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Cases of listeriosis are becoming more common - are ready-to-eat foods to blame?

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Over the last few years, cases of listeriosis in humans have been rising in Germany and across the EU. Food contaminated with *Listeria monocytogenes* has been the primary cause of these illnesses: although rare in the general population, infection with this pathogen can lead to fatal blood poisoning, encephalitis and meningitis. Pregnant women, babies, the elderly and those who have an immune system weakened by pre-existing medical conditions or medication are all at greater risk of contracting a case of listeriosis. In pregnant women, who often have only flu-like symptoms or none at all, the infection can cause a premature birth or miscarriage. Listeriosis is not usually a health hazard for healthy adults: in most cases, the infection proceeds without any symptoms and therefore goes undetected.

Over the last few years, ready-to-eat food products were the foods most often contaminated with *Listeria monocytogenes*. Listeria are both widespread and persistent in the environment. As a result, it is able to contaminate foodstuffs while these are being produced and processed. Although temperatures of 30 to 37 °C present ideal growth conditions for the bacterium, it can also reproduce slowly even in a refrigerator. If storage times are sufficiently long, colonies may grow to a size that represents a human health hazard.

In light of the above, the German Federal Institute for Risk Assessment (BfR) has assessed 40 ready-to-eat foods capable of harbouring listeria to determine whether these have been consumed more frequently in recent years and whether such products were contaminated with *Listeria monocytogenes*. To do so, the BfR analysed data from market research company GfK SE and results from food monitoring in Germany.

A trend towards greater consumption was found for 14 foods from various categories, including pre-cut fruit salads, various ready meals that are consumed without first being (re-)heated, heat-treated fish and poultry products, deli salads, and fresh sprouted seeds and vegetables.

During the last 10 years, ready-to-eat fish products such as cold- or hot-smoked fish and marinated (gravlax) fish were more frequently found to be contaminated with *Listeria monocytogenes*, as were meat products - especially raw (pork and beef steak) minced meat and spreadable raw sausage products such as pâtés. While *Listeria monocytogenes* was less commonly found in heat-treated meat products, concentrations of the pathogen in these foods were often too high. Occasional contamination with *Listeria monocytogenes* was also found in deli salads, cheese made from cow’s milk, speciality pastries and ready meals.

However, the available data cannot be used to establish the increased consumption of such foods contaminated with *Listeria monocytogenes* as a contributory factor to the rise in cases of listeriosis in Germany with any certainty. This would require targeted surveys of consumption patterns in sensitive population subgroups and supplementary data for ready-to-eat foods not investigated sufficiently to date. Other reasons for the rise in cases of listeriosis in Germany and the EU could include an increase in the number of susceptible individuals and improvements in the systems used to report these kinds of illnesses.

The BfR has also assessed a number of innovative technical methods for the production, preservation and distribution of ready-to-eat foods designed with the aim of reducing the incidence of listeria.
The BfR has also published a consumer guide to avoiding food-borne listeriosis infections (see https://www.bfr.bund.de/cm/350/verbrauchertipps-schutz-vor-lebensmittelinfektionen-mit-listerien.pdf). For people at greater risk of contracting listeriosis, special rules apply for kitchen hygiene and for the consumption of certain kinds of foods. Above all, foods that are not (re-)heated before consumption should be prepared at home from fresh ingredients and consumed as soon as possible. Foods stored temporarily in the refrigerator should be consumed within two to three days.

Subject of the assessment

In recent years, the incidence of listeriosis in humans has been rising both in Germany and across the EU. Transmission to humans occurs primarily as a result of the consumption of foods contaminated with *Listeria monocytogenes*. As a result of recent listeriosis outbreaks in Germany caused by ready-to-eat foods, concerns have been expressed as to whether the hygiene standards for ready-to-eat foods that are intended to minimise the risk of infection are sufficient in the specific case of *Listeria monocytogenes*.

In light of the above, the German Federal Institute for Risk Assessment (BfR) has addressed the following questions:

1. Over the last 10 years, is there evidence pointing to an increase or decrease in the consumption of ready-to-eat foods that promote the growth of *Listeria monocytogenes* or which could be contaminated with *Listeria monocytogenes*?
2. Which types of ready-to-eat food (e.g. of animal or plant origin) were most frequently found to be contaminated with *Listeria monocytogenes* during the last 10 years?
3. Is there evidence to support the hypothesis that the increased production of ready-to-eat foods and general growth in the market for ready-to-eat foods as part of the food retail sector has led to an increase in cases of listeriosis in humans?
4. Which innovative technological methods for ready-to-eat foods are suitable for preventing the occurrence and growth of *Listeria monocytogenes* during production, handling and distribution?
5. Can additional risk communication measures be taken (and if so, which ones) to influence the frequency of occurrence of infections involving *Listeria monocytogenes*?

In the following sections, the BfR proceeds to assess these questions in the same order as introduced above. The answers given to questions 1 and 4 have been approved jointly by the Max Rubner Institute (MRI).

1. Response to the following question: Over the last 10 years, is there evidence pointing to an increase or decrease in the consumption of ready-to-eat foods that promote the growth of *Listeria monocytogenes* or which could be contaminated with *Listeria monocytogenes*?

1.1 Underlying data

To answer the question as outlined above, the underlying data need to meet the following criteria:

(1) Data are available at a level of aggregation that enables a distinction to be made on the basis of methods of production or processing that are relevant for contamination with *Listeria monocytogenes* (e.g. whether the food in question is a freshly-prepared or ready-to-eat, pre-packaged salad).
(2) Data are available from at least two survey periods that ideally represent a trend line extending over 10 years.
(3) Data from both survey periods are comparable in terms of methodology and level of detail.

<u>Consumption data</u>
To answer research questions with relevance for consumption, the BfR can draw on representative consumption surveys conducted in children and adults from Germany (VELS [1], ESKIMO [2] and NVSII [3, 4]). For the following reasons, however, these data are not suitable for answering the present question in its full complexity:

- The level of detail of the survey questions in the consumption studies does not provide adequate information about food preparation (e.g. distinction between fresh and ready-to-eat).
- Data are also only available for a single point in time, which prevents the construction of a time series.

Following a consultation with the MRI concerning the option of using National Nutrition Monitoring (NEMONIT) data, it transpired that, while the follow-up study for NVA II for adults aged between 14 and 80 does permit the consideration of an additional period between 2008 and 2015, both the level of detail and sample size in this study would preclude their use in providing a valid answer to the above question. In a NVSII subsample, approximately 2,000 individuals were also surveyed twice yearly about their food consumption using 24-hour recall. As data aggregation was performed for the evaluation at the food group level, the level of granularity no longer permits the consideration of individual foods. While a statement about cheese can be made, this is not possible for types of cheese such as soft cheese made from cow's milk. Nor was the necessary level of detail provided about processing or the type of preparation involved, such as whether fruit was pre-cut or salad was pre-packaged. The number of days surveyed is also too low to cover all of the foodstuffs eaten less regularly by any one individual. Such foodstuffs include fish, sprouted vegetables and raw milk cheese.

In light of these problems, market data was consulted to obtain a valid answer to the question. While these data cannot substantiate statements about individual consumption quantities/frequencies, they are nonetheless considered to be a current and adequately detailed dataset in this context.

► <u>Market data</u>
In the preparation of answers to this question, survey data was used from the household and fresh food panel maintained by GfK SE.

This household panel is a representative sample of households throughout Germany, whose purchasing patterns are recorded on a regular basis. The panel consists of a gross sample of 30,000 households, which record their purchases using a barcode scanner for transfer to GfK SE (to create the 'household panel' for foods such as cheese and dairy products, deli salads, ready meals, baked goods, etc.). Foods without an EAN barcode are either scanned using a code book or entered manually via an input screen. A subsample of 13,000 households is also taken from the household panel, to form the 'Fresh Food Panel' (e.g. for fresh meat and fresh fish as well as fresh vegetables and fruit). The representativeness of the household panel and fresh food panel is ensured by making comparisons with the micro-census conducted by the German Federal Statistical Office.

The use of market data offers a key advantage: the large sample size means that valid data can be collected about the increased or decreased consumption of products throughout Germany. Since the methodology remains the same, an exact comparison can also be made between two different timespans. Barcode scanning also ensures a high level of accuracy since respondents are not asked to tax their memory about foods that they have consumed. In addition, the barcodes can also be used to distinguish between different kinds of product processing and packaging, which allows information to be obtained that is of relevance for answering the above question (such as whether the fruit is pre-cut, for example).

Food selection

The term 'ready-to-eat food' is defined by EU Regulation (EC) No 2073/2005 of the Commission of 15 November 2005 on microbiological criteria for foodstuffs as follows: *"…food intended by the producer or the manufacturer for direct human consumption without the need for cooking or other processing effective to eliminate or reduce to an acceptable level micro-organisms of concern"*. This definition includes both conventional ready meals as well as other kinds of products that can be consumed without further processing (e.g. fresh fruit, fresh vegetables).

Since this definition encompasses a broad range of products, the selection of foods to be considered was restricted by applying the following two criteria:

1) Presence of relevant prevalence figures for *Listeria monocytogenes* from 2008 to 2017
2) Matrix or type of processing that promotes the growth of *Listeria monocytogenes*.

Accordingly, 40 relevant foods were identified from the following groups: meat products, fish products, dairy products, baked goods, deli salads, ready meals, dried spices, salads and vegetables, and fruit (table 1). To enable an easier interpretation of the data, these foods are introduced briefly below.

The selected foods include all types of ready-to-eat meat products, including heat-treated, dried and raw foods. Products are differentiated by animal species in each case. The heat-treated products include roasted or fried, stewed and cooked meat products, such as pork sausage, luncheon meat and cooked ham as well as pre-fried rissoles. The category 'Other preserved meat products' includes products such as raw sausage, raw ham or dried meat (jerky). Raw meat is minced (ground) into a ready-to-eat form and sometimes seasoned (steak tartare or pork mince with salt, pepper, onions). Minced meat is also included in this group, since it can be assumed that consumers may eat the product raw, may also taste the meat during preparation or may eat it without it being fully cooked through.

Ready-to-eat fish products includes heat-treated products such as pre-cooked prawns, shrimp and crayfish, marinated products such as rollmops and fried herring or herring snacks (some of which reuse the marinade for cooking), as well as hot- or cold-smoked and gravlax products such as smoked trout or mackerel, and hot-/cold-smoked salmon and gravlax salmon.

The dairy product group includes cheese made from the milk of various animal species as well as other dairy products. Cheese is differentiated based on soft or semi-hard types (such as brie, camembert or 'Butterkäse') and all other types of cheese. Dairy products excluding cheese include all other types of products such as yoghurt, curd cheese and buttermilk.

The category of 'Pastries' includes not only the various Danish pastries eaten in Germany, featuring blancmange or cherry fillings, etc., but all other baked goods such as biscuit dough/yeast dough pastries and fruit cakes.

With deli salads, specific recipe categories are used to distinguish between products - i.e. whether they contain fish, poultry, vegetables, egg or meat. The 'Other' section includes products using recipes for cheese or pasta salads, soy/tofu salads, festive salads and speciality salads from different cultures. This last category includes couscous, bulgur wheat, tabbouleh and quinoa salads.

The 'Ready meal' product group is composed of products that can be consumed without needing to be (re-)heated as well as products that need to be (re-)heated before consumption. Ready meals intended for consumption without further heating include complete meals, such as sushi, as well as sandwiches, filled rolls, bagels and baguettes, pasties, and ready-to-eat salads/bowls. Ready meals that need to be re-heated before consumption are further subdivided into non-refrigerated, chilled and frozen ready meals. The category of non-refrigerated ready meals includes traditional dried products such as dried noodle or soup dishes. Chilled meals include refrigerated pizzas, soups or quiches. The last category of frozen ready meals includes frozen pizzas, other frozen meals (e.g. lasagne bolognese, nasi goreng, etc.) and frozen snacks (e.g. pizza baguettes, spring rolls, mozzarella sticks, pizza burgers, etc.). Although dried products and frozen products are viewed as less critical for contamination with *Listeria monocytogenes*, these products are listed for the sake of completeness. It is also possible for a consumer to fail to heat through a technically 'ready-to-eat' product, only warming it up to a temperature that is merely comfortable for consumption: this particular case would constitute a microbiological hygiene risk. It should also be emphasised that the out-of-home consumption of ready meals could not be accounted for: accordingly, the evaluation does not include any 'to go' foods such as a sandwich bought at a rail station bake shop or other meals eaten at a snack bar, canteen or restaurant.

Dried spices includes both individual herbs and spices as well as mixed spices and herb-flavoured salts as a single item in the table.

Salad and other vegetables are grouped into lettuce, leafy vegetables, vegetables that can also be consumed raw (e.g. tomatoes, cucumbers, peppers, etc.), and fresh sprouted vegetables or seeds. A special category in the table is reserved for pre-cut vegetables and lettuce. This category covers vegetables and lettuce that are already pre-cut into bite-sized portions and then packaged. This category constitutes a particular risk for contamination, since chopping the vegetables increases their surface area, thereby promoting proliferation and contamination.

The 'Fruit' category covers the general fruit market. As with the previous section, this section also distinguishes between products that have been chopped into bite-sized pieces and packaged accordingly; these are considered separately under the category ‘Mixed fruit salad/(pre-cut) fruit’.

Preserves were not included in the survey, since contamination of the product after heating in the can or jar is not to be expected. No data were available for certain items in the table. This affects the differentiation of dairy products (pasteurised/not pasteurised), the differentiation of smoked fish (hot-/cold-smoked), and the differentiation of pastries (with/without a cream filling).

<u>Time frame</u>
A survey extending over 10 years is not possible since the maximum retention period for market data at GfK SE is only five years. As a result, the evaluation extended only over the periods of September 2012 to August 2013 (survey period 1) and September 2017 to August 2018 (survey period 2). In each case, the data were analysed for a period of 12 months, so as to also account for seasonal variation during the year.

<u>Purchase volumes and buyer households</u>
The data as presented include sales volumes quoted in tonnes (t) and the percentage difference in sales volumes between the two survey periods. In addition, the percentage difference between buyer households between the two survey periods is also specified. As one example, the figure for households buying heat-treated meat products made from beef was 10% higher in 2017/18 when compared with 2012/13. It should also be noted that the number of households in Germany also increased by 3.7% in the time between the two survey periods. In recent years, the structure of households has also undergone changes: as a result, around 42% of households in Germany were only one-person households in 2017.

A comparison of sales volumes across both survey periods provides evidence of a product being purchased in greater or lesser quantities on average by German households. From this, an indirect conclusion can be drawn as to whether the product was therefore being consumed more or less frequently.

Accounting for the number of buyer households provides indirect information about whether the respective product is being consumed by more or fewer individuals, as well as the overall increase/reduction in consumption. This further substantiates the reliability of data on sales volumes, since portion and product sizes have been subject to systematic changes over the periods considered, and this could therefore influence the figures for sales volumes. If a product is being bought more often while simultaneously being consumed by more households, then more frequent consumption overall is very likely.

1.2 Results

Table 1 lists all of the foods selected, including sales volume in tonnes (t), as well as the difference in this volume between survey periods (%) and the difference between buyer households between survey periods (%). The items shown with a grey background can be understood as the ‘parent group’ for the categories shown below them - their sales volume figures represent the total for these foods.

If only these parent groups are considered, then changes within the five-year period are small, with a difference in sales volume between −6% and +6%, and −2.7% and +0.3% in the number of buyer households. Consideration of the individual subcategories reveals a heterogeneous picture, however. Across all of the foods considered, ‘Heat-treated meat products from other meat, excluding poultry’ (e.g. game) shows the strongest decline in sales volume at −43% (and −30% buyer households). ‘Mixed fruit salad/pre-cut fruit’ shows the strongest growth at +242% (+53% buyer households). When interpreting these data, however, one should remember that these products each make up a small proportion of the overall sales market. The sales volume for ‘Fruit salad/pre-cut fruit’ accounts for only 0.4% of the total sales volume of fruit, for example.

