NEW Food | IN-DEPTH FOCUS

Food Safety

L. monocytogenes could spread in new ways with the introduction of alternative proteins. Masja Nierop Groot, Senior Scientist at Wageningen Food & Biobased Research, explores

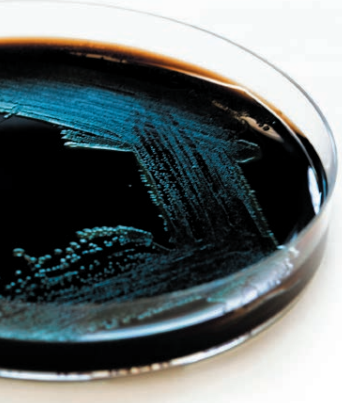
Olive oil is a common target for fraud; learn how one company is using NIR spectroscopy to determine the quality and safety of its edible oils

Dr Sylvia Pfaff and Vanessa Kordt assess the possible limits of quality management systems and how one may elicit a more effective food safety culture

Food safety expert, François Bourdichon, highlights some of the more devious sites where microbials can survive within a manufacturing plant

Challenges to the control of *Listeria monocytogenes* in food products

The rise of alternative proteins and novel side streams for more sustainable food production could introduce new ways for *Listeria monocytogenes* to spread. Masja Nierop Groot explores.



TO ASSURE OUR future food requirements and to protect the planet, developments are ongoing to make our food system more sustainable. Measures adopted to realise this include reduction of food loss and waste, and a transition to a more plant-based diet.

It has been estimated that about 25 percent of all foods produced globally are lost due to microbial growth.[1] In the context of sustainability, product shelf life is an important aspect to consider, as a substantial amount of current food waste can be attributed to products that have exceeded their expiration date.

From a logistical point of view, supply and demand for products with a short shelf life, such as chilled, fresh products or ready-to-eat (RTE) foods, is particularly challenging. Food producing companies are faced with the challenge of maximising the shelf life of their products to meet the demand of retailers and consumers but without compromising its safety. This raises concerns when expiration dates are stretched to avoid food waste. Moreover, the consumer's preference for clean label and aversion to E-numbers poses new challenges for food producers to minimise (future) food safety risks.

Food safety has not received the same level of attention as food loss and waste; however, the impact of food recalls due to microbiological hazards on food loss is high. *Listeria monocytogenes* is one of the pathogens of concern in chilled food products.

Listeriosis

Listeriosis is the disease caused by the bacterium *L. monocytogenes*, and is among the world's most severe foodborne diseases. Although it has a relatively low incidence (in the EU 4.7 cases per million people in 2016),[2] the impact on the disease burden is high due to the mortality rate of 20-30 percent. The elderly are known to be more susceptible to infection with *L. monocytogenes* compared to the younger population, hence with the ageing population, prevention of listeriosis will be even more important in the future. Neonates, pregnant women and immunocompromised persons are also at higher risk of listeriosis.

The most severe listeriosis outbreak dates back to 2017-2018 in South Africa, involving more than 1,000 cases of which almost 200 patients died. Eventually, the contamination source was traced back to polony, which is a processed RTE meat product. Whole genome sequencing of isolates from patients, the environment and the product indicated that the outbreak was caused by polony produced at a single production facility.[3]

Foodborne outbreaks have been typically associated with RTE food products including dairy, fish, seafood and processed meat product categories,[4] but also RTE salads and leafy greens. A survey among RTE meat and fish products in Europe for the period 2010-2012 revealed a prevalence of *L. monocytogenes* of 2.07 percent and 10.3 percent, respectively, in these food categories at the end of shelf life.[4]

New commodities

A severe *L. monocytogenes* outbreak occurred in 2018 in Europe involving frozen vegetables. Traceability information for the contaminated products indicated the source of contamination to be in a freezing plant by a persistent *L. monocytogenes* present in one of the freezing tunnels. Implicated frozen products were distributed to 116 countries and led to reported illness of 54 people in six countries, of which 10 died. This case shows that new commodities, which have not been previously considered a risk of listeriosis, are emerging. This concern was also raised in a recent expert opinion report from the European Food Safety Authority.[5] Another example is the *L. monocytogenes* outbreak in 2015 caused by Blue Bell ice cream in the US (causing illness in 10 people from four states, and three deaths). The outbreak led to a recall of all Blue Bell products and a shutdown of its production plants.

L. monocytogenes is ubiquitously present in the environment, entering a factory via an array of raw materials or plant-based products. *L. monocytogenes* is able to survive in biofilms in the food processing environment, which could lead to recurrent contamination. The prevalence of *L. monocytogenes* on plant or vegetable food »

"The most severe listeriosis outbreak dates back to 2017-2018 in South Africa, involving more than 1,000 cases of which almost 200 patients died"

EXPERT VIEW

Eurofins Tecna

Giulia Rosar
Mycotoxins Product Manager, Eurofins Tecna

Detecting contamination in milk

Giulia Rosar explains the need for rapid and effective solutions to detect aflatoxin M1 in milk and highlights a method which eliminates potential errors caused by human intervention in the analysis.

Milk is a highly nutritious foodstuff and an essential part of many people's lives, but it can also be a source of natural food contaminants that may pose serious health problems. To ensure food safety, one of the key concerns of the dairy industry is the timely detection of aflatoxin M1 contaminations that originate from animal feed. Aflatoxin M1 analysis in milk can be run with various rapid methods such as ELISA and strip tests, supported by instrumental analysis.

ELISAs are immunoassays that represent the most cost-efficient method, with the lowest time-to-result for high analytical volumes. Dozens of samples can be run in parallel, with quantitative results available in just over an hour.

Nevertheless, the manual implementation of ELISA kits could be affected by environmental changes and mistakes caused by human intervention that could jeopardise the assay's reliability. Automated analysis by an ELISA robot leads to performance standardisation, reducing the impact of the environment or the analyst. The load-and-walk-away principle simplifies lab processes and helps to increase productivity.

