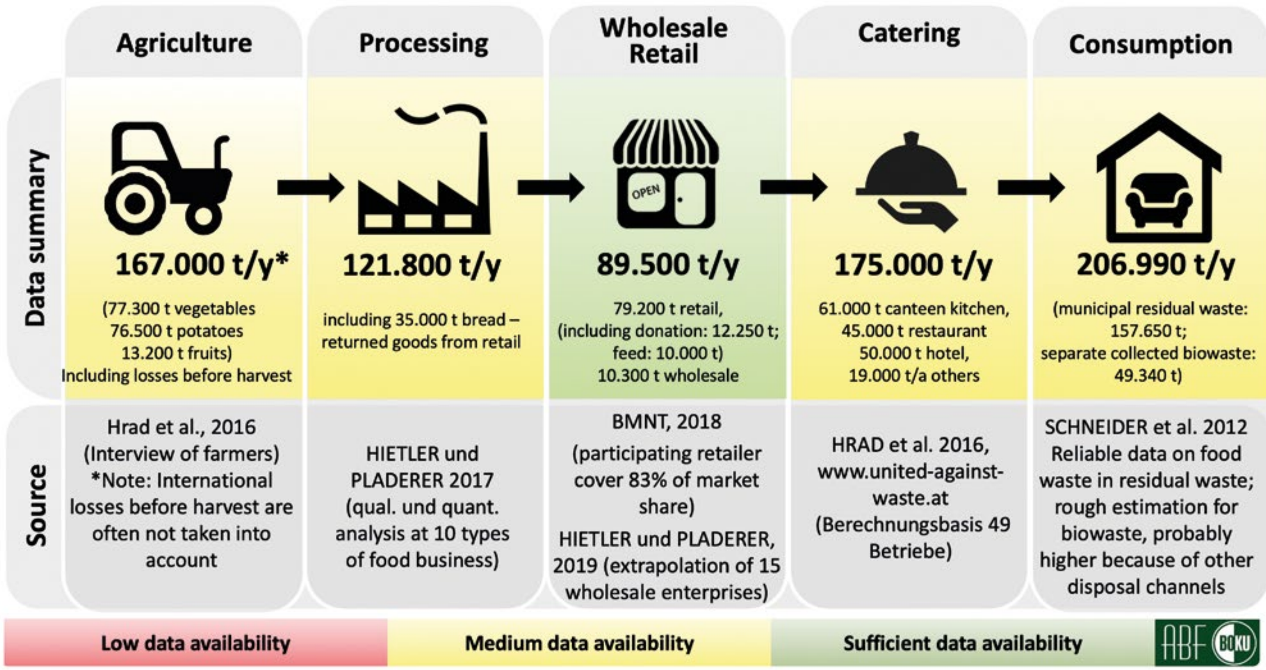
1.1. Food is precious – therefore food waste should be minimised

One third of the food produced for human consumption is lost or wasted along the entire supply chain.[5] In the European Union, about 88 million tonnes of food are wasted annually.[22] In Austria too many foods are not used for their original purpose.

Reasons for the wastage of food are numerous, ranging from marketing standards or surpluses in agriculture to a lack of coordination within the retail sector, and consumer habits.

The environmental impact of food production and consumption is further increased when food is wasted and not consumed.

Generation of (avoidable) food waste in Austria



Food waste prevention therefore has to be the main aim so that the invested resources are not squandered. One way of achieving this could be the optimisation of packaging.

A distinction is made between avoidable food waste that is still fully edible at the time of disposal (e.g. leftover pieces of pizza) or would have been edible if consumed in time (e.g. mouldy bread) and unavoidable food waste (e.g. inedible parts such as bones or peelings, but also potentially edible parts such as potato peelings).

1.2. Stages along the value chain of food – and how they contribute to LCA results

According to a recent report by Quantis [19] globally, 28-34% of total greenhouse gas emissions are related to food, depending on the definition of the system boundaries. 24% are caused by agriculture including effects of land use (e.g. rainforest deforestation), another 5-10% by the rest of the supply chain, including preparation and waste treatment.

Within agriculture, animal husbandry is responsible for 60% of the climate impacts. [19] The influence of packaging is often overestimated, whereas the significant influence of heated greenhouses or shopping trips is little known.

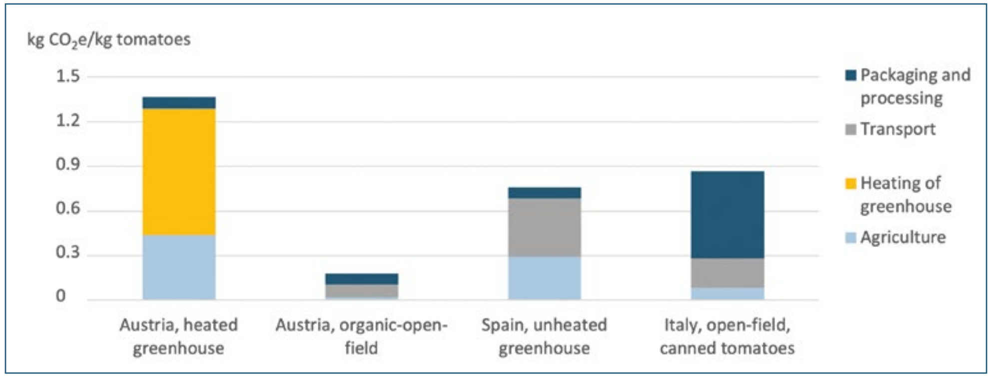
Food's impact on climate	
	Share within global greenhouse gas emissions
Produce + grains	9.5%
Animal agriculture	14.5%
Total agriculture, incl. land use change	**24.0%**
Primary + secondary processing	0.4%
Storage, packaging, transport	0.9%
Refrigeration	1.2%
Retail activities	0.5%
Catering + domestic food management	0.4%
Waste + disposal	0.2%
Total food system	**27.6%**

Source: Quantis Food Report 2020 [19]

While the carbon footprint of vegetables, fruit and bread typically ranges from 0.2-2.0kg CO_2e, 5-10kg CO_2e are produced per kg of chicken and pork, and 20-30kg CO_2e per kg of beef. [31] Since we lose about one third of all food produced worldwide, the avoidance of such waste can reduce our carbon footprint by 5 to 10%.

IFEU – Study [20] on the importance of life-cycle phases

- **Apples** from the region have a smaller carbon footprint than apples from overseas (refrigerated storage is less costly than transport).
- Spanish **lettuce** produces fewer greenhouse gas emissions in winter than regional lettuce from heated greenhouses. Hardy lettuce varieties from the region perform best.
- In the case of **beef**, it is particularly important that no forest has been cleared for soya in the feed (much greater influence than transport).
- Significant impact of long **shopping trips**: If the distance to the store divided by the purchased amount in kg is approximately "1" (e.g. 5km outward journey, 5kg purchased), then (depending on the purchased mix of goods) the climate impact of the shopping trip alone can be at least half as large as the total carbon footprint of food production and distribution to the store.

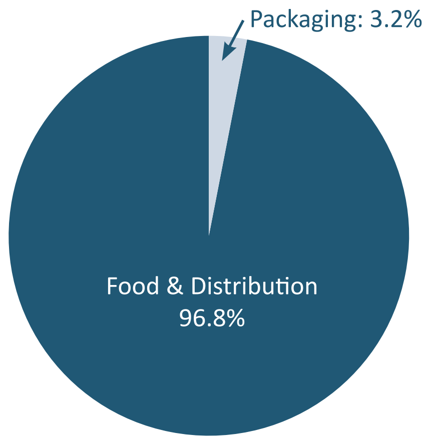


Spanish tomatoes deriving from unheated production perform better in winter than domestic tomatoes from heated production despite the lengthy transportation. [24] The type of heating is essential: the graph refers to district heating. The balance either deteriorates with natural gas or improves with wood (and especially with geothermal energy.

1.3. Comparison of environmental impacts of packaging vs. packaged food

General packaging causes approximately 1.5-2.0% of the carbon footprint of a European consumer, whilst 0.7% are caused by food packaging. [29] On average, the carbon footprint of the packaged product (production, distribution) is about 30 times higher than the carbon footprint of packaging itself. [30]
In other words, only about 3.0-3.5% of the climate impact of packaged food, on average, comes from the packaging process itself. It follows from this: If (due to the protective function of packaging) on average more than 3.5% of food waste is avoided, then the use of packaging has paid off from a climate protection perspective.

Anteil der Verpackung am Klimafußabdruck von verpackten Lebensmitteln		
Butter	0.4%	[7]
Roast Beef	0.5-0.6%	[4]
Beef cuts	0.6-0.7%	[28]
Brioche	0.7-1.5%	[4]
Camembert	0.9-1.5%	[28]
Semi-hard Cheese	1.2-3.2%	[4]
Ham	1.5-4.1%	[28]
Ground Coffee	1.6%	[5]
Cream Cheese	1.6-2.9%	[28]
Cucumber	approx. 2%	[4]
Eggs	2.3-2.7%	[28]
Bread	approx. 3%	[20]
Fish Fingers	3.2%	[8]
Frozen Spinach	3.4%	[7]
Milk	approx. 4%	[20]
Beer	approx. 4%	[20]
Milk Chocolate	7.0%	[7]
Frozen Vegetables	10%	[8]
Mini cucumbers	10-23%	[28]
Frozen Fruit	11%	[8]
Cherry Tomatoes	approx. 12%	[28]
Frozen Herbs	18%	[8]



On average, only about 3.0-3.5% of the climate impact of packaged food is caused by the packaging process itself. In individual cases this proportion can of course be significantly higher, e.g. in the case of very heavy packaging or very small portion sizes.

Environmental assessments within the research project "STOP waste – SAVE food"

- All relevant phases in the life cycle of packaging and food (waste) were considered (production and processing, transport, waste management).
- As a rule, several relevant environmental effects were examined (e.g. greenhouse gas emissions, cumulative energy consumption, water consumption, acidification, eutrophication).
- For the sake of clarity, only the results relating to climate effects are presented in this guide. If results for other environmental impacts differ, this will be explained in the text.

1.4. Environmental benefits of the protective function of packaging

One of the primary tasks of packaging is to maintain the quality of the packaged product or to protect it from damage and spoilage. In fact, the resulting benefit is usually the most important factor in the environmental evaluation of packaging.Unfortunately, however, this benefit is rarely calculated quantitatively.

In order to evaluate the usefulness of packaging, however, we must take into account how much food we waste and the environmental impact that would arise without packaging, or through defective packaging.

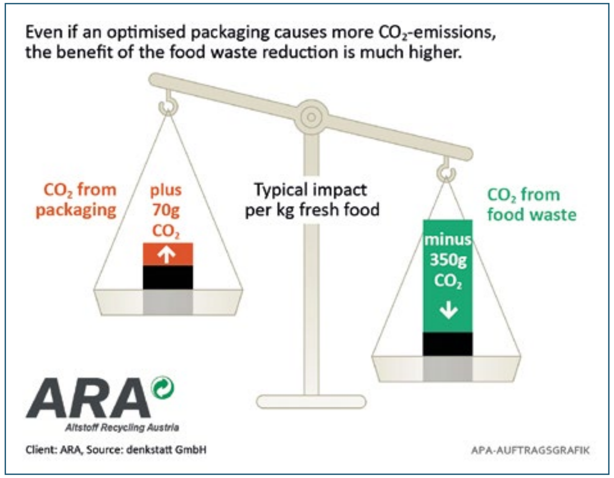
The further food is transported, the more sensitive it is to spoiling, therefore, the longer the shelf life must be, the sooner it will require packaging to get it to the consumer without loss.

Optimized packaging almost always generates environmental advantages, because the benefit of avoiding food waste by packaging is significantly higher than the costs of packaging production or packaging optimization. A study by denkstatt [4] has quantitatively proven this for six examples (roast beef, semi-hard cheese, yeast plait, garden cress, cucumber, chicken).

In this guide, further examples are presented which show the same relationship: **ham** and **mini cucumbers** were examined unpackaged and in optimised packaging (pages 13, 21-23, 35).
For **eggs** (pages 13, 27), **cherry tomatoes** (page 34), **beef cuts** (pages 12+31), **coffee capsules** (pages 32-33) and **cool boxes** (page 36), different packaging options were compared.

Finally, portion packaging can help reduce food waste when consumption is low (examples: **cream cheese**, **camembert** and **jam**, pages 24-26).

Carbon Footprint of Packaging and Food



Biodegradable plastic packaging was not a central topic in this research project, but was included as an example in the case studies of mini cucumbers and coffee capsules. Such materials are particularly useful if they provide a better shelf life for the packaged product than other materials. The properties of compostability do not actually show any advantages in the quantitative evaluation within the framework of a life cycle assessment, but energy recovery or fermentation in a biogas plant (together with food waste) do.

2. Packaging in the retail sector

The research project "STOP waste – SAVE food" investigated the relationship between packaging and food waste in three different areas: In the food retail sector; amongst consumers; and for certain product groups. With some examples it could be quantitatively proven that optimised packaging can contribute to reducing food waste in the retail sector. Such packaging amendments should be evaluated more intensively in the future in order to increase knowledge on this topic. A more detailed analysis of costs and cost savings is equally interesting and shows that it is economically beneficial to invest in sustainable packaging.

