

**> Preventing poisoning by pathogenic bacteria:  
*Bacillus cereus*  
Better knowledge of the bacteria  
and improving hygiene methods**

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## Summary

*Bacillus cereus* is a bacterium responsible for foodborne illnesses and since 2011 has been the second biggest cause of collective food poisoning outbreaks in France. Yet the public health impact of *B. cereus* was previously largely underestimated. In addition, because *B. cereus* is a pathogenic bacterium mainly transmitted by food, it represents an important issue for the agri-food sector. In the 1990s, several INRAE laboratories focused their research on *B. cereus*, forming the basis of the eponymous network supported by the Microbiology and the Food Chain department. In order to better answer the questions posed by the bacterium for hygiene, food safety and human health, the network has been extended in France to include researchers from ANSES, Institut Pasteur and European laboratories. Collaborative research projects involving ANSES, manufacturers and technical centres, in addition to training, participation in the development of standards and opinions from health authorities, have made it possible to circulate knowledge between all stakeholders involved in food safety.

In the context of monitoring food safety, the research conducted by INRAE and its partners has had a significant impact on public health policy. This stems from an awareness among actors of the risk represented by *B. cereus*, against a background of underreporting of the pathogen in the 1990s, the development of methods for characterising the bacteria based on new knowledge and, more recently, standards to apply them. A public health impact has been obtained by improving hygiene in the agri-food industries and reducing food contamination. A new generation of impacts is emerging, through the contribution of INRAE and its partners to an awareness of the underestimated risks that *B. cereus* poses to public health.

## Background

### *Bacillus cereus*, *Bacillus thuringiensis*, public health issues

*B. cereus* is a bacterium that causes foodborne illnesses which lead to vomiting, nausea, abdominal pain and diarrhea. Patients generally recover spontaneously but more serious forms may require hospitalization (4% of cases in 2018) and a few deaths have been reported. *B. cereus* can also cause other types of infections, especially in new-born babies where it has been identified as a cause of death in maternity/neo-natal wards. In the 1990s in France, *B. cereus* was rarely declared as a cause of collective food poisoning (defined as the appearance of at least two similar cases, the cause of which can be attributed to the same food origin). However, since 2011 it has been the second most common cause of collective foodborne disease outbreaks. *B. cereus* was therefore a pathogenic bacterium whose impact on public health was very largely underestimated.

*Bacillus thuringiensis* is a species very similar to *B. cereus*. Some strains of *B. thuringiensis* are of great importance to the agricultural sector as it is the most widely used bio-insecticide in the world and is indistinguishable from *B. cereus* only through the ability to produce toxins that are lethal to certain insects. Since these toxins are encoded by plasmid genes, the two bacteria share much of their genetic background and the question arises as to whether they have the same abilities to cause disease in humans. In other words, is a bacterium widely sprayed on food crops also capable of inducing food poisoning? This paradox highlights the lack of knowledge about the pathogenic power of these bacteria. Are all strains of *B. cereus* pathogenic? Are some strains of *B. thuringiensis* too? How can we distinguish pathogenic *B. cereus* or *B. thuringiensis* from those which are not ?

## Economic issues

*B. cereus* is a pathogenic and spoilage bacterium mainly transmitted to humans through food, representing an important issue for the food industry. In the 1990s, two major developments created favorable conditions for the bacteria. On the one hand, there was the development of food products using minimal heat treatments. These offered optimal preservation of the product's organoleptic qualities but treatments were insufficient to stop bacteria such as *B. cereus* from producing forms of resistance (spores). On the other, aseptic or ultra-clean packaging was developed, requiring perfect equipment hygiene, while *B. cereus* is particularly resistant to cleaning and disinfection processes.

In addition, the 1990s saw a profound change in the regulation of food hygiene, which shifted from an obligation of means, set by regulations, to an obligation of results, with the means to obtain them being the responsibility of food companies. This new regulatory approach, combined with major innovation in food and processes, has prompted manufacturers to take an interest in the microbial ecology of their products and in pathogens threatening safety, such as *B. cereus*.

## Inputs

In the 1990s, several INRA laboratories focused their research on *B. cereus* with the aim of answering questions posed by the bacterium on hygiene, food safety and human health.

### *Bacillus cereus* and the safety of new food products

At the end of the 1990s and the completion of their first studies on the microbiology of ready-to-use products (pasteurised foods in their final packaging, requiring cold chain storage), highlighting the importance of *B. cereus*, microbiologists at INRA's Plant Product Technology Unit and pioneering companies in the sector were concerned about the risk the bacterium posed and how it could be controlled. The researchers set up a European project to bring together a network of laboratories and manufacturers able to respond effectively to the questions being posed (2001-2004). They have built up a large collection of *B. cereus* strains from various origins, foods, environments and food poisoning outbreaks, and have mobilized their skills to characterize it from a genetic, phylogenetic, virulence and adaptive capacity point of view.

