CARBON FOOTPRINT
Frozen Food

FINAL REPORT

Life Cycle Assessment of Various Product Options and
Identification of Optimization Potentials
for Selected Frozen Food Products

Carried out by:

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Inhalt

A. INTRODUCTION 3
Background 3
Objective of the Carbon Footprint Study 3
Core Results 4
B. METHODOLOGY 5
Data and General Assumptions 5
Product Categories and Exemplary Products 5
System Boundaries 6
Functional Unit 7
Interpretation of Results 7
C. DETAILED RESULTS 8
Product Category of Bakery Products 8
Product Category of Ready-to-Eat Dishes 11
Product Category of Vegetables 13
Product Category of Pizza 16
Product Category of Potato Products 19
Key Factor of Distribution along the Product Life Cycle 22
Conclusion 22
D. OPTIMIZATION POTENTIALS 23
1. FOR THE FROZEN FOOD INDUSTRY 23
2. FOR THE CONSUMER 24
E. APPENDIX 25
Background Information on the Deutsches Tiefkühlinstitut 25
Background Information on the Oeko-Institute 25

A. INTRODUCTION

Background

On behalf of the Frozen Food Industry, the Deutsches Tiefkühlinstitut (**dti**; German Institute for Frozen Food) commissioned the Oeko-Institute to carry out a carbon footprint study aiming at determining the greenhouse gas emissions throughout the life cycle of five product categories which are representative for frozen foods, and at comparing it with other product options. In the context of this study, the **dti** member companies furthermore place a great deal of emphasis on identifying optimization potentials for reducing greenhouse gas emissions on the part of producers and consumers.

The study provides one of the first industry-wide analyses based on updated and consolidated primary data obtained from the Frozen Food Industry. It was conducted on the basis of the standardised LCA method according to DIN EN ISO 14040:2006 and 14044:2006. Methodology and results were verified and confirmed in an external scientific review.

The following report summarizes the main findings of the study.

Objective of the Carbon Footprint Study

The central objective of the study is a comprehensive and systematic accounting of the climate change impact of frozen food as compared to conventional industrial comparators as well as to home-made dishes.

In addition, the study pursues four overall objectives. **First** of all, the carbon footprint study should help to objectify the debate. With hard data and scientifically sound information, facts and results on to the entire product life cycle (from raw materials up to private households), the study elucidates the climate effects of frozen food, the sound database of the study providing a reliable basis for a comprehensible communication concerning the climate change impact of frozen food.

Secondly, the study's objective is to decisively contribute to more transparency and to a differentiated state of information on the issue of climate protection and frozen food. The acquisition of knowledge about the environmental impact during production does not only have a special importance to manufacturers. Consumers, too, will be informed on how their behaviour as regards the handling of frozen foods will affect the carbon footprint. The study provides the consumer with easy access to reliable information.

Thirdly, the carbon footprint study is to identify optimization approaches for climate protection measures to be implemented by both the participating companies and the consumers. On the one hand, the German Institute for Frozen Food, on the basis of the overall results and in coordination with the Oeko-Institute, will provide enterprises with recommendations as to what actions to take, thus enabling them to further develop and reinforce their activities in the area of climate protection. On the other hand, however, opportunities should be set out, helping consumers to adapt their conduct towards an improved carbon footprint.

Fourthly, a uniform system for measuring and communicating climatic data for the German Frozen Food Industry is to be established on the basis of the carbon footprint study in cooperation with the Oeko-Institute. These accounting rules ("Product Category Rules") establish uniform boundary conditions necessary for a scientifically-based method for measuring the climate change impact in the Frozen Food Industry, and are an important step to reinforce the Frozen Food Industry's efforts to promote a sustainable development. The "Product Category Rules" are particularly intended to provide orientation for smaller enterprises implementing carbon footprint assessments and establishing time series.

It was not the intention of this study to derive a comparative statement as regards the general environmental advantages of frozen food. It should rather provide a well-founded comparison between the climate footprint of frozen foods and that of other product options in order to gain a better understanding of this food product in terms of its relative share of greenhouse gas emissions. Moreover, it was intended to discern the respective shares of emissions in all stages of the value chain, and, in particular, to identify the responsibilities of the different players along the product life cycle.

Core Results

This study clearly indicates that the carbon footprint of frozen foods and other product options (home-made, chilled, unchilled) are comparable and approximately at the same level. In comparison to unfrozen or home-made products, the carbon footprint of the frozen food products investigated within the scope of this study is generally similar (deviations are not significant according to methodological rules). A blanket condemnation of frozen products in terms of climate aspects is therefore untenable from a scientific point of view.

Distribution (transportation and storage) of the investigated frozen products represents only a small percentage of the overall carbon balance and does not harm the climate as much as is often suggested.

The ingredients of the products as well as the shopping trip and processes taking place in private households, such as storage and preparation, have a larger influence on the carbon footprint than the different product options

Data and General Assumptions

With its carbon footprint, the German Institute for Frozen Food has published one of the first industry-wide studies based on primary data. The enterprises involved in the study provided extensive, representative and sound data on the product option of frozen food, some of them having been collected through new surveys. The data situation in areas that are typical for the system, as well as for important raw materials, has been updated and consolidated, where necessary. Further product-specific assumptions, such as, for example, on storage and preparation, are based on conventional, valid market surveys (e.g. Nielsen) and various market research studies commissioned by the enterprises involved, as well as on findings released by scientific institutes. More explanations can be found in the results section.

The calculations concerning the other product options are based on secondary data researched with utmost carefulness and – where no data were available from the enterprises involved – on assumptions made by the Oeko-Institute in close collaboration with industry experts.

According to the European standard EN 50242, a standard place setting consists of the following tableware, cutlery and items: 1 dinner plate ø 26 cm, 1 soup plate ø 23 cm, 1 dessert plate ø 19 cm, 1 saucer ø 14 cm, 1 cup 0.2 l, 1 glass 250 ml, 1 knife 203 mm, 1 fork 184 mm, 1 tablespoon 195 mm, 1 teaspoon 126 mm, 1 dessert spoon 156 mm.

Product Categories and Exemplary Products

The study investigated the specific life cycles of exemplary products from the following five categories of products which have identical ingredients:

- bakery products
- ready-to-eat dishes
- vegetables
- pizza
- potato products

These product categories are representative for the products on the German market for frozen foods, and account for a relevant market share.

In addition, the following products were selected as examples for each product category:

- wheat bread rolls (for bakery products)
- chicken fricassee (for ready-to-eat dishes)
- peas (for vegetables)
- salami pizza (for pizza)
- potato pancakes (for potato products)

The selected product examples are not only known to be very popular among consumers, but also ensure a good comparability with respect to other product options, such as chilled, unchilled or home-made goods.

System Boundaries

Following the principle of life cycle assessment, the entire life cycle of each investigated product was considered in this study. The analysis included upstream chains of production as well as main processes and downstream chains.