2.1. Correlation between product protection, minimum shelf life and amount of waste at retailers

2.2. Test packaging changeovers and document data

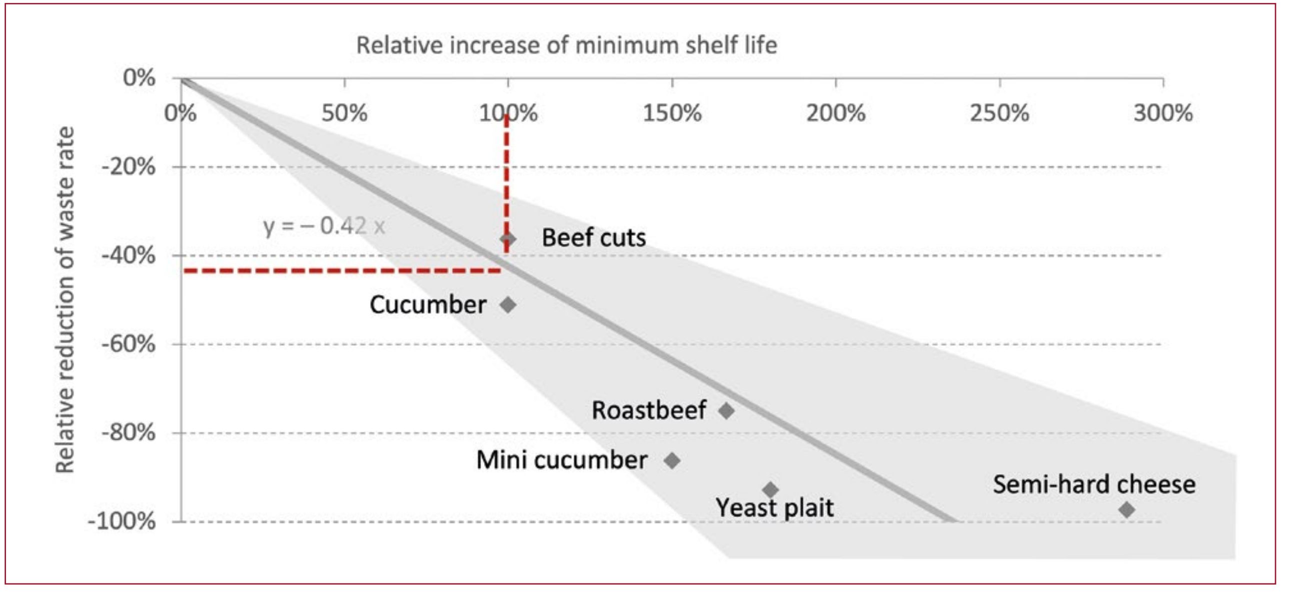
2.3. Additional costs of innovative packaging versus cost savings: sustainability that pays off

2.1. Correlation between product protection, minimum shelf life and amount of waste at retailers

Optimised packaging, which protects the packaged product better, often extends the minimum shelf life. This can help to reduce waste. However, a blanket statement is not possible in this context. Whether an extension to the minimum shelf life of a product actually leads to a reduction of waste at the retailer, must ultimately be examined for each individual case using the evidence of concrete data, before and after a changeover. However, examples examined in detail so far show the first trend: doubling the minimum shelf life can reduce the waste rate in the retail sector by about 40%.

In the following diagram six concrete examples evaluated the relationship between increased minimum shelf life and reduced waste volumes. [4, 28] The resulting trend shows that, on average, by doubling the minimum shelf life the waste rate at the retailer was reduced by about 40%, tripling effectiveness by about 80%. In future projects, further case studies should be evaluated in this direction.
Using Roast Beef as an example, we explain how the individual data points in the diagram are to be understood: by switching from MAP packaging to vacuum skin packaging, the minimum shelf life of high-quality beef products on the shelves increases from 6 days to 16 days. This corresponds to a relative increase of 167% the minimum shelf life. At the same time the waste rate at the retailer decreased from 12% to 3%; the amount of waste was therefore 75% lower after the change. In order to estimate the possible effect of a shelf-life extension, the current waste rate of the product in question must be known.

Until concrete evidence of waste reduction is provided, the effect of an extended shelf life can only be considered as a potential solution for waste avoidance. In practice, counterproductive effects can also occur which cancel out the targeted waste reduction or even reverse it. For example, prolonged shelf life can lead to too many products being offered or purchased at the same time, or the duration of storage can be extended for other reasons, which can increase the amount of waste again.



2.2. Test packaging changeovers and document data

Concrete data helps us to be objective when discussing the advantages and disadvantages of packaging. Especially in conjuncture with the food industry, such evidence should be collected and evaluated more frequently in the future. Whenever food packaging is converted or tested, packaging and waste data should be documented and evaluated. In this way, best practice knowledge about the relationship between food waste and packaging could be significantly expanded.

Chapter 2.2. deals with the possible link between increased minimum durability and reduced waste volume. However, the concrete effect of a changeover should be quantified for each individual case, since the theoretical potential of waste reduction can be reduced or eliminated by simultaneous changes in goods management.

The examples presented in chapter 2.2. were compiled in cooperation with Austrian retail chains and are based on practical data from a large number of stores and representative periods.

We would like to motivate the entire European food industry to actively participate in the expansion of this database. In cooperation with packaging manufacturers, food processors and research institutions, as many packaging conversions as possible should be evaluated in the future.

From this data, it can be quantitatively derived whether the packaging changeover, including its effect on food waste, improves environmental indicators such as the carbon footprint of the overall food and packaging system.

In addition, the following can be examined during conversions:

- Survey of the packaged product's protection and the machinability
- Additional costs and cost savings across the entire supply chain (see page 14-15)
- Further potential for reducing packaging weight and improving recyclability
- Surveys at the point of sale as well as simulations to investigate consumer satisfaction

2.3. Additional costs of innovative packaging versus cost savings: sustainability that pays off

The actual packaging costs for innovative packaging solutions are often somewhat higher than the costs of conventional packaging.

However, this perspective is too narrow: in addition to packaging costs, cost savings should also be taken into account, especially those resulting from reduced food waste.

This extended economic assessment will often lead to win-win situations in which environmental and economic benefits go hand in hand.

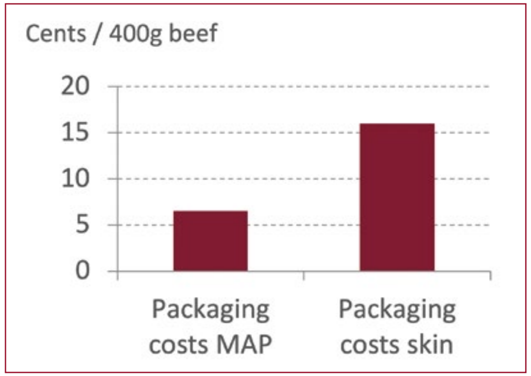
More expensive packaging currently only has a viable chance with higher value products. However, comparing quantitative examples of additional costs and saved costs (e.g. through avoided food waste) show that the benefit can be higher than the additional costs. Investments in innovative, sustainable packaging can therefore be worthwhile. In the example of beef packaging presented here (for details see page 31), the waste rate in the retail sector fell from 5.8% to 3.7% due to the use of vacuum packaging.

Recommended Measures

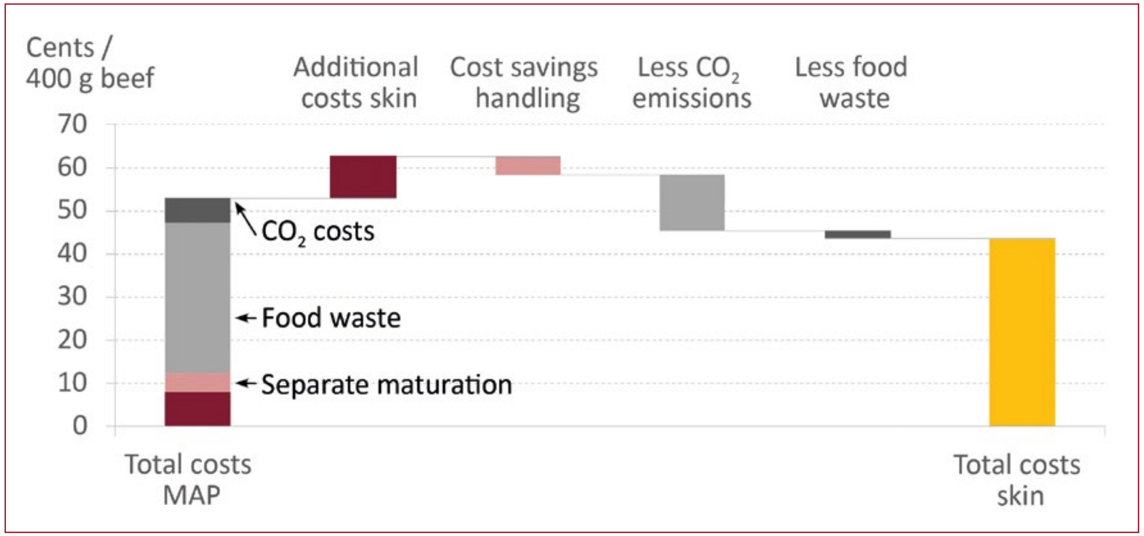
- Demonstrate the benefits of innovative packaging solutions (e.g. reduced food waste) to retailers or consumers through testing
- Compare additional costs & saved costs
- Communicate the beneficial features within the value chain to the consumers
- The sales success is not just measured by packaging costs

Example of packaging for beef:

At first glance, vacuum skin packaging for beef appears more expensive than MAP packaging…



… but when including the reduction in food waste and reduced need for maturing, the costs are lower.



In many cases, retailers have the greatest influence on the packaging in which products are offered – if alternatives are available. Criteria, according to which buyers in retail select packaging, are, in particular: acceptance by consumers; the presentation of the product in the branches; the functionality of the packaging; and often primarily the cost of the packaging.

The examples examined here show that when comparing costs, the advantages and disadvantages of all changes should be compared, not just packaging costs!

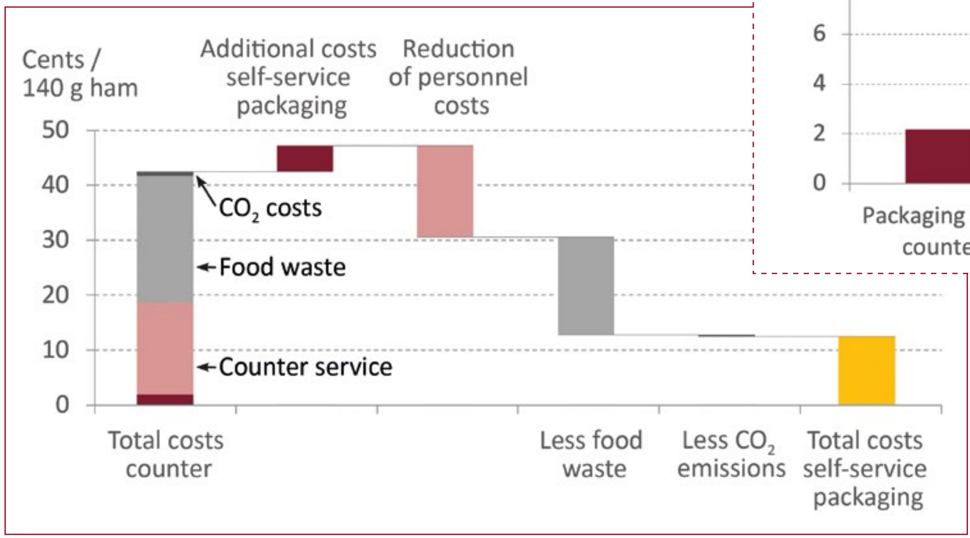
Example 1: beef:
Vacuum skin packaging increases the shelf life from 6-7 days to 12-14 days. The diagram on page 14 shows that the additional costs of vacuum skin packaging are more than offset by the advantages:

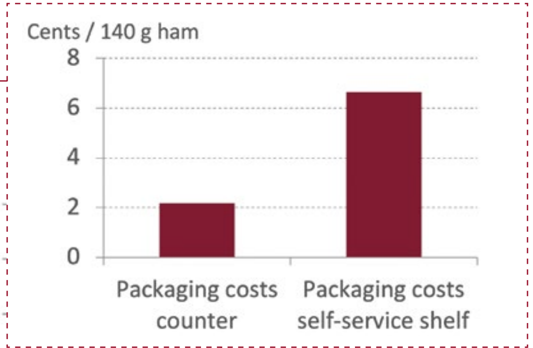
- Separate meat maturation is not required.
- The industry waste rate was around 35% lower in the trial.
- The benefits, in terms of climate impact, would amount to EUR 70/t CO_2 at 2 cents per pack.

Example 2: packaged ham:
The packaging for fresh ham from the counter costs less than the packaging for ham on the self-service shelf. But the freshly packed ham spoils at least 3 days earlier (see pages 22-23). Extra costs resulting from additional food waste are almost four times greater than the additional costs of self-service packaging. The lower personnel costs in the case of the self-service shelf also play a role when comparing the total costs. Finally, the CO_2 emissions of both variants can also be expressed in monetary terms. About 70 EUR/t CO_2 would be necessary to achieve the Paris climate targets.

Example 3: Egg packs from recycled PET bottles have many environmental advantages (see page 27) and are also significantly cheaper over their entire life cycle, despite slightly higher costs for waste recovery. In addition to the effects shown in the following table, R-PET egg packs also reduce transport and storage costs due to the smaller space required before filling.

Overall view of costs and savings





Net packaging costs

	Cents/pk for 15 eggs
Status quo: Eggs in carton packs	
Cardboard packaging costs	15.4
Packaging recovery costs	0.8
Monetised environmental impact	1.5
Total Cost of Cardboard	**17.7**
Effects of changeover to R-PET packs	
R-PET cost savings	-4.4
Additional costs of waste recovery	0.6
Environmental benefit of R-PET	-0.1
Gesamtkosten R-PET	**13.8**

Total egg carton costs minus 3.9 cents cost saving of changeover = total costs R-PET egg packs

3. Packaging and the consumer

Packaging does not have the best reputation amongst consumers, even though it helps to protect food and ensures the best possible quality by the time it reaches consumers. Only when the benefits of packaging are recognised will it be positively accepted. Some examples show that reducing or eliminating packaging does not always lead to an overall improvement: sometimes, even more packaging is beneficial. If portion packaging helps to reduce food waste, this benefit can be greater than the disadvantage of additional packaging.

3.1. Packaging function for consumers: perception and purchase decision

Optimised packaging does not guarantee a sale!