### *Bacillus cereus*, a tool for hygienic equipment

Over the same period, scientists from INRA's Laboratory of Process Engineering and Food Technologies in Villeneuve d'Ascq were focusing on the study of equipment surfaces and equipment-food interfaces. As part of a European project, they sought to characterize the effectiveness of cleaning/disinfection practices and the hygienic design of equipment and developed a method using *B. cereus*/*B. thuringiensis*. As part of a UNIR project, a national project bringing together several food manufacturers in the dairy sector, they applied their skills on equipment hygiene to characterize several strains of *B. cereus* isolated from processing plants, some of which are particularly persistent and difficult to eliminate.

### *Bacillus cereus*, cause of spoilage in egg products

In 2003 microbiologists from UMR INRA-Agrocampus Ouest STLO were working with an egg product manufacturers association and identified a bacterium of the *B. cereus* group in a container of spoiled egg products. The egg products were pasteurized to eliminate pathogenic bacteria such as salmonella, but this had no effect on the spores of bacteria such as *B. cereus*. Very little scientific data on *B. cereus* in egg products existed at that time. UMR STLO then worked with the industry, the technical centre concerned (ITAVI), ADRIA and academic partners to establish several research projects to identify the sources of contamination and understand the mechanisms of *B. cereus* persistence in the egg product chain.

### Genetics and virulence of *Bacillus cereus* / *Bacillus thuringiensis*

The INRA Microbial Genetics and Environment unit was historically a pioneer in the genomics and genetics of the *B. cereus*/*B. thuringiensis* group. By the end of the 1980s, it had been the originator of several genetic tools, which were subsequently essential for research carried out by the scientific community on *B. cereus*. From the end of the 1990s, the unit became interested in the virulence of *B. cereus*/*B. thuringiensis* for humans and discovered the role of a key virulence regulator, which provided a backdrop for subsequent research into the bacteria's pathogenicity. It then developed a method for measuring oral virulence in insects, to date the only method for reproducing infection in the human digestive tract in an animal model for *B. cereus*/*B. thuringiensis*. INRA's Microbial Genetics Unit participated in and initiated the first complete sequencing of the genomes of strains of *B. cereus* representing its diversity and providing a reference for subsequent studies.

### Collaborative research brought together by INRA's Microbiology and the Food Chain department

When it was created in 2004, INRA's Microbiology and the Food Chain department brought together research on *B. cereus* by setting up a network of the laboratories concerned. The network has been extended in France to researchers from AFSSA and the Institut Pasteur and in Europe to Belgium's University of Louvain La Neuve in and Norway's University of Oslo.

From its initial work, INRA acquired a set of recognised skills in the diversity, adaptation capacities, adhesion to surfaces, virulence and genetics of *B. cereus*. The network made it possible to strengthen the links between INRA and AFSSA for the study of *B. cereus* and to set up collaborative projects with AFSSA, manufacturers and technical centres in the food industry (ADRIA Normandy, ADRIA Développement), in livestock farming (ITAVI) and equipment (CETIM) to further enhance this wide range of skills.

For manufacturers, collaborations with INRA enabled them to learn about a pathogenic and/or spoilage bacterium in which they had not yet taken an interest and to address its ecology in their products (prevalence, sources of contamination and control methods). AFSSA researchers had been interested in *B. cereus* for several years. In particular, AFSSA had investigated a 1998 collective food poisoning in which *B. cereus* caused several deaths and had identified (in collaboration with a Norwegian researcher) a new toxin. AFSSA needed to better understand the prevalence of *B. cereus* collective foodborne illnesses in France and to produce the tools to better characterize them. A question common to industry and AFSSA came from the diversity of *B. cereus* strains isolated from food, the production chain and collective food poisoning investigations, and to know which ones represented a risk for products or which were responsible for disease outbreaks.

### *Bacillus cereus* causes nosocomial infection

More recently, from 2013, researchers from INRA (MICALIS mixed research unit), together with hospital doctors, have been interested in nosocomial infections linked to *B. cereus*.