Sectors involved in the **upstream chain** are:

- production of auxiliary materials and supplies
- energy supply
- production of packaging material
- production of diesel and other fuels

Sectors involved in the **main processes** are:

- cultivation of raw materials
- processing of raw materials
- production of intermediate products (ingredients)
- storage of raw materials or ingredients
- production
- storage of finished product
- distribution to retailers
- shopping (trip) and preparation

The **downstream chain** includes:

- recycling or disposal of waste
- waste water treatment

Thus, it is ensured that the carbon balance takes into account all stages of the product life cycle – from the procurement of raw materials to production and manufacturing of packaging materials to distribution and use of the product by the final consumer. On this basis, an evaluation of the environmental effects as accurate and complete as possible is obtained.

Processes, each of which, in cumulative terms, constitutes less than 1% and not more than 5% of the overall GHG emissions, could not be taken into account. Furthermore, raw materials making up less than one percent of all ingredients (e.g. spices), packaging components accounting for less than one percent of the final product (e.g. labels), transportation of auxiliary materials and supplies as well as heating/light consumed during the use phase were excluded from the scope of analysis. Due to insignificance, capital goods (the so-called "capital equipment") were not included in the system boundaries either.

Functional Unit

All products were accounted for taking as a basis the packaging sizes that are most commonly used by two-person-households. Subsequently, results were scaled down to 100 grams, the commonly used reference unit for foods. Bread rolls, for example, were accounted for as packaged finished products of 450 grams – a packaging volume that is commonly sold at retail level – and subsequently scaled down to 100 grams.

Calculation

The greenhouse gas emissions resulting from processes occurring along the entire value chain of the frozen food products are expressed in CO_2 equivalents (CO_2e). The CO_2 equivalent is a unit of measurement used to describe the influence of different greenhouse gases such as carbon dioxide, methane or refrigerant on the climate.

Throughout the carbon footprint study, the CO_2 equivalent emissions were measured per 100 grams of the product. In concrete terms, this means that the absolute figures of greenhouse gas emissions of a specific product were scaled down to 100 grams of this product.

Interpretation of Results

When interpreting the results, account needs to be taken on the fact that results of highest accuracy – as a matter of principle – cannot be achieved by means of an LCA. Firstly, this is because the complex reality can generally only be mapped approximately by the modelling set up within the scope of a life cycle assessment. Another reason is practical representability.

This applies particularly in view of the fact that the ingredients and packaging types of commercially available products vary significantly between the different suppliers. Even products from the same supplier may be subject to fluctuations and adaptations. When meals are prepared at home, a variety of recipes, personal experiences and behaviours may also have a major impact on the carbon footprint.

When interpreting the results, the significance of these influencing factors must therefore be taken into account. Differences between the different product options are especially relevant, if they make up more than 10 percent (as is the case with basic frozen food products such as bread rolls, peas or potato pancakes, that have not been heavily processed) or 25 percent (with complex frozen foods such as pizza and chicken fricassee, i.e. the selected examples), respectively.

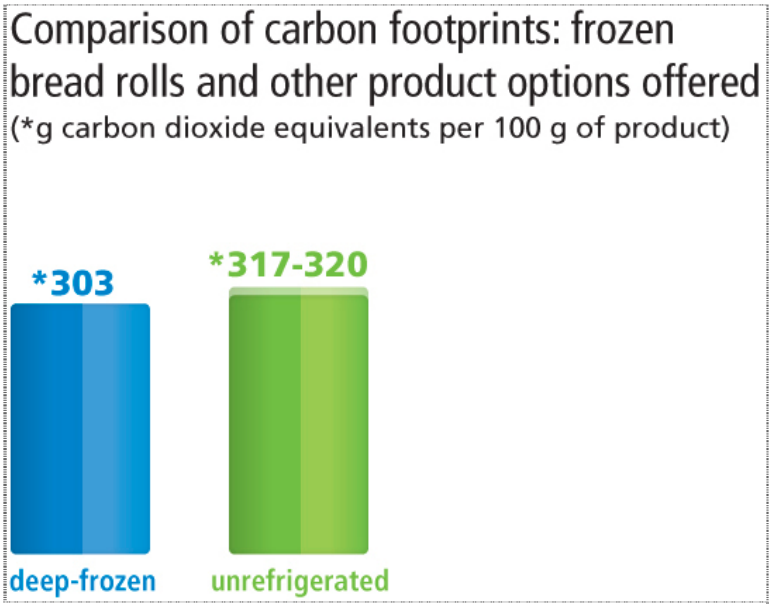
C. DETAILED RESULTS

Product Category of Bakery Products

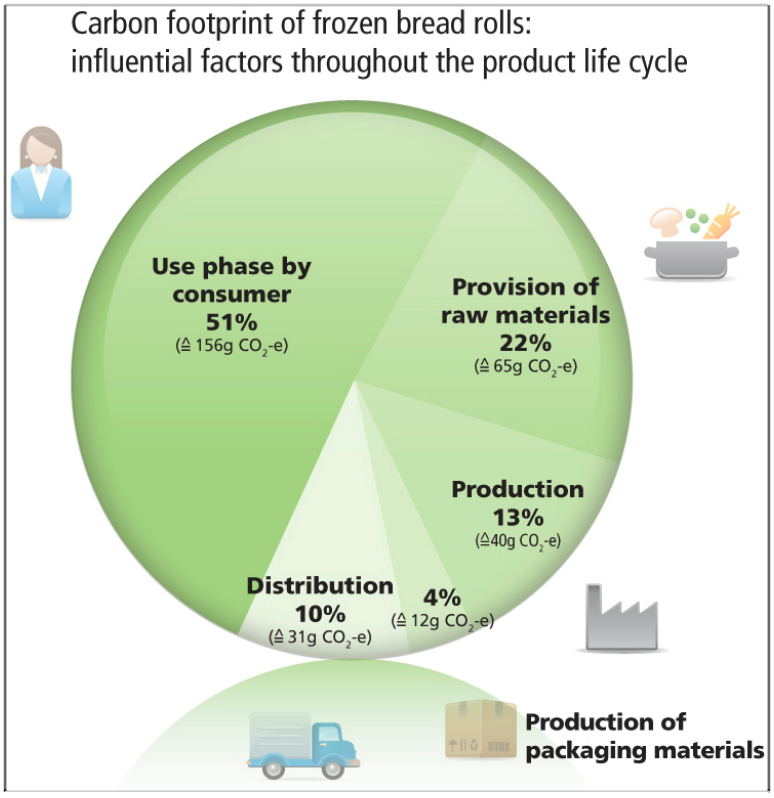
In the product category of bakery products, the greenhouse gas emissions of frozen wheat rolls were compared to the carbon footprint of unchilled parbaked bread rolls. The production of 100 grams of **frozen bread rolls** results in total in **303 grams** of CO_2e emissions. This compares to **unchilled rolls** which cause **between 317 and 320 grams**. As compared to unchilled rolls, frozen bread rolls are at the same level as regards their carbon footprint. The slightly better value calculated for deep-frozen rolls is not significant in consideration of the methodologically typical bandwidth of results. The previously released interim results from a survey conducted in July 2011 were updated and recalculated in the course of the study, the results, however, remaining virtually unchanged.

