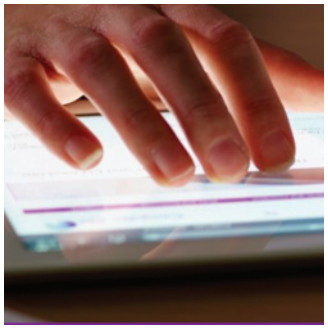

Number 1

FOCUSING on food industry research projects

by Campden BRI. www.campdenbri.co.uk

Campden BRI has over 2,600 food and drink organisations as members from 80 different countries, including the world's biggest and best-known brands. Fundamental to its work is the focus on conducting research for its members, who make up the bulk of the food and drink industry. Here, we cover the priorities they have set and summarise a few key research projects that will benefit the sector in the years ahead.

Every year the organisation consults and surveys its members to identify their scientific and technical requirements, to deliver research that the industry wants. Table 1 details some of their priorities.

Following these findings into the needs of the industry, 18 research projects have been approved. This article outlines just a few of them.

Effective control of viruses

It is essential that the food industry has effective control measures in place for viruses. The assessment and validation of antimicrobial treatments against viruses is critical. Selection of the correct surrogates for validation of food control measures is also important. This project will investigate the effect of product composition on survival and inactivation of various surrogates. The effects of processing and fresh produce decontamination technologies combined with ongoing storage will also be assessed.

The project will deliver data on the effect of product composition, processing and storage on the survival and inactivation of various surrogates.

Cleaning and disinfection of factories

A number of changes have been made in the management of hygiene in food production over the past decade. For example:

- In the US (under the Food Safety Modernisation Act), new controls have been introduced concerning sanitation.
- BRC issue 8 has requirements concerning cleaning (both microbiological and allergens). Cleaning is included as an integral part of the food safety management system in the Codex Alimentarius.

New cleaning chemicals and techniques have also become available along with the production of different product types, equipment and methods. This project will provide updated guidance on cleaning and disinfection in the manufacturing process, based on practical case studies.

New technologies for preservation and processing

Manufacturers need independent data on ways to effectively validate and understand the benefits that new technologies have for improving product quality. Understanding how processing and preservation technologies impact on the quality and shelf-life of products continues to be a key area.

Continued on page 26

Table 1. Scientific and technical needs of the food and drink supply chain 2018-2020.

Drivers for industry needs	SUPPLY CHAIN			
	Primary production, raw materials and ingredients	Manufacturing and supply	Product and packaging	Food, drink and the consumer
Safety	Minimising contamination in production	Managing product safety hazards and risks in processing, distribution and sale	Delivering products that are safe throughout shelf-life	Protecting the consumer through appropriate guidance
Quality and value	Ensuring suitability for purpose at proportionate cost	Maintaining and enhancing quality through cost-effective process technologies	Maintaining product quality throughout shelf-life	Exceeding consumer expectations
Nutrition, health and well-being	Enhancing nutritional potential	Preserving and enhancing nutritional value in processing, distribution and sale	Delivering nutritious products that meet dietary needs	Responding to nutritional requirements and dietary habits
Sustainability, resilience and food security	Producing and securing 'more with less'	Assuring efficient and resilient manufacturing and distribution	Delivering safe and compliant products that minimise waste	Building consumer trust in the supply chain and its management
Skills and knowledge	Developing and maintaining skills, knowledge and 'tools' in production	Developing and maintaining skills, knowledge and 'tools' in manufacture, retail and food service	Anticipating and responding to regulatory and technical changes and their impacts on product & packaging	Engaging consumers in production, process, product and packaging knowledge

Continued from page 25

This project will focus on emerging technologies for improving quality and value and will conduct feasibility studies on those with commercially relevant applications.

Understanding safe shelf-life using advanced microbial profiling

Recent work using advanced microbial profiling (AMP) has shown that our knowledge of the progression of microflora during shelf-life of certain products is incomplete. AMP offers a way to confirm existing specifications, or to amend them.

AMP also offers an opportunity to verify that a reduction in viable counts of selected pathogens are caused by competitive inhibition from the product's microflora.

This project will evaluate microbial specifications for a range of chilled products and analyse the effect that naturally occurring microflora has on the growth of pathogenic microflora.

This will allow specifications to be set for only those organisms of concern, potentially extending shelf-life. Indication of the effects that spoilage flora has on pathogens will give producers more confidence in the ability of their products to remain safe, should contamination occur.