## Research Outputs

### *Bacillus cereus* and food

INRA and its partners have provided knowledge on the prevalence, contamination pathways and the persistence mechanisms of *B. cereus* in food chains, and its consequences for health risks and product spoilage in collaborative projects involving food manufacturers and technical centres (Choma et al., 2000; Baron et al., 2007). For example, they have demonstrated the role of certain ingredients involved in food formulation as a source of contamination and the role of biofilms in the persistence of bacteria in parts of processing equipment. Given its highly diverse virulence and adaptive capacities, it was difficult for manufacturers to interpret the presence of *B. cereus* in food or the production chain. INRA, for example, has shown that *B. cereus* strains have different characteristics depending on their origins. Scientists at the institute have developed knowledge (Guinebretière et al., 2008) making it possible to attribute to any *B. cereus* strain a potential for virulence and to determine its capacity for cold growth, two determining factors for risk in refrigerated products. A database, accessible free of charge on the Sym'Previus showcase site, was developed from this knowledge by ADRIA Développement and INRA (Guinebretière et al., 2010).

### *Bacillus cereus* and the hygiene of agri-food equipment

Using *B. cereus*/*B. thuringiensis* spores, INRA has developed a method to characterise the hygienic design and cleanability of food processing equipment (Faille et al., 2000). It makes it possible to precisely quantify the risk of depositing bacterial spores in the different parts of the equipment tested. Conversely, it also makes it possible to quantify the effectiveness of cleaning/disinfection on all areas of equipment. Its applications include design flaws which create areas that are easily contaminated and/or difficult to clean, or to test new cleaning and disinfection products. Researchers have also used the exceptional adhesion properties of *B. cereus*/*B. thuringiensis* spores to determine the relevant parameters for characterizing the cleanability of stainless steel. (Faille et al., 1999).

### *Bacillus cereus* and collective food poisoning

INRA and AFSSA have developed a grid to characterise the strains of *B. cereus* isolated during collective food poisoning investigations (De Buyser et al., 2008). This grid uses methods developed by INRA to identify genetically identical strains, assign strains to phylogenetic groups and to characterize their virulence potential and ability to develop in cold conditions. INRA and AFSSA (then ANSES) have since refined the characterization of *B. cereus* by adding new virulence factors (Cadot et al., 2010).

## *Bacillus cereus* and the hospital environment

More recently, INRA, with hospital doctors and ANSES researchers, has applied its knowledge to the study of nosocomial *B. cereus* infections in hospitals, particularly in neo-natal wards. At this point *B. cereus* had been a bacterium that was little known and not considered seriously in French hospitals. While the origin of infections could not be identified, studies have highlighted potential risky practices and cross-contamination within and between hospitals (Glasset et al., 2018).

## Knowledge flow and intermediaries

The circulation of knowledge has been facilitated by collaborative research projects involving stakeholders in food safety, training for industry and the participation of researchers in the development of standards and opinions from authorities and health agencies.

### Manufacturers

As early as the 1990s, manufacturers expressed their interest in participating in collaborative *B. cereus* projects, several of which were set up at the initiative of INRA, in order to refine their knowledge. INRA has obtained detailed knowledge of the questions posed by *B. cereus* for food safety and processing plants and has built up collections of strains with particularly interesting properties. For manufacturers, these projects were an opportunity to better understand the risk the bacterium represented for their products and to understand the origin of contaminations. The participation of INRA scientists in training courses dedicated to industry has allowed the knowledge acquired on *B. cereus* to be widely disseminated.

### Technical institutes

Technical institutes such as ADRIA, ACTALIA, ITAVI and CETIM have regularly participated in collaborative projects on *B. cereus* with INRA, opening the way to a wider dissemination of knowledge to the profession and the establishment of tools and services for manufacturers based on the results of research projects. Technical institutes have gained new skills and services, while INRA has benefited from better use of its results. For example, ADRIA developed with INRA in 2010 a database and online tool for assigning strains of *B. cereus* to phylogenetic groups discovered by INRA. It uses this tool, in combination with other knowledge from INRA, to develop services for manufacturers in order to characterise the risk represented by the strains of *B. cereus* isolated from their products.

### Health agencies and authorities

At the end of the 1990s, relations between AFSSA and INRA were informal, based on exchanges of isolated strains from collective food poisoning incidents, knowledge and advice on the genetic proximity of isolated bacteria (determining whether one or more strains were involved in an incident) and their potential virulence (are the isolated strains really the cause of symptoms?). In 2005, a collaborative project coordinated by INRA aimed at studying the emergence of *B. cereus* as an agent of collective food poisoning incidents in France made it possible to collect strains from outbreaks in the country. This project formalised the initial collaboration and was followed by many others: INRA-AFFSA to develop tools for characterising strains involved in collective foodborne illnesses; AFSSA and then ANSES to better identify agents responsible for incidents in which *B. cereus* was suspected; INRA's public health

promotion of its knowledge and methods on the bacteria. As part of the same project, AFSSA, via the Directorate General of Food, sent an official request accompanied by instructions, to the Departmental Directorates of Veterinary Services (DDSV) for the transmission of *B. cereus* strains from collective food poisoning incidents. Knowledge about *B. cereus* thereby circulated from the Ministry to actors in the field in charge of investigating outbreaks.