Comparison of CO_2e emissions of various product options offered

	Frozen bread rolls	Unrefrigerated bread rolls
Stage of value chain	in g CO_2e per 100 g of bread rolls	
Production and provision of raw materials	65	65
Industrial production of finished products	40	23-26
Production of packaging	12	21
Distribution and storage at the retailer	31	10
Purchase, home storage, preparation and dish-washing	156	198
Total	303	317-320



Measuring of greenhouse gas emissions
The carbon dioxide equivalent (CO_2-equivalent or CO_2e) is a standard unit used to describe the impact of the different gases on the global climate. The reference unit for this climate impact, i.e. the so-called Global Warming Potential (GWP), is carbon dioxide (CO_2).



More than half of the greenhouse gas emissions emitted along the entire value chain of both frozen as well as unchilled rolls are produced by the **final consumer** (shopping trip, storage and preparation at home). Unchilled rolls account for 62 percent of all emissions (198 grams of CO_2e), frozen rolls for **51 percent** (156 grams).

Approximately two thirds of these 156 grams of CO_2e (66 percent) are produced during the baking of the frozen rolls in the oven, more than a quarter (27 percent) during storage in the freezing device in the private household, and another 7 percent during the shopping trip.

These calculations have been carried out under the assumption that frozen rolls are bought two times a month, stored in the private household for 14 days on average, and are prepared in accordance with the preparation instructions on the package, i.e. without preheating the oven.

The **raw materials provision** for frozen rolls causes 65 grams of CO_2e (the figure for unchilled rolls is also 65 grams of CO_2e). The **provision of raw materials** thus accounts for **22 percent** of the emissions arising along the value chain of frozen rolls. The largest share of emissions is attributed to flour as the main raw material (94 percent), while malt, yeast, sugar and salt contribute only marginally to the greenhouse gas emissions of raw materials.

13 percent of greenhouse gas emissions along the value chain for frozen rolls are released during **production**; this corresponds to 40 grams of CO_2e (unchilled rolls: 23 - 26 grams), three quarters (75 percent) of emissions arising during the production of frozen rolls being caused by the forming and baking processes, whereas storage processes account for 18 percent. Only small emission volumes or no greenhouse gas emissions at all are released during dough production (5 percent) and the packaging processes (2 percent).

Along the product life cycle of frozen rolls, 31 grams of CO_2e are released during **distribution** (transportation and storage) (unchilled rolls: 10 grams). Thus, approximately **10 per cent** of the total GHG emissions of frozen rolls are produced in this area of the value chain, 70 percent of these 31 grams of CO_2e being generated during the process of storage and 30 percent during transportation. On the basis of sound assumptions, the storage of frozen rolls in the food retail market was calculated assuming a period of 4 days in the storeroom and 1.6 days in the chest freezer of the sales area.

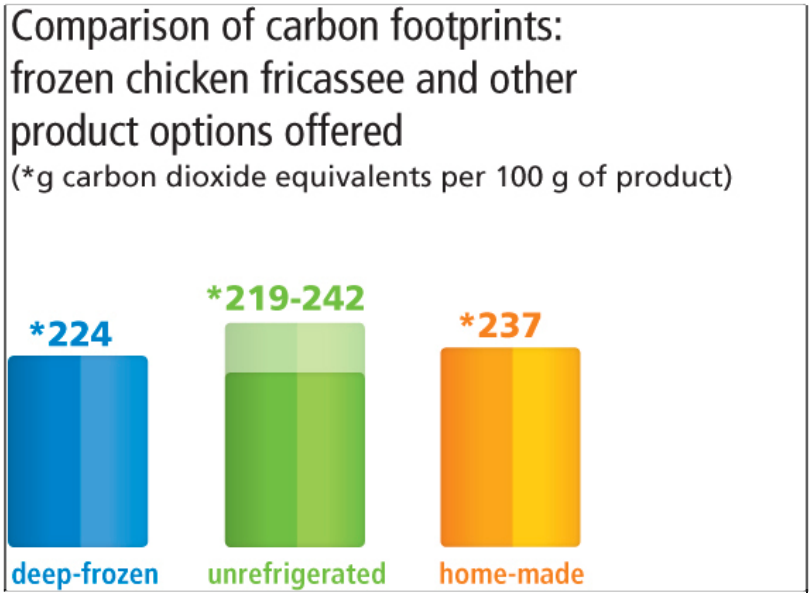
The smallest volume of greenhouse gas emissions (12 grams of CO_2e, or **4 percent** of the total emissions produced along the value chain of frozen rolls) is emitted during the **production of packaging materials**. For unchilled rolls, this figure is 21 grams, since a more sophisticated barrier packaging is required because of the nature of the system. This corresponds to a share of about 7 percent of total emissions.

Product Category of Ready-to-Eat Dishes

In the product category of ready-to-eat meals, the greenhouse gas emissions of frozen chichen fricassee with freshly boiled rice were compared to chicken fricassee with rice contained in the tray meal, and to home-made chicken fricassee. In order to establish a comparable basis, a typical recipe was defined for all products that were compared to each other in this study. In total, **224 grams of CO_2e** arise from the production of 100 grams of **frozen chicken fricassee**. In comparison, **unchilled fricassee** causes between **219 and 242 grams**, while the emissions for home-made fricassee total **237 grams**. In sum, however, the different versions do not deviate significantly from each other.

Comparison of CO_2e emissions of various product options offered

	Frozen fricassee	Fricassee as tray meal	Home-made fricassee
Stage of value chain	in g CO_2e per 100 g of chicken fricassee		
Production and provision of raw materials	139	155	145
Production and seasonal storage	3	6	
Production of packaging	8	37	
Distribution and storage at the retailer	5	5	6
Purchase, home storage and preparation	69	16-39	85
Total	224	219-242	237