By applying the AOAC International PTM-approved I'screen AFLA M1 milk ELISA kit to The Bolt™, a compact, reliable and flexible ELISA robot, Eurofins Tecna developed and fully validated a novel aflatoxin M1 analysis method. Raw bovine milk samples were run in the instrument without any prior sample preparation. The validation included verification of the calibration, confirmation of the absence of any drift and cross-contamination effect, an accuracy and precision assessment, and a machine stress test which involved running +550 raw milk materials through the machine in a few weeks. This demonstrated that the presence of the fat matrix does not affect the robot or the results at any time.

The dairy industry and laboratories now have access to a fully validated package consisting of the instrument, the method and the kit, to support their efforts to improve the safety and quality of their products.

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L. monocytogenes is one of the pathogens of concern in chilled food products

products worldwide has been reported at levels of 0.9 to 25 percent.[6]

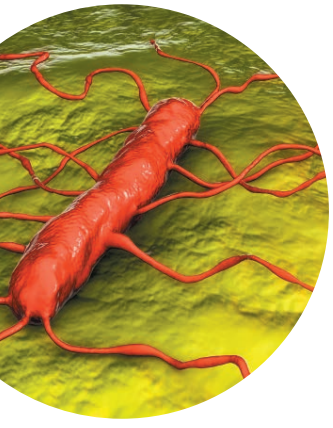
To date, there have been no recalls or outbreaks reported for plant-based protein products such as meat analogues; however, *L. monocytogenes* could be associated with chilled plant-based protein foods. Furthermore, the market for plant-based meat and dairy replacers is growing rapidly, increasing the demand for effective strategies to control *L. monocytogenes* in response.

"New protein sources or side streams for more sustainable food production systems could introduce new vehicles for L. monocytogenes"

Legislation

In European Food legislation, a food safety criterion has been laid down for *L. monocytogenes* for RTE food products. Intrinsic food conditions that do not support *L. monocytogenes* growth have been established in EU regulation and include a pH < 4.4, Aw < 0.92, or a combination of pH < 5.0 and Aw < 0.94, or NaCl > 16 percent (Regulation (EC) No. 2073/2005). When products do not meet these parameters and/or rely on other inhibiting factors to control growth, they need to be validated for each specific RTE food product in a challenge study.

In the USA, the food safety standard for *L. monocytogenes* differs from that of the EU; according to US legislation, a zero tolerance is in place for RTE products placed on the market.



Control measures for *Listeria monocytogenes*

The use of adequate sanitation procedures is a prerequisite in risk prevention, but besides this, new and effective control measures for this food pathogen are required, as the use of new protein sources or side streams for more sustainable food production systems could introduce new vehicles for *L. monocytogenes*.

The implementation of natural antimicrobials is one approach to control *L. monocytogenes* in food products that meets the consumer preference for clean label solutions. New solutions could, for example, be provided by using food cultures, ferments or bacteriophages. Organic acids and ferments already have a long history of use and proven efficacy for many food products, including processed meat products.

It remains important to assess the effectiveness of these solutions for new food matrices that appear on the market, driven by the protein transition movement. This may require adjustment of currently developed solutions to optimise performance in plant-based counterparts.

Traditionally, food cultures have been used to improve the shelf life and safety of foods, and their use has increased enormously over the last decade – receiving increasing attention as clean label solutions to preserve food products. Bacteriophages have proven to be capable of eliminating low-level contaminations with pathogenic bacteria including *L. monocytogenes* and therefore is a feasible option for a biocontrol agent for food.

Predictive models are increasingly being used in food safety control as they can reduce expensive experiments. For wider implementation and accuracy of these models, more antimicrobials must be quantified and implemented. One area for innovation is the development of models that have the flexibility to include new (combinations of) antimicrobials and/or a broad product range. However, more parameters must be quantified and implemented in relevant product matrices for this to be feasible, including plant-based meat and dairy analogues.

Wrap-up

Food safety is of eminent importance for the protection of consumers and brand reputation. Besides the societal impact of listeriosis on public health, the financial impact for companies can be huge in terms of lawsuits, recalls, loss in sales and consumer trust.

The use of new protein sources and side streams to create sustainable food production systems could also introduce new commodities for food pathogens. For chilled RTE food products, *L. monocytogenes* is a pathogen of concern that limits shelf life. Effective, validated solutions are desired as interventions for plant-based meat and dairy alternatives that meet the consumer's preference for clean solutions to enhance shelf life, but also assure product safety.

Potential ingredients such as bacteriophages, use of food cultures and fermentation can provide new (natural) solutions to control growth of *L. monocytogenes* in plant-based products. New mathematical models to describe and predict microbial growth are required.

Wageningen Food & Biobased Research intends to set-up a consortium project focusing on innovative solutions for enhanced control of *L. monocytogenes* in plant-based meat and dairy alternatives and developing predictive mathematical models. The MINIScreen (Matrix INteractIon Screening) platform will be used for fast screening in miniaturised food. For more information visit: www.wur.eu/MINIScreen.

Masja Nierop Groot, PhD

Masja is Senior Scientist at Wageningen Food & Biobased Research. Her activities focus on the control of food pathogens and spoilage organisms to safeguard the safety and quality of food and ensure shelf life.

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The right tools

Alexander Gertz

Alexander studied economics in Bochum, North Rhine-Westphalia and is co-founder and managing partner of the family company Maxfry GmbH.

Alexander Gertz from Maxfry explains how the company uses NIR spectroscopy to determine the quality and safety of olive oil.

GENERALLY SPEAKING, edible oils are not common targets for fraud; yet, as a high value product, we find that olive oil is subject to frequently occurring cases of fraudulent activity. In any case, as with any other foodstuff, oils and fats must be subjected to permanent and comprehensive quality control to ensure their safe consumption.

Why NIR spectrometry is an important tool

As our main business at Maxfry is the optimisation of industrial and gastronomic deep-frying processes, we analyse (via NIR spectrometry) oils and fats mainly to monitor degradation processes and how these are influenced by our use of stabilising ingredients. And, of course, we use the data we gather to ensure general compliance of our raw materials with our specifications.