Figures 1 and 2 provide an overview of the percentage changes in the two parameters considered, namely sales volume and buyer households, over the two survey periods. These changes reflect the heterogeneity in the trends for the types of food considered. If a parallel rise in sales volume and buyer households is taken as an underlying criterion, then this indicates more frequent consumption for 14 of the 40 foods investigated. In the same way, 5 of 40 foods display a decline in frequency. These are listed separately in Table 2. All foods are included that exhibit a difference >1% in either of the two parameters. All other foods either show changes of ≤1% or exhibit opposing trend trajectories for sales volume and buyer households. A good example of the latter case is cheese made from buffalo milk. While sales volume rose by 39%, the proportion of buyer households fell by 9%: accordingly, larger quantities are probably being consumed by fewer households.

Table 1: Selected ready-to-eat foods that have the potential to be contaminated with *Listeria monocytogenes*. Figures for sales volume in tonnes (t), percentage change in sales volume (%), and percentage change in buyer households (%) between the two survey periods of 2012/13 and 2017/18 (GfK SE, Consumer Panels & Services, 2018).

	Sales (t)			
Food	**Survey period 1 (9/2012 - 8/2013)**	**Survey period 2 (9/2017 - 8/2018)**	**% difference sales volume**	**% difference buyer households**
Heat-treated meat products	**1,210,616**	**1,172,124**	**-3**	**-1**
Poultry (chicken, turkey)	53,667	68,226	27	3
Poultry (other domestic poultry)	79,594	85,662	8	-5
Beef	19,285	21,919	14	10
Pork	1,048,946	991,149	-6	-1
Other meat (excluding poultry)	9,124	5,168	-43	-30
Other preserved meat products	**320,718**	**317,816**	**-1**	**-1**
Beef	1,700	2,990	76	37
Pork	318,533	314,376	-1	-1
Other meat (excluding poultry)	485	450	-7	-9
Raw meat	**294,978**	**302,118**	**2**	**-2**
Steak tartare, pork mince with seasoning	63,566	60,154	-5	2
Minced meat (overall)	231,412	241,963	5	-2
Fish producсts	**105,667**	**99,408**	**-6**	**-3**
Fish, heat-treated	4,637	7,006	51	23
Fish, marinated	51,812	52,412	1	-6
Fish, hot-/cold-smoked or gravlax	49,219	39,990	-19	-7
Cheese and dairy products	**4,840,594**	**4,851,023**	**0.2**	**−1**
Soft cheese/semi-hard cheese - cow’s milk	168,772	177,932	5	−0.3
Soft cheese/semi-hard cheese - goat’s milk	3,632	3,402	-6	5
Soft cheese/semi-hard cheese - sheep’s milk	251	307	22	13
Other cheese - cow’s milk	582,187	627,456	8	−0.2
Other cheese - buffalo milk	842	1,169	39	-9

Food	Sales (t) Survey period 1 (9/2012 - 8/2013)	Sales (t) Survey period 2 (9/2017 - 8/2018)	% difference sales volume	% difference buyer households
Other cheese - goat's milk	8,734	8,545	-2	6
Other cheese - sheep's milk	11,582	15,438	33	13
Dairy products (excl. cheese)	4,064,594	4,016,773	-1	-1
Pastries	**149,566**	**158,740**	**6**	**-3**
Deli salads	**179,423**	**186,075**	**4**	**-1**
Deli salads - with meat	52,485	51,035	-3	-5
Deli salads - with fish	19,076	19,295	1	-7
Deli salads - with poultry	7,103	7,259	2	-8
Deli salads - with vegetables	81,227	82,969	2	1
Deli salads - with egg	4,639	5,638	22	7
Deli salads - other	14,893	19,878	33	14
Ready meals	**668,562**	**708,770**	**6**	**−0.4**
Ready meals consumed without further heating	25,257	45,965	82	23
Ready meals consumed with further heating, non-refrigerated	251,193	234,288	-7	-3
Ready meals consumed with further heating, chilled	75,919	96,123	27	3
Ready meals consumed with further heating, frozen	316,193	332,394	5	-1
Spices, dried	**16,468**	**16,225**	**-1**	**-2**
Lettuce and vegetables	**2,271,037**	**2,320,519**	**2**	**0.2**
Pre-cut vegetables and lettuce	26,035	30,075	16	8
Lettuce	236,445	225,376	-5	-1
Leafy vegetables	27,562	31,771	15	16
Other fresh vegetables, excluding rhubarb	1,980,324	2,032,327	3	0.3
Sprouted vegetables and sprouted seeds (fresh)	672	970	44	26
Fruit	**3,504,792**	**3,616,834**	**3**	**0.3**
Fresh fruit, including rhubarb	3,500,961	3,603,722	3	0.3
Mixed fruit salad/pre-cut fruit	3,832	13,112	242	53

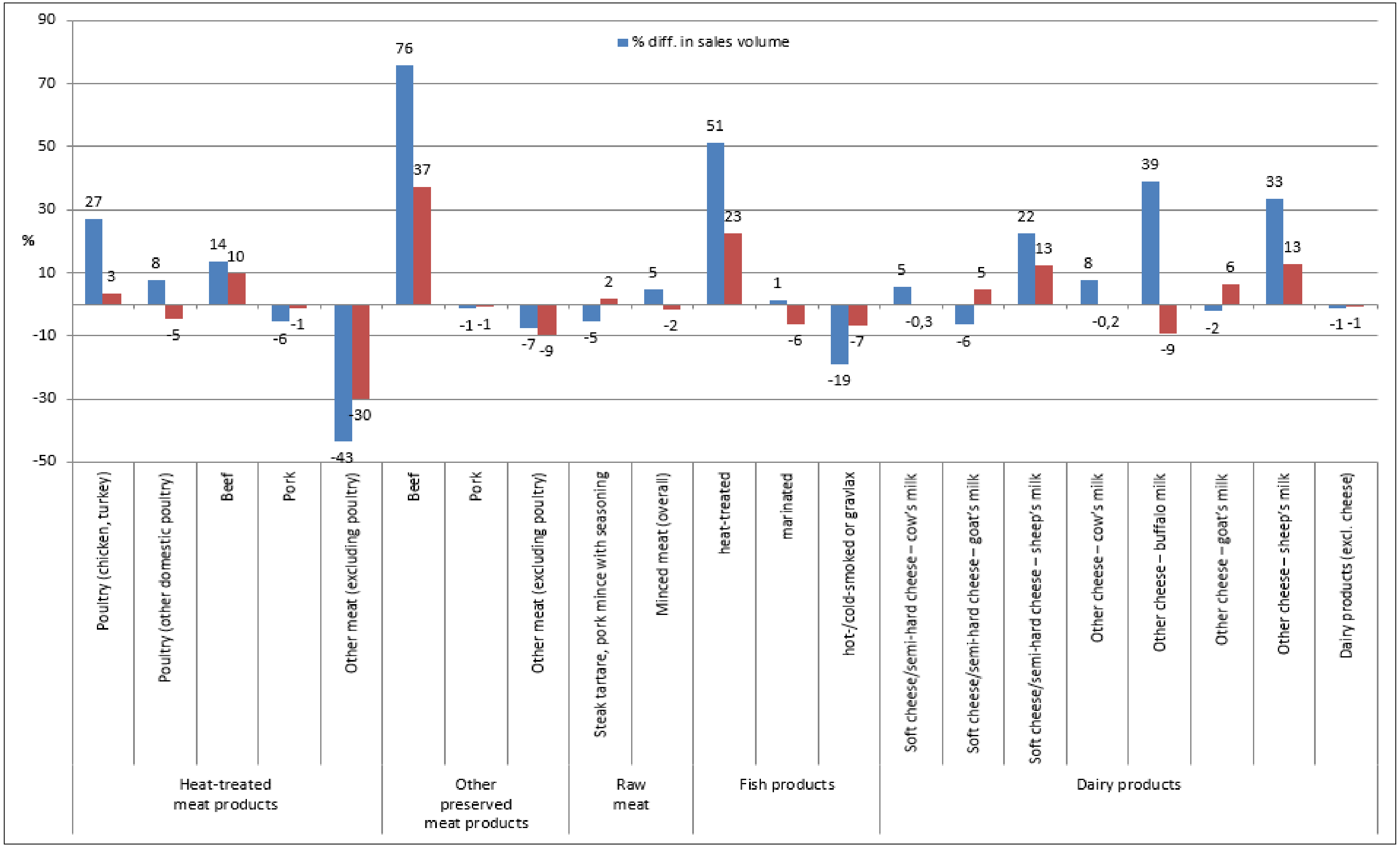

Figure 1: Percentage difference (%) in sales volume and buyer households as a comparison between the two survey periods of 2012/13 and 2017/18 (GfK SE, Consumer Panels & Services, 2018).

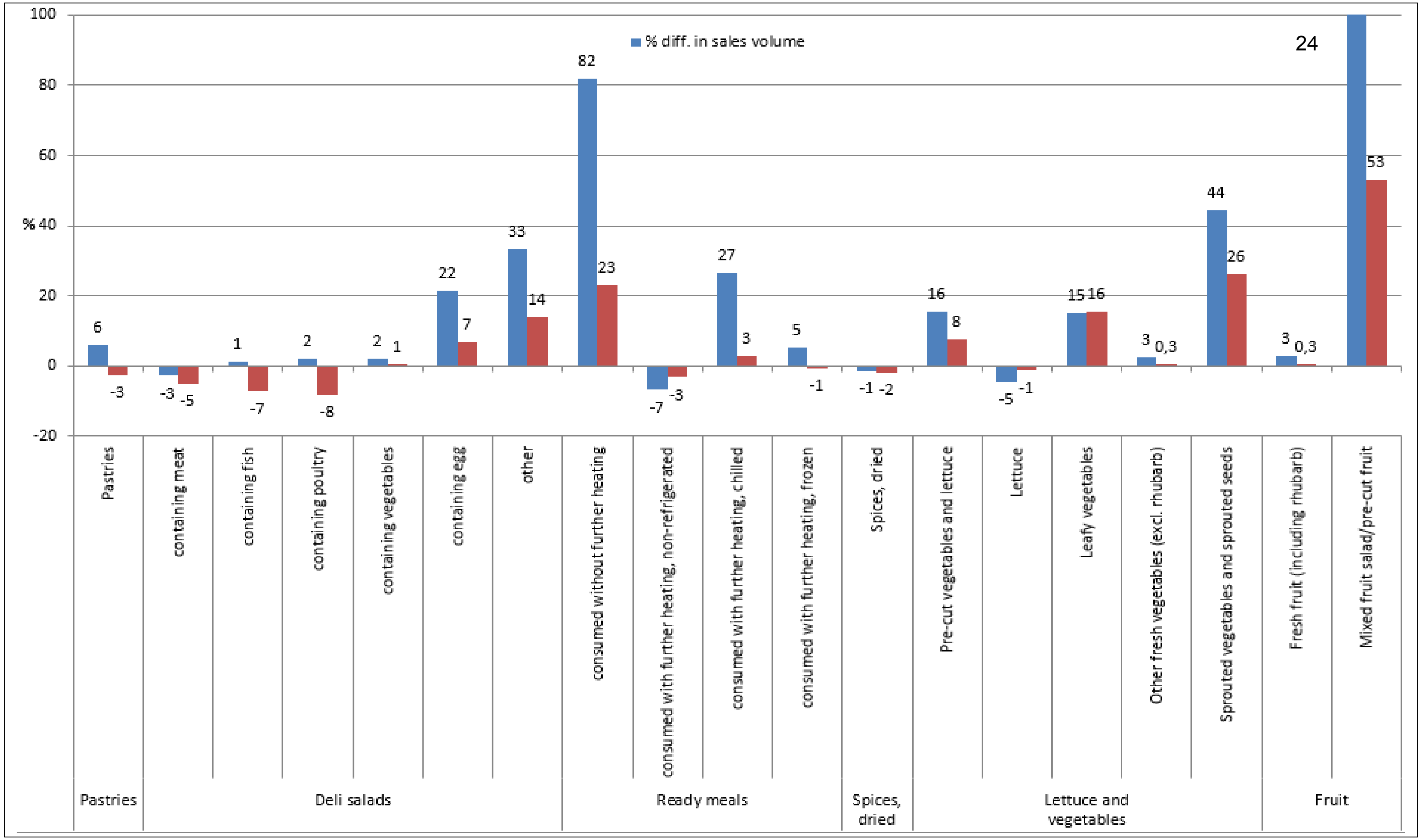

Figure 2: Percentage difference (%) in sales volume and buyer households as a comparison between the two survey periods of 2012/13 and 2017/18 (GfK SE, Consumer Panels & Services, 2018). [continued]

Table 2 lists all foods that fulfil the criterion of a parallel rise/fall in sales volume and buyer households, sorted in descending order by percentage change in sales volume (%). The largest percentage changes, with increases in sales volume of over 50%, can be seen in ‘Mixed fruit salad/pre-cut fruit’ (242%), ‘Ready meals consumed without further heating’ (82%), ‘Other preserved meat products - beef’ (76%) and ‘Fish products, heat-treated’ (51%). Noteworthy is the fact that the top two foods originate in the conventional to-go segment, i.e. these foods can be consumed immediately after purchase (e.g. pre-cut fruit salad or a sandwich purchased from the supermarket). It should also be mentioned that these figures are probably underestimates. Firstly, these products are often forgotten as a result of the immediate consumption (packaging is thrown away and not then scanned in at home). Secondly, identical products that are offered for immediate out-of-home consumption are not accounted for in the present figures (i.e. a filled roll bought from the baker at the station or a sushi-to-go box from a snack bar). Amounting to around 46,000 tonnes, ready meals sold for immediate consumption represent a large and highly diverse market. As a result of data aggregation, however, no further differentiation is possible into individual products.

All of the other foods listed in Table 2 display sales growth figures ranging from 44% (sprouted vegetables) to 14% (heat-treated meat products made from beef). This also includes a variety of deli salads, sheep’s cheese, heat-treated meat products made from poultry and chilled ready meals, as well as pre-cut vegetables and lettuce, and leafy vegetables.

A look at foods exhibiting declining trends in sales figures and buyer households reveals that products made from ‘other meat excluding poultry’ (e.g. game) are the primary types for which demand has fallen (−43% and −7%, respectively). Sales volumes for hot- and cold-smoked or gravlax fish products have also fallen significantly (by 19%). In this case, however, no differentiation is possible between smoked fish types: this reduction may have affected both or only one type of smoked products. Lastly, conventional dried ready meals such as dried noodles and soups (‘Ready meals consumed with further heating, non-refrigerated’) and deli salads containing meat were also purchased in smaller volumes (−7% and −3%, respectively).

Table 2: Ready-to-eat foods with the potential for contamination with *Listeria monocytogenes*, for which a greater [↑] or lesser [↓] frequency of consumption is likely in the period 2017/18 compared with the period 2012/13. Sorted in descending order by difference in sales volume (%).