Measuring of greenhouse gas emissions
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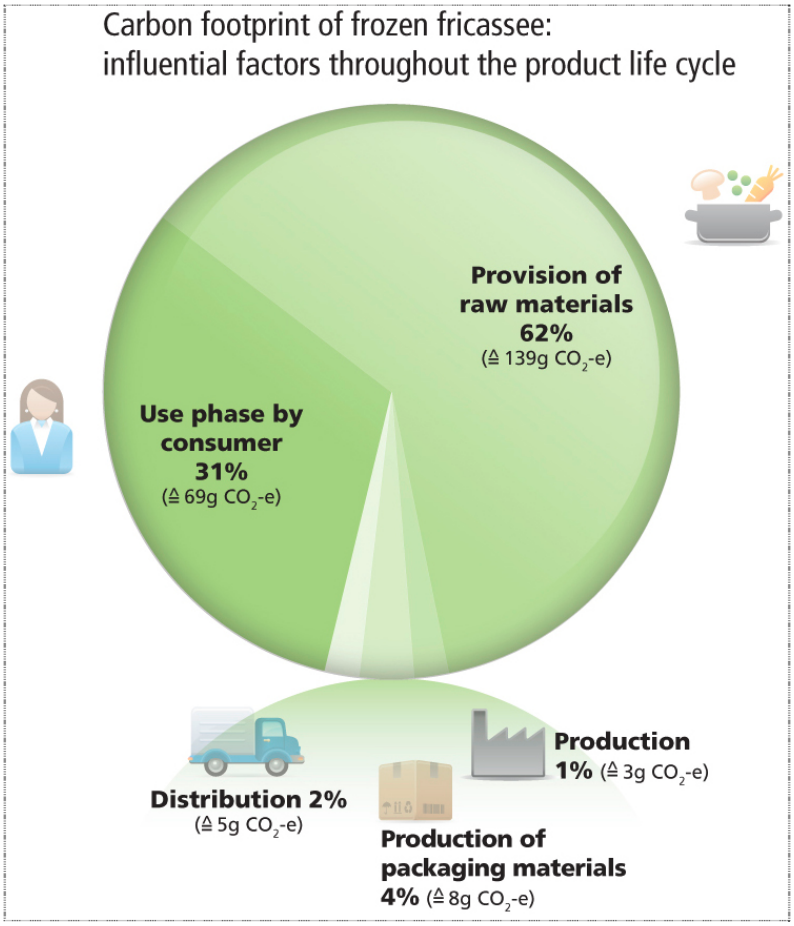


When looking at the entire value chain for frozen fricassee, the **provision of raw materials,** making up just under two-thirds (**62 percent**) or 139 grams of CO_2e, accounts for the largest share of greenhouse gas emissions. As for the unchilled and home-made variations, the provision of raw materials also causes the largest share of greenhouse gas emissions.

The figure for unchilled fricassee is 155 grams of CO_2e, while the same amount of home-made fricassees totals 145 grams. Concerning the raw material provision for deep-frozen fricassee, approximately one-third is allocable to each of the ingredients, i.e. the raw material of rice (35%) and of chicken (42 percent). Cream accounts for 10 percent and milk powder for 4 percent of total emissions, while raw materials such as asparagus, oil, peas, flour, chicken fat, carrots, starch, mushrooms and water do not contribute significantly to the greenhouse gas emissions of raw materials.

In private households, 69 grams of CO_2e (**31 percent**) of emissions are generated by frozen fricassee, 41% of which are produced during the preparation of fricassee and 34 percent during the preparation of rice. The washing of cooking and tableware cause 13 percent of emissions, while shopping trip and storage in the private household are responsible for 6 per cent each.

These calculations have been carried out under the founded assumption that fricassee is bought two times a month, stored in the private household for 14 days on average, prepared in accordance with the preparation instructions on the package and that one standard place setting is required for this meal. By comparison, 16 to 39 grams of CO_2e are generated by the final consumer for unchilled fricassee, while 85 grams are emitted for the home-made variant.

Other areas along the value chain of frozen food fricassee contribute only marginally to the greenhouse gas emissions of the product. The **manufacturing of the packaging** causes 8 grams of CO_2e (**4 percent** of the total greenhouse gas emissions along the value chain). In this area, unchilled fricassee produces more emissions (37 grams) due to the intrinsically more sophisticated packaging.
As regards **distribution**, 5 grams of CO_2e (**2 percent**) are produced for frozen fricassee. The other product options are at almost the same level (5 grams for unchilled fricassee; 6 grams for home-made fricassee). They were calculated on the basis of the following market data: the frozen product was stored for 4 days in the storeroom of the retail grocery store and for 1.3 days in the chest freezer of the sales area, while the average storage period of trade for ingredients that are used to prepare the home-made product is 3 days.

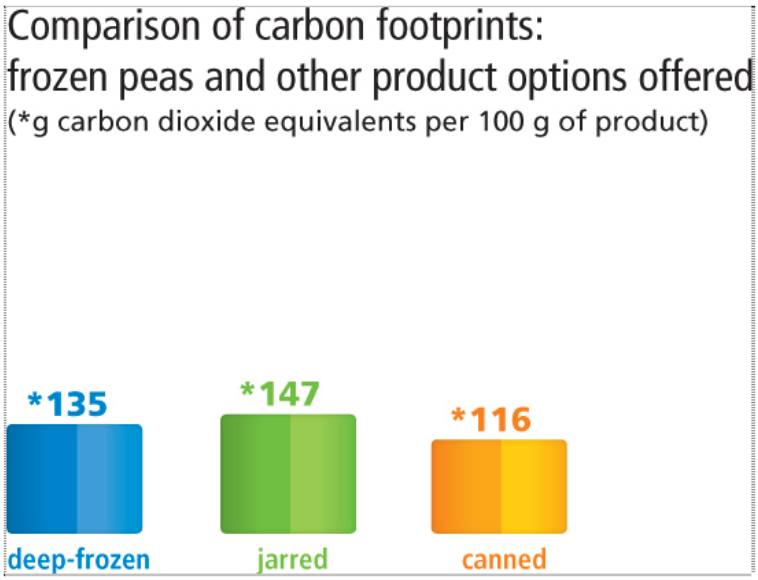
The **production** of frozen fricassee causes another 3 grams of CO_2e (**1 percent** of the total GHG emissions along the value chain). For unchilled fricassee, the corresponding value is somewhat higher (6 grams).

Product Category of Vegetables

In the product category of vegetables, the greenhouse gas emissions of frozen peas, canned peas and jarred peas were compared to each other. The production of 100 grams of **frozen peas** results in a total of **135 grams of CO_2e**. The corresponding value for **jarred peas** is **147 grams**, while equal amounts of **canned peas** are responsible for **116 grams**. Hence, the different product options are close to each other in terms of values.

Comparison of CO_2e emissions of various product options offered

	Frozen peas	Jarred peas	Canned peas
Stage of value chain	in g CO_2e per 100 g of peas		
Production and provision of raw materials	29	29	29
Production and seasonal storage	21	13	14
Production of packaging	10	61	35
Distribution and storage at the retailer	26	14	11
Purchase, home storage and preparation	52	30	28
Total	135	147	116