NIR spectrometry also allows us to verify the authentication, identification and (sensorial) assessment of olive oils. Fraud in olive oil can present itself in a variety of forms, such as being marketed with a false origin declaration, not meeting the necessary quality requirements,

Extra virgin olive oil is highly regarded and therefore expensive, meaning it can be a target for fraudsters

or through intentional adulteration. This can manifest in olive oil being blended with other lesser quality oils or even chemical/physical treatment to change analytical markers; the motivation for these kinds of practices are usually financial.

An NIR spectrometer is an easy-to-use device that needs only low-level training. With the right well-calibrated software methods, you gain a huge variety of information from just one sample and measurement. This promotes onsite quality assurance/management to a new level.

Furthermore, it does not require the skills of a chemist who is educated in conventional analysis and wet chemistry to conduct the analysis; neither must you buy and store flammable, poisonous or otherwise problematic laboratory chemicals onsite to satisfy objective and databased quality management requirement. As it gets easier and cheaper, it becomes more attractive to comprehensively monitor product quality.

What can NIR spectrometry be used for?

In our case, NIR spectrometry allows us to assess a wide variety of parameters that are used in the assessment of oils and fats, as well as for other general and complex tasks such as the olive oil analysis we undertake. »

"An NIR spectrometer is an easy-to-use device that needs only low-level training"

EXPERT VIEW

Bruker Optics

Dagmar Behmer, MSc
Marketing Manager,
Food Analysis Solutions,
Bruker Optics

For further information, visit:
www.food-analysis-nir.com

FT-NIR spectroscopy – a powerful technology for the analysis of edible oils

Oils and fats are recognised as essential nutrients in our daily diet. Numerous parameters are used to assess their quality and FT-NIR solutions enable rapid analysis to ascertain these characteristics of edible oils.

Today's Fourier transform near-infrared (FT-NIR) spectrometers offer many advantages over classical, wet-chemical and chromatographic analyses. FT-NIR is quick, cost effective and safe, as no hazardous chemicals, such as gases or solvents, are used.

FT-NIR also avoids the typical error sources of traditional lab methods, such as those that occur during the sample preparation stage. For edible oil analysis, the neat sample is simply filled into a glass vial and placed into the spectrometer for a temperature-controlled measurement. With this measurement, multiple components can be analysed in less than one minute.

Olive oils

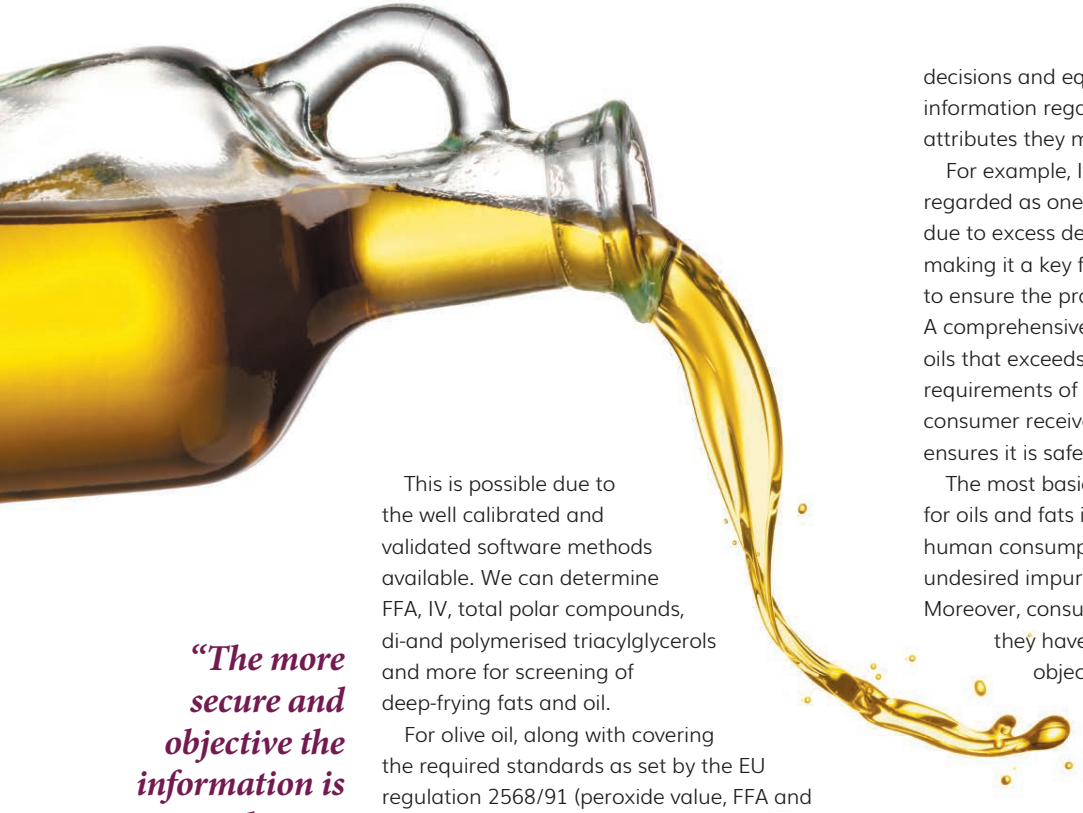
An acidity value below 0.8 percent is the main criterion for the classification of olive oil as 'extra virgin'. Other quality parameters include the peroxide value, an indication of the rancidity of the oil; the amount of 1,2-diglycerides; as well as the pyropheophytin content in the oil, which reveals if an olive oil was stored for too long or even adulterated with refined (olive) oils to obtain lower acidity values.

All these critical parameters can be tested with a single FT-NIR measurement, enabling a thorough quality control process along the production chain of the olive oil.

Frying oils

Frying is a well-established method of food preparation; however, frying oils, used continuously and repeatedly at high temperatures, are subject to degradation. This can lead to the deterioration of sensory qualities and potentially health issues if consumed.

FT-NIR spectroscopy is a proven method to assess the quality of deep-frying oil with regard to its key parameters, including acidity and total polar compounds, describing all aspects of the fat degradation. This was acknowledged by the DGF in its standard method DGF C VI 21a (13).