	Sales (t)				
Food	**Survey period 1 (9/2012 - 8/2013)**	**Survey period 2 (9/2017 - 8/2018)**	**% difference sales volume**	**% difference buyer households**	**Trend**
Mixed fruit salad/pre-cut fruit	3,832	13,112	242	53	↑
Ready meals consumed without further heating	25,257	45,965	82	23	↑
Other preserved meat products - beef	1,700	2,990	76	37	↑
Fish products, heat-treated	4,637	7,006	51	23	↑
Sprouted vegetables and sprouted seeds (fresh)	672	970	44	26	↑
Deli salads - other	14,893	19,878	33	14	↑
Other cheese - sheep's milk	11,582	15,438	33	13	↑
Heat-treated meat products - poultry (chicken, turkey)	53,667	68,226	27	3	↑
Ready meals consumed with further heating, chilled	75,919	96,123	27	3	↑
Soft cheese/semi-hard cheese - sheep's milk	251	307	22	13	↑
Deli salads - with egg	4,639	5,638	22	7	↑
Pre-cut vegetables and lettuce	26,035	30,075	16	8	↑
Leafy vegetables	27,562	31,771	15	16	↑
Heat-treated meat products - beef	19,285	21,919	14	10	↑
Heat-treated meat products - other meat (excluding poultry)	9,124	5,168	-43	-30	↓
Fish products - hot-/cold-smoked or gravlax	49,219	39,990	-19	-7	↓
Other preserved meat products - other meat (excluding poultry)	485	450	-7	-9	↓
Ready meals consumed with further heating, non-refrigerated	251,193	234,288	-7	-3	↓
Deli salads - with meat	52,485	51,035	-3	-5	↓

1.3 Quality of the underlying data set

For the present evaluation of consumption trends for ready-to-eat foods, data on sales volumes and buyer households have been supplied by GfK SE. These data are based on a representative sample of private households in Germany (N = 30,000), stratified according to certain attributes such as German state ('Land'), household size, age, number and age of children, social status, nationality, etc. The data can therefore be viewed as representative for the sum total of all German households. For each survey period, data for 12 months are consolidated. This also accounts for the seasonal variability in patterns of buyer behaviour. Since the panel data are retained for only five years, only this period of time can be accounted for by the evaluation. A 10-year retrospective analysis is therefore not possible. The survey method did not change between the two periods considered: as a result, the data records from both periods can be compared with one another.

The survey method, using the scanning of the EAN barcode on the food product, enables an exact record of the purchase while minimising recall bias. Nonetheless, it is still possible that products without an EAN barcode (e.g. fresh fruit) in particular or products that are consumed immediately (e.g. ready meals that require no further heating) are underrepresented, as the data input is more complicated or the purchase was simply forgotten after consumption. Nor are any products reported on from out-of-home consumption (bakers, canteens, snack bars, etc.), since the 'forget rate' is too high, which makes the available data unreliable. Accordingly, one may assume that the actual consumption in this convenience segment is underestimated.

The underlying criterion for what is probably a more frequent rate of consumption consists of sales volume in tonnes and the number of buyer households in percent, which are compared in two periods spaced five years apart. A rise in sales volume with a simultaneously constant number of buyer households suggests that the purchasing households are either buying the products more frequently or that the quantity per purchase was increased. At the same time, however, this can also be influenced by retailers increasing the available pack contents. If figures for sales volume and buyer households rise simultaneously, one would expect an increase in acceptance by households, as can be observed with many products from the convenience segment (ready meals, pre-cut fruit). This criterion permits the interpretation of a very high likelihood of more frequent consumption. However, this criterion does not exclude a scenario where products with increased sales volume and a constant or even lower number of buyer households are also being consumed in greater quantities. The sales volume for buffalo milk cheese has risen sharply, for example, although the number of buyer households has fallen. Since both sales volume and buyer households in the 'Cheese and dairy products' parent group have remained the same overall, one may suspect a substitution effect is at work here. Accordingly, households are actually buying the same quantity of cheese but some of this is now buffalo milk cheese. Once again, this would mean that buffalo milk cheese was being consumed more frequently. Overall, data considered at a higher level of aggregation show less movement than when data are considered for foods differentiated by type. In the 'Fruit' group, for example, virtually no change is seen, while the sub-group of 'Mixed fruit salad/pre-cut fruit' shows an increase in sales volume of 242%. As a result, movements within larger segments cannot be discovered on the basis of the available data. One group affected by this fact is 'Other preserved meat products - beef', which exhibits a high rate of growth, even though no statement can be made about the underlying cause. Increases similar to those observed for fruit salad/pre-cut fruit can therefore be assumed even in more differentiated segments. Nor can ready meals, pastries or various items of dairy products be further differentiated, since neither the budget nor the level of detail provided for the product description permit a more differentiated analysis. The latter affects the microbiologically relevant distinction applicable to raw milk products, cream-filled pastries and hot- or cold-smoked fish products. While the criterion of a parallel rise in sales volume and buyer households permits conclusions to be drawn about a strong possibility of more frequent consumption, it does not exclude scenarios where other products are being consumed more frequently with a rise only in sales volume or at a lower level of data aggregation.

The present data are marketing data surveyed at the household level. As such, they do not permit any conclusions to be drawn about actual consumption quantities or frequencies, however, as no information is available about the further use of these products or food waste generated. Nor can any statements be made about subpopulations such as children, pregnant women or older individuals, since the data were not surveyed at an individual level. Whether sensitive groups of individuals consume ready-to-eat foods with a greater or lesser frequency cannot be evaluated using the present data.

1.4 Conclusions

To answer the question of whether ready-to-eat foods with the potential for contamination with *Listeria monocytogenes* were consumed with greater or lesser frequency, market data was consulted from the representative household panel from GfK SE. Since these data provide no information about actual consumption quantities or frequencies, a criterion for an increased/reduced consumption was specified as the parallel decrease/increase in sales volume and the number of buyer households as a comparison between two periods spaced five years apart. A total of 40 products were selected for the assessment. Of these, 14 show an increase in sales volume and buyer households. These include a variety of products from the food groups of fruit, vegetables, cheese, deli salads and ready meals. Products from the convenience segment (‘Mixed fruit salads/pre-cut fruit’ and ‘Ready meals consumed without further heating’) in particular show the largest gains from a low starting-point. These gains are also in all likelihood underestimated, since no out-of-home consumption is accounted for and products from high street retail are often not reported (recall bias). Five of the 40 products show a decline in sales volume and buyer households, including various foods from the category ‘Other meat (excluding poultry)’ (e.g. game), hot- and cold-smoked or gravlax fish, ready meals (dried products) and deli salads containing meat. All remaining foods show only small changes or changes in opposite directions (e.g. growth in sales volume plus decline in buyer households). The products for which a parallel increase/decrease in sales volume and buyer households is recorded are in all probability also more frequently or less frequently consumed, respectively. This does not mean that products whose trends move in opposite directions are not in fact consumed more frequently or less frequently, merely that this statement cannot be made with an adequate level of confidence.

2. Response to the following question: Which types of ready-to-eat food (e.g. of animal or plant origin) were most frequently found to be contaminated with *Listeria monocytogenes* during the last 10 years?

2.1 Underlying data

In answering the question about the types of ready-to-eat food most frequently found to be contaminated with *Listeria monocytogenes* during the last 10 years, the annual trend reports from the BfR on pathogens for zoonoses in Germany were consulted as the most significant source of underlying data [5-12]. The basis for these reports is formed by the annual surveys of the results of investigations into zoonotic pathogens, which are carried out by state-level authorities in Germany as part of the monitoring of food, animals, feed and environmental samples. For the evaluation, the qualitative and quantitative results of investigations for *Listeria monocytogenes* were consulted from routine samples taken from 2008 to 2016. At the time when the answer to the official decree was being prepared, data for routine samples from 2017 had not yet been fully validated and were therefore not considered in the evaluation.

As a supplement to the data from food monitoring, the results of zoonoses monitoring from the years 2012 to 2017 were also consulted [13-18]. In this context, qualitative and quantitative investigations relating to *Listeria monocytogenes* have been performed since 2012, primarily for product groups such as ready-to-eat foods, for which only sparse data were available. The investigation period for the individual food matrices covered a year in each case for zoonoses monitoring. Unlike the annual surveys performed by the food monitoring authorities, these data therefore do not reveal a trend extending over the past few years. Since representative sample sizes for the whole of Germany were typically investigated, however, these data can offer initial indications of ready-to-eat foods that are more frequently contaminated with *Listeria monocytogenes*.

In the context of an EU baseline study on the occurrence of *Listeria monocytogenes* in certain ready-to-eat foods, prevalence data for smoked and gravlax fish, for heat-treated meat products, and for cheese made from cow's milk were also investigated in 2010 and 2011. The results of this study for Germany were also included in the evaluation [19, 20].

To be able to compare the prevalence data on the occurrence of *Listeria monocytogenes* in ready-to-eat food with the consumption data evaluated for question 1, the surveyed product groups of ready-to-eat foods were examined, where possible, at the same and smallest-possible level of aggregation for the first two questions of interest. The product groups considered have been briefly outlined above as part of the answer to question 1 (see section 1.1, 'Underlying data'). As a result of differences in the surveying and reporting of consumption data and prevalence data, however, the foods reported on are not identical across all product groups. Corresponding deviations are compared with one another in table 3.

Table 3: Deviations in the grouping applied to obtain product groups and foods for the evaluation of prevalence data on *Listeria monocytogenes* in ready-to-eat foods and the consumption of ready-to-eat foods in Germany

Product group/ food	**Grouping used for the evaluation of prevalence data on *Listeria monocytogenes* in ready-to-eat foods**	**Grouping used for the evaluation of consumption data for ready-to-eat foods**
Heat-treated meat products	• Pork • Beef • Poultry (overall) • Other meat (excluding poultry)	• Pork • Beef • Including poultry (chicken, turkey) • Including poultry (other domestic poultry) • Other meat (excluding poultry)
Fish products	• Fish, cold-smoked or gravlax (marinated accordingly) • Fish, hot-smoked • Fish, other means of preservation (marinated accordingly, not gravlax) • Fried fish and boiled fish foods, fish in aspic, long shelf-life fish products	• Fish, hot-/cold-smoked or gravlax • Fish, marinated (not gravlax) • Fried fish and boiled fish foods, fish in aspic, long shelf-life fish products, pre-cooked prawns, shrimp, crayfish
Cheese	• Soft cheese • Other cheese (incl. semi-hard cheese)	• Soft cheese and semi-hard cheese • Other cheese
Minced meat preparations intended to be consumed raw	• Minced meat preparations (any, incl. those for raw consumption such as steak tartare and pork mince with seasoning, as well as others not intended for raw consumption)	• Steak tartare, pork mince with seasoning
Ready meals	• Ready meals (any, with/without further heating)	• Ready meals consumed without further heating • Ready meals consumed with further heating, non-refrigerated • Ready meals consumed with further heating, chilled • Ready meals consumed with further heating, frozen

2.2 Results

With only a few exceptions, ready-to-eat foods can be found in almost all product groups of vegetable and animal origin. As a result of the widespread presence of *Listeria monocytogenes* in the environment, and its high degree of tenacity in production environments in companies that manufacture and process food products, the pathogen can contaminate a wide variety of ready-to-eat foods prior to, during or after processing.

In Germany, high rates of detection have been recorded over the last 10 years in routine samples taken from cold-smoked and gravlax fish (7-18%), hot-smoked fish (3-9%), fish with other means of preservation (4-10%) (table 10) and other preserved meat products (10-17%) (table 8). In all of these product groups, quantitative investigations have regularly determined values that exceed the safety criterion for *Listeria monocytogenes* as specified in EU Regulation (EC) No 2073/2005 for ready-to-eat foods (tables 9 and 11). In this analysis, concentrations of *Listeria monocytogenes* (a 'viable colony count' in subsequent sections) in cold-smoked and gravlax fish as well as hot-smoked fish were more likely to exceed 100 CFU/g (in 0.3-2.4% and 0.1-1.8% of quantitatively investigated samples) than in fish with other means of preservation and other preserved meat products (0.2-0.8% and 0.3-0.8% of quantitatively investigated samples). Viable colony counts exceeding even 1,000 CFU/g were detected in all product groups at isolated to regular frequencies. Differentiation of other preserved meat products by animal species revealed slightly higher rates of detection for products made from pork (8-13%) than for products made from the meat of other animals, excluding poultry (5-10%). *Listeria monocytogenes* was also detected regularly in the category of other preserved meat products from beef. Since available data here are sparse, however, this prevents the derivation of valid statements about prevalence (table 8).

High rates of prevalence for *Listeria monocytogenes* are also exhibited by minced meat (7-22%) and minced meat preparations (15-24%) (table 4). In the minced meat preparations product group, prepared pork mince is offered by retailers to the consumer for raw consumption as a seasoned mince product, while raw beef mince is offered as a steak tartare or other minced steak product. These foods are therefore to be considered as ready-to-eat. However, the detection rates specified here relate to all minced meat preparations, including those that are intended to be heated before consumption. This therefore limits the derivation of conclusions from trend reporting data about certain minced meat preparations intended to be eaten raw - such as seasoned pork mince and steak tartare. During 2017 zoonoses monitoring, *Listeria monocytogenes* was detected in 11% of the samples of steak tartare/minced beef steak investigated (table 21).

In routine samples of minced meat and minced meat preparations, viable colony counts exceeding 100 CFU/g were detected regularly and even viable colony counts exceeding 1,000 CFU/g were detected frequently (Table 5). In contrast, the samples of steak tartare/minced beef steak investigated during 2017 zoonoses monitoring did not exceed the limit value of 100 CFU/g (Table 22).

In recent years, lower detection rates of *Listeria monocytogenes* occurred in heat-treated meat products overall (1.0-3.3%) (Table 6), deli salads (1.0-4.1%) (Table 17), cheese from cow's milk (0.0-2.2%) (Tables 12 and 13), pastries (0.4-1.4%) (Table 15) and ready meals (0.0-2.7%) (Table 18).

In heat-treated meat products differentiated by animal species, some detection rates are higher than for heat-treated meat products overall (pork products 1.6-4.4%; products from other meat excluding poultry 1.1-6.5%; including poultry 1.5-5.6%) (Table 6). For heat-treated meat products made from beef, available data are sparse; for cheese, valid statements can be made only for cheese made from cow's milk. Slightly higher rates of detection were recorded here for soft cheese made from raw milk (0.0-1.6%) and from pasteurised milk (0.0-2.2%) than for other cheese made from pasteurised milk (0.2-0.8%) (Tables 12 and 13).

Values exceeding the safety criterion specified for ready-to-eat foods of 100 CFU/g were reported for isolated cases of deli salads, cheese made from cow's milk, pastries and ready meals, as well as regularly for heat-treated meat products (0.1-0.2%) (Table 7). Viable colony counts even exceeding 1,000 CFU/g were reported in samples from all food groups mentioned, excepting ready meals.

Listeria monocytogenes has been detected sporadically in recent years in lettuce and vegetables, fruit, and goat's/sheep's cheese and other raw milk cheese made from cow's milk. However, the available data are inadequate for the purpose of deriving valid statements about prevalence for these product groups.

2.3 Individual results by product group

The following section provides a detailed description of the results on the occurrence of *Listeria monocytogenes* in the individual product groups of ready-to-eat foods and summarises the relevant data from Tables 4 to 22 in the annex.

<u>Minced meat and minced meat preparations</u>
Over the last few years, qualitative investigations of routine samples of minced meat and minced meat preparations reveal constantly high detection rates for *Listeria monocytogenes*. For minced meat, 15-22% positive samples were reported in the years from 2008 to 2016 (median of annual sample size N = 1,070). One exception was the year 2013, with only 7% of samples being positive (Table 4). The results of quantitative investigations of minced meat reported in the same period revealed viable colony counts exceeding 100 CFU/g in 0.1-1.6% of samples. In seven out of nine years, viable colony counts exceeding 1,000 CFU/g were reported in 0.1-0.2% of samples (Table 5).