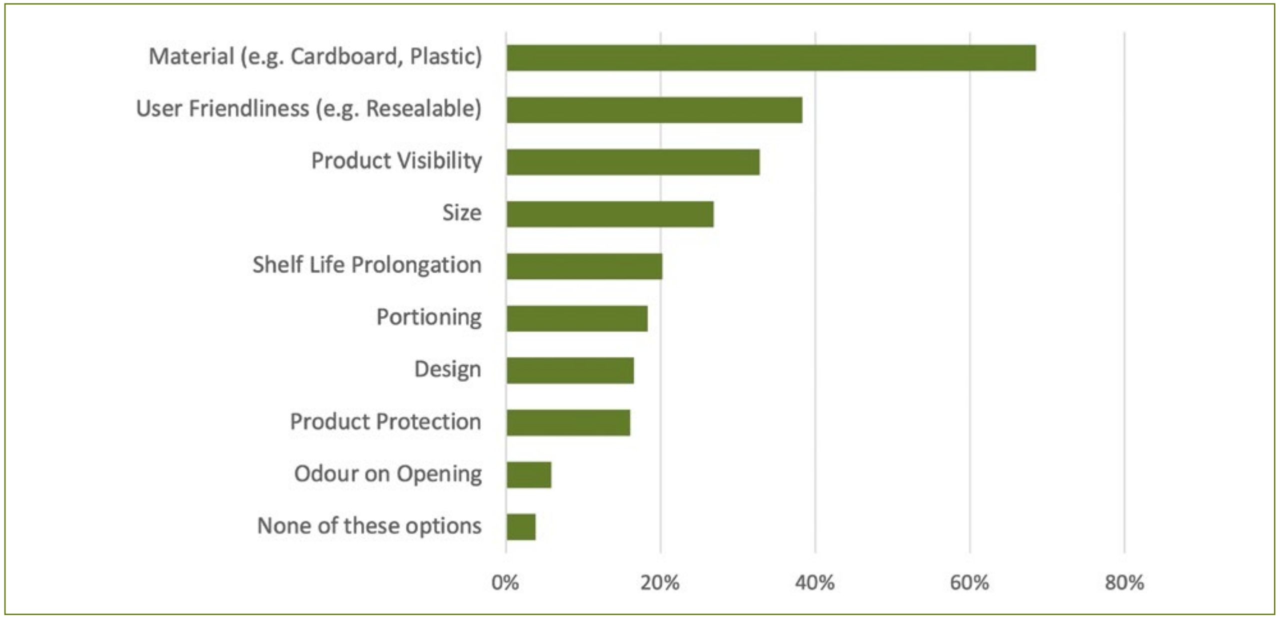
Although many consumers understand the various attributes of optimised packaging, it does not play an important role in their decision to buy. It seems preference is given to packaging that consumers consider to be environmentally friendly. However, the most important benefit of packaging is product protection. Only about one third of consumers notice the shelf life extending function and consider packaging primarily as a possibility to display information about its content. The product characteristics are the most decisive factor for a purchaser.

Analyses show a rather negative attitude towards food packaging among consumers. Food is perceived as over packaged. From the consumer's point of view, environmentally friendly packaging is preferred to the functionality of optimised packaging. Plastics in particular are viewed negatively. Many consumers state that they prefer unpackaged goods, however, product characteristics are the main factor in their decisions to buy.

Packaging is a vital provider of information between the producer and the consumer. Although consumers in surveys say they would like to see more information and instructions on the packaging, the information already available is only insufficiently perceived and is largely not implemented. How the consumer stores their food does not seem to be influenced by the storage information displayed on the packaging (according to 90% of respondents).

At present, around 70% of survey respondents consider packaging waste to be a greater environmental issue than food waste, although facts show the opposite (pages 8-9). From the consumer's point of view, the ideal pack should be environmentally friendly. Preferred materials are cardboard, glass and biodegradable or compostable plastics. But also with regard to optimum materials, assumptions and facts often diverge widely (see following examples).

Influence on Purchasing Decision (no. = 1117)



3.2. Packaging function for consumers: handling food and packaging at home

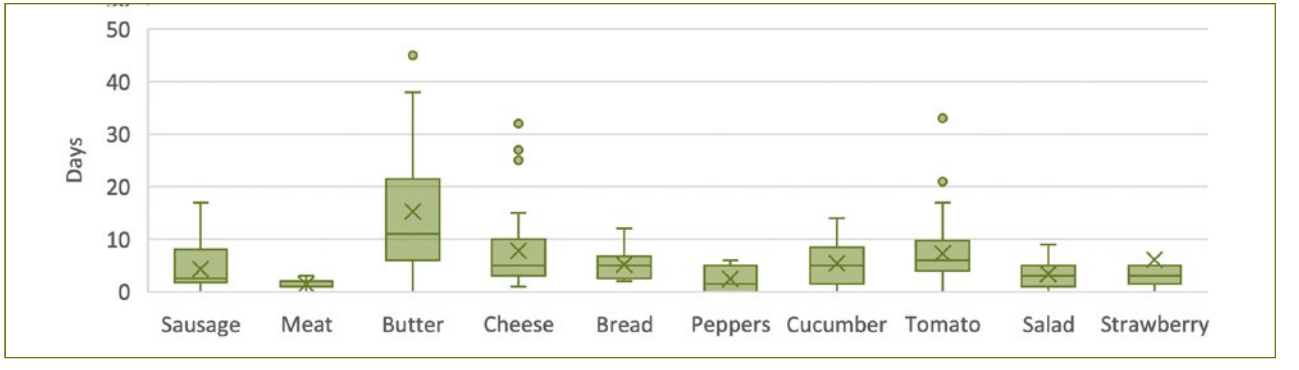
In connection with optimised packaging, it is not only storage and transport costs that must be considered. The storage habits of consumers have to be considered, and the length of stay or average time of consumption of food in the household is also an important factor. For many products real values are far below the expected duration, which means that the shelf life extending function rarely comes into effect.

Refrigerator temperature also plays a significant role with regard to early spoilage.

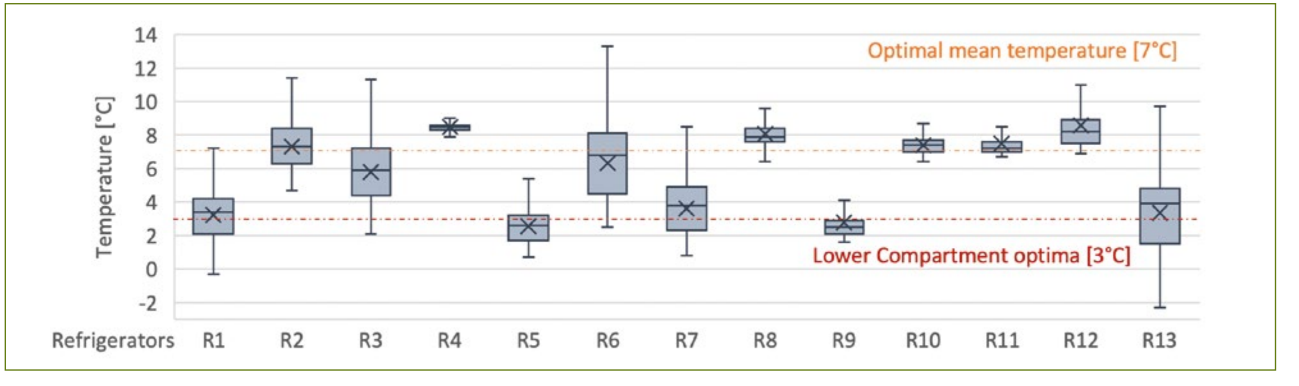
As box diagram 1 shows, most food is only stored for a few days before being consumed or, in the worst case, thrown away. The shelf-life-extending function of the packaging therefore only comes into effect if the consumer opens the food consciously straight before eating and does not repackage the product or store it loose. The box 1 graphic covers the middle 50% of the values. The median line marks the median, the cross indicates the mean value. The lines represent the range of the data, and the points indicate the outliers.

As shown in box diagram 2, refrigerators in many households are not ideally adjusted, i.e. the optimum temperature is usually exceeded. Measurements were taken in the meat drawer (= lower compartment above the vegetable drawer and coldest zone) and with few exceptions, all temperatures are well above the recommended levels of 3°C in the lower compartment. Some measurements even exceeded the ideal average temperature (across all temperature zones in the refrigerator) of 7°C. [27]

Box diagram 1: **Duration of stay of selected food in households**



Box diagram 2: **Data on refrigerator temperature**



The functionality of the packaging stops at home!

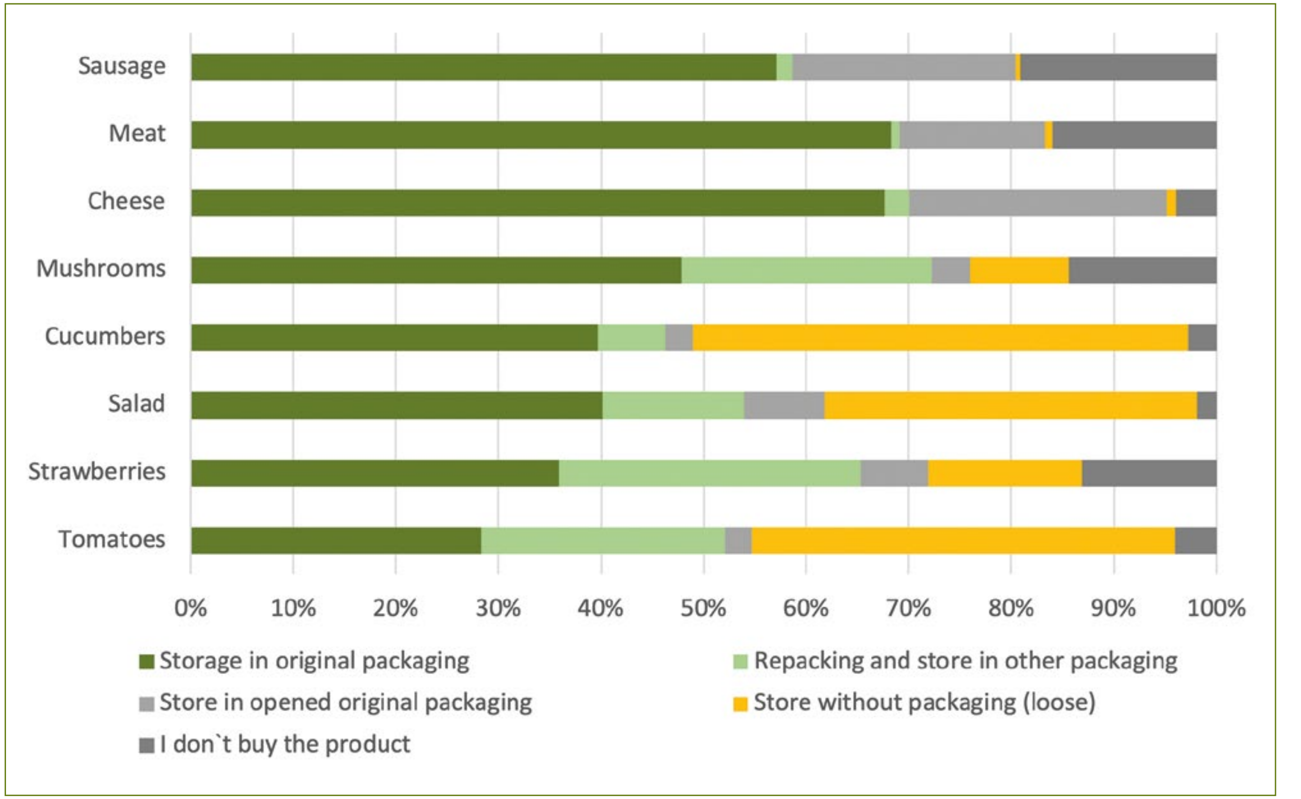
After opening the packaging food is usually unpacked or repacked. Fruits and vegetables in particular are removed from the packaging immediately after purchase. Consumers are most likely to use the original packaging for cheese, meat and sausages. Less than 30% of tomatoes are kept in their original unopened packaging.

Surveys show consumers rarely or never utilise the optimised packaging in their own homes. In most cases, the shelf-life-prolonging feature of food packaging is not perceived as such. Existing storage habits determine how the product is handled regardless of the specific packaging itself. However, when the advantage of packaging is recognized, it is consciously accepted by consumers (e.g. vacuum packaging of meat).

Change in storage habits, upgrading of the packaging and its functionality

- The consumer should be made aware of the functionality of packaging and the problem of food waste
- Education through awareness building measures
- Exemplary storage of food within the industry
- Clearly visible information on packaging

Handling of unopened Packaging at Home (Survey no. = 1117)

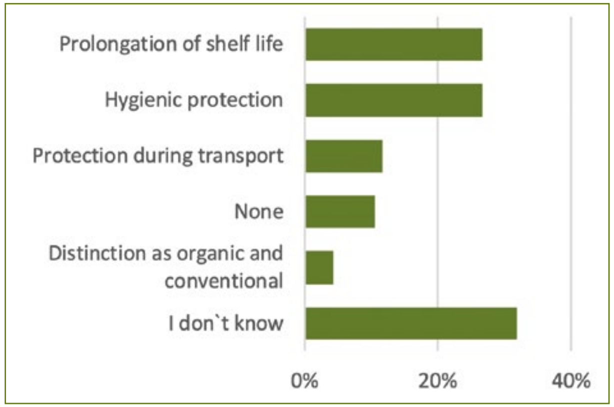


3.3. Packaging function for consumers: knowledge and fnformation

Lack of information and knowledge about packaging!