Technical challenges of replacing plastic packaging

Plastic, not surprisingly, continues to be a hot topic. The usage of single-use plastic packaging is widespread across many food and beverage categories, such as:

- Plastic bottles for juice/milk.
- Trays and pots for goods such as meats, and combination meals.
- Multilayer plastics for snacks, and packaging to cook products.

At the same time, consumer convenience has to be maintained and cross contamination prevented. Consumers have become aware of the negative effect single-use plastic packaging is having when discarded irresponsibly and they want to see a reduction in their use.

This project will provide a better understanding of the UK's recycling infrastructure for single-use plastic packaging and explore alternative materials.

It will also cover the technical challenges faced by packaging and food companies as they try to reduce and remove single-use plastics, so they can make tactical and prompt changes. Alternative materials for a range of food and drink applications will also be tested and practical case studies will be produced.

Consumer understanding of recycling and their acceptance of alternative materials will also be explored. The aim is to allow the food and drink industry to make longer term strategic choices.

Practical control of listeria

A number of reports and guidance documents have been written by sources such as FSA, EFSA and FDA. They all offer advice on how to control L. monocytogenes in the food production environment, however there is a need to summarise and consolidate key approaches and tools for controlling listeria.

This project sets out to produce an up to date one-stop-shop guideline document on controlling listeria during food production.

Blockchain and emerging approaches supporting food safety management systems

Blockchain is a continuously growing list of records, called blocks, which is linked and secured using cryptography. Each block typically contains a cryptographic hash of the previous block, a timestamp and transaction data.

This project will investigate different tools, including blockchain, to decide if they are applicable to food safety management and how they can be used.

In addition, the project will assess other emerging approaches to hazard and risk analysis, and how these can best be communicated.

Research will be conducted through interviews and discussions with industry contacts, by participating in the Global Food Blockchain Initiative and through partnering with selected companies to test and challenge potential systems. ■

Information on these and further research projects, is available at campdenbri.co.uk/mfrp
Alternatively email support@campdenbri.co.uk

Number 2

FOCUSING on process validation

by Danny Bayliss, New Technology Research Team Leader, Campden BRI. www.campdenbri.co.uk

Unlike the thermal processing industry, new food processing technologies, by their very nature, will not have a long history of data and experience to back up general assumptions. In the absence of such data it is therefore important to validate products on a case-by-case basis and this may even mean that their effectiveness on individual products has to be re-evaluated.

Process validation is the collection and evaluation of data to establish that a process is capable of consistently delivering a safe product. If a product or process is not properly validated, it could lead to unsafe products and potential financial losses.

When validating new processing technologies, key issues to consider are:

- Target micro-organisms and resistance to the lethal factor.
- Process conditions.
- Product characteristics.
- Chemical changes.

Target micro-organisms and resistance to the lethal factor

The worst-case organism must be tested and the correct strains selected for trials relevant for the product. When using a surrogate, ensure that it behaves the same as the pathogen being targeted.

Campden BRI has a class II microbiology process hall where we can challenge pathogens and surrogates for various processing technologies.

Process conditions

Making the correct assumptions for validation is important:

- What are the worst-case conditions for the product and process?
- What are the critical parameters of the process important for inactivation?
- What is the variability of these parameters?
- How consistent and representative are the conditions?
- How long does the product need to be held at these conditions?

These areas should be determined as part of the validation trials. The answers to these questions will impact on how you effectively monitor the process to ensure that it meets your critical control points (CCP).

- **Example 1:**

Effective ultraviolet-C (UV-C) inactivation relies on the dosage delivered to the surface of the product. This can be influenced by the conveyor belt and support structures blocking light to the product or the positioning of the lamps. The process would need to be mapped out to know where the lowest dose is delivered to ensure it achieves the target dose set out in the CCP.

- **Example 2:**

High pressure processing (HPP) allows pressure to be transmitted instantaneously throughout a vessel. For this process you would need to monitor the hold time and pressure achieved and, depending on the product, you may also need to monitor time to pressure and the temperature of the process.

Product characteristics

The product itself may influence the process lethality, so understanding the variability in the product characteristics is important for new technologies.

- **Example 1:**

HPP lethality has been shown to be impacted by the pH, aw, salt concentration and fat composition of a product.

This differs to thermal processing, which mainly considers the pH of a product when determining the process to use.

Recipe changes or formulation changes can have an impact on the process lethality, so it is important that this is recognised and tested to ensure you are still able to achieve your target log reductions.