Health agencies and authorities have a major expert role in supporting public policies. ANSES for France and EFSA for the European Union have been asked several times about the risks posed by *B. cereus* and *B. thuringiensis* in food. INRA researchers, in particular, have participated in the preparation of EFSA scientific opinions on *B. cereus* and *B. thuringiensis* in 2005 and 2016, contributing to the circulation of the knowledge acquired on these bacteria to the competent services of the European Commission.

### Developing standards

The knowledge produced by INRA and the expertise of its scientists have been used in the development of standards, through their participation in the April 2020 update of the NF EN ISO 7932 standard on the enumeration of *B. cereus* in food, thereby ensuring the dissemination and enhancement of knowledge among laboratories carrying out monitoring, self-monitoring of food and investigations in the event of outbreaks.

More indirectly, the knowledge acquired by INRA on equipment hygiene (Faille et al., 1999) has been taken up by professional organisations and incorporated into the 2003 NF EN 13951 standard on the hygienic design of liquid pumps in the food industry, which made it possible to disseminate this knowledge to manufacturers of equipment for the food industries.

### Targeted training for companies

Within the specific framework of supporting French food manufacturers, INRA has participated in the creation of intra or inter-company training courses on request and in connection with hygiene training organisations in the agri-food sector and with CETIM (centre for engineering industries), mainly on hygienic equipment design

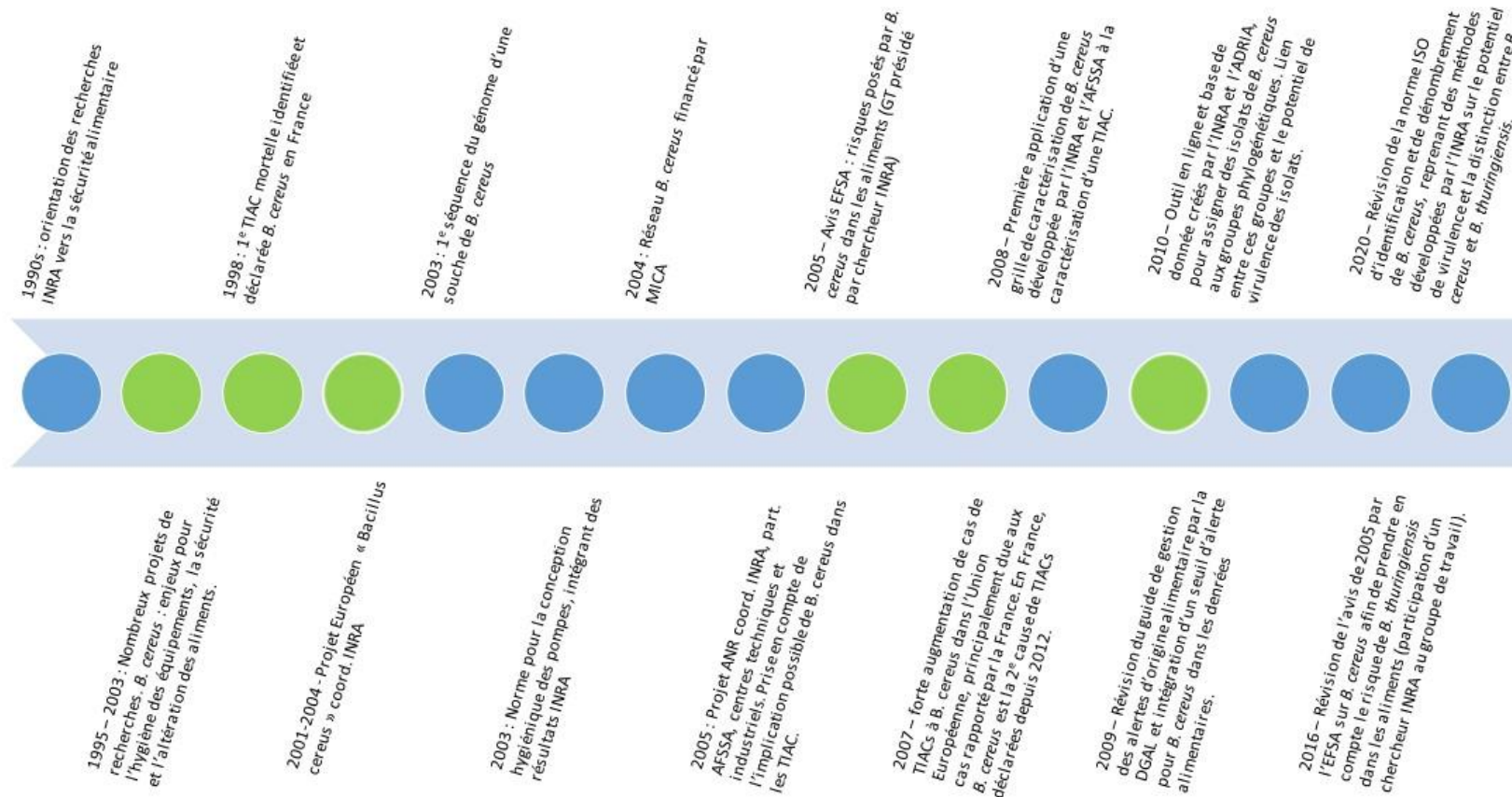
### Dissemination of knowledge to the medical profession