"The more secure and objective the information is regarding an oil product, the better informed the purchase decision can be"

This is possible due to the well calibrated and validated software methods available. We can determine FFA, IV, total polar compounds, di-and polymerised triacylglycerols and more for screening of deep-frying fats and oil.

For olive oil, along with covering the required standards as set by the EU regulation 2568/91 (peroxide value, FFA and k-values), this technique provides us with a plethora of additional information that helps to detect adulteration and sensorial defects, and enables us to determine the likely geographic origin.

The analytical parameters that we establish are just segments of the whole image we construct of the products we are testing. The information tells us a story about how it has been produced, stored and treated, up until the point that we have it in our possession.

The data we gather during analysis of olive oil samples helps marketers to make purchase decisions and equips them with secured information regarding the quality and sensory attributes they may use in their marketing.

For example, Italian extra virgin olive oil is widely regarded as one of the best in the world; therefore, due to excess demand, the price point is fairly high, making it a key fraud target. Buyers therefore want to ensure the product they're buying is genuine. A comprehensive surveillance of the marketed olive oils that exceeds the basic and already outdated requirements of current EU regulation means the consumer receives the product they paid for and ensures it is safe for consumption.

The most basic and minimum requirement for oils and fats is for them to be safe for human consumption and therefore free of undesired impurities and contamination. Moreover, consumers should always get what they have paid for. The more secure and objective the information is regarding an oil product, the better informed the purchase decision can be.

Our olive oil analysis by far exceeds the requirements of EU regulations, and we have developed uniquely extensive methods based on NIR spectrometry. Over the course of several years these have been calibrated using huge amounts of olive oil samples from all over the world, together with the secured information derived from conventional laboratory analysis. These methods are now validated and deliver secure information that are consequently used in chemometric methods. This combination enables the high-level assessment we offer at a low cost and in a timely manner.

What results can customers expect following a screening?

The screening of a deep-frying oil sample contains important key figures and parameters that characterise the current state of thermal-oxidative stress. The customer receives information on acid value, total polar compounds, polymerised triacylglycerols, anisidine value and iodine value, for example. This is derived from one measurement of an oil sample within seconds.

Mostly, these kinds of samples are not analysed as single samples but usually as a row of samples from a production interval to monitor the development of the oil/fat degradation under thermal oxidative stress. This approach is part of many food producers' quality assessment and allows them to adjust their process until they achieve perfect production results or, equally, is used to troubleshoot.

An olive oil screening customer receives all the basic information required by the EU regulation 2568/91 enabling them to create an accurate

Maxfry tests oils to ensure its customers are buying genuine and safe products

product label (eg, fatty acid structure for the nutrition table). Furthermore, they receive a sensory profile describing the degree of fruitiness, bitterness, pungency and overall harmony. This is followed by a value on a scale (from green to ripe) and a statement about whether sensory defects were found, and if so, which kind.

The next point of the report deals with adulteration and the percentual probability of adulteration by 'stranger' oil or prohibited chemical/physical treatment.

The report contains information on the identification (extra virgin or none), geographical origin and biological age and, based on this, a recommendation for the best before date is given. The final quote is a quality grade from one to eight, with eight being premium quality. This information depends on the sensory harmony in combination with the absence of sensory defects and alterations.

Olive oil manufacturers are facing the challenge of improving harvesting and production techniques in times of climate change to maximise the output of high-quality olive oils. Only with comprehensive and fast analysis will they be able to control the impact of changes to their processes, and determine the quality of products and that such items are purchased at the right price and according to the requirements of the consumer.

@NewFoodMag

Certification in the food sector

Two experts from FIS Europe look at quality management systems and their possible limits.

Dr Sylvia Pfaff

Sylvia studied food chemistry and received her doctorate at the University of Hamburg. She has been implementing quality management systems since 1996. She has advised numerous companies in the food industry on the development of HACCP and quality management systems.

A PROCESS-ORIENTED quality management system (QMS) enables flexible handling within a company, so that it can be adapted if changes occur. The central approach to food safety should be based on the foundations of a solid QMS.

A procedure originally developed in 1959 on behalf of NASA for space-suitable food products, has now become an integral part of food safety. We are referring to the Hazard Analysis and Critical Control Points (HACCP) concept, which is used in food production plants worldwide, and in many countries acts as the legal basis for safe production.

Since HACCP's inception, there has been constant development of food safety strategies. In addition, standards in the form of QMS (such as BRC, IFS and FSSC 22.000) have been developed by interest groups and the retail trade for the consideration of food companies.

For example, in May 2000 the Global Food Safety Initiative (GFSI) launched – a group of leading food safety experts from trade, manufacturing and service companies, as well as representatives from academia and government.

The GFSI publishes a guideline for food safety management systems worldwide in order to assess schemes and ensure comparable standards across the board. Standards such as IFS Food, BRC Food and FSSC 22.000 are recognised by the GFSI.

Today, most companies that supply to the food retail trade have at least one food safety-relevant certification. A GFSI-recognised certification is practically a ticket into the retail trade. Meanwhile, the addition of food fraud defence measures to the food safety assessment has added further dimensions to the security features. The standards of food safety management systems are thus improved as versions are updated.

The level of food safety standards is rising and, consequently, it's becoming increasingly difficult for artisanal businesses to meet these standards, which is why the GFSI developed the Global Markets Programme (GMaP). This two-stage system ensures a slow start; with additional requirements being built upon and ultimately checked via an assessment – the ultimate goal being IFS or BRC certification. For trade, the programme serves as proof that the supplier controls their processes. In this way, the relevant products can be included in the product range.

The GMaP enables entry into a QMS without the pressure of certification and also opens the door to the retail trade for craft businesses.

The next stage of quality improvement is the expansion of the concept of food safety to include food safety culture, as is currently happening with the new version of IFS Broker 3 and the new IFS Food 7.

Defining food safety culture

The word 'culture' comes from the Latin word 'cultura' (to build, to work, to cultivate), which is derived from the Latin 'colere' (to cultivate, to educate). The concept of culture is defined by the United Nations Educational, Scientific and Cultural Organization (UNESCO) as follows: "Culture can be considered in its broadest sense as the totality of the unique spiritual, material, intellectual and emotional aspects that characterise a society or a social group. This includes not only art and literature, but also ways of life, fundamental human rights, value systems, traditions and beliefs."