It is also important that you consider the worst-case parameters of the product when validating, to ensure the new processing technology can produce a safe product within the agreed product specifications.

- **Example 2:**

UV-C can be influenced by the surface topography of a product, which can shield and protect micro-organisms from the light. The way a product is exposed to the light also needs to be considered as too much product on a conveyor belt will create areas on the product which could be shadowed by the light, impacting on the effectiveness of UV-C inactivation.

Chemical changes

When validating a new process with a new product it is important that potential impacts on chemical changes, which may occur to the product during the process, are considered. This will help to ensure the product is safe for consumers.

- **Example 1:**

UV-C shelf-life extension of milk boosts vitamin D3. Whilst this is a positive effect, it illustrates the need to understand if the nutritional quality of a product is affected or compromised by the treatment used to make it safe.

- **Example 2:**

The impact of HPP on enzymes can be variable. Some enzymes are inactivated or reduced which can improve product quality such as retaining the green colour with avocado, whereas other enzymes are not affected, such as Pectyl Methyl Esterase (PME) in juices, which results in cloud loss and sedimentation. ■

Number 3

FOCUSING on cooking instructions

by Greg Hooper, Instruction Services Manager and Microwave Specialist, Campden BRI. www.campdenbri.co.uk

BRC Global Standard Issue 8 for Food Safety was released in 2018 and the first audits began earlier this year. BRC is the world's most widely-applied food safety standard. One significant change in Issue 8 is the inclusion of on-pack instruction validation, known as *Clause 5.2.5: Cooking (heating) instruction validation*, for the first time.

What is instruction validation and why is it so important?

Instruction validation relates to the need to ensure that cooking and heating instructions for consumers are tested rigorously, to ensure that food is safe to eat and of acceptable quality.

From a commercial perspective it is worth remembering that understanding and incorporating scientific instruction validation principles at the start of any NPD, product changes or even validating existing instructions, will allow you to achieve both of these aims.

For consumers to have confidence in heating instructions they need to be meticulously validated. For food safety it is important to work to worst-case scenarios rather than averages – essential when you consider the need to eliminate the risk from Listeria monocytogenes, E. coli and Salmonella spp.

The thermal process and its equivalent

The target combination of minimum temperature and cooking time is known as the thermal process. It is vital that this is measured in the slowest heating location (cold spot) of worst-case product samples – although this cold spot can be notoriously difficult to locate.

For most chilled and frozen products which are not considered 'ready to eat' the thermal process required is 70°C for two minutes, or an equivalent, i.e. a higher temperature for a shorter time or vice-versa. Table 1 shows equivalent process times at temperatures above and below the 70°C two-minute target. You will probably be quite surprised at how much longer it takes to reach the equivalent thermal process at 60°C and how it is only a few seconds at 80°C.

Finding the cold spot

It is imperative that the cold spot is identified and the temperature at this location is monitored using a probe. You can probably guess that it is likely to be at the most dense or thickest part of a product, but it is not always that simple.

It may not be where you would expect, for instance during microwave heating it is possible that the cold spot may be near the product surface (depending on the microwave field patterns).

The thermal image in Fig 1 shows the complex heating pattern of a microwave heated product, with cold spots at the surface not in the centre as may be expected (white shows temperatures of above 90°C and black/blue as much colder, below 40°C:

If the cold spot is missed and this slowest heating location does not receive the required minimum thermal process, then there is a possibility that any food poisoning bacteria present will not be sufficiently killed and consequently pose a risk to consumers. Using a 'hedgehog' device (multiple probes set into a grid array to measure several product location temperatures at the same time) or a given number of temperature measurements may not locate the cold spot, as it may well lie between the probes. Careful and thorough probing of the sample is necessary.

Post heating stand times must also be considered when perfecting heating instructions – as cold spot temperatures can continue to increase due to conduction from hotter product areas.

Table 1. Equivalent processes to achieve 70°C for two minutes.

Temperature at the slowest heating point (°C)	Time required at the reference temperature to achieve an equivalent process (minutes)
60	43.48
65	9.30
70	2.00
74	0.43 (26 seconds)
80	0.09 (5 seconds)

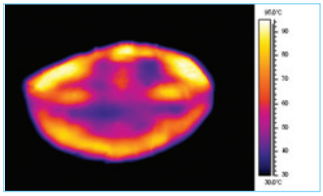

Fig. 1. Thermal image showing the complex heating pattern of a microwave heated product.