For minced meat preparations, data are available for the years 2011 to 2016. For this period, a prevalence of 15-24% was determined (median of annual sample size N = 1,363). The viable colony counts reported here were over 100 CFU/g for 0.5-1.0% of the quantitatively investigated samples and, in four out of six years, over 1,000 CFU/g in 0.1-0.3% of samples (Table 5). For routine samples reported for pork mince preparations, a significantly smaller data set is available for the years 2011 to 2016 (median of annual sample size N = 94). *Listeria monocytogenes* was detected here in 5-25% of the qualitatively investigated samples. In three out of six years, 0.5-1.5% of samples exhibited viable colony counts between 100 and 1,000 CFU/g.

For steak tartare/minced beef steak, valid data are available only from zoonoses monitoring in 2017. *Listeria monocytogenes* was detected qualitatively in 11% of samples investigated (N = 278) (Table 21). Of the quantitatively investigated samples (N = 251), 2% exhibited *Listeria monocytogenes* at a level under 100 CFU/g. No sample exhibited a viable colony count over 100 CFU/g (Table 22).

<u>Heat-treated meat products</u>
For heat-treated meat products, qualitative investigations of routine samples taken from 2008 to 2016 reported 1.8-3.3% of samples positive for *Listeria monocytogenes* (median of annual

sample size N = 2,367). One exception was the year 2016, with only 1.0% (Table 6). A comparison differentiated by animal species revealed detection rates for heat-treated meat products made from pork of 1.6-4.4% (median of annual sample size N = 731), for heat-treated meat products made from other meat excluding poultry of 1.1-6.5% (median of annual sample size N = 614) and for heat-treated poultry meat products of 1.5-5.6% (median of annual sample size N = 368). A significantly smaller data set was available for heat-treated meat products made from beef (median of annual sample size N = 35). The detection rates for *Listeria monocytogenes* varied here between 0 and 8%.

For quantitatively investigated heat-treated meat products, routine samples with viable colony counts exceeding 100 CFU/g (0.1-0.2%) were reported for all years with the exception of 2016. In four years, 0.1% of samples also exhibited viable colony counts exceeding 1,000 CFU/g (Table 7). For heat-treated poultry meat products, the viable colony counts reported in 0.3-0.9% of quantitatively investigated samples were more frequently above 100 CFU/g than in heat-treated meat products made with meat from other animals (0.2-0.5%). In heat-treated meat products made from beef, no viable colony counts were determined in excess of 100 CFU/g. As with the qualitative investigations, only a few samples were quantitatively investigated here (median of annual sample size N = 35).

In the course of the 2010/2011 EU baseline study on *Listeria monocytogenes* in ready-to-eat foods, the pathogen was detected in 1.9% of the samples of heat-treated meat products investigated in Germany (N = 915) (Table 21). Viable colony counts in excess of 100 CFU/g were exhibited by 0.1% of samples investigated (Table 22).

<u>Other preserved meat products</u>
During the years 2008 to 2016, qualitatively investigated routine samples of other preserved meat products (overall) in Germany exhibited high rates of contamination with *Listeria monocytogenes* amounting to 10-17% (median of annual sample size N = 2,392) (Table 8).

During the same period, viable colony counts of over 100 CFU/g were determined in all years for 0.3-0.8% of quantitatively investigated routine samples. With the exception of 2010 and 2016, 0.1-0.3% of samples investigated also exhibited viable colony counts exceeding 1,000 CFU/g (Table 9).

Other preserved meat products made from pork were more frequently contaminated, amounting to 8-13% of qualitatively positive samples (median of annual sample size N = 527) (Table 8). Viable colony counts exceeding 100 CFU/g were determined for 0.2-1.0% of quantitatively investigated samples. In the period under investigation, this affected six out of nine years. In 2008 and 2014, viable colony counts exceeding 1,000 CFU/g were also determined in 0.3-0.5% of samples investigated (Table 9).

For other preserved meat products made from beef, valid statements on the occurrence of *Listeria monocytogenes* are not possible, as a result of the limited availability of data from 2008 to 2016. In the few samples investigated annually, the pathogen was regularly detected, however. Viable colony counts exceeding 100 CFU/g were also determined.

For other preserved meat products made from other types of meat excluding poultry (e.g. game), usable data are available only for the period 2010-2014. *Listeria monocytogenes* was detected here in 5-10% of qualitatively investigated routine samples (median of annual sample size N = 488) (Table 8). During the same period, viable colony counts over 100 CFU/g were detected in three years in 0.2-0.3% of quantitatively investigated samples; in 2011, the viable colony count also exceeded 1,000 CFU/g in 0.2% of samples (Table 9).

During the course of the 2017 zoonoses monitoring, spreadable raw sausage products from the 'Other preserved meat products' group were investigated for *Listeria monocytogenes*. The pathogen was detected in 12% of qualitatively investigated samples (N = 393) (Table 21). In the quantitative investigation (N = 378), two samples (0.5%) exhibited viable colony counts exceeding 100 CFU/g, amounting to 220 and 580 CFU/g (Table 22).

Fish products

In the product group of fish products, routine samples investigated for cold-smoked fish, gravlax fish and hot-smoked fish as well as samples for fish using other means of preservation exhibited high levels of prevalence for *Listeria monocytogenes* on a continuous basis from 2008 to 2015. For cold-smoked and gravlax fish, 13-18% of qualitatively positive samples were determined, with the exception of 2011 (8%) and 2015 (7%) (median of annual sample size N = 374) (Table 10). In addition, 0.3-2.4% of samples with viable colony counts over 100 CFU/g were reported consistently across all years. With the exception of 2010 and 2011, 0.3-0.8% of quantitatively investigated samples also exhibited higher viable colony counts exceeding 1,000 CFU/g (Table 11).

For hot-smoked fish, a slightly lower prevalence of 3-9% was determined in qualitatively investigated routine samples (median of annual sample size N = 873). With the exception of 2015, viable colony counts over 100 CFU/g were determined in 0.1-1.8% of quantitatively investigated samples. In 2008 to 2012 and in 2016, viable colony counts exceeding 1,000 CFU/g were also detected in 0.2-1.0% of samples.

Smoked and gravlax fish were investigated in the course of the EU baseline study in 2010/2011 on the occurrence of *Listeria monocytogenes* in certain ready-to-eat foods. No distinction was made in this study between hot- and cold-smoked fish. The pathogen was discovered in 12% of qualitatively investigated samples (N = 474) (Table 21). Of these, 1.5% of samples exhibited viable colony counts of over 100 CFU/g (Table 22). These results are consistent with the determined prevalence data as reported annually for routine samples.

In the category of 'Fish with other means of preservation', lower prevalence was also detected here (4-10%) compared with cold-smoked and gravlax fish (Table 10). With the exception of 2010, quantitative investigations revealed viable colony counts over 100 CFU/g in 0.2-0.8% of routine samples. In isolated years, 0.1-0.4% of samples exhibited viable colony counts exceeding 1,000 CFU/g (Table 11).

For routine samples of heat-treated fish, only a small data set was reported that does not permit valid statements to be made about the occurrence of *Listeria monocytogenes*. Isolated positive samples were nonetheless discovered. Quantitatively investigated samples exhibited viable colony counts under 100 CFU/g.

Cheese

Prevalence data for *Listeria monocytogenes* in routine samples of cheese from 2008 to 2016 were grouped into categories according to cheese type (soft cheese, other cheese excluding soft cheese), the milk processing condition (raw milk, pasteurised milk) and milk origin (animal species). Samples of cheese made from cow's milk made up the majority of the samples investigated here. With the exception of the year 2012 (0% with N = 91), a prevalence of 0.4-1.6% was determined for raw milk soft cheese made from cow's milk (median of annual sample size N = 192) (Table 12). In soft cheese made from pasteurised cow's milk, 0.3-1.0% positive samples were detected with only a few exceptions (median of annual sample size N = 601). In 2009 and 2014, a slightly higher level of prevalence was determined, at 2.2% (Table 13). Other cheese from pasteurised cow's milk exhibited levels of prevalence from 0.2-

0.8% in the years under investigation (median of annual sample size N = 3,148). For other raw milk cheese made from cow's milk, and for all cheeses made from sheep's and goat's milk, some sample sizes investigated were very small and others very varied, rendering valid statements about rates of detection in these types of cheese impossible. Isolated positive cases of *Listeria monocytogenes* were also detected here, although viable colony counts over 100 CFU/g were not identified. In contrast, raw milk soft cheese made from cow's milk, and soft cheese and other cheeses made from pasteurised cow's milk, exhibited viable colony counts over 100 CFU/g in individual years. As a proportion of quantitatively positive samples, viable colony counts over 1,000 CFU/g were also reported more frequently (Table 14).

Soft cheese and semi-hard cheese made from cow's milk were investigated in the course of the EU baseline study in 2010/2011 on the occurrence of *Listeria monocytogenes* in certain ready-to-eat foods. The results in Germany tallied largely with those from official food monitoring surveys. With the qualitative method, the pathogen could not be detected in samples of soft cheese and semi-hard cheese made from pasteurised milk (N = 509), but could be detected in 1.6% of samples of soft cheese and semi-hard raw milk cheese (N = 320) (Table 21). The quantitative method found one positive sample each of soft cheese and semi-hard cheese made from pasteurised milk and raw milk, respectively. One sample (raw milk soft cheese) exhibited a viable colony count of 6,200 CFU/g (Table 22).

Certain kinds of cheese were also investigated nationwide in Germany for the occurrence of *Listeria monocytogenes* in selected years as part of zoonoses monitoring. In 2014, the pathogen was found in only a single sample (0.3%) of raw milk cheese (N = 332). The viable colony count was under 100 CFU/g. In 2015, the pathogen was detected in 1 of 288 samples of raw milk cheese made from sheep's or goat's milk (0.3%) (Table 21). The viable colony count was 570 CFU/g (Table 22).

<u>Pastries</u>
In 2009 to 2016, qualitative investigations of routine samples of pastries returned consistently low rates of detection of *Listeria monocytogenes*, at 0.4-1.4% (median of annual sample size N = 875). No positive samples were reported in 2008 (Table 15). In 2014 and 2016, however, viable colony counts over 100 CFU/g were reported in 0.6% and 0.3% of investigated samples, respectively. In 2010, viable colony counts exceeding 1,000 CFU/g were also detected in 0.1% of samples (Table 16).

<u>Deli salads</u>
In qualitative investigations carried out from 2010 to 2016, routine samples of deli salads returned detection rates for *Listeria monocytogenes* of 1.0-4.1% (median of annual sample size N = 649). In 2008 and 2009, with a smaller sample size investigated (N = 233 and N = 299), twice as many samples had been contaminated, at 7.3% and 7.0%, respectively (Table 17). Values in excess of 100 CFU/g were reported only for 2010. This affected 0.2% of samples for deli salads containing meat, with viable colony counts ranging from 1,000 to 10,000 CFU/g.

During the period under consideration, *Listeria monocytogenes* was regularly detected in deli salads containing meat and fish, and other deli salads, with isolated cases in deli salads containing vegetables, eggs, milk or poultry. The ingredients in deli salads primarily responsible for this contamination with *Listeria monocytogenes* cannot be established, as a result of the small - and occasionally highly variable - sample sizes available in the individual categories.

<u>Ready meals</u>

Listeria monocytogenes was detected in the product group of ready meals in 0.3-2.7% of the routine samples investigated in the years 2009 to 2016 (median of annual sample size N = 403). 2008 was the only year in which no positive samples were reported. However, the sample size investigated in this year was very small, at 57 samples (Table 18). In quantitative investigations, viable colony counts over 100 CFU/g were determined only in the year 2013, in 0.6% of routine samples.

Lettuce and vegetables
Only a small dataset is available on the occurrence of *Listeria monocytogenes* for the product group of lettuce and vegetables. Table 19 presents qualitative detection data from routine sampling for the categories of lettuce, leafy vegetables, sprouted vegetables, fresh vegetables for raw consumption (excluding leafy, chopped and sprouted vegetables), and pre-cut vegetables and lettuce. Although the pathogen was indeed regularly detected in all categories, no valid statements on prevalence can be derived from these data, due to the limited and widely varying scope of annual sampling.

As part of zoonoses monitoring in 2012, loose-leaf and butterhead lettuce from producing companies (N = 300) and retail (N = 422) was sampled, while pre-cut loose-leaf lettuce from retail (N = 344) was investigated in 2015. Detection rates here were 3.7%, 2.6% and 2.0% (Table 21). No sample exhibited a viable colony count over 100 CFU/g (Table 22). In 2016, fresh cocktail and cherry tomatoes, as well as fresh sprouted vegetables, were also investigated qualitatively for *Listeria monocytogenes*. While the pathogen was not detected in tomatoes, 1.8% of the samples of fresh sprouted vegetables tested were positive. *Listeria monocytogenes* was not detected by quantitative testing in any sample of sprouted vegetables (limit of detection <10 CFU/g).

Fruit
There is also a paucity of data for the detection of *Listeria monocytogenes* in the fruit product group in Germany over the last few years. Between 2011 and 2016, samples of both fresh fruit and fruit salads (pre-cut) have occasionally tested positive (Table 20). These data do not permit any estimate to be made about the prevalence of the pathogen, however.

As part of zoonoses monitoring, previous testing for *Listeria monocytogenes* has only covered fresh strawberries from producing companies (N = 300) and retail (N = 463) in 2013. Similar rates of detection were reported for both types of origin (1.3% and 1.1%, see Table 21).

2.4 Quality of the underlying data set

The currently available body of knowledge on the occurrence of *Listeria monocytogenes* in ready-to-eat foods permits comprehensive and valid estimates to be made only for heat-treated and other preserved meat products made from pork, with poultry or with meat from other animals excluding poultry (e.g. game), for cold- or hot-smoked and gravlax fish, and fish using other means of preservation, for cheese made from cow's milk (raw milk soft cheese, soft cheese and other cheese made from pasteurised milk) and, lastly, for deli salads (overall) and pastries (overall).

For the following ready-to-eat foods, the current available data is inadequate for making such estimates:

(1) Minced meat preparations intended to be consumed raw (seasoned pork mince, steak tartare/minced beef steak)
(2) Heat-treated and other preserved meat products made from beef
(3) Heat-treated fish
(4) Raw milk cheese other than soft cheese made from cow's milk
(5) Soft cheese and other cheese made from raw milk and pasteurised milk from other animal species
(6) Deli salads specified by the origin of their main ingredient (e.g. containing meat, fish and vegetables)
(7) Ready meals for consumption without further heating
(8) Lettuce and vegetables
(9) Fruit

In order to be able to analyse the prevalence data for *Listeria monocytogenes* collected annually as part of official food monitoring, both in general and specifically for selected ready-to-eat foods (e.g. spreadable raw sausage, meatballs, sandwiches), a detailed set of information is also required on the matrix and on the state of preparation for these food products. While these data are indeed surveyed by the German states, in the past these data were submitted for data evaluation at a national level in an aggregated format not specific to product groups - meaning that this detailed information was therefore lost. Since 2011, the results of the annual survey of zoonotic pathogens in food in Germany have increasingly been transferred with ADV coding at sample level: as a result, a more detailed analysis of prevalence data on *Listeria monocytogenes* in ready-to-eat foods will therefore be possible in the future.

3. Response to the following question: Is there evidence to support the hypothesis that the increased production of ready-to-eat foods and general growth in the market for ready-to-eat foods as part of the food retail sector has led to an increase in cases of listeriosis in humans?

Only indirect conclusions can be drawn about the occurrence of cases of listeriosis as a result of an increased production of ready-to-eat foods and an increased volume of these foods offered for sale in the food retail sector. Instead, it is the quantities consumed and frequency of consumption of ready-to-eat foods contaminated with *Listeria monocytogenes* by sensitive groups of people that have a direct effect on the number of cases of listeriosis. The sensitive groups of people that have an elevated risk of falling ill from listeriosis include the elderly, individuals with a weakened immune system (generally as a result of a serious systemic disease such as cancer or the long-term consumption of immunosuppressants), as well as pregnant women and neonates.