Recently, because of its expertise on the subject, INRA has intervened on problems linked to *B. cereus* in hospitals, elucidating the cause of contamination of injectable anesthetic solutions. INRA and ANSES have also intervened to investigate nosocomial infections in neo-natal care. On the latter, an INRA press release on a publication relating to the study of nosocomial infections was picked up by the medical press. The INRA researchers concerned have since been regularly contacted by the medical community.

## Chronology

- 1990s: INRA research steered towards food safety.
- 1995-2003: Numerous research projects on *B. cereus*: issues for equipment hygiene, food safety and spoilage.
- 1998: First fatal collective food poisoning identified and declared to be due to *B. cereus* in France.
- 2001-2004: European project '*Bacillus cereus*' coordinated by INRA.
- 2003: First sequencing of the genome of a *B. cereus* strain.
- 2003: Norm for the hygienic design of pumps, incorporating INRA's results.
- 2004: *B. cereus* network financed by MICA.
- 2005: ANR project coordinated by INRA and in partnership with AFSSA and technical and industrial centres. Consideration of the possible involvement of *B. cereus* in collective food-borne illnesses.
- 2005: EFSA opinion: risks posed by *B. cereus* in food (working group chaired by INRA researcher).
- 2007: Sharp increase in *B. cereus* collective food poisoning cases in the European Union, mainly due to cases reported by France. Since 2012, *B. cereus* has been the second most declared cause of collective food-borne disease outbreaks in France.
- 2008: First application of a *B. cereus* characterisation grid developed by INRA and AFSSA for the characterisation of collective food-borne illness outbreaks.
- 2009: Revision of the guide for the management of food-related alerts by the DGAL and inclusion of an alert threshold for *B. cereus* in foodstuffs.
- 2010: Online database tool created by INRA and ADRIA to assign *B. cereus* isolates to phylogenetic groups. Link between these groups and the virulence potential of isolates.
- 2016: Revision of EFSA's 2005 opinion on *B. cereus* in order to take into account the risk of *B. thuringiensis* in food (an INRA researcher participated in the working group).
- 2020: Revision of the ISO standard for the identification and enumeration of *B. cereus*, incorporating methods developed by INRA on the virulence potential and distinction between *B. cereus* and *B. thuringiensis*.

## Chronologie



En bleu : évènement impliquant l'inra  
 En vert : contexte

## Impacts 1

### Public health policy impact: monitoring food safety

The main impacts of research conducted by INRA and its partners concern public health, particularly the food safety aspects. This stems from an awareness among actors of the risks represented by *B. cereus*, starting from a background of underreporting of the pathogen in the 1990s through to the development of methods for characterising the bacterium based on new knowledge and of standards for applying them.

#### Better investigative capacity for collective foodborne illnesses when *B. cereus* is suspected

Thanks to the use of methods developed by INRA, AFSSA and then ANSES have been able to classify *B. cereus* strains according to a robust phylogenetic reference system and to assess their ecological aptitudes and their virulence potential, thereby improving their investigation methods when *B. cereus* is suspected to be the cause of collective foodborne illnesses. France thereby has knowledge based on a unique collection of *B. cereus* strains associated with collective food poisoning incidents (Glasset et al., 2016).

#### Better monitoring of *B. cereus* collective foodborne disease outbreaks

As part of a project coordinated by INRA between 2005 and 2008, AFSSA sent a letter to DDSV requesting the transmission of strains from collective foodborne disease outbreaks, resulting in an increase in incidents due to *B. cereus* reported to AFSSA. This initiated a better declaration of outbreaks in France, which showed a strong increase in the next few years. From 2007 onwards, the increase in *B. cereus* outbreaks declared by France was reflected in European statistics and gave the pathogen greater visibility in European epidemiological reports. From a simple mention in a section headed 'Other bacterial agents', *B. cereus* has since been the subject of a separate section alongside other outbreak agents that produce toxins. From 2011, *B. cereus* became the second most common cause of collective food poisoning outbreaks reported in France. From 2006 to 2011, outbreaks attributed to *B. cereus* increased from 50 to around 250 per year, reaching 339 reported incidents in 2018.