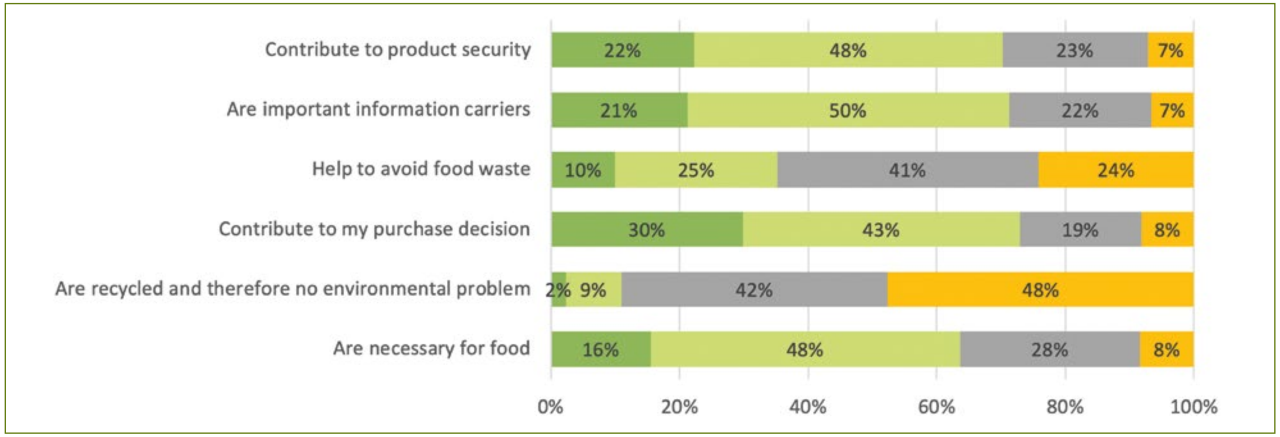
The consumer sees the need for food packaging in today's supply chain but there is a lack of awareness about the advantages and functions of optimised packaging. Only when the benefits of a packaging are recognised, will it be positively accepted.

Function of film packaging for cucumbers
(Survey no. = 94)



Food packaging is as indispensable as transport and hygiene protection during distribution within the supply chain. Consumers are only slightly aware of the advantages of packaging in their own homes.
Only in the case of sensitive products such as fresh meat or sausage do consumers recognised the advantages of packaging – especially the extended shelf life. Also there is a growing willingness to continue using this in the household. However, consumers do not recognise the relationship between packaging and the possible reduction of food waste.

Statements on packaging (Survey no. = 1117)



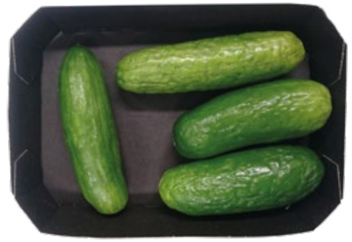
Statements on food (Survey no. = 1117)

3.4. Unpackaged versus packaged: example cucumber and mini cucumbers

Doing away with packaging is not necessarily better!

Today it is often propagated that we should avoid packaging wherever possible. However no such general statement can be derived from the results of life cycle assessments. Rather, it depends on whether the omission of packaging generates more food waste in retail and/or households because the products are less protected. The disadvantages of additional waste must then be compared with the advantages of no packaging at all.

Better packed or unpacked?

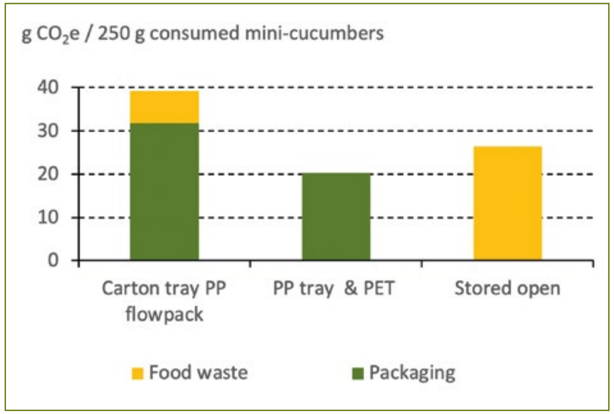


In all cases where unpackaged goods generate no waste either within the industry or with consumers, packaging should, of course, be avoided. Before packaging is omitted entirely we should test whether the quantities of food waste within the market are altered by the omission of packaging.
When consumers buy unpackaged food they should be sure that the products they buy will be consumed swiftly and in their entirety.

Examples: Since 2014 a concrete study has been carried out for ham, cucumbers and mini cucumbers to determine how the unpackaged variant performs compared to the packaged variant.

Example 1: For **cucumbers** a thin plastic film reduces the waste rate in the retail trade from 9.4% to 4.6% (6-month observation period in more than 250 stores). The environmental benefit of reducing waste is three times higher than the cost of packaging [4].
In another Austrian retail chain, the protective film has not been used for salad cucumbers since 2019. This increased the amount of waste by a factor of 2.7. The carbon footprint of the additional waste is four times higher than the carbon benefit of reduced packaging.

Example 2: mini cucumbers
At the OFI Institute the durability of mini cucumbers was determined in storage tests. At an ideal storage temperature of 8°C, the shelf life in a **carton tray with PP flowpack and macro-perforation (1)** was 12 days, in a **PP tray with microperforated PET flowpack (2)** 23 days and **unpacked** only 6 days. In combination with assumed, plausible consumption scenarios (see page 35) this resulted in the following waste rates (sum of retail and household): 14.5% for unpackaged mini cucumber figures; 4.0% in packaging (1); and 0% in packaging (2). The life cycle assessment suggests packaging (2) to be the winner, followed by the variants unpackaged and packaging (1). For results for other packaging options, see page 35.



3.4. Unpackaged versus packaged: example ham

Choose the option you actually need!

In an online survey, over two thirds of the respondents preferred fresh ham from the deli counter to already packaged goods, whereas the sales trend in reality suggests the reverse of these results. In any case, the choice should really depend on the duration until the product is actually consumed! If the ham is eaten within a few days after purchase, the advantages of the deli counter outweigh the disadvantages. However, as the period until consumption increases, the advantages of the packaged goods are more apparent. Here, the advantages of a longer shelf life (even after opening the packaging!) speak for themselves.

Resealable MAP Tray (MAP)

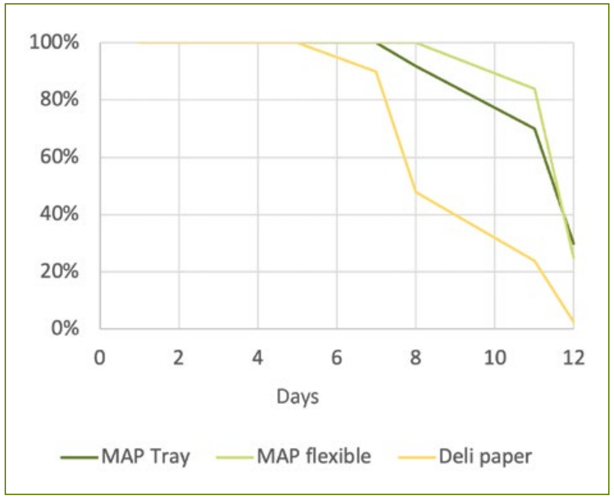
Flexible Plastic Paper MAP Packaging

Deli Wrap with Intermediate Foil

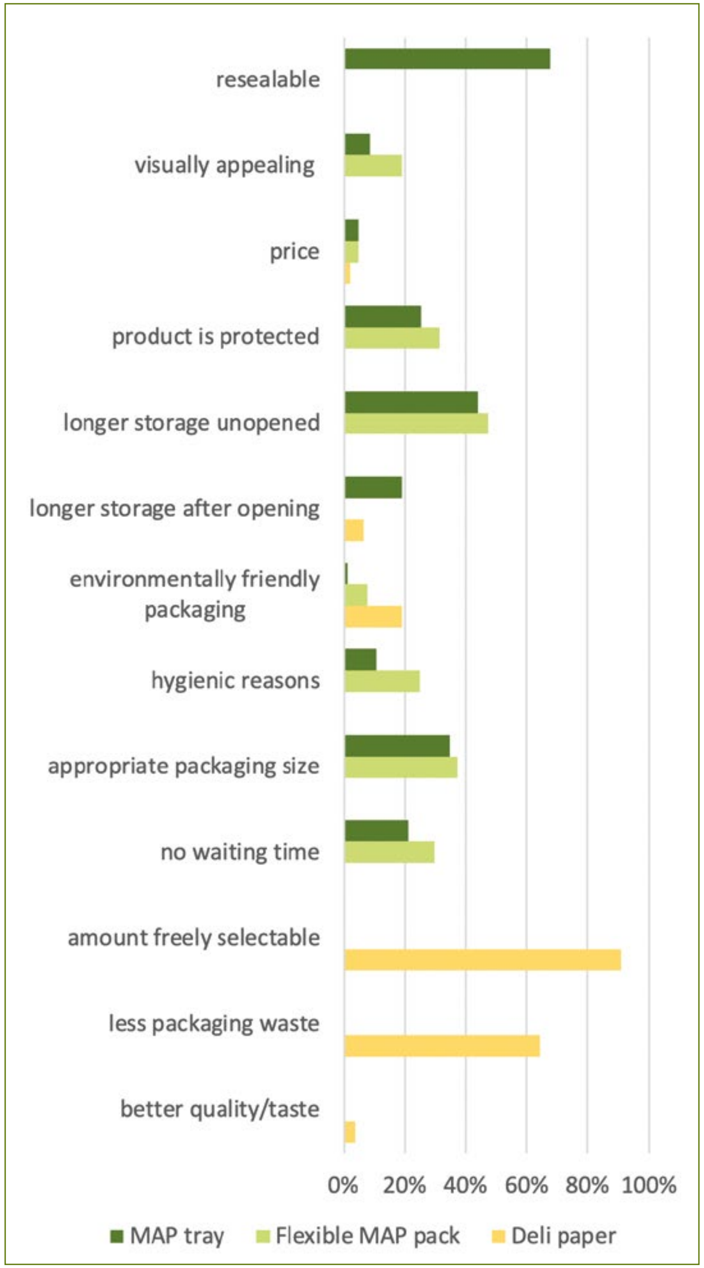
Cooked ham example: consumer case study:
The presumed fresh ham from the deli counter is not always the most suitable choice – it depends strongly on the length of time it takes until the product is finally eaten. The consumer studies confirm this assumption. Whilst those surveyed prefer ham from the deli counter, they drift towards packaged alternatives as the consumption period progresses (pictured left). A side note: products from the fresh food counter are often not considered packaged by customers, even though they are packed in delicatessen wrapping.

Less than 50% of the respondents stated that the longer shelf life for packaged ham was a reason for their purchase decision.

Consumer's Perception of Ham's Edibility after Opening the Packaging



Reasons for choosing packaged ham
(Poll no. = 885)

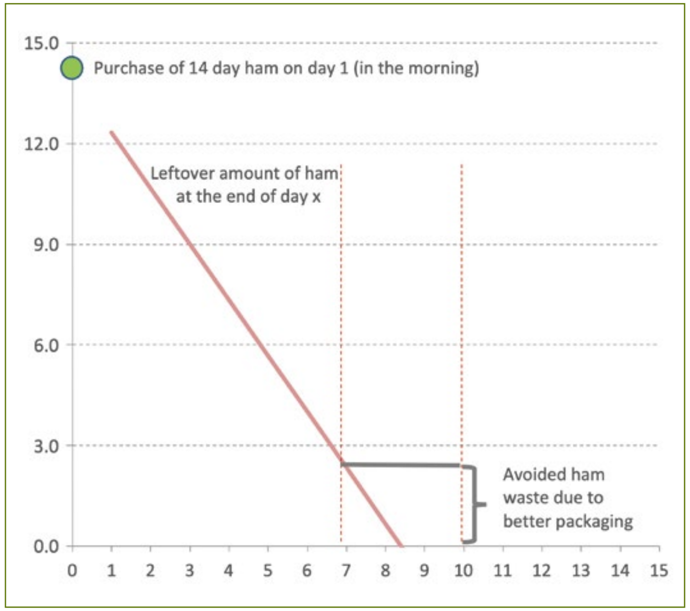


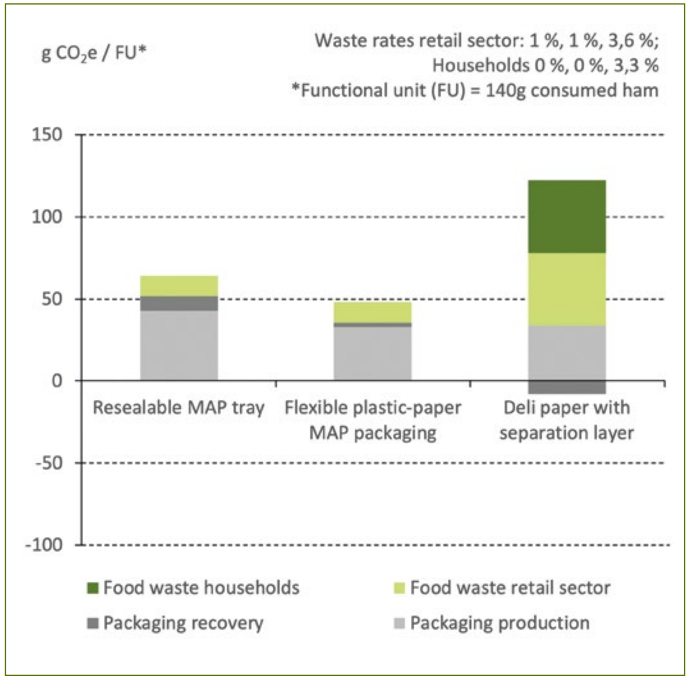
Cooked ham: environmental evaluation

140g of cooked Ham was compared in three types of packaging:

1. Re-sealable MAP tray from the self-service shelf (PET/PE tray, PET/PE top film, protective gassing, re-sealable); approx. 1% waste in retail
2. Flexible MAP pack from the self-service delicatessen (paper laminate film at the bottom, PET/PE film at the top); approx. 1% waste in retail
3. Delicatessen paper with intermediate film and paper bag (with 3 products) from the fresh food counter; approx. 3-4% waste in retail

The consumer case study showed that they no longer ate the open ham from the deli counter from day 8 onwards, whereas the products from packages (1) and (2) were not thrown away until day 10. For example, it was assumed that the following "worst case" scenario occurs in only 20% of all cases: when all 3 of the ham products are in the fridge for the same length of time, consumption is in line with the Austrian average. Then after the 7th day, 16.6% is still left (= on average 3.3% waste of ham from the deli counter). **When comparing the climate impact, packaging (1) and (2) perform better, even if no waste is produced in households. However the much shorter shelf life of ham from the fresh food counter significantly increases the risk of waste.**





3.5. Portion packaging

Although today consumers consider food products to be over packaged, portioned packaging offers a sensible way to reduce food waste.
By packaging in sections the spread of mould and bacteria is restricted.
This type of packaging is particularly beneficial for food that is not eaten every day and can therefore easily be forgotten in the refrigerator.