Data are therefore needed that enable the verification of evidence for a rising trend in the consumption of ready-to-eat foods by sensitive groups of people and/or an increase in prevalence for *Listeria monocytogenes* in these foods in recent years in Germany.

The data available to the BfR concerning food consumption in Germany provide only an incomplete picture of the consumption of ready-to-eat food products. Accordingly, the present assessment has consulted consumption data from the ‘Household and fresh food panel’ provided by GfK SE (see answer to question 1). Unlike prevalence data, these data are only able to capture changes occurring over the last five years. An evaluation of these market data demonstrated a parallel rise in sales volume and buyer households in 14 of 40 of the product groups considered to be relevant for answering this question. For these product groups, more frequent consumption in the overall population can be assumed to be very likely. This has affected in particular ready-to-eat foods from the convenience segment, such as pre-cut fruit and fruit salads, ready meals intended for consumption without further heating, other preserved meat products made from beef, sprouted vegetables and heat-treated fish products. While *Listeria monocytogenes* has been detected in all of these foods in recent years, valid estimates of the prevalence of the pathogen cannot be made for most foods as a result of a lack of available data.

In contrast, the consumption data reveals a trend towards reduced consumption for some product groups that exhibited high rates of detection for *Listeria monocytogenes* in recent years. Affected groups include other preserved meat products made from other meat excluding poultry, as well as cold- or hot-smoked fish and gravlax fish.

The available consumption data offer no insights into the actual quantities consumed or frequencies of consumption. Furthermore, the surveyed data are aggregated at household level and therefore permit no statements to be made about consumption patterns in various age groups - and therefore in sensitive groups of people. Indications of a decrease or increase in consumption for certain kinds of ready-to-eat foods in the overall population do not necessarily imply a reduced or increased rate of consumption by sensitive groups of people. Countervailing trends in various age groups may also arise simultaneously, although these will not be visible in the evaluated consumption data. As a result, consumption figures in various age groups may be over- or underestimated.

To be able to assess whether an increased consumption of ready-to-eat foods contaminated with *Listeria monocytogenes* shares responsibility for the rise in cases of listeriosis in Germany, surveys of the consumption patterns of sensitive groups of people focusing on ready-to-eat foods are necessary, as are valid data on the prevalence of the pathogen in ready-to-eat foods that have previously been inadequately surveyed. The available data permit neither the establishment nor rejection of a correlation of this kind.

The number of cases of listeriosis is rising steadily not only in Germany but also within the European Union (EU) and within the European Economic Area (EEA). In the years 2008 to 2015, a significant rise in incidence was reported in the EU/EEA in the subpopulation of women aged 25 to 44 (women of childbearing age) and in the subpopulation of women and men aged over 75. These were the findings announced by EFSA in their opinion paper on the contamination of ready-to-eat foods with *Listeria monocytogenes* and the risks to human health in the EU, which was published in January 2018 [21]. In their paper, EFSA had identified factors along the food chain, terminating at the consumer, with the potential to influence the number and incidence of cases of listeriosis. Based on the quality of the data available within the EU/EEA, an estimate was made of the probability that these factors were in fact influential in this way. A rising number of elderly and sensitive individuals, and a rise in the proportion of sensitive persons in the subpopulation of women and men aged over 45 are considered likely to be responsible for the rising trend towards a higher case count and increased incidence of listeriosis in the EU/EEA (probability 66-99%). An exception to this is the subpopulation of women aged between 25 and 44 (women of childbearing age), whose number has declined but for whom a rising incidence has also been reported. An increased frequency in the consumption of ready-to-eat foods was cited with a low probability (33-66%). In their risk assessment, EFSA referred to indications of an increased consumption in foods such as heated ready-to-eat foods and smoked fish, but also noted that these indications were based on sparse data. EFSA concludes by stating that the current available data permit no reliable inferences to be drawn about a rise in consumption quantities and frequencies for ready-to-eat foods in the EU/EEA, nor about the degree to which these could be co-factors in the upwards trend in cases of listeriosis in humans.

The authors also consider improvements in the reporting systems of some EU member states with high reporting figures as potentially co-responsible for this upwards trend (probability also 33-66%). This statement also applies to Germany. In 2015, the case definition for listeriosis was adjusted: a number of criteria were included for the clinical picture and the nucleic acid test (e.g. PCR) was also included in the lab diagnostics laboratory method [22].

Other factors mentioned include the prevalence and concentration of *Listeria monocytogenes* at the point in time of the sale, variations in the potential virulence of *Listeria monocytogenes* strains, and the storage time and temperature after sale to the consumer. An assessment of the likelihood with which these factors have contributed to the upwards trend in cases of listeriosis in the EU/EEA did not produce any usable results (probability 0-100%) [21].

4. Response to the following question: Which innovative technological methods for ready-to-eat foods are suitable for preventing the occurrence and growth of *Listeria monocytogenes* during production, handling and distribution?

In the following section, the BfR and MRI have listed innovative technological methods for ready-to-eat foods, and assessed these in terms of their suitability for reducing or eliminating *Listeria monocytogenes*. In addition to preventive avoidance of contamination during production, options for deploying these methods for food handling and distribution should also be evaluated.

As a result of the sheer number and diversity of the various ready-to eat food products and production environments, many of the technological methods discussed below are not suitable for all application scenarios. None of these methods is currently known to be suitable for eliminating *Listeria monocytogenes* completely; instead, the pathogen can merely be reduced in concentration. Any bacterial cells not sensitive to or killed off by the method remain viable and can, if conditions are suitable, continue to grow in ready-to-eat food, ultimately resulting in breaches of the microbiological limits set by Regulation (EC) No 2073/2005. These methods should therefore be deployed only in addition to existing HACCP plans, and in combination with conventional measures for cleaning and disinfection as part of a layered approach. Such a deployment does not exempt the food business operator from their responsibility to verify their compliance with existing food safety criteria for *Listeria monocytogenes* in ready-to-eat foods.

Various methods have been described as having a reductive effect on *Listeria monocytogenes*. As a result of the partly very low number of meaningful studies available, the benefits from implementation of these methods for ready-to-eat foods in production, handling and distribution cannot be definitively evaluated in every case. The following methods will be considered in detail:
(1) High-pressure treatment
(2) Use of bacteriophages
(3) Application of cold plasma
(4) Utilising combinations of antimicrobial substances
(5) UVC disinfection
(6) Ohmic heating
(7) High-voltage pulse treatment
(8) Non-thermal electron beam irradiation
(9) Ozone fumigation of production environment

4.1 High-pressure treatment

High-pressure treatment exposes foods to very high pressure that destroys microorganisms and can reduce their viable colony count. To achieve an even distribution of pressure for solid foods, these can be packaged in film and treated by the application of a fluid in a pressure cylinder. Pressure exceeding 450 MPa (4,500 bar) is necessary in order to damage or reduce *Listeria monocytogenes* [23]. A range of studies on raw and ready-to-eat meat products has shown that the procedure can achieve considerable reductions in the viable colony count of *Listeria monocytogenes*. In addition, the storage temperature of the food has a decisive influence on the subsequent growth of bacterial cells not killed by the process. Following high-pressure treatment at 600 MPa for 3 to 10 minutes at room temperature followed by storage for 35 to 120 days at 4 °C, *Listeria monocytogenes* was no longer detectable in either natural samples or artificially contaminated samples [23-25]. If samples were stored at 10 °C following high-pressure treatment, however, the pathogen was able to replicate in boiled sausage from the 21st day by 4.5 log levels within two weeks [23], and by 7-8 log levels within 70 days following surface contamination of boiled ham [26]. One explanation for these data could be that some of the bacterial cells were only sub-lethally damaged by the process and were again capable of growth in suitable conditions. Additionally, there are also indications that psychrotrophic bacteria (which grow in the cold) lose their capability to grow at low temperatures as a result of the high-pressure treatment [25]. This fact is of particular interest for *Listeria monocytogenes*, since the pathogen is typically able to grow even at 4 °C and therefore has a selective advantage over other microbes in cold conditions. Investigations conducted with yeasts and *Enterobacteriaceae* have further shown that high-pressure treatment of boiled ham reduced overall colony counts to less than 10 CFU/g after 120 days of storage. In untreated boiled ham, this colony count figure rose by three log levels [25]. In raw ham, the overall viable colony count was reduced by two log levels. One other consequence of the procedure was a delay in the negative changes experienced by the food in terms of stickiness, as well as changes in odour and colour [25]. Shelf life and the retention of an appealing, taste, odour and appearance play an important role in foods that are especially perishable as a result of microbial action. From a food technology perspective, an establishment of this method would therefore seem especially appropriate. Available data on the material and chemical changes induced by high-pressure treatment have been sparse to date, however. On this view, not all foodstuffs are suitable for high-pressure treatment.
The effectiveness of the high-pressure treatment also varies depending on the properties of the respective foodstuff: the appropriateness of the method for a specific product category must therefore be ascertained. Strains of *Listeria monocytogenes* that are insensitive to pressure have also been discovered: their degree of reduction by high-pressure treatment can differ to that of pressure-sensitive strains by up to 2.5 log levels [27]. Research data on the occurrence and spread of pressure-sensitive *Listeria monocytogenes* strains have been sparse to date.

4.2 Use of bacteriophages

The use of lytic bacteriophages from the environment is a promising method for reducing pathogenic microbes in food and the production environment. In recent years, there has been growing interest in the use of phages to treat food - or, more accurately, its undesirable bacterial flora. In the case of *Listeria monocytogenes*, an average reduction of 1-3 log levels has been demonstrated for a wide variety of foodstuffs (e.g. cheese, fish, meat, fruit and vegetables - for a review, see [28]). The efficiency of the method depends on the properties of the food product (surface characteristics, water activity, pH, etc.), the species and concentration of the bacteriophages themselves, the type of application, the process temperature and duration, and the occurrence of potential resistance factors. In the case of solid foods, a reduction can be achieved only on the surface but not within the interior of the food product. Phage treatment is also suitable for the reduction of *Listeria monocytogenes* in biofilms - as

found on stainless steel surfaces. Reductions by 3-5 log levels have been observed here. To improve efficiency further, a combined application with disinfectants is recommended [29-32]. One challenge posed is the development of resistances by bacterial strains versus the bacteriophages deployed, when phage preparations are applied more broadly and more frequently. This applies in particular to broad-based deployment in the production environment and the use of mono-preparations. This risk can be reduced by deploying 'phage cocktails' that contain a variety of phages with a broad spectrum of activity, and also by ensuring these are deployed towards the end of the production process wherever possible (e.g. immediately before the food product is packaged), so as to reduce selection pressure and make the development of resistance less probable.
Alongside the question of the microbiological suitability of phage preparations, issues relating to health concerns must also be addressed with such applications. In this context, the reader is referred to the EFSA opinion on the safety and efficiency of the phage preparation Listex P100 for the reduction of *Listeria monocytogenes* in a number of ready-to-eat foods [33].

4.3 Application of cold plasma

A plasma is a mixture of neutral and charged particles that is created for use in technical applications by applying energy to various kinds of gases. The disinfectant properties of a plasma stem from reactive radicals and ultraviolet radiation. Industrial applications include the use of cold plasma methods in medical technology, material manufacturing and lighting systems. In principle, the method can be applied to reduce microbial contamination at low temperatures on surfaces, and is therefore an interesting option for application to heat-sensitive foods such as fresh fruit and vegetables, meat or eggs.

On strips of bacon, for example, the application of cold plasma has been shown to reduce *Listeria monocytogenes* by 1-2 log levels [34], with an average reduction of 2.5 log levels on other types of meat [35]. When applied to glass surfaces, however, a reduction in *Listeria monocytogenes* of up to 4 log levels has been demonstrated. The rate of reduction depended on the distance to the plasma source and the exposure time [36]. Accordingly, the use of cold plasma could be a highly promising method for the decontamination of production environments - and particularly in the case of moving parts having contact with food. One possible scenario here is the continuous decontamination of (rotating) cutting blades during production [35]. Research has also shown that the rate of reduction of *Listeria monocytogenes* is dependent on the type of gas that is utilised [37].
One disadvantage of the method is an increase in fat oxidation in the food. Very fatty foods and meat/sausage products containing tissue fat are therefore particularly liable to turning rancid as a result of fat oxidation. The technical properties of the cold plasma also necessarily result in an increased concentration of free radicals in the food products treated. Definitive data on potential effects on health as a result of this treatment are unavailable to date.

4.4 Utilising combinations of antimicrobial substances

Strictly speaking, the treatment of food products with antimicrobial substances does not itself constitute an 'innovative' idea. What is innovative is their combination and optimised application in food matrices, carefully adjusted to specific requirements. Common to all of these antimicrobial substances, whether naturally occurring or synthesised, is their ability to inhibit or prevent the growth of microbes that are pathogenic or promote spoilage. These substances include essential oils made from spices, lysozyme, chitosan, nisin and reuterin. As is generally true of the other methods, efficacy here is also strongly dependent on the food and its properties, and the form of application. In particular, diffusion within the foodstuff is a decisive - and limiting - factor for antibacterial potency.
Regarding nisin (a peptide formed from *Lactococcus lactis*), for example, it has been shown that *Listeria monocytogenes* was reduced by one log level on sausage casings impregnated

with nisin [38]. Another study investigated the efficacy of cinnamon essential oil on endive lettuce. In this case, *Listeria monocytogenes* was reduced only by 0.4 log levels. When combined with the quaternary ammonium compound cetylpyridinium chloride, a reduction by 0.8 log levels was then possible [39].
These comparatively low levels of reduction of bacterial contaminants are typical for the kinds of antimicrobial substances that can be deployed in food products. One limiting factor in particular here is the level of concentration above which sensory changes then take place within the foodstuff. As a rule, the concentrations required to achieve a significant antimicrobial effect cannot in fact be employed as a result of a lack of consumer acceptance or for reasons relating to food technology.
As a consequence, antimicrobial substances represent only one potential 'building block', which can be one of several measures deployed in combination to achieve a reduction in microbes within foods. The creation of cross-resistances is another aspect that must be kept in mind in this context.

4.5 UVC disinfection

One strategy that can be adopted as part of a layered approach is the irradiation of food or surfaces having food contact with ultraviolet light at a wavelength between 100 and 280 nm. Traditionally, UVC light was generated with mercury lamps. More recently, LED lamps emitting UVC light are now increasingly used in accordance with environmental protection legislation. In terms of application, a distinction is made between direct irradiation of the food itself and the irradiation of packaged food products. In general, however, the method is suitable only for surface decontamination, since UVC irradiation does not penetrate very deeply into an object. Packaged food can be treated most effectively if it is enclosed in a film made from polypropylene or polyethylene. Films made from polyethylene terephthalate and polyvinyl chloride are unsuitable, however [40]. The typical plastic film thickness of 0.04 mm is also unproblematic, as relevant reductions in UVC intensity occur only at thicknesses of at least 0.07 mm [40]. Investigations evaluating various types of film often involve tests conducted under standardised conditions with bacteria on culture media. Higher rates of microbial reduction may be demonstrated here than in tests involving packaged food. This fact also reveals the weaknesses of UVC irradiation as a method, since its antibacterial effect is hugely dependent on the roughness of the surface.
For *Listeria monocytogenes*, it has been shown that UVC irradiation of polyethylene films contaminated with the pathogen is capable of reducing the viable colony count by up to 2.2 log levels [41]. On fruit, direct irradiation for a period of five minutes reduced the pathogen by 1-1.7 log levels [42]. On salad, a reduction in *Listeria monocytogenes* of up to 2.2 log levels was achieved [41], with another study demonstrating a reduction of the pathogen by 0.9 log levels on beef [43].