The increase in outbreaks due to *B. cereus* is partly due to catching up of past underreporting. Above all, though, the better monitoring of outbreaks reflects greater vigilance vis-à-vis the pathogen and results in the better application of control measures.

#### Integrating *B. cereus* in the alert guide

The greater visibility of *B. cereus* as a cause of collective outbreaks and its introduction by several food processors into their own checks led to its inclusion in the alert guide during a review conducted by the DGAL in 2009 (memorandum of July 7 2009). The addition of *B. cereus* in alerts (2009) created an obligation for food manufacturers to take *B. cereus* into account since exceeding the threshold value results in a product recall. It also allowed the authorities to better understand the *B. cereus* risk by highlighting cases of significant contamination. For example, a batch of parsley exceeding the alert threshold was found to be contaminated with *B. thuringiensis*, alerting the relevant authorities to the proximity issue of *B. cereus*/*B. thuringiensis*, motivating a referral to ANSES in 2011 and the creation of an AFNOR working group (Impact 2).

## Public and economic health impacts: improved hygiene and reduced contamination

### Improving the hygienic design of food processing equipment

INRA's results defining the parameters to be used to define the hygienic nature of materials were used in the AFNOR NF EN 13951 standard of May 2003 'Pumps for liquids - safety requirements - agri-food equipment - design rules to ensure hygiene in use', as well as in its latest version (AFNOR NF EN 13951 2012). INRA has thereby contributed to improving the hygienic design of pumps used in the food industry. Beyond standards, several manufacturers have introduced to the market equipment that has been modified to improve its cleanability or watertightness following studies carried out by INRA using the method developed for *B. cereus*/*B. thuringiensis* spores.

### Standards for the characterisation of *B. cereus*/*B. thuringiensis* isolated from food

Two INRA scientists specialising in *B. cereus* and *B. thuringiensis* participated in the revision of the ISO standard for the enumeration of *B. cereus* in foods (NF EN ISO 7932, April 2020 revision) which incorporates methods for characterising the virulence of *B. cereus* and of *B. cereus*/*B. thuringiensis* distinctions developed by or with INRA. This revised standard will allow for better consideration of the virulence of *B. cereus* strains and better understanding of the role of *B. thuringiensis* in food contamination and collective food poisoning outbreaks.

### Control of food product contamination (health and economic impacts)

Better control of *B. cereus* contamination of food products by manufacturers has a double impact: it reduces the economic risk for manufacturers (recall of defective products) and it reduces the health risk for consumers. The food products concerned are mainly processed products in 'fresh ready meal' ranges, representing a total production of around 1 million tonnes in 2020 (Adepale) and their ingredients such as, for example, egg products, which account for 39% of all the eggs consumed in France (CNPO). Mass catering, which serves an average of 7.3 billion meals per year in France (Ministry of Agriculture), is also affected by *B. cereus*.

Companies which have collaborated with INRA have been able to modify their processes to eliminate *B. cereus* from the products studied and more generally to integrate *B. cereus* into their quality assurance plans. For example, the quality laboratory of one of the major players in ready meals and refrigerated catering products in France currently performs 13,000 *B. cereus* analyses per year in self-monitoring at all stages of the production chain, making it one of its main microbiological targets. Another example is one of the main players in egg products, which has developed, based on research carried out with professors from an INRA-Agrocampus West mixed research unit, a unique know-how allowing it to control *B. cereus* contamination, to respond to the specifications for customers manufacturing products that are particularly sensitive to *B. cereus* spoilage and thereby gain a competitive advantage.

## Other impacts

### European political impact on food safety

Due to his expertise on *B. cereus*, an INRA researcher chaired the working group that drew up EFSA's expert opinion on *Bacillus* spp., an opinion that served as the scientific basis for the drafting of European regulation 2073/2005 on microbiological criteria and its modification 1441/2007. EFSA's opinion largely reproduced the research carried out at the time by INRA and its partners, mentioned the importance of the risk that *B. cereus* represents for a whole category of products, with an emphasis on those intended for sensitive populations such as infant formulas, but did not recommend the definition of general criteria for *B. cereus* because only certain foods, according to their manufacturing and storage processes, were concerned and there remained too much uncertainty on the ingested dose/risk relationship and its diversity within the *B. cereus* species. In accordance with the opinion, the 2005 regulation did not define general criteria for *B. cereus* with the exception of unsafe infant formulas in the 2007 amendment.