A culture is not created by the individual, but is developed and lived out by a group, its values, knowledge and actions. A culture is a community of shared knowledge and ideologies. Therefore, food companies should define their values in terms of food safety and food quality: Why am I proud to produce this? Why would I buy our products?

So food safety culture is based on the knowledge of how to produce, process, transport and handle food safely, and is characterised by the people who live and breathe safety standards. Such a culture can be exchanged across companies and may strengthen the sense of community.

This concept also contains basic ethical and social values that are part of the food safety culture. So perhaps improved social aspects can make the food sector less vulnerable to fraud or deliberate tampering.

Finally, a culture values its principles and traditions without losing sight of the future.

So, can a food safety culture serve as the corporate identity of all companies; and what are the limits?

How much food safety do you want?

This is a question we ask ourselves more often in regard to the demands of certification auditors. It is precisely within the certification audits that the limits of feasibility are revealed.

We see limits, for example, in the area of food defence and its control options in companies »

Vanessa Kordt

Vanessa is a trained hotel manageress and BSc oecotrophologist. In September 2020 she joined FIS Europe as a Junior Consultant. She has more than 10 years of experience in the food and packaging industry as a quality management officer.

"The level of food safety standards is rising"

"Food safety culture is based on the knowledge of how to produce, process, transport and handle food safely, and is characterised by the people who live and breathe safety standards"

seeking broker certification. These companies trade via exchanging documents; they commission the manufacturer, the transporter, the shipping company, the warehouses, and/or act on behalf of the customer. They have full responsibility for their food and need a binding commitment that the contracted companies produce, transport, store and deliver their products to the customer safely and as agreed in specifications. Here, written documentation, contractual obligations, including the required quality parameters, and the transfer of information to all parties involved are the most important core elements for ensuring food safety.

During a certification audit, auditors often ask the question: How do you ensure that your product is not manipulated during transport in order to harm your company? Brokers and agents often do not have first-hand knowledge regarding this point; however, they can prove it by commissioning only those food suppliers and service providers with GFSI-approved certifications. Although they can follow up any complaints from customers on this topic and implement measures to avoid any future manipulation, they are not physically transporting the goods and so this remains the responsibility of the haulage companies.

Additionally, the acting companies can use questionnaires to ask for and evaluate the relevant points regarding food safety. They can present the individual process steps and their hazards in the risk analysis. In practice, it is difficult to do more than just check these points, regulate them contractually and, if necessary, control them through their own supplier audits.

In most cases, this leads to the corresponding risk analyses for the individual processes being very one-sided and monotonous. Manufacturers certified according to IFS Food are commissioned and contractually recorded in writing; however, despite many auditors preferring more detailed information or descriptions, these cannot be delivered as the processes are not subject to the broker.

Further difficulties arise with the knowledge of recipes. According to the certification catalogue of IFS Broker Version 3, the broker company is responsible for all product recipes. However, manufacturers generally keep their recipes under lock and key – this procedure is common practice and comprehensible. The recipe remains confidential so that the manufacturer is not suddenly replaced by a competitor. Therefore, if the broker does not have a recipe, he cannot be held responsible as such. Compliance with food laws and regulations is the basis of food safety in every branch.

How high is the risk? How likely is it to occur and how severe might the effects be (a) on the human body and b) on the profitability of the company if the hazard occurs? These are still key questions that are posed in a risk analysis.

Ultimately, the principle of dual control is being increasingly demanded and promoted. If you build on this and view every certification, customer and supplier audit as an exchange of knowledge, so that you can challenge and promote each other, then the food safety culture will be able to be implemented more effectively.

EXPERT VIEW

KNAUER

Dr Kate Monks
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Sweet HPLC

Dr Kate Monks describes the current problems with HPLC solutions and how she envisions the market evolving in the near future.

We were all told as children that too much sugar rots our teeth, yet the adverse effects of sugar, according to health organisations, can be even greater than dental issues. The World Health Organization (WHO) and American Heart Association urge people to restrict their added sugar intake, due to their association with obesity, heart disease and type 2 diabetes.

To keep control of sugar levels, it is helpful to know how much sugar there is in the foods and beverages we consume. Nutritional labelling is a great controlling aid, as food products are required to list sugar and total carbohydrate content. The measurement of sugars in foodstuffs is typically carried out via high-performance liquid chromatography (HPLC).

Another issue facing the food and beverage industry is adulteration; key examples of which include wine and honey. The price of natural bee honey is much higher than other sweeteners, making it susceptible to adulteration with cheaper sweeteners, primarily sucrose. As well as sucrose, high fructose corn syrup and lactose (high in calories) are added to some foods to increase sweetness at a low cost. Adulteration can often be monitored via HPLC.

HPLC technology has matured over recent decades and we now have some great equipment in the field. Unfortunately, it's not being used to the best of its capabilities. HPLC manufacturers are pushing the boundaries up to ultra-high pressures, with ever more complex optimisation features. At the same time, lab analysts are expected to master a myriad of software packages and equipment with different tasks and skillsets. In the near future, I see a move away from equipment that is faster, bigger and stronger, to tailor-made, highly intelligent solutions. For example, an increase in convenient online and automatic sample preparation techniques solutions combined directly with the analytics.

The analysis of sugars remains an essential task for increasing awareness and improving health. Modern and smart HPLC system solutions need to keep things simple for the user in the lab, in order to better fulfil the modern challenges facing the food and beverage industries.