4.6 Ohmic heating

This method utilises the resistance of the food, which results in the generation of heat when the foodstuff is subjected to an electric current. Compared with conventional heating, this type of heating occurs at low temperature gradients in food. Simultaneously, it also avoids the creation of hot surfaces. The antibacterial properties are created primarily by heat, although the influence of the electric field has yet to be conclusively investigated. To date, industrial use has generally involved the decontamination of liquids. As a result of their homogenous properties and good conductivity, these substances are ideally suited to this method and can be treated continuously in special-purpose chambers. Studies with relevant data on the reduction of *Listeria monocytogenes* in solid foods are not yet available. As has often been mentioned in the case of other methods, microbial reduction here is also highly dependent on the matrix deployed. In addition, a not inconsiderable reduction in effectiveness

as a result of the food's fat content (particularly in liquids, e.g. milk) has also been described [44].
As a result of the heat produced, the method is not suitable for the decontamination of temperature-sensitive foods. More detailed investigations are also required in terms of the effective temperatures achievable in various matrices, and the degree to which these temperatures are applicable to the same kinds of foods and manufacturing processes. This applies in particular to non-homogenous foods and ready-to-eat foods consisting of multiple components.
In technical terms, particular attention must also be paid to the choice and suitability of the electrodes used. Significant quantities of iron, chromium and manganese can be transferred to the food as a result of food contact. While limit values are unlikely to be exceeded [45], critical observation and evaluation is still necessary - particularly since applicable limit values are not always available or clearly defined. For technical reasons, the process times taken for heating are also not necessarily shorter than those used with conventional heat sources.

4.7 High-voltage pulse treatment

This method generates its antibacterial effect from the discharge of a capacitor whose high-voltage pulses are then transmitted to the food, with the ultimate effect of generating heat. Many studies (including in vitro studies in particular) have demonstrated significant effects on a range of microorganisms (for a review see [46]), which also include *Listeria monocytogenes* [47, 48]. As with other methods based on electricity (see 'Ohmic heating'), limitations in the reduction of microbes must be expected in the case of solid foodstuffs. In order to ensure the reliable destruction or reduction of pathogens and microbes that promote spoilage, dedicated investigations of reduction and effectiveness must therefore be completed for each food matrix. In addition, defined process parameters (voltage and temperature) must also be determined. Since temperature is a factor that is limited by sensory changes occurring in food, this treatment should also be deployed only in combination with other methods.

4.8 Non-thermal electron beam irradiation

The non-thermal electron beam irradiation process involves the use of the cathode-ray tube principle to emit and accelerate electrons. Bacterial cells irradiated by the process are damaged or killed outright. The penetration depth of the beam can be controlled by adjusting parameters affecting the current intensity. Investigations of *Salmonella enterica* on melons demonstrated a reduction by 3.6 log levels for this method [49]. Even stronger effects have been published for enterohaemorrhagic *Escherichia coli* in strawberry purée, which was reduced by 4 log levels following electron beam irradiation [50]. After the application of this method on alfalfa sprouts contaminated with approximately 6 log CFU/g, *Listeria monocytogenes* was no longer detectable [51]. Since the number of available studies is small, an estimate is not currently possible as to whether the method is suitable for preventing or at least reducing the occurrence and growth of *Listeria monocytogenes* during the production, handling and distribution of ready-to-eat foods.

4.9 Ozone fumigation of production environment

Ozone fumigation is capable of reducing *Listeria monocytogenes* on stainless steel and granite by 3.4 log levels. However, this requires ozone concentrations of 45 ppm [52]. In addition, these figures also relate to adherent cells. In biofilms, such as would occur in reality, the efficiency is probably lower. Alongside ozone, Open Air Factor (OAF) is also promoted as an effective reagent. This is generated by the reaction of ozone with unsaturated hydrocarbons and exhibits a stronger antibacterial effect. However, an evaluation cannot be made in this case owing to a lack of studies on OAF and *Listeria monocytogenes*. Notwithstanding this fact, the technology should be monitored further as a potential and innovative disinfection strategy.

5. Response to the following question: Can additional risk communication measures be taken (and if so, which ones) to influence the frequency of occurrence of infections involving *Listeria monocytogenes*?

Risk communication is defined as a continuous and interactive process, and characterised by a participative dialogue with various target groups. It therefore goes beyond informing all of the involved and interested parties about the assessment work of the institute and the results of this work. Providing timely information to the public about potential health-based risks, as well as insights obtained and working results forms the basis for this dialogue. To ensure risk communication is appropriate, it is essential to have a clear understanding of the extent to which risks are perceived and which factors influence this risk perception. To obtain information about the importance attached to a topic by the general public or certain groups within society, the BfR investigates the risk perception and the risk attitudes shown by various target groups. The results can be utilised in order to design more effective risk communication processes.

Messaging should be repeated at regular intervals and presented in a format that is considered relevant for the target groups. The internet is increasingly the most important channel for information: the use of social media, web-based tools and videos has the potential to reach certain target groups very rapidly. Whether behavioural changes will indeed be achieved depends on whether consumers consider the risk information provided to be relevant for them as individuals.

One subject area that researchers consider to be significantly underappreciated by consumers is the topic of food hygiene at home.
The BfR has published a range of fact sheets about protective measures that can be taken to prevent foodborne illness: these are aimed at consumers, medical practice staff and other professions, and provide recommendations for action specific to the respective target group. On its website, the BfR also provides a range of Opinions and answers to frequently asked questions (FAQs) that address the same topic area.

<u>Recommendations for private households</u>
Risk communication measures that are capable of influencing the frequency of cases of listeriosis are addressed to a wide range of target groups. These include consumers and particularly those consumers who belong to a subpopulation that is sensitive to listeriosis. Also relevant are their relatives and persons of status in society who are capable of influencing risk perception and the risk attitudes of sensitive subpopulations. Since only individuals with a severely weakened immune system and pregnant women are especially sensitive to listeriosis, the attending doctor has an important role to play in risk communication - although this role has perhaps not received due attention to date. Although pregnant women are likely to search online for information about steps they can take for risk mitigation, this behaviour cannot in all likelihood be assumed as a given in the case of the older generation.

On the topic of *Listeria monocytogenes* and protection against listeriosis, the BfR has published a fact sheet ‘Consumer advice: protection against foodborne illness from listeria’ that summarises recent research on the subject and offers dietary recommendations for especially sensitive and at-risk groups of people [53]. In addition, the Federal Ministry of Food and Agriculture has also published a leaflet prepared together with the BfR, which sets out the most important recommendations to protect against listeriosis during pregnancy [54]. Other recommendations on the safe handling of food are provided in the BfR’s fact sheet ‘Consumer advice: protecting against foodborne infections at home’, which is also aimed at the consumer target group [55].

The extent to which especially sensitive groups of people are aware of the BfR's recommendations - and also understand and implement them - cannot be estimated. No surveys have been conducted that focus on consumption patterns and the handling of foods in sensitive subpopulations in Germany. Within the EU, EFSA estimates that a third of the cases of listeriosis reported can be traced back to the growth of *Listeria monocytogenes* in foods prepared at home or stored in the refrigerator [21]. The extent to which this growth can be ascribed to the handling of foods in the consumer household also remains unclear, as does the impact of food handling on the overall number of cases of listeriosis. Only a few studies to date have accounted for consumer age as a relevant factor. These studies have also been conducted only in isolated countries (for a review, see [56]). On the basis of these few studies, EFSA estimates the proportion of elderly people in the EU who fail to handle ready-to-eat foods properly as roughly >10%. This handling may vary between EU countries, however, based on aspects such as socioeconomic factors, traditions and preferences in dietary habits [21]. In terms of the handling of food, the following errors were identified that lead to contamination with or promote the growth of *Listeria monocytogenes* in ready-to-eat foods in private households: (i) failure to maintain the recommended storage temperatures (e.g. as a result of ignorance about recommended storage temperatures or the use of refrigeration equipment 'set too warm', or a failure to check refrigerator temperatures in one's own household); (ii) cross-contamination of unpackaged foods in the refrigerator; (iii) consumption of products after the expiry of the use-by date specified by the manufacturer; and (iv) storage and consumption of foods once started beyond the recommended 2 to 3 day period [56].

These circumstances are addressed in the abovementioned BfR fact sheets, and also on regular occasions in BfR Opinions, press releases and recommendations for action to avoid these kinds of errors when handling food products. On the BfR website, there is also a general page on the subject of listeria and on kitchen hygiene, which provides information and recommendations for conduct aimed at protecting against foodborne illnesses. The BfR posts regularly to its social media profiles on Twitter and Instagram. These profiles are not only used to address the topic for ongoing incidents, to draw attention to the recommendations made by the BfR, but also feature service and informative posts using storytelling techniques. The BfR has also produced films on kitchen hygiene, some of which also address the topic of listeria.

To verify that the content, type and channels used for existing risk communication are suitable and effective enough to inform target groups about risks in relation to *Listeria monocytogenes*, and to encourage these groups to take appropriate risk mitigation action, surveys of risk perception and attitudes in these target groups can be useful (e.g. surveys conducted by the BfR Consumer Monitor, general population surveys).

Additional risk communication measures can be considered as a supplement to existing activities. The BfR is already active in Wikipedia, for example: here, the topic of protecting against foodborne infection from listeria could be communicated with specific recommendations for action for risk groups. Another approach to communication would be to prepare FAQs for certain target groups or articles for specific risk groups. Recommendations for risk groups are therefore an option, in which the topic of listeria is also addressed. Films that directly address these risk groups are another option for preparing material on listeria in accordance with needs.
A greater involvement of doctor's practices in risk communication work is another potentially useful approach: such practices play an influential part in disseminating information about listeria safeguards, and this role can be further strengthened with targeted measures such as a

poster/flyer campaign and the proactive distribution of materials like the fact sheet. Pharmacies can also be included as another set of influential stakeholders.
The degree to which the additional measures as stated are able to influence consumers to develop an improved perception of risk and risk attitudes should also be evaluated in order to determine their effectiveness.

Recommendations for community facilities that care for especially sensitive groups of individuals
Those responsible for the management of community facilities that regularly care for especially sensitive groups of individuals (hospitals, sanatoria, retirement homes, nursing homes and day nurseries) represent another important target group. The BfR therefore presented a set of recommendations for action for such community facilities in its fact sheet 'Safe and sound - especially sensitive groups of individuals in community facilities' [57].

In 2017, a survey conducted as part of the National Control Plan (BÜp) revealed that this BfR fact sheet has not yet reached a wide audience in Germany. A total of 1,880 community facilities (retirement and nursing homes, hospital kitchens and sanatoria) across 15 German states were asked whether they were familiar with the recommendations made by the BfR for the care of especially sensitive individuals. Only 45% of respondents answered in the positive. Only 10% of the facilities questioned followed the BfR recommendations and excluded those types of foods from their meal plans that could potentially pose a risk to especially sensitive individuals if not re-heated through adequately and immediately before consumption. The types of ready-to-eat foods most commonly offered by respondents included deli salads, spreadable raw sausage, soft washed-rind cheeses and smoked fish - and therefore foodstuffs in which *Listeria monocytogenes* has been detected on a regular basis [58]. As a consequence of the results of this survey, closer attention should be paid to the BfR recommendations in future and the benefits thereby achieved, both as part of official food monitoring work, and in the course of training provided to nursing and care staff in community facilities. One way to achieve this would be to ensure uniform and prominent linking on the official websites maintained by food monitoring authorities and public health services.

Recommendations for food business operators
Food business operators play an extremely important role in helping to prevent outbreaks of listeriosis. Accordingly, risk communication strategies should also address this group. If estimates from EFSA attribute a third of listeriosis cases in the EU/EEA to the growth of *Listeria monocytogenes* in food in consumer households, two thirds of listeriosis cases may conversely be attributed to the presence of *Listeria monocytogenes* in these foods before purchase by the consumer - thereby illustrating the importance of measures taken to reduce the pathogen at this stage [21]. Accordingly, the effective minimisation of cases of listeriosis in Germany therefore requires the continuous monitoring of the pathogen by food business operators and the prevention of transmission into ready-to-eat food products. Measures for risk communication must therefore target the food business operators themselves as well as the competent food monitoring authorities.

EU Regulation (EC) No 2073/2005 on microbiological criteria in food not only sets out the permissible maximum values for *Listeria monocytogenes* in ready-to-eat foods, but also specifies implementing rules. For ready-to-eat foods (other than those intended for infants or for special medical purposes) that could promote the propagation of *Listeria monocytogenes*, the manufacturer must provide proof acceptable to the competent authority that the food product does not exceed the maximum value of 100 CFU/g during its entire shelf life. Proof

can be submitted in the form of shelf-life studies, for example. In addition, food business operators that manufacture ready-to-eat foods must, as part of their sampling plan, investigate samples from their processing units and from items of equipment for the presence of *Listeria monocytogenes*.
Two guideline documents on *Listeria monocytogenes* provided by the EU and the European Reference Laboratory (EURL) are available for ensuring the correct execution of shelf-life studies for *Listeria monocytogenes* in ready-to-eat foods [59-61]. The EURL for *Listeria monocytogenes* has also prepared recommendations for action for use in taking samples from food preparation areas and items of equipment [62].

These documents, which directly address the manufacturers of ready-to-eat foods, outline the current state of scientific research while also providing information about execution and interpretation, and therefore constitute important risk communication and management measures. In addition, advice on the execution of audits for internal control systems in relation to *Listeria monocytogenes* has also been provided by the AFFL in Germany: these guidelines are aimed at state-level food monitoring authorities, and are intended to ensure the effective and uniform auditing of in-house controls. The question of the extent to which guideline documents and advice on execution are sufficiently well-known, understood and implemented also applies in this case. Accordingly, knowledge of these documents and their correct implementation by food business operators should be surveyed as part of official food monitoring work. An evaluation of these measures could serve to verify whether the existing documents and communication channels are adequate or need to be improved, and whether additional risk communication measures are necessary.

One particular challenge facing food business operators is the persistence of *Listeria monocytogenes* in their production environments. The pathogen can persist for years in niche areas that are often inaccessible or hard to reach by cleaning and disinfection work, leading to a continuous series of new contamination incidents in sensitive production areas and ready-to-eat food products. To prevent contamination of ready-to-eat foods, sources of contamination and contamination pathways in company operations must be identified and eliminated following the detection of *Listeria monocytogenes* in the production environment and in/on raw, interim and final products (even at low concentrations). Important roles are played here by hazard analysis, the identification of critical process steps and control points, corrective actions for eliminating the pathogen and the regular performance of checks intended to verify the success of the corrective actions implemented.

Following a series of listeriosis outbreaks in recent years in Germany, it has become very clear that even if the occurrence of the pathogen in the production environment or in the finished product is known, insufficient measures have then been taken in order to identify and eliminate the sources of contamination in company operations. This indicates that the risk presented by contaminated ready-to-eat foods is not always adequately acknowledged by food business operators and/or that measures taken to minimise the risk are not adequately implemented and monitored by means of internal company controls. One reason for this could be the lack of a general zero-tolerance policy for *Listeria monocytogenes* in ready-to-eat foods to date. Accordingly, a comprehensive programme of education is urgently required on the part of the food monitoring authorities. A helpful approach here would be a set of uniform recommendations for action at federal level (ideally at EU level) for food business operators.