### Public health impacts in France's hospital sector

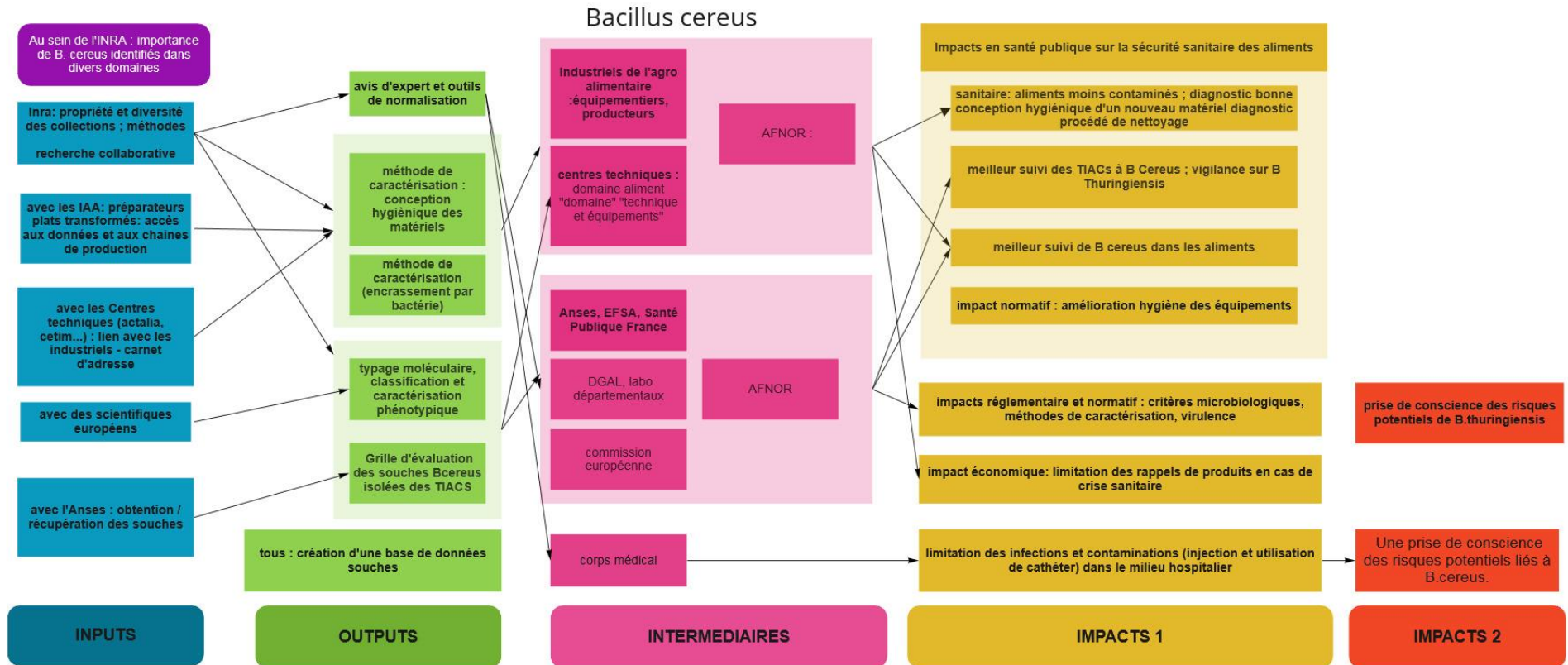
INRA's skills and research have helped solve health problems posed by *B. cereus* in hospitals. An investigation carried out by INRA with hospital staff on cases of *B. cereus* infection among premature babies in neo-natal wards led to an improvement in the methods of administering milk to premature babies in hospitals. In another sphere, INRA has made it possible to resolve the problems of *B. cereus* contamination of epidural anaesthetic injection equipment. INRA researchers also participated in the design of a disinfectant foam for use in hospitals, using the methods they had developed with *B. cereus*/*B. thuringiensis*.

### Alert on underestimated dangers in public health policy

An awareness of the presence of large numbers of *B. thuringiensis* in certain food products, and the question of the risk that this could represent for consumers due to its very close proximity to *B. cereus*, is the result of better monitoring of *B. cereus* in food (Impacts 1).

In the hospital sector, the first studies conducted by INRA, ANSES and their partners in the medical field led to an awareness of the role of *B. cereus* as a cause of nosocomial infections, as illustrated with the publishing of a joint press release on the subject (INRA, ANSES, INSERM and APHP).