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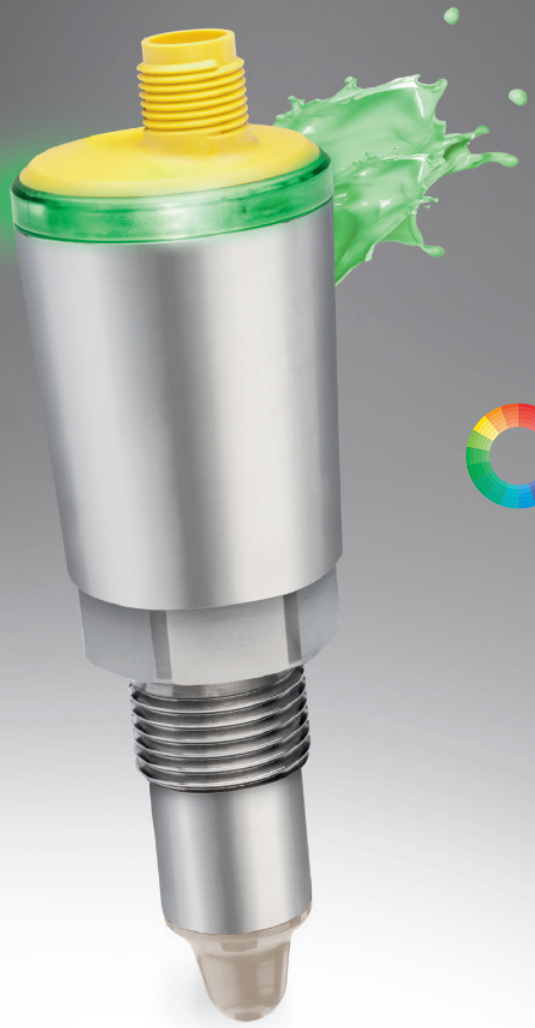

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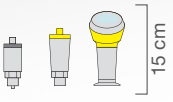

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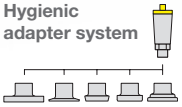

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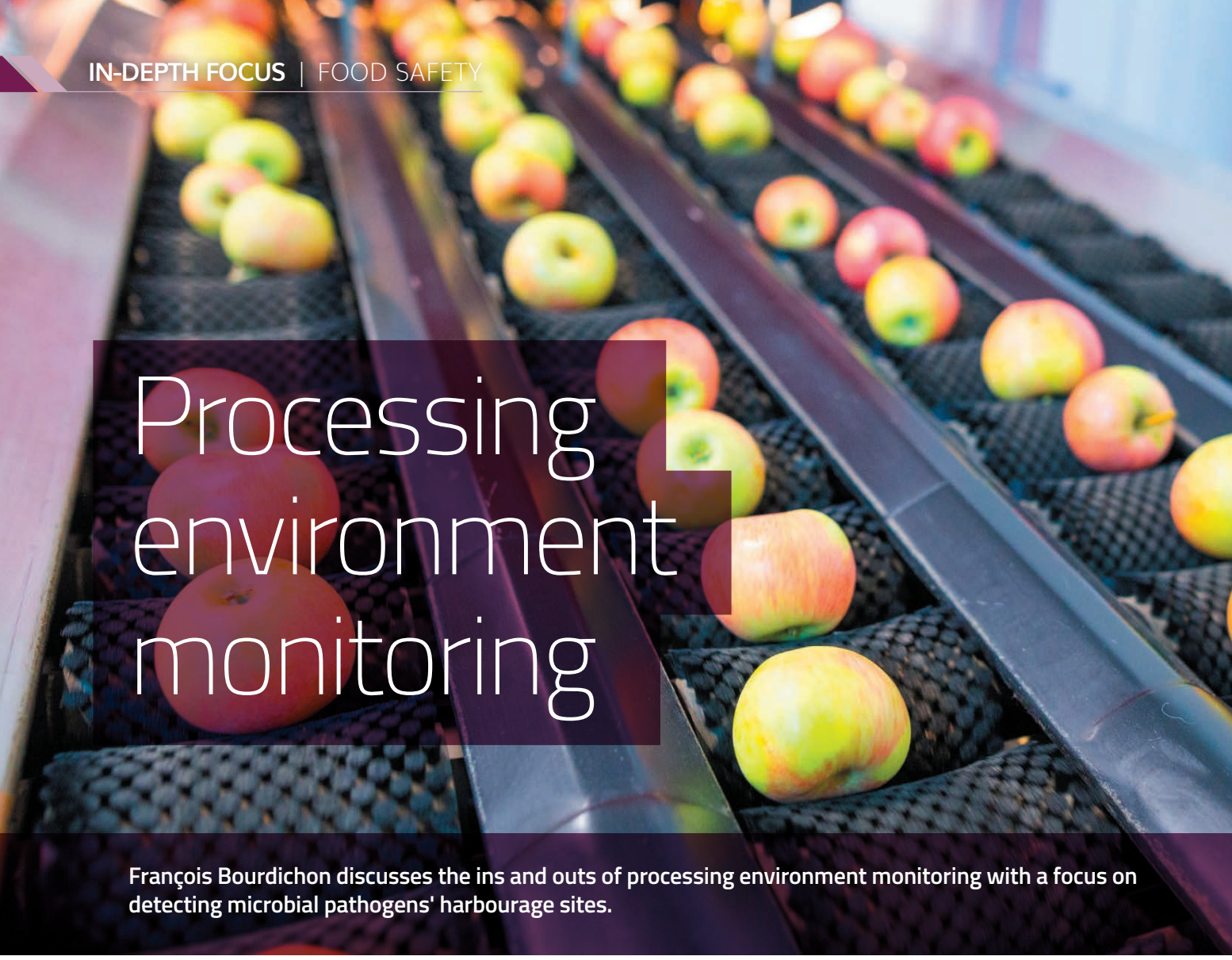


Processing environment monitoring

François Bourdichon discusses the ins and outs of processing environment monitoring with a focus on detecting microbial pathogens' harbourage sites.

"15 years after the publication of this regulation, where do we stand? What have we learned, if anything?"

RECENT MAJOR foodborne outbreaks (*Listeria monocytogenes*, *Salmonella* spp.) caused by contamination in the processing environment have piqued the interest of the food sector and analytical companies to proactively look for harbourage niches for pathogens of concern.

This disquiet was highlighted in the European regulation EU2073/2005: "Sampling of the production and processing environment can be a useful tool to identify and prevent the presence of pathogenic micro-organisms in foodstuffs."