Bite-sized food instead of tons of waste

Products that tend not to be eaten daily and are not consumed in their entirety (especially in single households) often remain open in the refrigerator for long periods. By the time the appetite for the products returns, the items are thrown away because they are usually classified as inedible. The visual impression is usually the decisive factor in this decision. In contrast to this, consumers will eat a whole single serving portion packaged product after opening it for the first time.

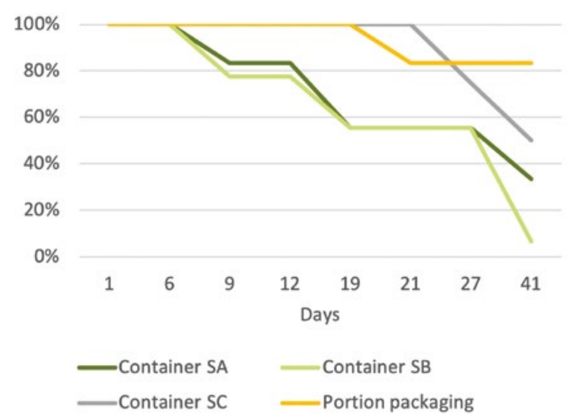
Recommended steps:

- Convey to consumers that food spoilage has a greater impact on the environment than additional packaging
- Communicate the advantages of single serving portion solutions, especially to consumers from single households

Cream cheese example

Example 1: cream cheese:
150g in comparison with portion packaging (8 x 15 g) – Case Study: a layperson sensory test with both types of packaging (under defined sampling scenarios) clearly shows the difference in shelf life in favour of the portioned versions. The diagram shows from when and which portion of the fresh cheese would be thrown away. The question was: "Would I still eat the product at that current time?“

Consumer's Perception of Cream Cheese’s Edibility After Opening Packaging



SA...Scenario A: Removal with clean Knife
SB... Scenario B: Removal with contaminated Knife
SC... Scenario C: Removal with licked Knife

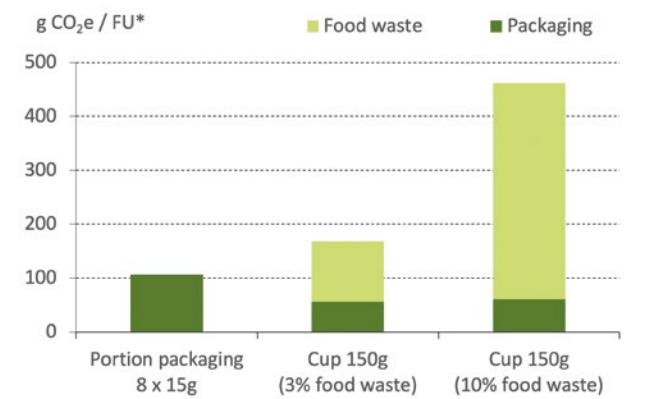

150g cream cheese


Portion packaging 15g

Cream cheese: 150g compared with portion packaging (8 x 15g) – environmental assessment

In the life cycle assessment (LCA), all packaging components and the results of the consumer case study were taken into account (150g container: about 45% of the samples were discarded at the end of the 18th day; portion packaging: no waste by the 19th day). The following consumption scenario was assumed: consumption of 15g/day; after the initial period of 4-8 days, 30% of consumers will leave the product in the refrigerator for 10 days and forget it; after that, consumption is continued. Resulting waste rates: on average 3% or 10% in those cases where it has been left forgotten in the refrigerator.

The study shows a positive environmental impact as the higher cost of portion packaging is offset by a 1.5% reduction in food waste. In addition, effects of eutrophication, acidification, water and energy consumption were also calculated, with similar results.



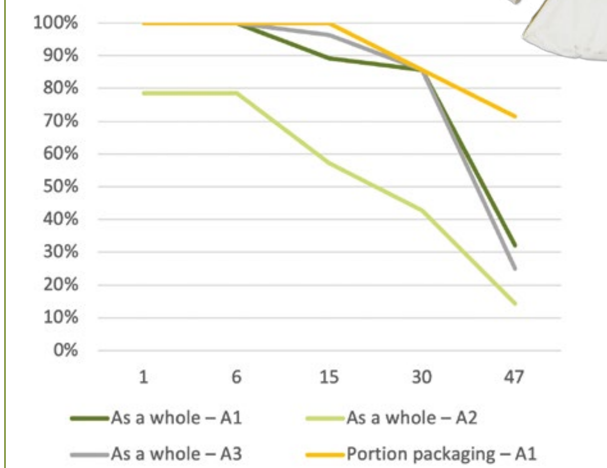
*Functional unit (FU) = 150g consumed cream cheese

Camembert Example

Example 2: whole camembert, 300g compared with portion packaging (6 x 50g) – case study

The camembert example also shows the advantage of portion packaging over a longer period of time. While 65-85% of the whole camembert samples were discarded on the final assessment day by the testers. Depending on storage, this was only 30% for the portioned alternative. In addition, the majority of those tested still ate the remaining packaged portions, even though, as with packaging whole cheese, the optimum consumption date had been exceeded.

Consumer perception of camembert's edibility after opening the packaging

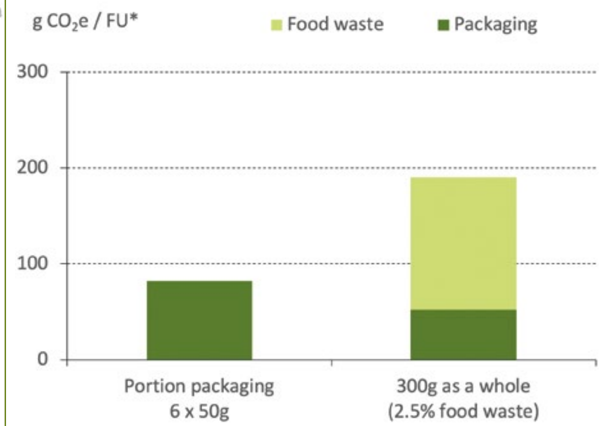


Storage in original packaging (A1), in plastic containers (A2) or cling film (A3))

Camembert: environmental assessment

Portioning from 300g to 6 x 50g means that 3.3g more composite paper is required. The cardboard outer packaging remains the same. The consumption is modelled at 15g/day. In the consumer case study, the Camembert was still consumed on the 15th day (25% of product still remaining); 10% of the samples were discarded. The resulting waste rate of 2.5% was taken into account in the LCA (no waste in portion packaging). The following diagram shows that the effort required for portioning is worthwhile.

The CO_2 benefit of this reduction in food waste is approx. 4-5 times higher than the environmental effects of the additional packaging, which would be offset by as little as 0.6% of avoided waste.



*Functional unit (FU) = 300g consumed Camembert

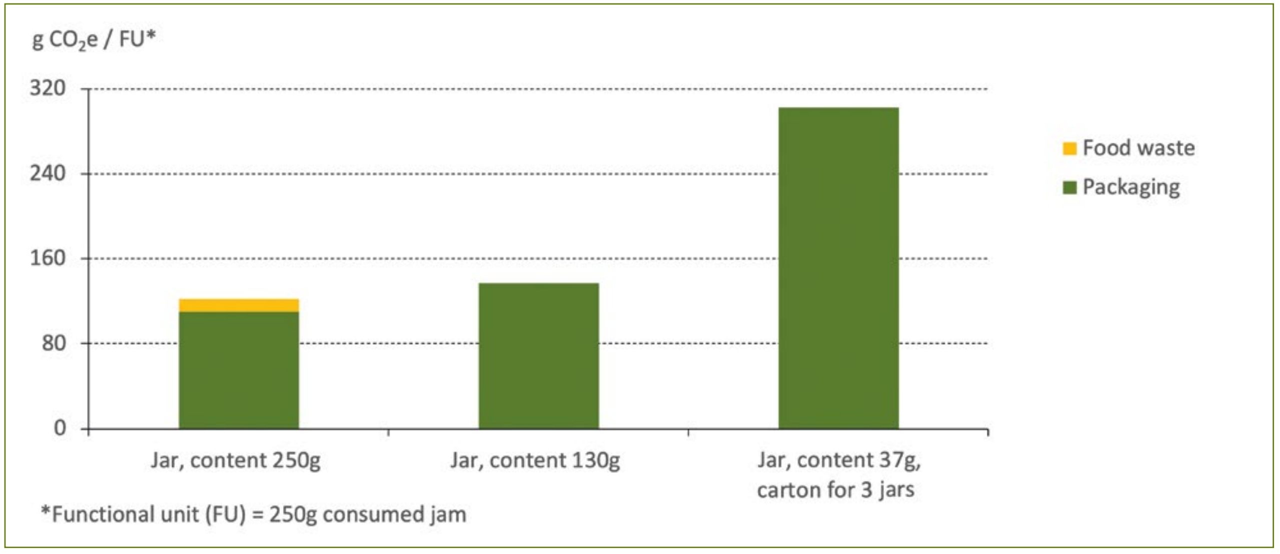
Jam example

Example 3: jam in various packaging sizes
For jam, the following package sizes were compared: 250g; 130g; and 3 x 37g. In the case study, the shelf life of the opened jam jars were examined at different storage temperatures and under specific dispensing scenarios. The simplified results are as follows: If jam is stored at 4-8°C in the refrigerator, with minimum contamination and not left open for long periods at room temperature, the product quality is maintained for about 6 weeks after opening. If the jam is heavily contaminated by spoons or knives and left to stand (open) at room temperature for a long time, mould can appear after 14-28 days.

In this LCA assessment, the following consumption scenario was presented for strawberry jam: the average consumption of jam is about 7.3g per day (it was assumed that 25% of all people do not eat jam). It has been assumed that 20% of consumers heavily contaminate the jam when eating it and leave jam jars out at room temperature for longer. In these cases, jam is consumed on average for 21 days (152g in total), the rest is thrown away. On average, this results in 7.7% of jam waste for the 250g jar. There is no waste with the smaller package sizes.

So, when considering a 250g jar (packaging materials and food waste; without the effect of the amount of food consumed) the 7.7% of jam wasted is only responsible for a 16% share of the overall environmental impact. On the one hand, this is due to the fact that only seasonal strawberries with a low carbon footprint are used for jam production (no heated greenhouses). On the other hand, the production of glass packaging requires a relatively large amount of energy, even with a high proportion of recycled material, which is why food waste is less significant here than in the case of lighter packaging. **A packaging size of 130g would only pay off at approx.** 20% of jam wasted (at 20%, the additional expense incurred for the smaller packaging and the benefit of reduced food wastage is the same for the larger packaging).

The additional expense for smaller package sizes is significantly greater than the environmental expense for the average jam waste (7.7%), which is modelled in a straightforward manner. The smaller jar with 130g content is only economical if the 250g jar produces an average of 20% waste.



*Functional unit (FU) = 250g consumed jam

3.6. Data and facts versus image and perception: example egg packaging

Example: egg packs made from 100% recycled PET beverage bottles, compared with conventional egg cartons.

For eggs, it was examined how different packaging materials and transport packaging influence both the breakage rate and the life cycle assessment results.

Practical data from the Austrian retail sector (from all shops of the participating retailer, over the course of a whole year) show that the breakage rates for eggs in Austria are below one per thousand. In comparison to experiences in other countries (breakage rates of 0.5% - 2%) this is extremely low and demonstrates excellent product protection.

Results of the life cycle assessment are mainly influenced by the fact that egg cartons are about 42% heavier than packs made from 100% recycled PET beverage bottles (R-PET). In addition, the high water consumption of carton processing also leads to higher energy consumption.

Methods and data sources were checked by a critical review panel. Page 15 also shows the comparison of costs.

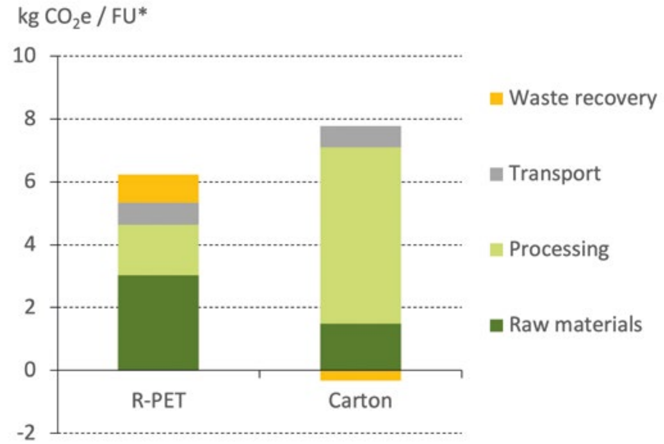
Two interesting conclusions:
The example of egg packaging shows that the assessment of packaging is often too simplified. Alternatives to plastic do not automatically have to perform better and differentiations must also be made within plastic packaging.

1) The R-PET egg pack is actually the perfect example of sustainable 'circular plastics' packaging:

- made from 100% recyclate, this contributes to reduction of marine littering by increasing the value of used bottles
- transparent mono-material
- 100% recyclable, giving high quality recyclate
- very high product protection
- minimum material consumption
- often cheaper (page 15) and advantageous in the packaging process

2) For the consumer a quantitative evaluation of the environmental impact is not necessarily an intuitive process. It is therefore essential to examine the environmental effects in detail:

- lower carbon footprint than egg cartons
- lower energy and water consumption



No relevant difference between breakage rates
*Functional unit (FU) = 1000 eggs, 10 eggs/pckg.