Measuring of greenhouse gas emissions
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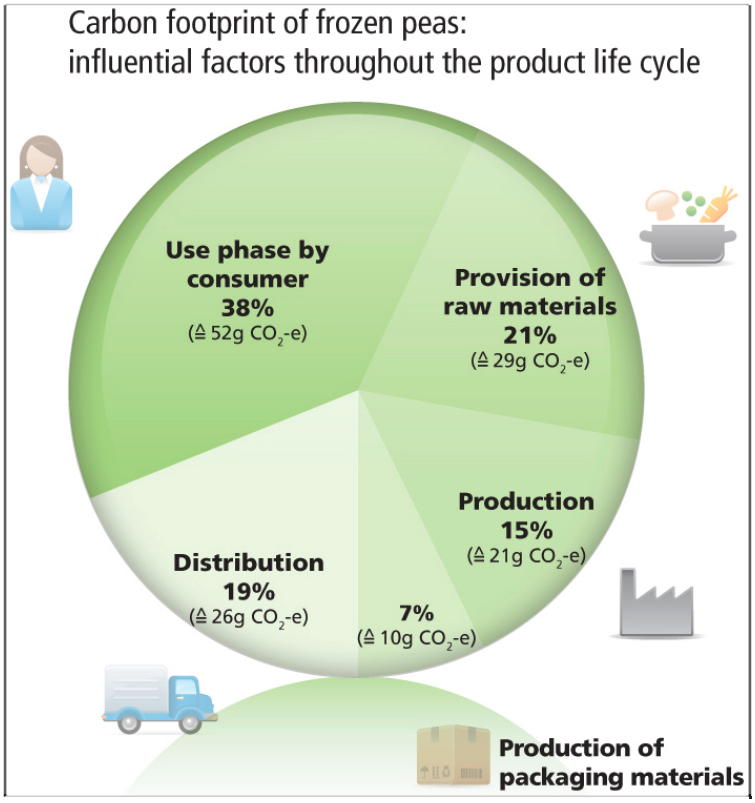


The results, however, largely depend on the individual boundary conditions. The storage period in the freezer, for example, has a great influence on the overall result of frozen peas.

A shorter storage period in the private household could reduce greenhouse gas emissions accordingly. Conversely, a longer storage period would mean an increase of the emissions generated. The cultivation phase of the peas was equated for all three variants, although in practice, different types of peas are used for the frozen food sector on the one hand, and for the canned or jarred variants, on the other hand.

Consumer behaviour plays a crucial role in the carbon footprint of frozen peas. The **final consumer** is responsible for 52 grams of CO_2e; as related to the entire value chain, this corresponds to about **38 percent**. The value of the other product variants is 28 grams (canned peas) and 30 grams (jarred peas) respectively. The frozen peas-related greenhouse gas emissions caused by the consumer can be broken down as follows: the largest share of emissions is attributable to the preparation of the product, generating 44 percent, followed by storage in the private household (33 percent). The washing up and the shopping trip account for 13 and 10 percent respectively.

On average, frozen peas are usually purchased twice a month and are stored for a period of 14 days on average. Furthermore, the assumption has been made that the product is prepared according to the instructions for handling and preparation specified on the packaging. Since it can also be assumed that peas are mostly consumed as a side-dish, the assumption was made that they require one fifth of a standard place setting when it comes to the washing-up.

Along the entire value chain of frozen peas, the **provision of raw materials,** making up **29 grams of CO_2**e (21 percent), also plays a significant role (the volumes released by the other two product options are exactly the same), 42 percent caused by frozen peas being attributable to emissions on the field, 33 percent to diesel exhaust gases, 12 percent to seeds and 6 percent to transportation. The contribution of fertilizers in terms of greenhouse gas emissions released as a result of raw materials provision for the frozen food product, however, is relatively small (7 per cent), **19 Percent (**26 grams of CO_2e) of the greenhouse gases generated along the entire value chain of frozen peas are caused by **distribution** (canned peas: 11 grams; jarred peas: 14 grams), assuming a storage period of 5 days in the storeroom of the retail grocery store and 5 days in the chest freezer of the sales area.

About the same amount of greenhouse gas emissions (21 grams of CO_2e or **15 percent** in terms of the entire product life cycle) is generated by the **production** of frozen peas (canned peas: 14 grams; jarred peas: 13 grams).

The crucial factor in this area is season storage, causing 48 percent of the overall greenhouse gases emitted during the production of frozen peas. Freezing makes up nearly one third (31 percent), while the process of blanching accounts for 11 percent. Only small amounts of greenhouse gases, however, are emitted due to packaging (6 Percent) and processing (4 percent) of the product.

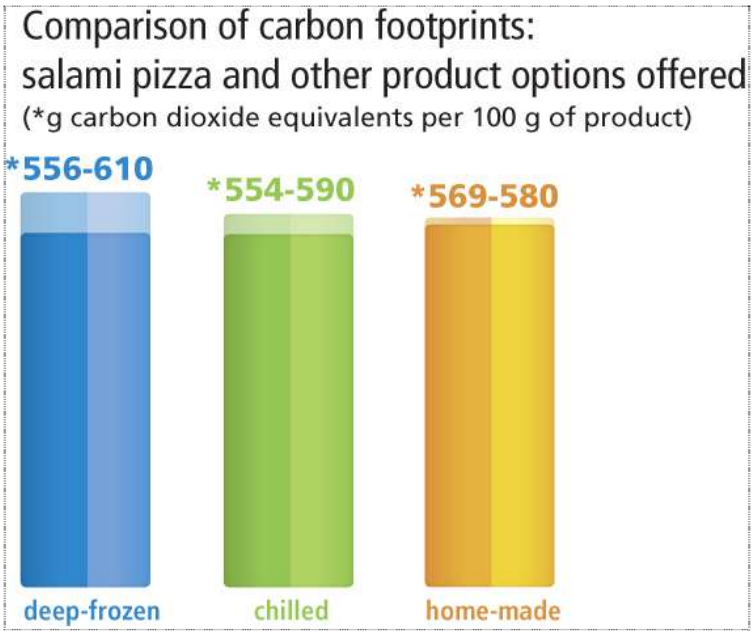
During the **manufacture of packaging materials** for frozen peas, only 10 grams of CO_2e are released (**7 percent** of total greenhouse gas emissions along the value chain). This can be considered a low figure relative to the other product options of peas. As regards canned peas, the manufacturing of packaging materials is responsible for 35 grams of CO_2e, as for jarred peas, the corresponding amount even totals 61 grams of CO_2e. The can packaging is a commercially availabe, lightweight can, here.

Product Category of Pizza

In the product category of pizza, the greenhouse gas emissions of deep-frozen salami pizza were compared to those of chilled salami pizza and home-made pizza (on the basis of the ingredients of the frozen product). 100 grams of **frozen pizza** cause overall emissions of **556 to 610 grams** of **CO_2e** CO_2e. The same amount **of chilled pizza** results in **554 to 590 grams of CO_2e**. **Home-made pizza**, by comparison, accounts **for 569-580 grams** of CO_2e. In consideration of all stages of the product life cycle, frozen pizzas have a footprint that is comparable to that of other product options. It should be noted that the different recipes of the manufacturers for frozen or chilled pizzas can be more decisive than the various product options.