So, 15 years after the publication of this regulation, where do we stand? What have we learned, if anything?

Lack of guidelines and standardisation

Article 5 'Specific rules for testing and sampling' of regulation 2073/2005 provides further explanation of the expectations on processing environment monitoring:[1] "Food business operators manufacturing ready-to-eat foods, which may pose a *Listeria monocytogenes* risk for public health, shall sample the processing areas and equipment for *Listeria monocytogenes* as part of their sampling scheme.

"Food business operators manufacturing dried infant formulae or dried foods for special medical purposes intended for infants below six months which pose an *Enterobacter sakazakii* (new taxonomy *Cronobacter* spp.) risk shall monitor the processing areas and equipment for *Enterobacteriaceae* as part of their sampling scheme."

Regulation 1441/2007 modified this statement:[2] "EFSA Biohazard panel concluded that it is not possible to establish a correlation between *Enterobacteriaceae* and *Salmonella*, and no universal correlation between *Enterobacteriaceae* and *Enterobacter sakazakii* (*Cronobacter* spp.) exists."

The targets are outlined here and the methodology briefly provided: "Samples shall be taken from processing areas and equipment used in food production, when such sampling is necessary for ensuring that the criteria are met. In that sampling the ISO standard 18593 shall be used as a reference method."

At that time, the standard was only a technical specification, and only recently (mid 2018) has it become a full ISO standard.[3] As for the sampling approach, the official recommendations in Europe

(eCDC, EFSA) are to identify Critical Sampling Sites (CSS) and build the sampling scheme upon them (production days, sampling time).

Codex Alimentarius' guidelines differentiate Food Contact Surface (FCS) and non-Food Contact Surfaces (nFCS).[4] Previously, in 2002, ICMSF proposed an approach based on product proximity - a four-layer proximity approach to be exact: one for FCS and three for nFCS. This approach is implemented by US Food and Drug Administration (FDA) and in US industry-based guidelines (Almond Board of California, 2010; GMA, 2014; United Fresh Produce, 2013)[5-7] as Zone 1 to Zone 4.

There is frequently a misinterpretation with the hygiene zoning classification, and shortcuts are often made, leading many to believe Zone 1 is high hygiene and Zone 4 low hygiene, which is certainly not the case! A classification used by some industry players is to use Line – L for FCS, and E1 to E3 for nFCS. The concept, definitions and names are provided in **Figures 1 and 2.** This proximity approach has also been considered in European industry-based guidelines, such as the recent one from the European Association of Fruit and Vegetable Processors.[8] The recognition of this approach by official authorities is still ongoing.

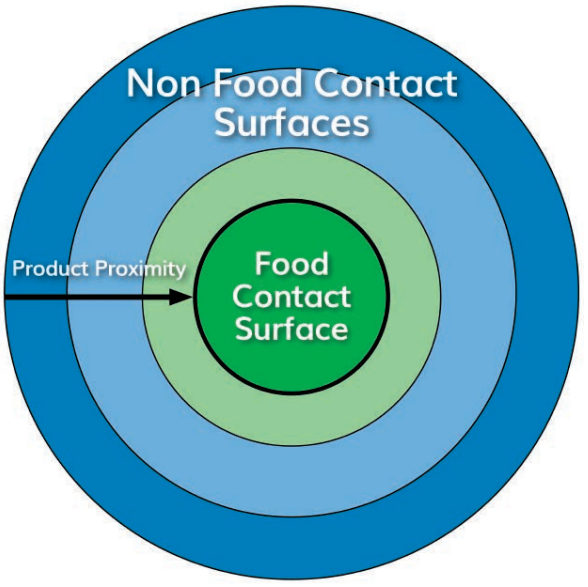
Indicators

While the European Regulation 2073/2005 refers to pathogenic micro-organisms as the target of the monitoring scheme, which one(s) should a food business operator be looking for? The mantra is quite straightforward: "Wet and chilled, *Listeria monocytogenes*. Dry and hot, *Salmonella* spp. Infant food production, *Cronobacter* spp."

A look at the history of finished product contaminations questions the role of the processing environment for other pathogens, such as *Bacillus cereus* or *Escherichia coli* STEC. In its recent assessment for STEC, the Bundesinstitut für Risikobewertung (BfR) does not regard the processing environment to be a source of contamination for flour.[9] Neither is it currently considered a source for *Bacillus cereus* contamination in dry dairy production.

For indicators, *Enterobacteriaceae* are recommended for hygiene monitoring. As previously mentioned, in the EU Regulation 1441-2007, there is no clear correlation between »

Figure 1



Promimity approach – concept

"A look at the history of finished product contaminations questions the role of the processing environment for other pathogens"

Figure 2

Classification from highest to lowest risk (Product Proximity)	Definition	Examples
Line L or Zone 1	Food Contact Surfaces	Anything that exposed food product may touch: utensils, conveyor belts, tables, slicers, dicers, filling/packaging machines, trays, vats and tanks interiors, scales, gloves, aprons, overhead structures via condensation (water droplets can fall on the production line)
Environment 1 or Zone 2	Non Food Contact Surfaces in close proximity to Food Contact Surfaces	Sites where the potential risk of transfer of contamination to exposed food exists: equipment framework, control panels, side of a tunnel
Environment 2 or Zone 3	Non Food Contact Surfaces remote from Food Contact Surfaces	Sites surrounding Zone 2 that could transfer contamination to Zone 1 and 2: floors, walls, drains, overhead piping, forklifts, carts, doorways, cleaning utensils
Environment 3 or Zone 4	Non Food Contact Surfaces outside processing areas	Sites away from food production areas: offices, locker rooms, restrooms, hallways, cafeteria, warehouse, loading docks, maintenance shops

Promimity approach – definitions and examples

Figure 3

Hygiene Zoning	Cleaning Practices	Product Proximity	
High Hygiene (15 Pa)	Dry	Food Contact Surface	L (Line) *Also Z1 (US)*
Medium Hygiene (10 Pa)	Controlled Wet	Non Food Contact Surface	E1 (Environment) *Also Z2 (US)*
Low Hygiene (5 Pa)	Wet		E2 (Environment) Also Z3 (US)
			E3 (Environment) *Also Z4 (US)*

Three criteria to keep in mind when considering a sampling point inside the premises of a food production site

Enterobacteriaceae contamination on one side, and *Cronobacter* spp. or *Salmonella* spp. on the other. Both hygienic indicators and pathogens should be looked for, and not necessarily at the same sampling sites.