Testing the protective function of egg packs
In drop tests, pallets with egg packs were dropped on one side by up to 15cm. According to the Austrian delivery logistics, 14 packs of 10 eggs were in one cardboard box. No damage to the eggs was found in either type of packaging (egg cartons, or R-PET). Also in the two practical trials carried out using small trucks no damage occurred to either type of packaging.

In Austria, transport boxes usually contain only two to three layers of egg packs on top of each other. Therefore breakage rates are very low in this country. In other countries with higher breakage rates up to 13 layers are often stacked on top of each other.

3.7. Data and facts versus image and perception: relevance of littering

Leaving packaging behind as litter in the environment is an absolute no-go. There is a broad consensus on this. All consumers must make their own contribution.

In Austria, where the quantities of litter left behind as waste in the enviroment are very small, this issue should not be the main driver of the image of packaging. The effects of packaging on CO_2 emissions, but also on food waste, are much more important.

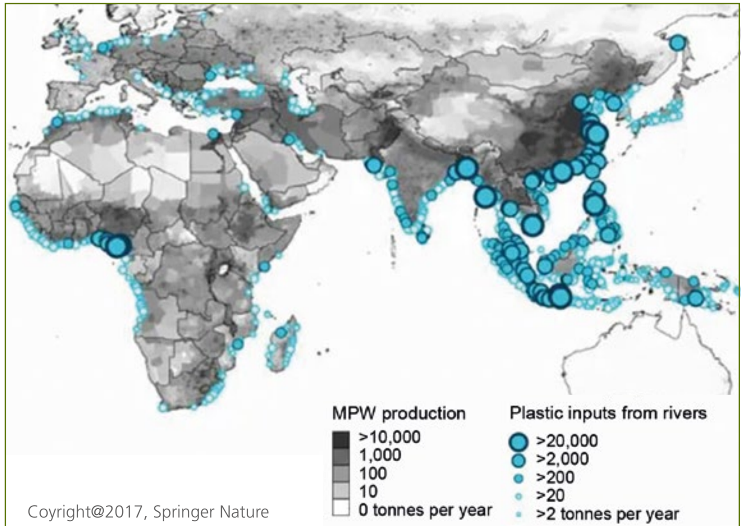
In recent years, the image of plastic packaging in particular has deteriorated due to the problems caused by marine litter. From a global perspective, there is a great need for action in certain regions. Two thirds of the plastic waste discharged into the sea comes from only 20 rivers, mainly located in Asia. [16]

However the situation in Austria, Germany and Switzerland differs significantly from countries where waste collection/recycling is only just beginning. In these countries, more than 99% of all packaging waste is collected and sent for mechanical recycling or energy recovery. [1]

The Environment Agency Austria [13] has measured the amount of microplastics, up to 5mm in size, that reaches the sea from Austria via the Danube. The volume of plastic particles included is 0.05 per thousand of the total Austrian plastic packaging waste volume. The largest source of microplastic pollution is tyre abrasion. The second most significant source of pollution in the consumer goods sector is abrasion from clothing (shoe soles, fibres from textile washing). [1]

A report by trucost [25] has studied the global environmental impact (converted into environmental costs) of plastic consumer goods. Despite much higher quantities of litter than in Austria, only 3.6% of the overall impact comes from marine littering and 51% from GHG emissions.

Plastic waste from rivers [16]



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Microplastics up to 5mm in size in the Danube [13]

The Environment Agency Austria and the University of Natural Resources and Applied Life Sciences carried out measurements of the microplastic load in the Danube in 2014. As a result, the annual freight leaving Austria via the Danube was estimated to weigh a maximum of 41 t/a. 14 tons of this amount already came from Germany and of the 27 tons from Austria, a maximum of 15 of these tons originated from packaging material. In comparison with the total plastic packaging waste quantity of about 300,000 t/a, this is 0.05 per thousand of the total quantity.

4. Product specific recommendations

The need for protection of food products is very different. For strawberries good cooling is crucial; for beef vacuum packaging is ideal. Some foods must be protected from oxygen or other influences using barrier layers. Even the number and size of the holes in a packaging film can be decisive. Packaging should therefore fulfil certain functions as well as possible and, if possible, be recyclable or reusable. Some examples in this chapter deal with the often important search for the optimum.

4.1. **Vacuum packaging for fresh meat: consumers' view**

4.2. **Vacuum packaging for beef: MAP trays versus vacuum skin packaging**

4.3. **Barrier layers: necessity, over performance, recyclability – example coffee capsules**

4.4. **Strawberries like it cold**

4.5. **Packaging for snack tomatoes: hole size in films**

4.6. **Packaging for mini cucumbers: hole size in films, bio-based films**

4.7. **Packaging for refrigerated transport: cooling capacity and choice of material**

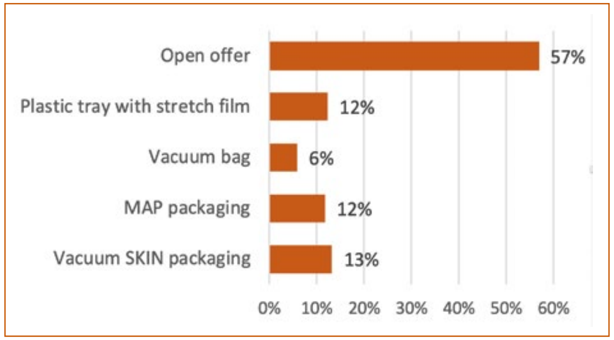
4.1. Vacuum packaging for fresh meat: consumers' view

Every year in Austria around 65kg of meat is consumed per person. Compared to other food categories, smaller amounts end up in the waste of an average household. Most of the time fresh meat is consumed immediately or frozen. The positive effect of shelf-life extending packaging within the industry is undisputed. However, the effects of such packaging on consumers can hardly be assessed due to a lack of comparable alternatives.
As soon as the protective function is understood by consumers it is actively desired. Vacuuming of fresh meat should therefore be offered in the delicatessen section of the retail environment.

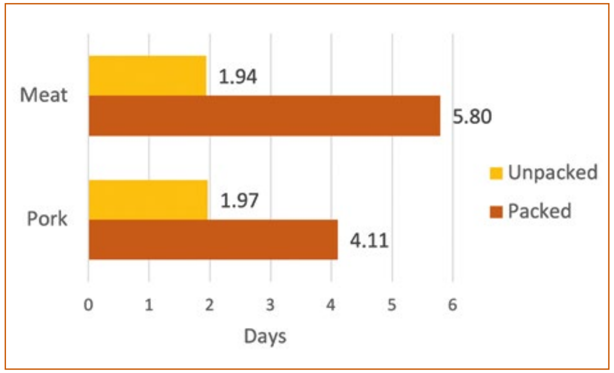
Survey Results:
In an online survey (no. = 1117) as well as in surveys at the point of sale, consumers stated that they prefer fresh meat. Fresh meat is mainly stored in the refrigerator for 1 to max. 3 days (according to two thirds of respondents) before being processed and consumed. Few respondents buy meat in bulk, mostly it is frozen immediately at home.

The option of vacuum packaging fresh meat from the counter is well known and is used predominantly in butchery shops.
Consumers are particularly aware of the advantages of vacuum packaging for sensitive products such as fresh meat. They are also used specifically to extend the shelf life during storage at home.

Information from consumers on the type of packaging they are most likely to buy for beef



Average Storage Period of Meat



Statements on Vacuum Packaging

4.2. Vacuum packaging for beef: MAP trays versus vacuum skin packaging

Example: Beef cuts in MAP packaging and in vacuum skin packaging
Beef cuts are currently offered in PET trays with protective atmosphere (MAP = modified atmosphere packaging; PET/PE lidding film).
As an alternative, vacuum skin packaging was investigated (PET base film with a high recycled percentage; PE top film with barrier layer).
Vacuum skin packaging increases the minimum shelf life on the retail shelves (excluding storage time for maturing meat) from 6-7 days (MAP) to 12-14 days (skin). The waste rates in the retail sector during the three-month test period were 5.8% for MAP and 3.7% for vacuum skin packaging. **This waste reduction is the main reason for reduced emissions when accounting for environmental impacts** (see graph).
In addition to the environmental advantages of vacuum skin packaging, the cost benefits of this type of packaging are also described on pages 14 and 15. Here all the relevant costs and savings in the supply chain are taken into account.

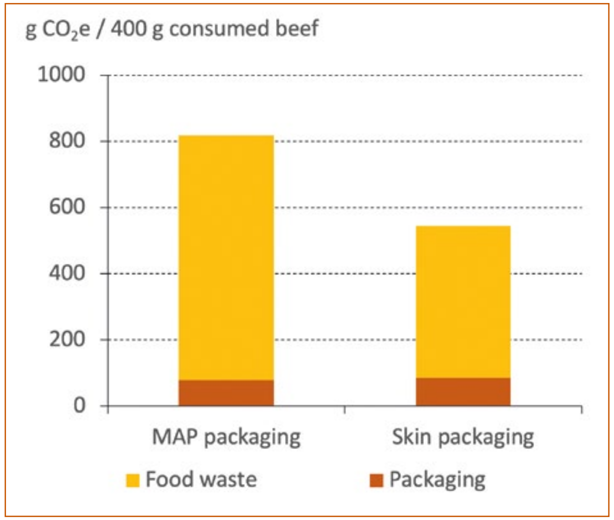
Adverse effects of vacuum packaging such as an odour from products when opened could not be detected in sensory tests, or in measurements using gas chromatography. Also in the interviews with consumers the smell of the products, when opening vacuum packs, was not considered disturbing or relevant.

Vacuum skin packaging has already established itself for high-quality beef products. Corresponding waste reductions were proven in the denkstatt [12,13] study. Organic beef cutlets have also been sold in vacuum skin packaging for some time.

During a three-month test within the framework of the project, conventional beef schnitzels were also offered in skin packaging. Interestingly, this type of packaging was not as well received by consumers during the test period as the MAP tray packaging. The reasons for this could, unfortunately, not be clarified in this research project. Offering both packaging variants alongside each other, combined with surveys at the point of sale, could provide valuable information for further research.

Vacuum thermoformed packaging is also used for many meat products. Vacuum packaging is currently only used to a limited extent for pork. The expectations of Austrian consumers regarding the colour of the meat often cannot be fulfilled with vacuum packaging.

The cost of packaging production and recycling is slightly higher for vacuum skin packaging (8% more CO_2e emissions).
However this is offset by the benefits of reduced food waste, which is 42 times higher than the additional cost of packaging.



4.3. Barrier layers: necessity, over performance, recyclability – example coffee capsules

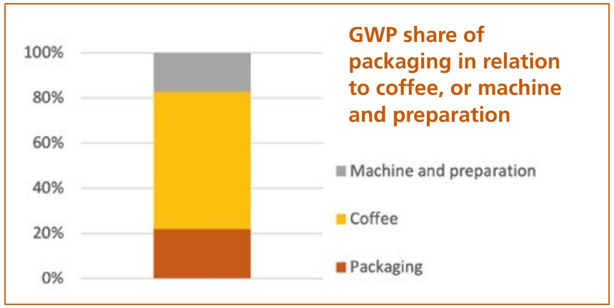
Coffee is valuable

Since the environmental costs of producing coffee beans are so high, it is worthwhile taking measures to make the best possible use of coffee. Coffee capsules can be useful, given the risk that some of the coffee brewed conventionally will then have to be thrown away later.

In order to preserve the aroma of the coffee as best as possible, the packaging must provide a barrier against the intrusion of oxygen. Using the example of coffee capsules, **it was examined how the requirements regarding barrier needs, as well as recyclability, can be best fulfilled.**

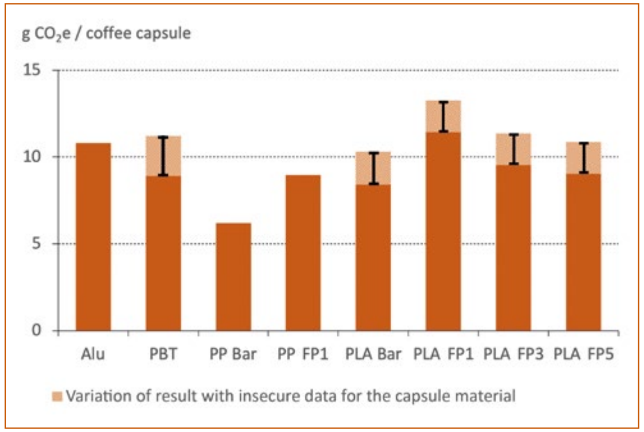
The results regarding **greenhouse gas emissions** show the following sequence: 1. PP capsule with EVOH barrier; 2. PP with flowpack (FP); 3. PLA with barrier in the capsule; 4. aluminium capsule and PBT capsule; 5. PLA capsules with flowpack. When looking at the coffee industry overall, by far the greatest impact on the environment comes from coffee production. The contribution to this from coffee capsules is only around 20%. Preserving the coffee aroma and thus reducing food waste is therefore the biggest factor when justifying packaging optimisation. The PP capsule with EVOH barrier scored best in regard to the other environmental effects investigated (energy and water consumption, mineral resource consumption).

Ideal barrier solution versus recyclability: the solutions using barrier layers in the capsules show better results than those with barrier layers in the additional flowpack. The PP capsule with EVOH barrier is generally very easy to recycle. An increase in recycling to 50% reduces the carbon footprint of the capsules by max. 10%; that of a cup of coffee by max. 1%; other environmental categories by max. 5%; or for a cup of coffee by max. 0.2%. Energy recovery is better for PLA than mixing it with recycled plastics.