Comparison of CO_2e emissions of various product options offered

	Frozen pizza	Chilled pizza	Home-made pizza
Stage of value chain	in g CO_2e per 100 g of Pizza		
Production and provision of raw materials	306	308	369-380
Production and seasonal storage	20-41	25	
Production of packaging	14-35	33	
Distribution and storage at the retailer	30-39	48-85	
Purchase, home storage and preparation	181-206	140	200
Total	556-610	554-590	569-580



Measuring of greenhouse gas emissions
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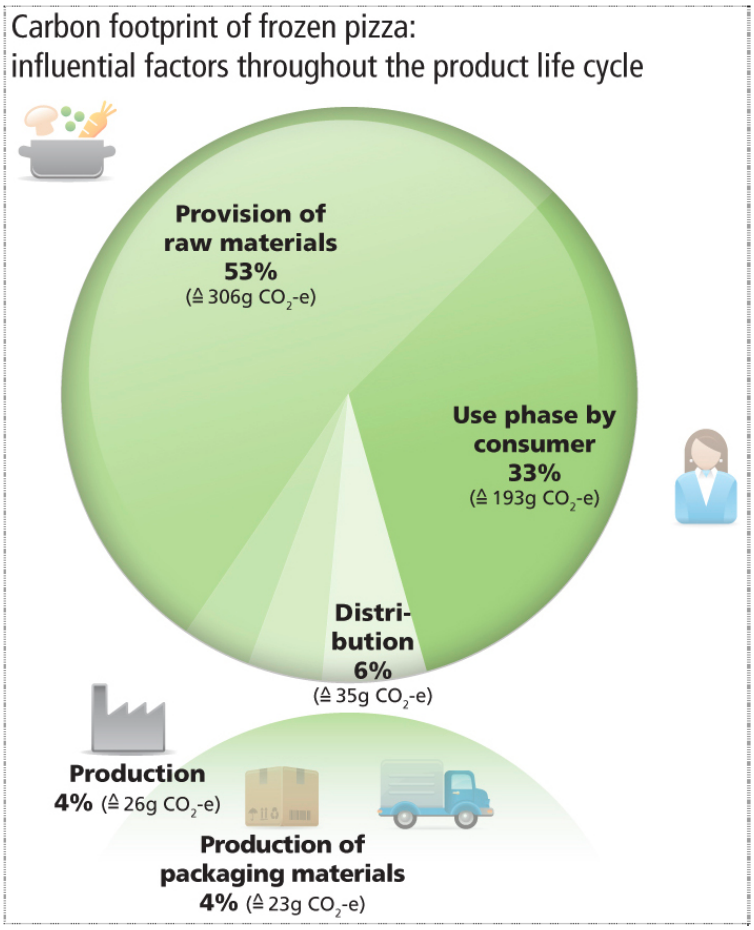


For all product options, the largest share of the greenhouse emissions arising along the value chain is attributable **to the provision of raw materials**. The provision of raw materials for frozen pizza accounts for 306 grams of CO_2e (53 percent), as regards chilled pizza for 308 grams of CO_2e, and concerning home-made pizza for 369 up to 380 grams of CO_2e. Approximately half the overall greenhouse gases (49 percent) caused by raw material provision for frozen pizza are attributable to the ingredient of cheese, while salami accounts for around 29 percent. Other raw materials such as flour (9 percent), tomato concentrate (8 percent), oil (4 percent), baking soda (1 percent) only play a minor role. Calculations are based on the assumption of a standard recipe, which means that raw materials are deemed to be equal to the amount and origin of the other two product options.

Another factor that influences the carbon footprint of frozen pizza decisively is **consumer behaviour**: the shopping trip, storage in the private household, preparation and dishwashing cause 181 to 206 grams of CO_2e (**33 percent** of greenhouse gas emissions along the entire value chain of deep frozen pizza). By comparison: the final consumer is responsible for 140 grams of CO_2e attributable to unchilled pizza, and for 200 grams of CO_2e which are due to home-made pizza.

When analysing the greenhouse gas emissions that arise from the handling of frozen pizza at the point of sale, the largest share is attributable to preparation (59 percent), followed by storage in the private household (23 per cent), dishwashing (11 per cent) and the shopping trip (7 percent). These calculations were based on the assumption that frozen pizza is bought twice a month and that the average storing period in the private household is two weeks. The calculation of greenhouse gas emissions for home-made pizza is based on the assumption that no ready-made dough is used and that the pizza is baked in the oven for about 30 minutes at 180 degrees, using the fan assisted function.

When considering the value chain for frozen pizza, it is found that between 30 and 39 grams of CO_2e are attributable to **distribution** (**6 percent** of the greenhouse gas emissions released during the entire product life cycle), 60 percent of which in turn are attributable to storage and 40 percent to transportation. On average, frozen pizza in the food retail trade is stored in the storeroom of the retail grocery store for 6 days and for 4 days in the chest freezer of the sales area. In this area of the value chain, no greenhouse gas emissions arise for home-made pizza, while the chilled variant results in the release of between 48 and 85 grams of CO_2e during distribution.

During the **manufacturing of the packaging** for frozen pizza, 14 to 35 grams of CO_2e (**4 percent)** of greenhouse gas emissions are released along the entire value chain. Relating to unchilled pizza, the corresponding amount is 33 grams of CO_2e.

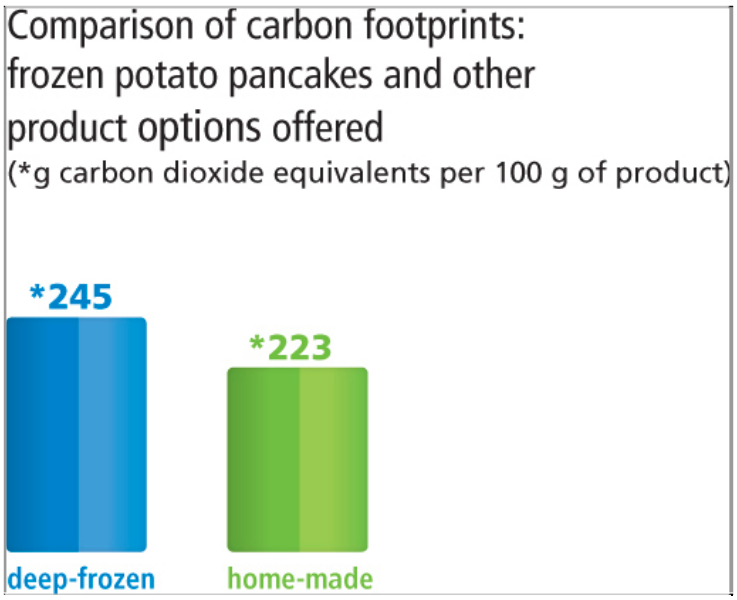
The **production** of frozen pizza causes another 20 to 41 grams of CO_2e (**4 percent**); while 25 grams of CO_2e arise due to the production of chilled pizza.