## Impact pathway



## Summary of impacts by dimension

Impacts	Importance	
<b>Political Impact</b>	4/5	<p><b>French public health policy on food safety</b> Greater investigative capacity for <i>B. cereus</i> outbreaks Improved declaration of <i>B. cereus</i> outbreaks. Greater vigilance on <i>B. cereus</i> in food products (Inclusion of <i>B. cereus</i> in alert guide).</p> <p><b>Alert on underestimated dangers</b> Awareness of the safety issue of <i>B. thuringiensis</i> in foods. Awareness of <i>B. cereus</i> nosocomial infections</p> <p><b>European policy in the food sector</b> Contribution to the EFSA opinion on <i>B. cereus</i> and its inclusion in the European regulation on microbiological criteria in food</p>
<b>Health Impacts</b>	4/5	<p><b>Improvement of hygiene and reduction of contamination in the food sector</b></p> <p><b>Improvement of the hygienic design of food processing equipment.</b> <b>Contributing to the update of the standard for the identification of <i>B. cereus</i> isolated from food.</b> <b>Elimination/reduction of <i>B. cereus</i> in food products by processors.</b> <b>In the hospital sector: improvement of the hygienic design of certain equipment in hospitals.</b></p>
<b>Economic Impacts</b>	major but difficult for estimate	<p><b>For food companies</b> <b>Avoiding product recalls: major economic impact</b> <b>Improved capacity of food processors to meet clients' specifications on <i>B. cereus</i></b></p>

## External references corroborating impacts

### Interviews (2019)

Who	Date of discussion
C Faille et T Benezech INRA – UMET (ex LGPTA)	13 june
N RamaRao INRA - Micalis	20 june
S Jan INRA – STLO	21 june
D Lereclus et V Sanchis INRA- Micalis	26 june
F Postellec ADRIA	8 october
J Puterflam Itavi	10 october
Manager of an agri-food-group	17 october
E Bille Lactarium Necker	22 october
V Rigourd AP-HP	12 novembre
A Brisabois Anses	29 november
D Cassin ADRO Ouest et groupe AVRIL	29 november

Title	Authors	Date
Avis relatif aux risques en termes de sécurité sanitaire liés à l'utilisation de souches de <i>Bacillus thuringiensis</i> (Bt) <b>en tant que substances actives dans des insecticides biologiques</b>	<b>Anses</b>	Avis de l'Anses <b>Saisine n° 2013-SA-0039</b>
Risks for public health related to the presence of <i>Bacillus cereus</i> and other <i>Bacillus</i> spp. including <i>Bacillus thuringiensis</i> in foodstuffs.	<b>EFSA Panel on Biological Hazards (BIOHAZ)</b>	SCIENTIFIC OPINION ADOPTED: 9 June 2016 doi: 10.2903/j.efsa.2016.4524
Opinion of the Scientific Panel on Biological Hazards on <i>Bacillus cereus</i> and other <i>Bacillus</i> spp in foodstuffs.	<b>EFSA Panel on Biological Hazards (BIOHAZ)</b>	(Question N° EFSA-Q-2004-010) <b>Adopted on 26-27 January 2005</b>
Brevet : Method of screening antibacterial compounds as inhibitor of Mfd		WO 2017/191184 A1
<i>Bacillus cereus</i> a jusqu'ici manqué de considération sur son rôle dans les infections nosocomiales	HOSPIMEDIA	Publié le 25/05/18 - 14h34
Infections nosocomiales : <i>Bacillus cereus</i> , une bactérie à surveiller de près, en particulier chez les prématurés	Charlène Catalifaud, Interview N RamaRao	Le Quotidien du médecin 25/05/2018
Bactériémies à <i>Bacillus cereus</i> en réanimation néonatale à l'AP-HP en 2016	Sandra Fournier, et al.	17 juillet 2018, BEH 25-26
Norme NF EN 13951 Mai 2003. Pompes pour liquides. Prescriptions de sécurité ; Matériel agroalimentaire — Règles de conception pour assurer l'hygiène à l'utilisation	AFNOR	Mai 2003

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### Table of acronyms :

Unité INRA : (Institut National de la Recherche Agronomique) :

MICALIS : microbiologie de l'alimentation au service de la santé - <https://www.micalis.fr/>

STLO : Science et Technologie du Lait et de l'Oeuf - <https://www6.rennes.inrae.fr/stlo>

UMET : Unité Matériaux et Transformation - <http://umet.univ-lille1.fr/>

LGPTA : Laboratoire de Génies des Procédés et Technologies Alimentaires

SQPOV : sécurité et qualité des produits d'origine végétale - <https://www6.paca.inrae.fr/sqpov>

Autres :

AP-HP : Assistance Publique – Hôpitaux de Paris - <https://www.aphp.fr/>

CETIM : centre technique des industries mécaniques - <https://www.cetim.fr/>

ITAVI : institut technique de l'aviculture - <https://www.itavi.asso.fr/>

This case study was carried out using the ASIRPA method (Analysis of the Societal Impact of Research) developed by INRAE.

For more information on the ASIRPA method: [https://www6.inrae.fr/asirpa\\_eng](https://www6.inrae.fr/asirpa_eng)

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