In cases where ready-to-eat foods do not meet the food safety criteria for *Listeria monocytogenes* according to Regulation (EC) No 2073/2005, the food business operator must withdraw the affected products from the market or issue a product recall (Regulation (EC) No

2073/2005, Art. 7(2)). In cases where *Listeria monocytogenes* was detected in products at a level below the limit value, the manufacturer may voluntarily withdraw these products from the market or issue a recall. Product recalls must be posted up in all affected sales outlets so they are highly visible to the consumer. Often, manufacturers will use their website to notify recalls. In addition, consumers can also visit the website www.lebensmittelwarnung.de to view public warnings and other information. To provide consumers with a comprehensive set of details explaining the risks of consuming the recalled food products, information and warnings could also be placed on all platforms used with precise details of the pathogen, the associated symptoms and the consumer groups who are most at risk. In the past, this approach has not always been taken in the case of foods contaminated with *Listeria monocytogenes*. A uniform approach to be taken by state-level authorities and using agreed wording (boilerplate text) should therefore be pursued as soon as possible.

Further information on the subject of Listeria from the BfR website

Consumer advice: Protection against foodborne Listeriosis infections, dated 6 December 2017
https://www.bfr.bund.de/cm/350/verbrauchertipps-schutz-vor-lebensmittelinfektionen-mit-lis-
terien.pdf

Listeriosis: Rare but dangerous for the elderly, expectant mothers and immunocompromised persons, press release no. 30/2018, dated 27 September 2018
https://www.bfr.bund.de/en/press_information/2018/30/listeriosis__rare_but_danger-
ous_for_the_elderly__expectant_mothers_and_immunocomprimised_persons-205419.html

Information: Safe and sound - especially sensitive groups of individuals in community facilities, dated 8 May 2018
https://www.bfr.bund.de/cm/350/sicher-verpflegt-besonders-empfindliche-personengruppen-
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Annex 1 Tabulated overviews of relevant prevalence figures

Table 4: *Listeria monocytogenes* in **minced meat and minced meat preparations**, Germany, 2008-2016, **qualitative investigations** - routine samples

Matrix	Year	Samples tested (N)	Positive samples (n)	Positive samples (%)	Confidence interval (%)
Minced meat	2008	1070	189	17.66	15.38-19.95
	2009	1267	278	21.94	19.66-24.22
	2010	1163	194	16.68	14.54-18.82
	2011	1545	237	15.34	13.54-17.14
	2012	1501	222	14.79	12.99-16.59
	2013	751	51	6.79	4.99-8.59
	2014	1046	179	17.11	14.83-19.40
	2015	642	128	19.94	16.85-23.03
	2016	478	82	17.15	13.78-20.53
Minced meat preparations	2011	1576	353	22.40	20.34-24.46
	2012	1352	305	22.56	20.33-24.79
	2013	586	85	14.51	11.65-17.36
	2014	1579	383	24.26	22.14-26.37
	2015	1374	285	20.74	18.60-22.89
	2016	494	94	19.03	15.57-22.49
Minced meat preparations made from pork	2011	514	65	12.65	9.77-15.52
	2012	135	24	17.78	11.33-24.23
	2013	25	2	8.00	0.00-18.63
	2014	30	3	10.00	0.00-20.74
	2015	73	4	5.48	0.26-10.70
	2016	114	29	25.44	17.44-33.43

Table 5: *Listeria monocytogenes* in **minced meat and minced meat preparations**, Germany, 2008-2016, **quantitative investigations** with >100 CFU/g - routine samples

Matrix	Year	Number of samples analysed (N)	Number of pos. samples (%)		
			$>10^2$ - 10^3 CFU/g	$>10^3$ - 10^4 CFU/g	$>10^4$ CFU/g
Minced meat	2008	1284	0.23%	0.08%	
	2009	1616	1.49%	0.06%	
	2010	1355	0.37%	0.22%	
	2011	1832	0.44%	0.05%	
	2012	1657	0.12%		0.06%
	2013	876	0.11%	0.11%	
	2014	1488	0.27%		
	2015	755	0.66%		
	2016	899		0.11%	
Minced meat preparations	2011	1532	0.46%		
	2012	1110	0.54%	0.09%	
	2013	631	0.63%	0.16%	
	2014	1382	0.43%	0.22%	0.07%
	2015	960	0.42%	0.10%	
	2016	396	1.01%		
Minced meat preparations made from pork	2011	395			
	2012	198	1.52%		
	2013	204	0.49%		
	2014	89			
	2015	136			
	2016	136	1.47%		

Table 6: *Listeria monocytogenes* in **heat-treated meat products**, Germany, 2008-2016, **qualitative investigations** - routine samples

Matrix	Year	Samples tested (N)	Positive samples (n)	Positive samples (%)	Confidence interval (%)
Overall	2008	2545	85	3.34	2.64-4.04
	2009	2572	66	2.57	1.95-3.18
	2010	3187	84	2.64	2.08-3.19
	2011	2333	56	2.40	1.78-3.02
	2012	2452	69	2.81	2.16-3.47
	2013	1477	27	1.83	1.14-2.51
	2014	2367	53	2.24	1.64-2.84
	2015	1646	46	2.79	2.00-3.59
	2016	1635	17	1.04	0.55-1.53
Beef	2008	22	0		
	2009	63	2	3.17	0.00-7.5
	2010	35	0		
	2011	38	2	5.26	0.00-12.36
	2012	25	2	8.00	0.00-18.63
	2013	24	0		
	2014	58	2	3.45	0.00-8.14
	2015	28	1	3.57	0.00-10.45
	2016	79	0		
Pork	2008	950	33	3.47	2.31-4.64
	2009	894	30	3.36	2.18-4.54
	2010	1073	35	3.26	2.20-4.32
	2011	731	16	2.19	1.13-3.25
	2012	803	35	4.36	2.95-5.77
	2013	222	9	4.05	1.46-6.65
	2014	532	21	3.95	2.29-5.60
	2015	506	15	2.96	1.49-4.44
	2016	630	10	1.59	0.61-2.56
Other meat excluding poultry	2008	55	2	3.64	0.00-8.59
	2009	66	2	3.03	0.00-7.17
	2010	639	14	2.19	1.06-3.33
	2011	614	10	1.63	0.63-2.63
	2012	694	8	1.15	0.36-1.95
	2013	730	8	1.10	0.34-1.85
	2014	808	12	1.49	0.65-2.32
	2015	46	3	6.52	0.00-13.66
	2016	9	0		
including poultry	2008	339	19	5.60	3.96-10.64
	2009	368	14	3.80	1.85-5.76
	2010	360	11	3.06	1.28-4.83
	2011	450	20	4.44	2.54-6.35
	2012	424	23	5.42	3.27-7.58
	2013	267	4	1.50	0.04-2.96
	2014	407	16	3.93	2.04-5.82
	2015	356	8	2.25	0.71-3.79
	2016	516	21	4.07	2.36-5.77

Table 7: *Listeria monocytogenes* in **heat-treated meat products**, Germany, 2008-2016, **quantitative investigations** with >100 CFU/g - routine samples

Matrix	Year	Number of samples analysed (N)	Number of pos. samples (%)		
			>10^2 - 10^3 CFU/g	>10^3 - 10^4 CFU/g	>10^4 CFU/g
Overall	2008	2322	0.22%		
	2009	2171	0.09%		
	2010	2768	0.11%	0.04%	0.04%
	2011	1951	0.10%	0.05%	
	2012	2093	0.19%		
	2013	1735	0.23%		
	2014	1980	0.05%		0.05%
	2015	832	0.12%		
	2016	1144			0.09%
Beef	2008	700			
	2009	61			
	2010	32			
	2011	59			
	2012	17			
	2013	28			
	2014	40			
	2015	24			
	2016	35			
Pork	2008	1405	0.28%		
	2009	1357	0.15%		
	2010	824	0.12%		
	2011	481		0.21%	
	2012	716	0.14%		
	2013	241	0.41%		
	2014	453			
	2015	317	0.32%		
	2016	409			0.24%
Other meat excluding poultry	2008	74			
	2009	67			
	2010	595	0.17%		
	2011	588	0.17%		
	2012	634	0.47%		
	2013	711	0.28%		
	2014	729			
	2015	2			
	2016	12			
including poultry	2008	197	0.51%		
	2009	242	0.41%	0.41%	
	2010	235	0.43%	0.43%	
	2011	331	0.30%		
	2012	539	0.74%		
	2013	236			
	2014	492	0.41%	0.20%	
	2015	311			
	2016	488	0.20%	0.20%	0.20%

Table 8: *Listeria monocytogenes* in **other preserved meat products**, Germany, 2008-2016, **qualitative investigations** - routine samples

Matrix	Year	Samples tested (N)	Positive samples (n)	Positive samples (%)	Confidence interval (%)
Overall	2008	2392	331	13.84	12.45-15.22
	2009	2403	329	13.69	12.32-15.07
	2010	2381	410	17.22	15.70-18.74
	2011	2441	321	13.15	11.81-14.49
	2012	2606	383	14.70	13.34-16.06
	2013	1627	185	11.37	9.83-12.91
	2014	2669	402	15.06	13.70-16.42
	2015	2289	328	14.33	12.89-15.76
	2016	1831	189	10.32	8.93-11.72
Beef	2008	38	2	5.26	0.00-12.36
	2009	24	2	8.33	0.00-19.39
	2010	30	2	6.67	0.00-15.59
	2011	40	2	5.00	0.00-11.75
	2012	39	5	12.82	2.33-23.31
	2013	27	0		
	2014	42	1	2.38	0.00-6.99
	2015	28	1	3.57	0.00-10.45
	2016	42	5	11.90	2.11-21.70
Pork	2008	998	127	12.73	10.66-14.79
	2009	856	86	10.05	8.03-12.06
	2010	500	66	13.20	10.23-16.17
	2011	580	59	10.17	7.71-12.63
	2012	669	77	11.51	9.09-13.93
	2013	172	18	10.47	5.89-15.04
	2014	481	40	8.32	5.85-10.78
	2015	472	43	9.11	6.51-11.71
	2016	527	50	9.49	6.99-11.99
Other meat excluding poultry	2008	30	2	6.67	0.00-15.60
	2009	42	5	11.90	2.11-21.70
	2010	297	16	5.39	2.82-7.95
	2011	558	56	10.04	7.54-12.53
	2012	488	33	6.76	4.53-8.99
	2013	472	29	6.14	3.98-8.31
	2014	512	39	7.62	5.32-9.91
	2015	23	5	21.74	4.88-38.60
	2016	31	4	12.90	1.10-24.70

Table 9: *Listeria monocytogenes* in **other preserved meat products**, Germany, 2008-2016, **quantitative investigations** with >100 CFU/g - routine samples

Matrix	Year	Number of samples analysed (N)	Number of pos. samples (%)		
			$>10^2$ - 10^3 CFU/g	$>10^3$ - 10^4 CFU/g	$>10^4$ CFU/g
Overall	2008	1795	0.45%	0.33%	
	2009	1943	0.41%	0.10%	
	2010	1817	0.61%		
	2011	2031	0.59%	0.10%	
	2012	2132	0.33%	0.09%	0.05%
	2013	1420	0.21%	0.07%	
	2014	2199	0.27%	0.09%	0.05%
	2015	1502	0.47%	0.07%	
	2016	1499	0.67%		
Beef	2008	33			
	2009	10			
	2010	25			
	2011	25	4.00%		
	2012	30			
	2013	22			
	2014	33			
	2015	27			
	2016	31	3.23%		
Pork	2008	1149	0.26%	0.26%	
	2009	1147	0.17%		
	2010	385	0.26%		
	2011	420	0.48%		
	2012	689			
	2013	182			
	2014	388	0.52%	0.26%	0.26%
	2015	342			
	2016	441	0.45%		
Other meat excluding poultry	2008	21			
	2009	16	6.25%		
	2010	234			
	2011	455		0.22%	
	2012	426	0.23%		
	2013	404			
	2014	384	0.26%		
	2015	15	13.33%		
	2016	26			

Table 10: *Listeria monocytogenes* in **fish products**, Germany, 2008-2016, **qualitative investigations** - routine samples

Matrix	Year	Samples tested (N)	Positive samples (n)	Positive samples (%)	Confidence interval (%)
Fish, cold-smoked or gravlax	2008	374	47	12.57	9.21-15.93
	2009	590	104	17.63	14.55-20.70
	2010	814	108	13.27	10.94-15.60
	2011	407	33	8.11	5.46-10.76
	2012	513	76	14.81	11.74-17.89
	2013	319	46	14.42	10.57-18.28
	2014	228	31	13.60	9.15-18.05
	2015	157	11	7.01	3.01-11.0
	2016	89	12	13.48	6.39-20.58
Fish, hot-smoked	2008	937	66	7.04	5.41-8.68
	2009	853	26	3.05	1.89-4.20
	2010	1000	37	3.70	2.53-4.87
	2011	1143	46	4.02	2.89-5.16
	2012	1222	56	4.58	3.41-5.76
	2013	862	40	4.64	3.24-6.04
	2014	873	58	6.64	4.99-8.30
	2015	536	23	4.29	2.58-6.01
	2016	787	71	9.02	7.02-11.02
Fish, other means of preservation	2008	820	32	3.90	2.58-5.23
	2009	715	27	3.78	2.38-5.17
	2010	788	40	5.08	3.54-6.61
	2011	826	50	6.05	4.43-7.68
	2012	933	53	5.68	4.20-7.17
	2013	580	23	3.97	2.38-5.55
	2014	836	57	6.82	5.11-8.53
	2015	624	49	7.85	5.74-9.96
	2016	535	55	10.28	7.71-12.85
Fish, heat-treated	2011	3	0		
	2012	70	2	2.86	0.00-6.76
	2013	10	0		
	2014	97	1	1.03	0.00-3.04
	2015	69	1	1.45	0.00-4.027
	2016	40	0		

Table 11: *Listeria monocytogenes* in **fish producсts**, Germany, 2008-2016, **quantitative investigations** with >100 CFU/g - routine samples

Matrix	Year	Number of samples analysed (N)	Number of pos. samples (%)		
			$>10^2$ - 10^3 CFU/g	$>10^3$ - 10^4 CFU/g	$>10^4$ CFU/g
Fish, cold-smoked or gravlax	2008	726		0.28%	
	2009	531	1.13%	0.38%	
	2010	706	0.99%		
	2011	412	0.97%		
	2012	406	0.49%	0.25%	0.25%
	2013	354	0.56%		0.28%
	2014	285		0.35%	
	2015	148	0.68%		0.68%
	2016	124	1.61%	0.81%	
Fish, hot-smoked	2008	1323	0.98%	0.15%	
	2009	869	0.23%	0.58%	
	2010	818	0.86%	0.61%	0.37%
	2011	1038	0.67%	0.19%	
	2012	1003	0.10%	0.10%	0.10%
	2013	864	0.81%		
	2014	826	0.12%		
	2015	439			
	2016	582		0.17%	
Fish, other means of preservation	2008	503	0.20%	0.20%	0.20%
	2009	687	0.15%		
	2010	624			
	2011	762	0.26%		
	2012	756	0.26%	0.13%	
	2013	679	0.15%		
	2014	680	0.29%		
	2015	396		0.25%	
	2016	397	0.76%		

Table 12: *Listeria monocytogenes* in **cheese made from raw milk**, Germany, 2008-2016, **qualitative investigations** - routine samples