Product Category of Potato Products

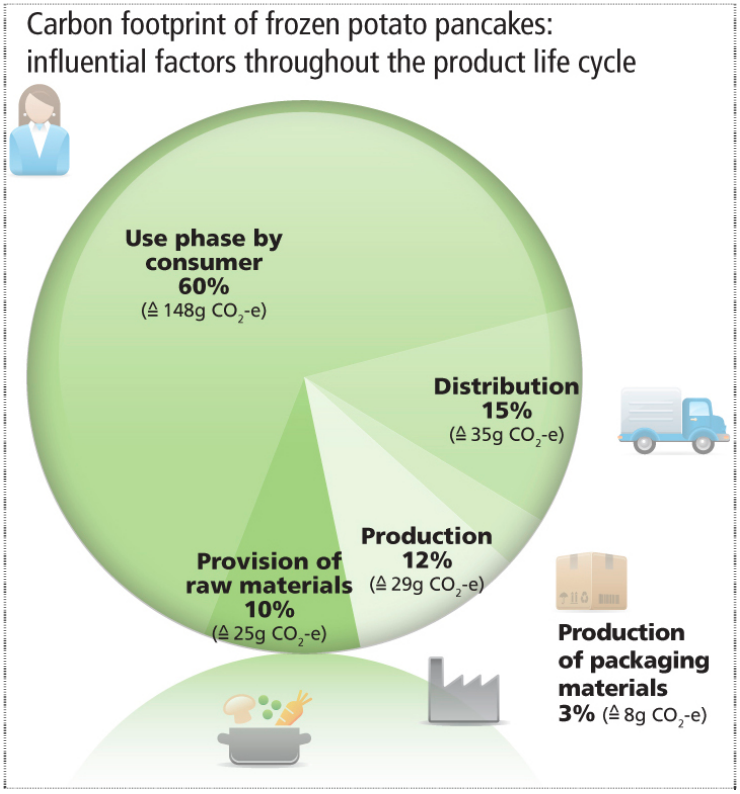
In the product category of potato products, the greenhouse gas emissions of deep-frozen potato pancakes were compared to those that are caused by home-made ones (based on the ingredients of the frozen product). Due to a lack of market relevance, a comparable industrial product option to the deep-frozen dish was not taken into account. 100 grams of **deep-frozen potato pancakes** cause a total amount of **245 grams of CO_2e**. The same amount of **home-made potato pancakes** results in the release of **223 grams**. By comparison, the amount of greenhouse gas emissions produced by the frozen variety is not much higher, while this option provides customers with a significantly higher degree of convenience.

Comparison of CO_2e emissions of various product options offered

	Frozen potato pancakes	Home-made potato pancakes
Stage of value chain	in g CO_2e per 100 g of potato pancakes	
Production and provision of raw materials	25	44
Industrial production of finished products	29	
Production of packaging	8	
Distribution and storage at the retailer	35	
Purchase, home storage, preparation and dish-washing	148	179
Total	245	223



Measuring of greenhouse gas emissions
The carbon dioxide equivalent (CO_2-equivalent or CO_2e) is a standard unit used to describe the impact of the different gases on the global climate. The reference unit for this climate impact, i.e. the so-called Global Warming Potential (GWP), is carbon dioxide (CO_2).



The **processes taking place in private households** have the greatest impact on the result. As for frozen potato pancakes, 148 grams of CO_2e are caused by the processes taking place after purchasing (**60 percent** in relation to the entire value chain); the home-made product is even responsible for 179 grams of CO_2e.

46 percent of the greenhouse gas emissions that arise in this area because of the frozen product are caused by the preparation of the product, 39 percent by the dishwashing of cookware and crockery, 8 percent by storage and 7 percent by the shopping trip. Calculations were based on the assumption that the average storage period in the household was one week. A normal frying pan with 10 grams of rapeseed oil per 100 grams of potato pancakes were used for preparation of the pancakes.

The product option of deep-frozen potato pancakes is responsible for the release of 35 Grams of CO_2e during **distribution** (**15 per cent** of the overall greenhouse gas emissions along the value chain), 78 percent being attributable to storage and 22 percent to transportation. These data were based on the assumption that frozen potato pancakes are stored in the storeroom of the retail grocery store for 5 days and for 5 days in the chest freezer of the sales area.

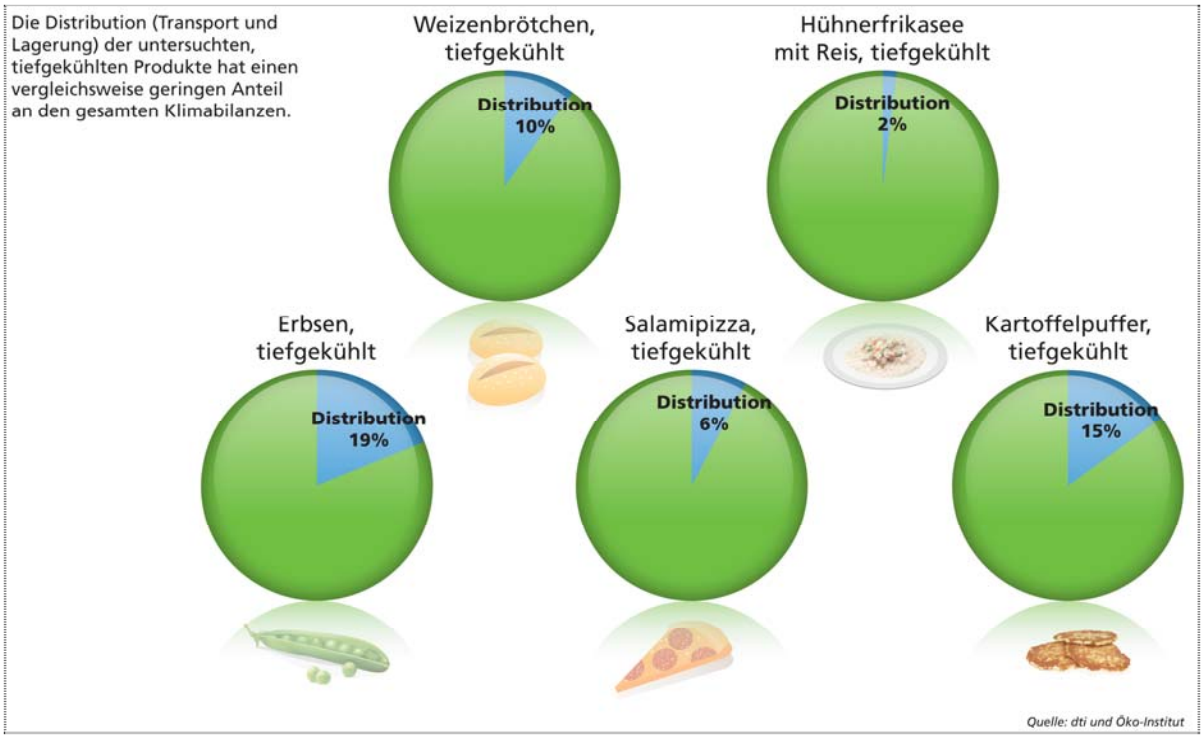
The **production** of deep-frozen potato pancakes causes 29 more grams of CO_2e (**12 percent** of the total GHG emissions along the value chain), whereof mixing and frying processes have the largest share (74 percent). Raw material provision (9 percent), storage processes (9 percent) and packaging processes (8 percent), however, only make up a minor part of the overall emissions resulting from the production of ready-made deep-frozen potato pancakes.