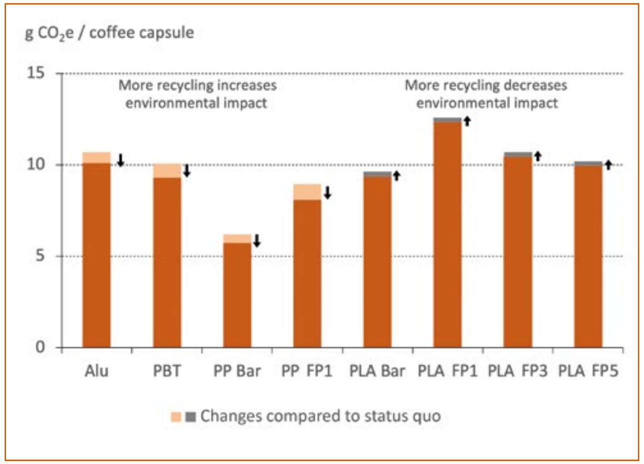
GWP share of packaging in relation to coffee, or machine and preparation

Climate impact throughout the life cycle vs current waste recovery



Investigated commercial capsule materials: Aluminium (Alu); Polybutylene Terephthalate (PBT); Polypropylene (PP); Polylactic acid (PLA). The capsules made of PP and PLA were examined in 2 variants: a) Capsule and Lid with a Barrier Layer (Bar): Alu, PBT, PP Bar, PLA Bar; b) Barrier in the flowpack instead of capsule and lid; 1-5 capsules per flowpack (FP1-FP5). Current estimated recycling rates: Alu 30%, PP and PLA 5%, PBT 0%.

Climate impact over the life Cycle vs 50% recycling for all capsules



In addition to the environmental assessment of coffee capsule variants, the OFI Institute carried out investigations into product protection and minimum shelf life. For the purpose of this study the standard coffee capsules were stored in accelerated conditions*. After storage, sensory tastings and the analysis of oxidation-sensitive substances in the coffee were carried out using headspace GC-MS analyses. It turns out that the manufacturers' minimum shelf life (9 and 12 months) are basically fulfilled by all capsule materials used for this ecological assessment (partly incl. flowpack with barrier). For comparison the product protection range for all capsule materials assumes a 9-month storage period.

The results of the life cycle assessment show, however, that it makes more sense to integrate the product protection of coffee capsules directly into the primary packaging than to achieve this with additional outer packaging. In the case of the PP capsule with EVOH barrier, the barrier property can even be combined to ensure full recyclability. Already now and especially in the future, recyclable high-barrier composites (probably also bio-based materials such as PEF) are available and thus, pave the way for environmentally improved packaging solutions.

Capsule material	Best before date
Aluminium	12 months
PBT	12 months
PP/EVOH/PP	12 months
PP with BFP	12 months
PLA Barrier	9 months
PLA with BFP	12 months

Stated shelf life, confirmed by accelerated storage tests; BFP...barrier flowpack

4.4. Strawberries like it cold

Strawberry waste reduction

Sufficient cooling during storage can, depending on the product, generate optimal shelf life. An additional packaging function beyond transport protection is, therefore, not necessary in these cases.

Continuous cold storage (3-5°C) for strawberries along the entire logistics chain and for consumers (usually in the lowest vegetable drawer of the refrigerator) are strongly recommended, based on the project results.

Strawberries were stored at 3-5°C for a shelf life of approx. 7 days (see picture below left), which could not be achieved using optimised additional packaging films at a storage temperature of 8°C (see picture below right: arrows mark strawberries with strong pressure marks, very soft strawberries or if beginning mould).

In future projects it should be clarified, especially for soft fruits, what has the greater impact on the environmental footprint: the energy required for cooling or the benefits of reduced waste.

*) Due to the long minimum shelf life of the coffee capsules between 9 and 12 months, accelerated storage tests were used. These were carried out at 40°C and 100% oxygen atmosphere and thus led to an acceleration of about 17 times compared to storage at 20°C and 20.9% atmospheric oxygen.

4.5. Packaging for snack tomatoes: hole size in films

Optimised perforations (hole size, position and quantity) can lead to extended shelf life for snack tomatoes in packaging films currently in use.

For example, there are currently 250g of snack tomatoes available in PET trays with a PET/PE lidding film. The packaging has several large holes. With adapted microperforation* (central row of holes, hole size approx. 1-2mm, 3-6 holes per package) the shelf life of snack tomatoes at a storage temperature of 23°C could be extended from approx. 14 days to approx. 35 days.

We expect that the shelf life of other types of tomatoes can also be optimised by using similar perforations adapted to the product in question.

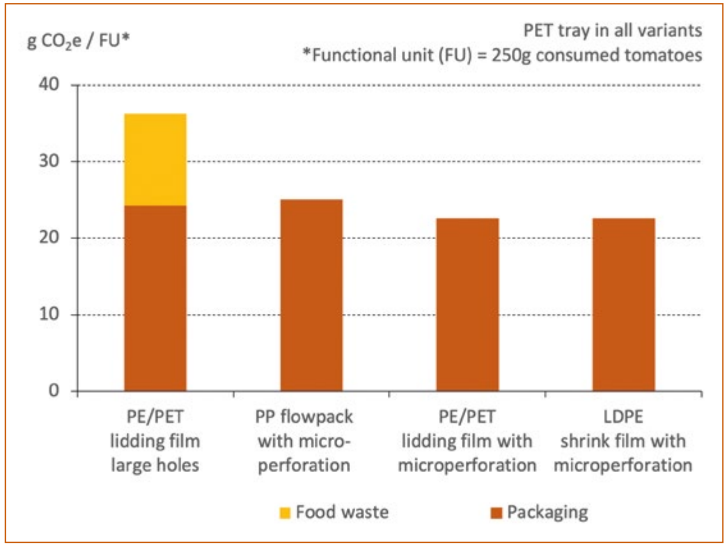
Packaging with adapted microperforation* in lidding films also scored best in the LCA assessment. The additional expenditure incurred for microperforation is minimal. At the same time, the environmental benefit of only a 6.6% reduction in food waste is equal to 50% of the production and recycling of the packaging.

The correct number, position and size of holes in a packaging film can contribute to an optimum storage time. This is especially true for moisture-sensitive foods, as the microclimate within the packaging is a beneficial feature.

Conventional packaging after 35 days

Perforated packaging after 35 days

*) The term "microperforation" is generally used for hole diameters of approx. 70-150 µm; the term "macroperforation" is used for hole diameters in the millimetre range (usually > 5 mm).



Packaging	Shelf life (days, 20°C)	Waste Rate
V1 - PET tray, PE/PET lidding film - large holes	14	6.60%
V2 - PET tray, PP flowpack - with microperforation*	35	0.00%
V3 - PET tray, PET/PE lidding film - with microperforation	35	0.00%
V4 - PET tray, LDPE shrink film - with microperforation	35	0.00%

The waste rates for snack tomatoes result from plausible models of storage times and consumption rates (75% consume the product quickly – no waste; 20% eat only two snack tomatoes per day and 5% only one).

4.6. Packaging for mini cucumbers: hole size in films, bio-based films

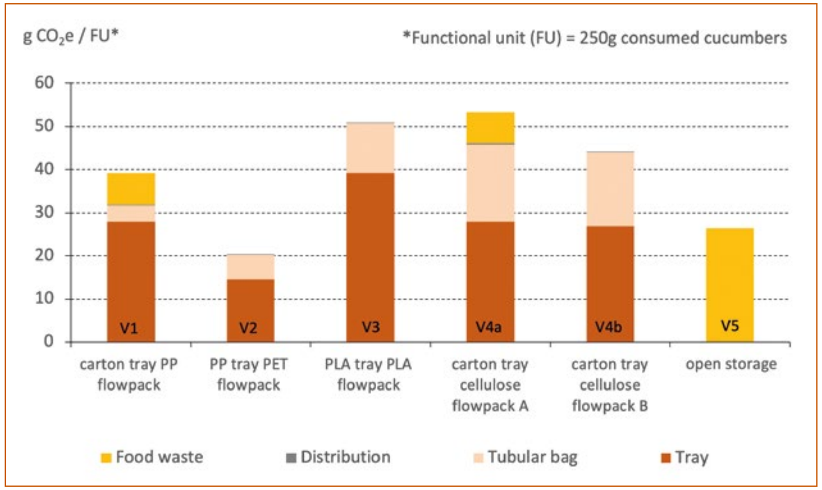
In the case of mini cucumber figures, optimised perforations (hole size, position and quantity) in packaging films currently in use and possibly also PLA films, can lead to extended shelf life. In a life cycle assessment of unpackaged mini cucumbers, compared with different packaging options, the PP tray with micro-perforated PET flowpack performs best. For the other options the cost of packaging outweighs the disadvantages of expected waste levels of unpackaged mini cucumbers.

In this example 250g mini cucumbers are displayed in a carton tray with a PP flowpack. The packaging has several large holes (macroperforation*). Storage tests at the OFI Institute at 8°C showed a shelf life of approximately 12 days. For unpackaged mini cucumbers the figures showed a 50% reduction in this shelf life. Temperatures that were too cool (4°C) also led to a reduced shelf life. Temperatures around 8°C (usually the uppermost part of the refrigerator) are apparently ideal for mini cucumbers. The use of a microperforated PET flowpack resulted in a shelf life of up to 23 days, with the item in excellent condition. The shelf life in the cellulose flowpack fluctuated in the tests, therefore 2 scenarios are shown here (a shelf life of 12 and 17 days respectively).
The waste rates for unpackaged mini cucumbers and for the different packaging options are based on plausible models of storage times and consumption rates (60% consume the product quickly – no waste; 30% eat only one mini cucumber per day and 10% eat an average of only 25g/day).

The biodegradable plastic films tested did not show any clear advantages over conventional plastics in terms of extending the durability of mini cucumbers. As with snack tomatoes, optimising the number and size of the holes has the greatest effect.

Unpacked:
All cucumbers clearly wrinkled after 8 days of storage at 8°C

Microperforated film:
crunchy cucumber without surface drying out after 23 days storage at 8°C



Packaging	Shelf life (days, 8°C)	Waste Rate (open storage after 6 days, packed after 12 days)
V1 - carton tray, PP flowpack - large holes	12	4.00%
V2 - PP tray, PET flowpack - microperforated	23	0.00%
V3 - PLA tray, PLA flow pack - unperforated	17	0.00%
V4a - carton tray, cellulose flowpack - without holes	12	4.00%
V4b - same packaging as in V4a, but longer shelf life	17	0.00%
V5 - Open storage	6	14.50%

*) The term "macroperforation" is used for hole diameters in the millimetre range (usually > 5 mm); the term "microperforation" is usually used for hole diameters of approx. 70-150µm.

4.7. Packaging for refrigerated transport: cooling capacity and choice of material


EPS insulation


Foodmailer


Hemp thermo-folding box


Hard box

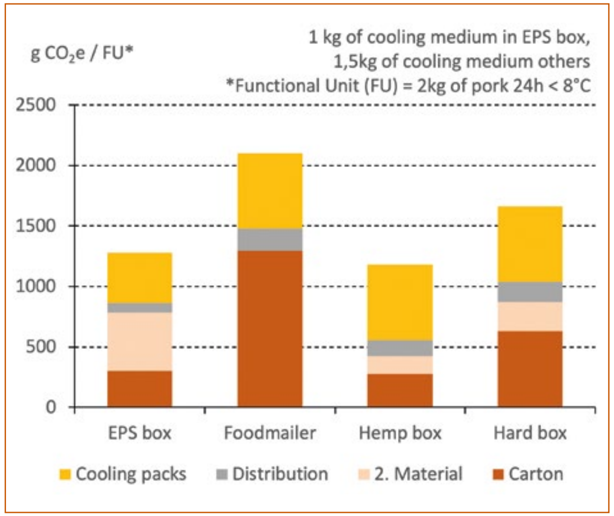
Comparing transport boxes
When considering the shipping of refrigerated products four different boxes were compared (e.g. for online ordering). In order to avoid food waste the desired maximum temperature must be maintained within a specified period of time.
In the example examined, when transporting 2kg of chilled meat over the course of 24h, the core temperature of 8°C must not be exceeded.

Checking the cooling capacity with the following contents: 1.2kg pork meat and 1kg sausage; cooling medium 2 x 0.5kg ice; initial core temperature 2°C; storage at 23°C for 24h.
The maximum acceptable core temperature of 8°C was reached in the various boxes after the following period of time: EPS box after 24h for both products; cardboard box with corrugated cardboard insulation (Foodmailer) after 17h (meat) or 18h (sausage); cardboard box with hemp insulation in PLA fleece after 21h (meat) or 16h (sausage); cardboard box with cellulose insulation in PE film (hard box) after 18h (meat) or 8h (sausage).

To guarantee the desired cooling capacity (24h < 8°C) for all boxes, an additional cooling aggregate was calculated for all boxes except the EPS box (1.5kg instead of only 1kg ice).

Transport boxes – environmental assessment:
When assessing the environmental effects the production of the products and cooling units (water in 0.5l PET bottles) transport and waste recycling were all taken into account.
When considering the environmental criteria of greenhouse gases, cumulative energy and water consumption, the coolers with EPS or hemp insulation perform similarly well and significantly better than the two alternatives. The EPS box has a clear advantage in terms of the environmental impacts of acidification and eutrophication. Incidentally, the cost of 0.5kg worth of additional refrigeration on CO_2e emissions is equivalent of the effect of 1% meat waste. If the poorer refrigeration performance was not compensated for by more refrigeration medium the transported meat could spoil in part.

All cooling boxes have a cardboard content. In the Foodmailer the cardboard weight is particularly high - hence the high carbon footprint. All materials can be easily recycled. The hemp insulation can be composted or incinerated (see also page 10). Modelling of waste recycling for LCA: cardboard is recycled to 77%, EPS to 50%; the remaining materials are incinerated.



5. Cooperation, strategy and initiatives

Finding the best solutions in the industry for food waste, packaging and sustainability can be quite a challenge. For this reason the cooperation of all players along the supply chain is essential. The combined effort to reduce food waste is, of course, not just about packaging. In agriculture and food processing there are already many ways to minimise losses and waste. Best solutions are often achieved in cooperation with upstream or downstream processes. A few examples of the numerous national and international initiatives dedicated to the reduction of food waste are mentioned at the end of this chapter.