Listeria spp. monitoring pushes proactivity a step further in terms of searching for harbourage niches of *Listeria monocytogenes*. As stated in the recent IDF Bulletin on *Listeria* in Dairy,[10] *Listeria* spp. "is not an indicator as classically understood while performing testing of *Enterobacteriaceae* and/or coliforms for hygiene, but rather as an indication of the capacity of *L. monocytogenes* to survive in the processing environment and to anticipate its introduction. Testing for *Listeria* spp. in PEM and reacting to positive results as if they were *Listeria monocytogenes*, provides for a more sensitive and broader verification and control programme, than would testing for *Listeria monocytogenes* alone, particularly considering the expected very low prevalence of this pathogen in a well maintained, cleaned and sanitised dairy processing environment".

"Pathogen environment monitoring is sometimes referred to as a 'seek and destroy' approach"

		Product Proximity			
		Food Contact Surface	Non Food Contact Surface		
		Line (Z1)	E1 (Z2)	E2 (Z3)	E3 (Z4)
Plant Hygiene	High Hygiene				
	Medium Hygiene				
	Low Hygiene				

Sampling prioritisation – from red (high) to green (low)

Sampling considerations

When considering the location of a sampling point inside the food production premises, one should consider three criteria (see **Figure 3**): zoning (hygiene level), cleaning practices in place (vs. choice of pathogen of concern) and product proximity.

Raw milk reception via a tube hole will fall within Zone 1 (low hygiene) where wet cleaning applies. Does it make sense to swab and search for *Listeria* there? Would a positive result, considering its location prior to pasteurisation, signify a food product contamination risk? As sampling takes time and money, prioritisation must be applied. **Figure 3** proposes three levels of priority, from red (high) to green (low). This priority is valid for routine sampling, ie, gate keepers. The IDF Factsheet on Processing Environment Monitoring proposes the distinction between investigation vs. gate keepers: "'Gate keeper samples' are food contact surfaces and non-food contact surfaces with high proximity to food contact surfaces, while 'investigation samples' are usually located further away with a lower potential of food product contamination (with the possible exception of those sampled during a foodborne outbreak). Results of routine results should be treated with trend analysis, separately from investigation results."

Pathogen environment monitoring is sometimes referred to as a 'seek and destroy' approach, or 'bear hunt'. This is valid for investigation sampling points, as you must isolate pathogens of concern and identify harbourage niches – but once you have, what should you do?

Be ready to be successful: what to do after a positive swabbing

Samples taken after a 'positive' are known as 'vector samples' by the FDA. In the different industry-based guidelines, 'starburst' sampling

is often referred to as the technique to perform following a positive. Here, the proximity sampling approach proves to be very useful. Unless the product itself could be the source of contamination, a positive should be considered as ascertaining how close the contamination is to the product.

An E2/Z3 positive needs further investigation to see if nearby E1/Z2 surfaces have been contaminated, and if the E3/Z4 surface nearby could be the source, or other points classified as E2/Z3. A reinforced finished product sampling scheme is not yet necessary.

An E1/Z2 positive is a more problematic story. It might be necessary to investigate L/Z1 and implement a reinforced finished product sampling scheme; this cannot be improvised. It is worth noting that a positive on a L/Z1 sample should be considered as a positive finished product testing. When sampling L/Z1, it is important not to release the product before an analytical result is available.

Food business operators should have a mitigation plan in case of a 'positive', rather than creating one when such an event occurs. If you do have a positive sample, come back to the last negative sample on the same location, and consider any deviations since then. It may be that you have to put present and previous production on hold.

As this will impact production, fast time to result (FTR) alternative methods of analysis should be used over cultured-based reference methods – and duly validated according to the ISO16140-2 scheme.

Cleaning monitoring vs. processing environment monitoring

Due to media coverage of the recent outbreaks in Europe caused by *Listeria monocytogenes* ST6, *Salmonella* Agona and *Salmonella* Poona, there is now a major focus from food business operators and regulators on the best approach to use, as well as analytical providers and third-party laboratories.

Confusion exists between cleaning monitoring and processing environment monitoring; these are two separate approaches. The ISO 18593 already makes a clear distinction in its abstract: "This document does not apply to the validation of cleaning and disinfection procedures." Timing of sampling is crucial to make sure one is indeed monitoring the conditions of the processing environment and not the efficacy of the cleaning practices.

In its supplier quality expectations guidelines, major food business operators ask for sampling to be carried out four hours after a production shift begins or, at the latest, before cleaning – but certainly not afterwards. Appropriate cleaning practices are necessary but not sufficient; zoning, hygienic design, and good manufacturing practices are monitored as well through processing environment monitoring.

Conclusion

Monitoring the processing environment for pathogens of concern and hygienic indicators is a simple concept, yet complex in its implementation. Careful consideration is needed to ensure one is looking where needed, with a preventative and corrective action plan in place.

When defining the sampling site, the remedial options should already be considered: would a positive outcome have an impact on the safety of the food production, and should a reinforced testing scheme be applied? Finally, one must assess whether to stop a finished product from being released during investigation.

Following the 2017 S. Agona outbreak in milk infant formulation, France set out certain expectations (article 50 of the EGALIM law): "As soon as one becomes aware of any examination results indicating that premises, installations and equipment used for the handling or storage of food and feed are likely to make products harmful to human health, the owner (...) inform the administrative authority of the measures taken to protect human or animal health". Under the expectation of the Regulation 178/2002 General Food Law, and the responsibility of the food producer to ensure safe production, the approach is reasonably expected to be generalised to other Member States.

There isn't presently any food business operator that can ignore the threat caused by harbourage niches and resident pathogenic strains in their premises.

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François Bourdichon

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