The **provision** of **raw materials** for deep-frozen potato pancakes results in 25 grams of CO_2e (**10 percent** of the total greenhouse gas emissions along the value chain), whereas 44 grams of CO_2e were calculated in this area for the home-made variant. Most emissions caused by the process of raw material provision, however, are due to potatoes, accounting for a share of 63 percent. A further 5 percent are attributable to starch. Although eggs as a raw material only make up approximately 1 percent of the mass content in the recipe of a frozen potato pancake, they account for 32 percent of the overall greenhouse gas emissions arising from the process of raw material provision.

The **manufacturing of packaging materials** is responsible for a further 8 grams of CO_2e (**3 percent** of the overall greenhouse gas emissions along the value chain).

Key Factor of Distribution along the Product Life Cycle

The study results also supplied evidence that distribution (transportation and storage) has a much lower impact on the climatic conditions prevailing during the product life cycle than is often suggested. In all product groups that were accounted for, distribution has the lowest level of greenhouse gas emissions. For chicken fricassee and pizza, for instance, it only accounts for two and six percent of the overall emissions, respectively.



Conclusion

The typical range of different kinds of frozen food products was covered by the examples investigated in this study: a vegetable that has not been subjected to many processing steps, two products whose composition of ingredients is rather uncomplex (bread rolls and potato pancakes), as well as two products with a more sophisticated recipe (pizza and chicken fricassee).

For all products, the levels of greenhouse gas emissions arising along the entire product life cycle of both the frozen food products as well as the other product options were close together, in consideration of the typical bandwidths and the significance level that has been defined in a methodical manner. Against this background, the result of the study is that frozen food products do no cause more damaging emissions than their comparators.

It is, however, equally true that the comparators are not more harmful for the climate than the frozen products. It could be shown that the ingredients of the products and consumer behaviour have greater influence on the results than the product option.

In addition to a comparable climate footprint, frozen food has even more to offer. As a matter of principle, the products are fresh, since vitamins are preserved during the process of shock freezing. Moreover, frozen food is easy to handle and allows portioning in the sizes needed, and thus may help to counteract food wastage.

The large-scale production also has a positive impact on the carbon footprint: cooking in the food industry is hardly different from the preparation of meals at home. The large quantities that are prepared every day as well as the use of high-tech devices, however, allow a more energy-efficient cooking as it can be achieved at home. Furthermore, most production facilities have so-called heat recovery systems, meaning that the energy consumed may be harnessed and reused for other purposes, such as for heating.

D. OPTIMIZATION POTENTIALS

1. FOR THE FROZEN FOOD INDUSTRY

The carbon footprint study not only identifies the greenhouse gas emissions of various product options from representative product categories, but also reveals optimization potentials to reduce emissions along the entire value chain. On the basis of the study results, the Frozen Food Industry enterprises participating in the study intend, during the next stage, to develop proposals for further optimization in terms of reducing the CO_2 emissions of frozen products.

The aim is to continually reduce energy consumption at all levels, if possible, thus jointly contributing to climate protection.

In addition, the German Institute for Frozen Food, with support from the Oeko-Institute, will draw up so-called “Product Category Rules”. These are accounting rules and criteria that can be used by the frozen food companies to obtain a consistent and comparative analysis of the climate change impact. The “Product Category Rules” are intended to provide orientation to particularly smaller firms carrying out life cycle assessments. Moreover, they are very important to the entire industry with a view to presenting trends in time series.

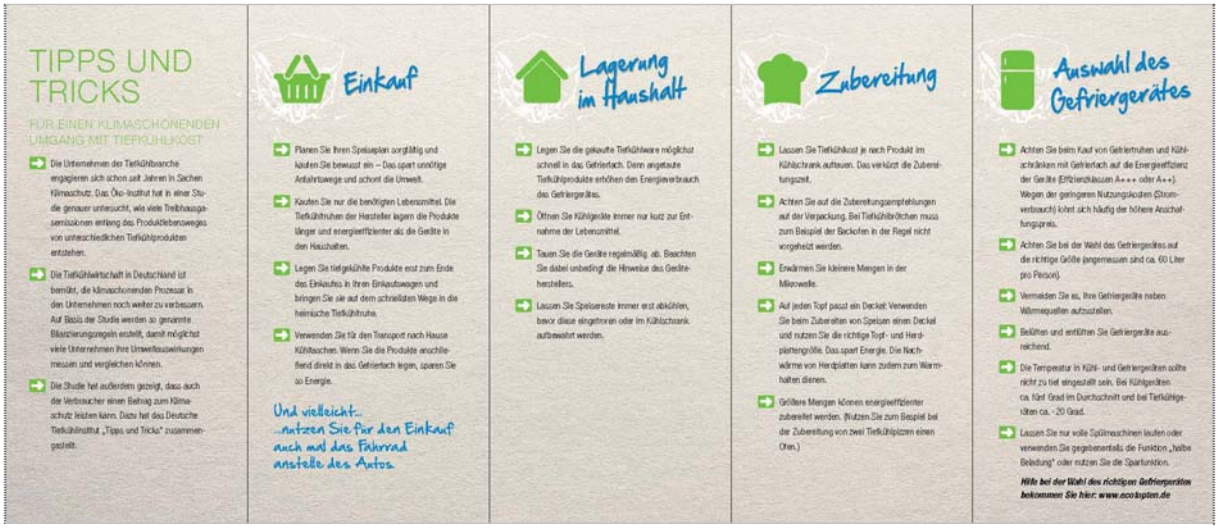
2. FOR THE CONSUMER

The study showed that the consumer, if he or she behaves in a certain way, can make a significant contribution to reducing greenhouse gas emissions.

The contribution of the consumer starts with the shopping trip. Furthermore, the consumer can protect the environment through a well-planned diet and by behaving more consciously when doing the weekly shopping. This way, unnecessary shopping trips can be avoided and the energy-intensive period of storing products in private households can be shortened.

The use of energy-efficient equipment in the private household and the best possible use thereof are further key factors to prevent excess greenhouse gas emissions. Exact adherence to the cooking instructions on the packaging (e.g. no need for pre-heating the oven) also plays an important role in reducing greenhouse gas emissions. As a general rule, instead of the own car, public transport may sometimes be used for the trip to the supermarket. It would furthermore be desirable, if short distances would occasionally be done on foot or by bike.

A flyer was created to provide consumers with further recommendations.



E. APPENDIX

Background Information on the Deutsches Tiefkühlinstitut

The Deutsches Tiefkühlinstitut (German Institute for Frozen Food), headquartered in Berlin, represents the communication and information platform of the German Frozen Food Industry. Founded in 1956, the German Institute for Frozen Food has around 180 members coming from the entire deep-freezing chain industry, i.e. from production via distribution up to the sale of frozen food to private households and the different catering industries. Major German companies are member of the German Institute for Frozen Food as well as foreign companies as long as they are operating on the German market.

Background Information on the Oeko-Institute

The Oeko-Institute is a leading European research and consultancy institute working for a sustainable future. More than 140 staff members complete approximately 300 projects each year, tackling both national and international issues and covering subjects such as Energy & Climate, Sustainability in Consumption or Resource Management and Industry.

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