5.1. **Cooperation between all parties in the supply chain is necessary and effective**

5.2. **Reduction of food waste in agriculture**

5.3. **Reduction of food waste during food processing**

5.4. **Further strategies to reduce food waste among retailers and consumers**

5.5. **National and international initiatives to reduce food waste**

5.1. Cooperation between all parties in the supply chain is necessary and effective

Globally about 30% of all greenhouse gas emissions are related to food. [9, 17, 26] What makes it even more alarming is the fact that around one third of all food is lost along the supply chain. [5]

For our food systems to become sustainable – and thus fit for the future – the environmental impact must, of course, also be reduced. One of the most important contributions to this is the reduction of food losses and waste. Cooperation between all the players in the supply chain is often decisive for implementation.

Cooperation is key…

- for determining the necessary shelf life and correct product protection
- to identify optimisation opportunities against the backdrop of complex production and distribution conditions on the one hand and consumer choice criteria on the other
- for the testing, optimisation and introduction of innovative and previously unknown solutions
- for the communication of important messages to consumers and the analysis of consumer behaviour

Most of the case studies presented in this guide could not have been investigated without the cooperation of the respective partners from the food processing, packaging production and retail sectors.

Joint projects between the respective parties involved provide the optimal framework for implementing the results and recommendations of "STOP Waste – SAVE Food" campaign and help develop it further.

Establish 'Food and Packaging Forum'

Because of the huge importance of the issue, its complexity and the need for coordination and networking, a 'Food and Packaging Forum' should be established in Austria. All parties in the supply chain should be represented. In the beverage industry, for example, the ARGE: Sustainability Agenda for Beverage Packaging has proven its worth in developing and implementing industry-wide strategies.

A Food and Packaging Forum could tackle this challenge amongst any conflicting concerns of the food/packaging/waste sectors and it could:

- develop strategies for sustainable solutions
- share best practice experiences
- encourage collaborative projects
- communicate progress
- inform the consumer

5.2. Reduction of food waste in agriculture

Food waste starts with a lack of appreciation!

Already, at the first step of the food supply chain in agriculture, food waste is generated. In order to fulfil existing contracts, planned overproduction is often necessary. According to some European definitions, waste before harvesting does not count as food waste. Nevertheless it is important to take this waste into account for future prevention.

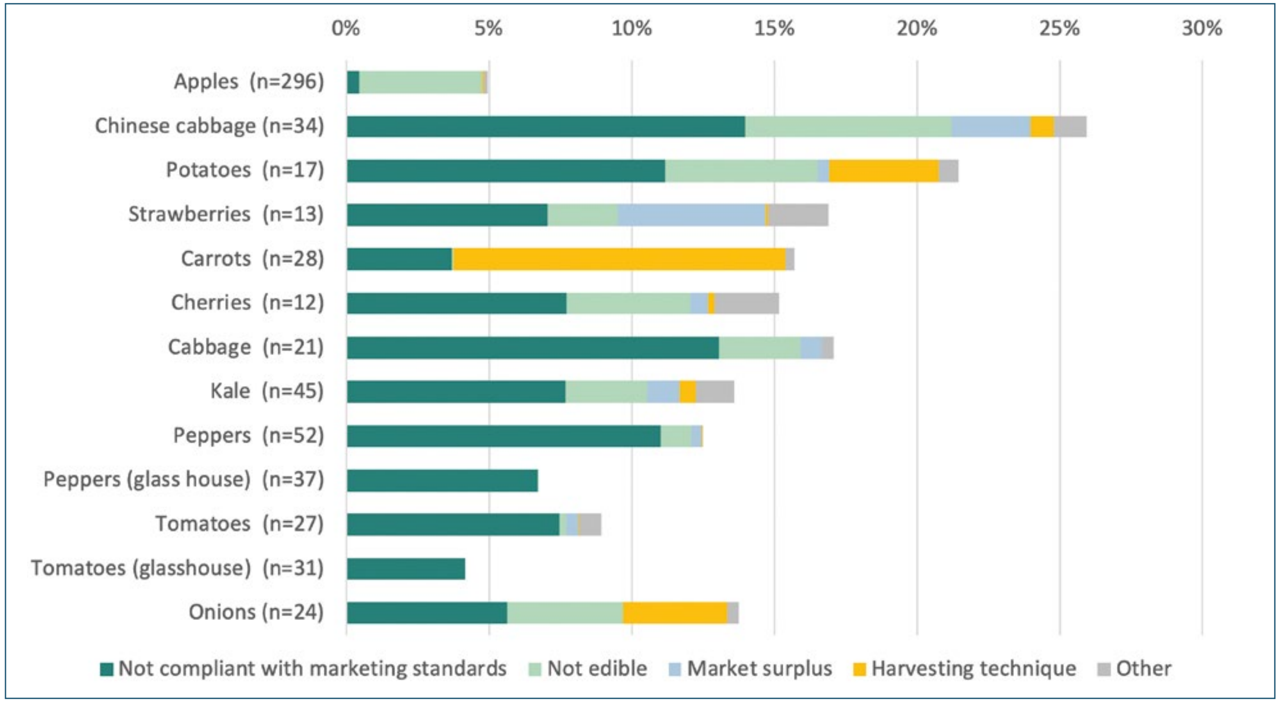
Reasons for food waste and agricultural losses

The primary causes of food waste and losses in agriculture were identified as non-compliance with marketing standards, lack of edibility and market surpluses. This applies to both products not harvested and for products harvested but not marketed.

Building networks and regional marketing – ways to reduce food waste and losses in agriculture

- Improvement of production, processing, harvesting and storage methods in order to avoid damage or loss or waste
- Development of new marketing channels for product sales
- Development of new products for the processing of unsaleable food and establishing a platform to encourage commercial cooperation
- Donation of unsaleable goods to local social organisations
- Combining harvesting activities
- Conveying values of agricultural products

Reasons for Food Waste and Losses in Agriculture
Potential Crop Yields = 100 %; [14]



5.3. Reduction of food waste during food processing

Less waste in food production through process optimisation

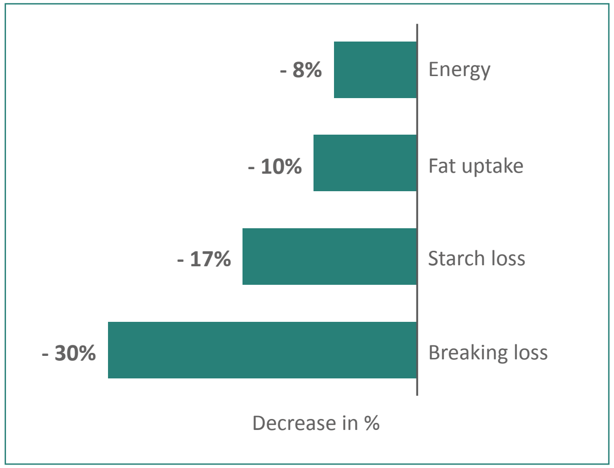
The primary aim of food processing is to convert the raw materials as efficiently as possible into consumer-friendly products. By utilising new technologies and processing previously unused raw materials, the industry can make a valuable contribution to the reduction of food waste. At the same time achieve an increase in value itself.

Raw materials that are discarded after the harvest due to blemishes and waste materials that are created during processing represent avoidable food waste. In addition, the use of outdated and sometimes inefficient processes during production can lead to an increased volumes of food waste. This is where product and processing innovations have to be implemented and concepts for further optimisation have to be developed.

Recommended measures:

- Development of new strategies for the conversion of residues (e.g. peeling waste, pressing residues, etc.) into food products
- Increasing the efficiency of existing production lines and optimising the product output
- Implementation of new and gentle processing
- The transfer of knowledge and support of food producers who can process residual materials into products

The use of new technologies in food production (such as the application of pulsed electric fields in potato processing) allows resources such as energy and raw materials to be used more efficiently. Also it reduces the volume of residues and achieves a higher product quality. In this process, a perforation of the cell membrane is achieved by applying short electric field pulses. This treatment leads to a smoother surface of cut potatoes used in the production of French fries and reduces the loss of starch.



The effects of pulsed electric fields in the production of French fries compared to conventional processing

5.4. Further strategies to reduce food waste among retailers and consumers

Preventing food waste goes beyond packaging optimisation

Most food waste can be allocated to vegetables, fruit and bakery products.

If these are unpackaged they are even more exposed to physical, chemical and microbiological influences and can be further affected by temperature fluctuations at various stages (distribution, storage, sales).

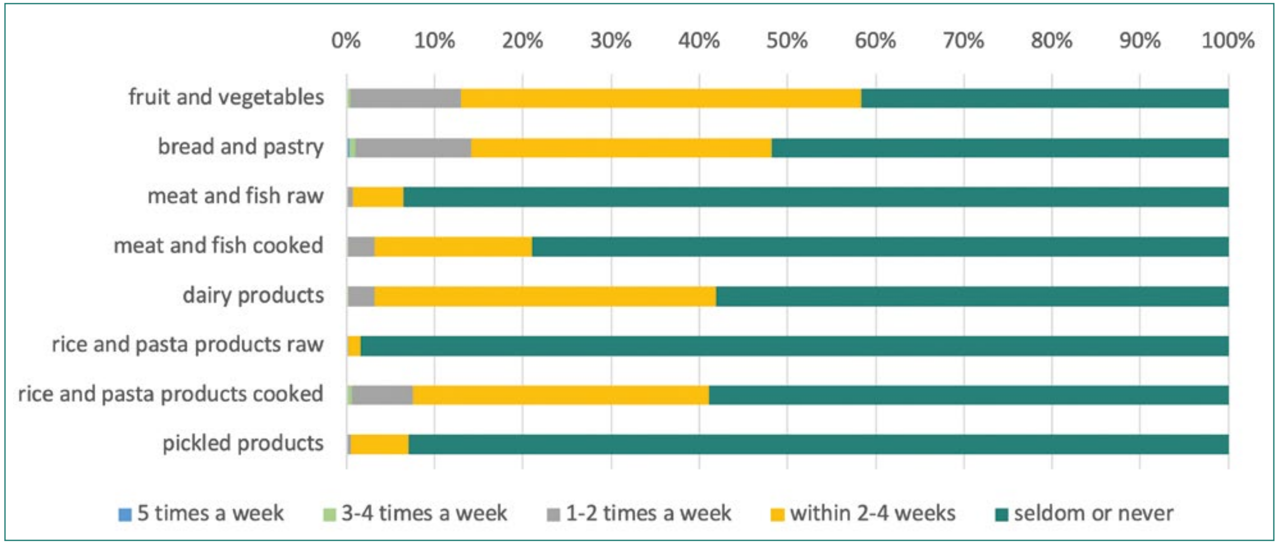
Food waste from the retail sector
The retail sector generates about 5% of the food waste (89 million tonnes) generated in Europe each year. [22] In addition to optimising packaging, the STREFOWA project has identified optimised (faster) transport, processing of fruit and vegetables at the point of sale, improved IT solutions and information and training for employees and consumers as key avoidance options. [18]

Household food waste
Incorrect storage (especially for fruit and vegetables) and an inaccurate best before date were identified as the main causes of food waste among consumers. In both cases, communication (industry, public authorities, etc.) can help to change the consumer's thinking.

Another important aspect is the general lack of appreciation of the value of foodstuff. This should also be mentioned.

Looking beyond the horizon
Collaborative thinking can help to make a significant contribution to the prevention of food waste beyond ones own area of responsibility. While each sector can play its part through process optimisation, more conscious procurement or timely recycling in both industry and private households these are not the complete answer., This collaboration includes, for example, the sale or purchase of products with blemishes or cooking seminars for consumers and recycling tips for food. Consumers can avoid food waste at supermarkets by consciously purchasing products close to the best before dates.

How often do you throw away the following categories of food (Survey no. = 2323) [23]



5.5. National and international initiatives to reduce food waste

Here are 5 examples of existing national and international initiatives:

www.bmnt.gv.at/land/lebensmittel/kostbare_lebensmittel.html

"Food is Precious" is the initiative of the Federal Ministry for Climate Protection, Environment, Energy, Mobility, Innovation and Technology, which has set itself the goal of bringing about a sustainable avoidance and reduction of food waste in close cooperation with the economy, consumers, communities and social institutions. In addition to regular stakeholder dialogues, the Austrian initiative offers the possibility of using the graphic "Lebensmittel sind kost- bar!" in internal and external communication – as a connecting brand and as a quality mark for projects and activities to reduce and avoid food waste.

www.lovefoodhatewaste.com

Love Food Hate Waste wants to raise awareness of the necessity of food waste prevention and help to take action. It shows how simple, practical, everyday things in the household can help to reduce food waste. Love Food Hate Waste is run by the British NGO WRAP. The site offers information on food storage, a wealth of recipes and suggestions about which food can be eaten completely.

www.reducefoodwaste.eu

The reducefood-waste.eu platform was set up as part of the Strefowa project and financed by the EU (Interreg Central Europe). Based on best-practice examples and project results, the web-based software tool provides specific information and guidelines for various interest groups on how to avoid food waste or to recycle and treat it in the best possible way. Currently, tool. reducefoodwaste.eu, has 294 initiatives from 10 countries on food waste prevention, which can be filtered by country, type of initiative and at any point along the supply chain.

www.refreshcoe.eu

The community of experts gathered within the Horizon 2020 research project REFRESH (2015-19), offers a platform for the exchange of expertise and best practices. The Virtual Resource Centre allows parties to easily find and exchange information on food losses and waste across the EU. Visitors to the website can search the resources but membership is required to comment on or upload resources. There are currently 243 contributions on this site.

www.save-food.de

SAVE FOOD is the joint initiative of the World Food and Agriculture Organization (FAO), the United Nations Environment Programme, (UNEP), Messe Düsseldorf and interpack, the world's leading trade fair for packaging and processes. The aim of SAVE FOOD is to combat global food waste and losses through a international alliance of all responsible parties. Together with its members from industry, politics and society, SAVE FOOD wants to drive innovation, promote interdisciplinary dialogue and initiate debates in order to create solutions – along the entire supply chain – from farm to fork and with the involvement of all participants.

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Footnotes

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