Matrix	Year	Samples tested (N)	Positive samples (n)	Positive samples (%)	Confidence interval (%)
Raw milk soft cheese made from cow's milk	2008	169	2	1.18	0.00-2.81
	2009	123	2	1.63	0.00-3.86
	2010	205	2	0.98	0.00-2.32
	2011	88	1	1.14	0.00-3.35
	2012	91	0		
	2013	179	1	0.56	0.00-1.65
	2014	258	2	0.78	0.00-1.85
	2015	228	1	0.44	0.00-1.30
	2016	278	1	0.36	0.00-1.06
Raw milk soft cheese made from goat's milk	2009	23	0		
	2010	31	1	3.23	0.00-9.45
	2011	26	0		
	2012	16	0		
	2013	9	1	11.11	0.00-31.64
	2014	11	0		
	2015	15	0		
	2016	6	0		
Raw milk soft cheese made from sheep's milk	2009	1	0		
	2010	11	0		
	2011	4	0		
	2012	3	0		
	2013	1	0		
	2015	17	0		
Raw milk cheese, other made from cow's milk	2008	176	2	1.14	0.00-2.70
	2009	307	2	0.65	0.00-1.55
	2010	373	3	0.80	0.00-1.71
	2011	107	1	0.93	0.00-2.76
	2012	278	0		
	2013	68	0		
	2014	118	2	1.69	0.00-4.02
	2015	31	0		
	2016	40	0		
Raw milk cheese, other made from goat's milk	2009	24	0		
	2010	41	1	2.44	0.00-7.16
	2011	34	1	2.94	0.00-8.62
	2012	48	0		
	2013	31	0		
	2014	21	0		
	2015	17	0		
	2016	7	0		
Raw milk cheese, other made from sheep's milk	2009	12	0		
	2010	25	0		
	2011	18	0		
	2012	66	0		
	2013	13	0		
	2014	32	0		
	2015	68	1	1.47	0.00-4.33
	2016	40	0		

Table 13: *Listeria monocytogenes* in **cheese made from pasteurised milk**, Germany, 2008-2016, **qualitative investigations** - routine samples

Matrix	Year	Samples tested (N)	Positive samples (n)	Positive samples (%)	Confidence interval (%)
Soft cheese made from cow's milk	2008	411	3	0.73	0.00-1.55
	2009	601	13	2.16	1.00-3.33
	2010	928	4	0.43	0.01-0.85
	2011	747	2	0.27	0.00-0.64
	2012	636	3	0.47	0.00-1.00
	2013	487	0		
	2014	559	12	2.15	0.95-3.35
	2015	525	5	0.95	0.12-1.78
	2016	684	5	0.73	0.09-1.37
Soft cheese made from goat's milk	2009	33	0		
	2010	32	0		
	2011	13	0		
	2012	10	0		
	2013	34	0		
	2014	7	0		
	2015	14	0		
	2016	22	0		
Soft cheese made from sheep's milk	2009	21	0		
	2010	24	0		
	2011	1	0		
	2012	3	0		
	2013	32	0		
	2014	11	0		
	2015	7	0		
	2016	4	0		
Cheese, other made from cow's milk	2008	3915	27	0.69	0.43-0.95
	2009	3336	16	0.48	0.25-0.71
	2010	3229	20	0.62	0.35-0.89
	2011	3306	27	0.82	0.51-1.12
	2012	3148	10	0.32	0.12-0.51
	2013	1949	3	0.15	0.00-0.33
	2014	2364	15	0.63	0.31-0.95
	2015	1660	6	0.36	0.07-0.65
	2016	2034	11	0.54	0.22-0.86
Cheese, other made from goat's milk	2008	280	1	0.36	0.00-1.06
	2009	142	0		
	2010	158	3	1.90	0.00-4.03
	2011	172	0		
	2012	170	0		
	2013	91	0		
	2014	155	0		
	2015	157	0		
	2016	101	2	1.98	0.00-4.70
Cheese, other made from sheep's milk	2008	146	1	0.68	0.00-2.02
	2009	141	2	1.42	0.00-3.37
	2010	99	0		
	2011	99	0		
	2012	56	0		
	2013	42	0		
	2014	49	1	2.04	0.00-6.00
	2015	66	0		
	2016	35	0		

Table 14: *Listeria monocytogenes* in **cheese**, Germany, 2008-2016, **quantitative investigations** with >100 CFU/g - routine samples

Matrix	Year	Number of samples analysed (N)	Number of pos. samples (%)		
			$>10^2$ - 10^3 CFU/g	$>10^3$ - 10^4 CFU/g	$>10^4$ CFU/g
Raw milk soft cheese made from cow's milk	2008	81			
	2009	186	0.54%		
	2010	181			
	2011	80			
	2012	80			
	2013	66			
	2014	114		0.88%	0.88%
	2015	70			
	2016	120			
Soft cheese made from cow's milk	2008	171			0.58%
	2009	474	1.05%	1.05%	
	2010	723	0.55%		
	2011	439			
	2012	488			0.20%
	2013	367			
	2014	334			
	2015	145			
	2016	302			
Cheese, other made from cow's milk	2008	1877			0.16%
	2009	2258		0.04%	
	2010	1421			
	2011	1303		0.08%	
	2012	1369			
	2013	1089			
	2014	1151			
	2015	557			
	2016	776	0.39%		

The table lists only those types of cheese for which samples >100 CFU/g were reported in at least one year.

Table 15: *Listeria monocytogenes* in **pastries**, Germany, 2008-2016, **qualitative investigations** - routine samples

Matrix	Year	Samples tested (N)	Positive samples (n)	Positive samples (%)	Confidence interval (%)
Pastries	2008	303	0		
	2009	275	1	0.36	0.00-1.08
	2010	577	4	0.69	0.02-1.37
	2011	1059	8	0.76	0.23-1.28
	2012	616	6	0.97	0.20-1.75
	2013	878	11	1.25	0.52-1.99
	2014	875	12	1.37	0.60-2.14
	2015	892	9	1.01	0.35-1.66
	2016	1034	13	1.26	0.58-1.94

Table 16: *Listeria monocytogenes* in **pastries**, Germany, 2008-2016, **quantitative investigations** with >100 CFU/g - routine samples

Matrix	Year	Number of samples analysed (N)	Number of pos. samples (%)		
			$>10^2$ - 10^3 CFU/g	$>10^3$ - 10^4 CFU/g	$>10^4$ CFU/g
Pastries	2008	109			
	2009	63			
	2010	901		0.11%	
	2011	537			
	2012	730			
	2013	219			
	2014	625	0.64%		
	2015	543			
	2016	313	0.32%		

Table 17: *Listeria monocytogenes* in **deli salads**, Germany, 2008-2016, **qualitative investigations** - routine samples

Matrix	Year	Samples tested (N)	Positive samples (n)	Positive samples (%)	Confidence interval (%)
Overall	2008	233	17	7.30	3.96-10.64
	2009	299	21	7.02	4.12-9.92
	2010	981	10	1.02	0.39-1.65
	2011	515	21	4.08	2.37-5.79
	2012	847	26	3.07	1.91-4.23
	2013	499	15	3.01	1.51-4.51
	2014	558	22	3.94	2.33-5.55
	2015	649	14	2.16	1.04-3.28
	2016	858	19	2.21	1.23-3.19
Containing meat	2008	51	2	3.92	0.00-9.25
	2009	52	7	13.46	4.18-22.74
	2010	906	8	0.88	0.27-1.49
	2011	45	3	6.67	0.00-13.95
	2012	183	7	3.83	1.05-6.60
	2013	102	4	3.92	0.15-7.69
	2014	175	8	4.57	1.48-7.67
	2015	146	2	1.37	0.00-3.26
	2016	176	9	5.11	1.86-8.37
Containing fish	2008	6	0		
	2010	16	0		
	2011	5	0		
	2012	149	8	5.37	1.75-8.99
	2013	38	2	5.26	0.00-12.36
	2014	76	2	2.63	0.00-6.23
	2015	73	5	6.85	1.05-12.64
	2016	77	0		
Containing vegetables	2008	11	4	36.36	
	2009	29	0		
	2010	27	0		
	2011	50	2	4.00	0.00-9.43
	2012	136	1	0.74	0.00-2.17
	2013	37	0		
	2014	36	0		
	2015	57	0		
	2016	80	0		
Containing egg	2008	1	0		
	2010	21	2	9.52	0.00-22.08
	2011	9	0		
	2012	50	0		
	2013	15	0		
	2014	25	1	4.00	0.00-11.68
	2015	25	0		
	2016	50	0		
Containing milk	2010	2	0		
	2011	13	0		
	2012	46	0		
	2013	7	0		
	2014	21	2	9.52	0.00-22.08
	2015	43	1	2.33	0.00-6.83
	2016	55	0		

Continuation of Table 17: *Listeria monocytogenes* in **deli salads**, Germany, 2008-2016, **qualitative investigations** - routine samples

Matrix	Year	Samples tested (N)	Positive samples (n)	Positive samples (%)	Confidence interval (%)
Containing poultry	2012	39	1	2.56	0.00-7.52
	2013	23	0		
	2014	14	0		
	2015	23	0		
	2016	64	1	1.56	0.00-4.60
Other	2008	164	11	6.71	2.88-10.54
	2009	218	14	6.42	3.17-9.69
	2010	9	0		
	2011	378	16	4.23	2.20-6.26
	2012	174	9	5.17	1.88-8.46
	2013	146	8	5.48	1.79-9.17
	2014	143	9	6.29	2.31-10.27
	2015	172	6	3.49	0.75-6.23
	2016	224	7	3.13	0.85-5.4
Unspecified	2011	15	0		
	2012	70	0		
	2013	131	1	0.76	0.00-2.25
	2014	68	0		
	2015	110	0		
	2016	132	2	1.52	0.00-3.60

Table 18: *Listeria monocytogenes* in **ready meals**, Germany, 2008-2016, **qualitative investigations** - routine samples

Matrix	Year	Samples tested (N)	Positive samples (n)	Positive samples (%)	Confidence interval (%)
Ready meals	2008	57	0		
	2009	152	2	1.32	0.00-3.13
	2010	431	2	0.46	0.00-1.11
	2011	236	5	2.12	0.28-3.96
	2012	896	9	1.00	0.35-1.66
	2013	374	10	2.67	1.04-4.31
	2014	466	2	0.43	0.00-1.02
	2015	330	1	0.30	0.00-0.90
	2016	505	8	1.58	0.50-2.67

Table 19: *Listeria monocytogenes* in **lettuce and vegetables**, Germany, 2008-2016,
qualitative investigations - routine samples

Matrix	Year	Samples tested (N)	Positive samples (n)	Positive samples (%)	Confidence interval (%)
Lettuce	2011	34	2	5.88	0.00-13.79
	2012	157	3	1.91	0.00-4.05
	2013	49	1	2.04	0.00-6.00
	2014	36	1	2.78	0.00-8.15
	2015	78	0		0.00-1.12
	2016	170	5	2.94	0.40-5.48
Leafy vegetables	2011	37	0		
	2012	649	11	1.69	0.70-2.69
	2013	133	3	2.26	0.00-4.78
	2014	210	4	1.90	0.06-3.75
	2015	264	1	0.38	0.00-13.95
	2016	20	1	5.00	0.00-14.55
Sprouted vegetables	2011	110	3	2.73	0.00-5.77
	2012	109	6	5.50	1.22-9.79
	2013	53	0		
	2014	35	0		
	2015	105	1	0.95	0.00-2.81
	2016	238	2	0.84	0.00-2.00
Fresh vegetables for consumption raw (excl. leafy, prepared and sprouted vegetables)	2011	97	1	1.03	0.00-3.04
	2012	121	2	1.65	0.00-3.92
	2013	59	1	1.69	0.00-4.99
	2014	79	2	2.53	0.00-6.00
	2015	45	3	6.67	0.00-13.95
	2016	252	0		
Pre-cut vegetables and lettuce	2008	24	2	8.33	0.00-19.39
	2009	38	1	2.63	0.00-7.72
	2010	7	1	14.29	0.00-40.21
	2013	3	0		
	2015	37	1	2.70	0.00-7.93

Table 20: *Listeria monocytogenes* in **fruit**, Germany, 2008-2016,
qualitative investigations - routine samples

Matrix	Year	Samples tested (N)	Positive samples (n)	Positive samples (%)	Confidence interval (%)
Fresh fruit, incl. rhubarb	2011	61	1	1.64	0.00-4.83
	2012	142	0		
	2013	337	1	0.30	0.00-0.88
	2014	67	0		
	2015	96	1	1.04	0.00-3.07
	2016	21	0		
Fruit salads (pre-cut)	2011	56	0		
	2012	94	0		
	2013	49	0		
	2014	65	0		
	2015	70	1	1.43	0.00-4.21
	2016	36	0		

Table 21: *Listeria monocytogenes* in food, Germany, 2010-2017, **zoonoses monitoring - qualitative investigations**

Year	Matrix	Number of samples analysed (N)	Pos. samples (n)	Pos. samples in % (95% confidence interval)
2010/ 2011[1]	Fish (hot- or cold-smoked) and gravlax fish	474	56	11.8 (8.9-14.7)
	Soft cheese and semi-hard cheese made from raw milk made from pasteurised milk	 320 509	 5 0	 1.6 (0.2-2.9)
	Heat-treated meat products	915	17	1.9 (1.0-2.7)
2012	Loose-leaf/butterhead lettuce from producing company	300	11	3.7 (2.0-6.5)
	Loose-leaf/butterhead lettuce from retail	422	11	2.6 (1.4-4.7)
2013	Fresh strawberries from producing company	300	4	1.3 (0.4-3.5)
	Fresh strawberries from retail	463	5	1.1 (0.4-2.6)
2014	Raw milk cheese	332	1	0.3 (0.0-1.9)
2015	Raw milk cheese from sheep's/goat's milk	288	1	0.3 (0.0-2.1)
	Pre-cut loose-leaf lettuce	344	7	2.0 (0.9-4.2)
2016	Tomatoes (cocktail, cherry)	478	0	0.0 (0.0-1.0)
	Sprouted vegetables (fresh)	271	5	1.8 (0.7-4.4)
2017	Steak tartare/minced beef steak (chilled)	278	31	11.2 (7.9-15.4)
	Spreadable raw sausage	393	48	12.2 (9.3-15.8)

Table 22: *Listeria monocytogenes* in food, Germany, 2010-2017, **zoonoses monitoring - quantitative investigations**

Year	Matrix	Number of quantitatively tested samples (N)	Number and proportion (%) of positive samples 10-100 CFU/g	Number and proportion (%) of positive samples >100 CFU/g	Viable colony count determined for samples >100 CFU/g
2010/ 2011[1]	Fish (hot- or cold-smoked) and gravlax fish	474	13 (2.7)	7 (1.5)	up to 6.4×10^4 by shelf life expiry date
	Soft cheese and semi-hard cheese made from raw milk made from pasteurised milk	 320 509	 0 1 (0.2)	 1 (0.3) 0	 6.2×10^3
	Heat-treated meat products	915	8 (0.9)	1 (0.1)	380
2012	Loose-leaf/butterhead lettuce from producing companies	292	0	0	
	Loose-leaf/butterhead lettuce from retail	427	2 (0.5)	0	
2014	Raw milk cheese	261	0	0	
2015	Raw milk cheese from sheep's/goat's milk	247	1 (0.4)	1 (0.4)	570
	Pre-cut loose-leaf lettuce	320	1 (0.3)	0	
2016	Sprouted vegetables (fresh)	321	0		
2017	Steak tartare/minced beef steak (chilled)	251	5 (2.0)	0	
	Spreadable raw sausage	378	14 (3.7)	2 (0.5)	220 and 580

[1] National data were surveyed as part of an EU baseline study on *Listeria monocytogenes* in ready-to-eat foods during 2010/2011.

About the BfR

The German Federal Institute for Risk Assessment (BfR) is a scientifically independent institution within the portfolio of the Federal Ministry of Food and Agriculture (BMEL) in Germany. The BfR advises the Federal Government and the States ('Laender') on questions of food, chemical and product safety. The BfR conducts its own research on topics that are closely linked to its assessment tasks.

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