Equipment – testing, calibration and selection

Accurate measurement of the temperature (and time) is, of course, essential when determining cooking instructions. All testing equipment must be correctly calibrated. This relates to temperature measuring devices, such as probes, as well as the appliances used to heat or cook food.

When it comes to appliances, we need to consider how the different types behave. Gas, electric and fan oven variants all behave and heat products differently. Air flow rates, temperatures throughout the cavity, and peak and trough temperatures as thermostats cut in and out – all of these can vary.

With this in mind, it is not acceptable to use a single oven type e.g. non-fan-assisted electric oven and then assume a product will heat in a similar time in a gas oven at the same temperature setting or a fan-assisted oven operating at 20°C less.

Further, correct instruction validation not only requires products to be tested on all three types of oven, but also that trials are replicated. At Campden BRI we suggest testing the same product five times in each appliance and the samples tested need to be worst case (e.g. thickest, heaviest, slowest heating). Similarly, microwave ovens will vary, so care needs to be taken when picking the right ones for your validation testing – several ovens are needed with a range of different features and different heating patterns. Microwaves with the same power rating can heat products differently. Factors which affect the way they cook include:

- The size of the cavity.
- Whether or not it has a turntable.
- The internal finish – paint or stainless steel.
- If it is a combination microwave – one which also has grill or hot oven.
- Where the microwave energy enters the oven cavity (top or side).

What will BRC 8 mean?

There are more issues to consider but hopefully this article has shone a light on some of the key areas on effective instruction validation required by BRC Issue 8.

Fundamentally it underlines the importance of recognising that products and equipment are not homogenous – product thickness varies, different oven types behave differently, as do hobs, grills and microwaves (even those of the same wattage). By identifying the many areas where variations exist, the new standard highlights best practice and how to build greater confidence in on-pack instructions.

Ultimately, it will help ensure that food safety and product quality standards are maintained and improved, which is great for both the consumer and the industry. ■

A free white paper on *Clause 5.2.5: Cooking (heating) instruction validation* is available at campdenbri.co.uk

Number 4

FOCUSING on food waste: commercial opportunities

by Dan Hall, Food Development Technologist, Campden BRI. www.campdenbri.co.uk

The issue of food waste is increasingly in the news and while coverage generally focuses on consumer and retail food waste, it is just as critical for manufacturers. They have long been conscious of minimising waste to reduce costs, but the focus has now turned to making use of by-products for other purposes – sometimes for food and sometimes for other applications.

In the UK, the Department for Environment, Food & Rural Affairs (Defra) has recently set a target to halve food waste by 2030 as part of its waste reduction programme. It is estimated that 1.8m of the 10.2m tonnes annually (worth £20bn) comes from food manufacture, with a much larger proportion coming from households.

Over 100 companies have already signed the pledge to reduce their waste and are starting to consider, through their business plans, how to achieve this.

Recycling and re-using food

There are many ways of repurposing waste streams, one of which is to use them as fuel for bio digestion to generate energy. Food is an ideal source of fuel as it provides a good source of energy per kg.

Aside from local authorities sending their food waste to anaerobic digestion facilities – which convert food waste into methane and fertiliser – retailers, food manufacturers and farmers are also moving to it as a more environmentally sustainable and socially responsible alternative. But what about making use of it in other ways? Deriving ingredients from waste offers intriguing possibilities for those prepared to explore them.

Many materials contain fibre, nutrients or chemicals, such as sugars and amino acids, that could be extracted and used in food or feed, or as feedstocks for microbial fermentations; and then there are non-food applications, such as packaging and pharmaceuticals.

Examples

The outer layers of coffee cherries, which house the green beans, have been highlighted as a key area of potential nutritive value, with high levels of fibre and polyphenols. They account for a large proportion of the plant and have been traditionally used to fertilise the soil the coffee is grown in.

However, as knowledge has developed on their use as a fertiliser, it has become apparent that they can accrue high levels of mycotoxins if left to degrade in the soil. These can then be passed on to the next set of crops. If the cherries were dried soon after harvesting they could be used in a variety of applications such as cocoa replacers, fibre enhancement and as a potential source of antioxidant.

The pulp from cacao pods, previously considered as waste after the beans have been extracted to produce cocoa and chocolate, has a fruity, floral flavour profile and pulpy texture. It contains high levels of magnesium and potassium and has the potential to be used in drinks and in cereals, baking and confectionery.

Protein chips, in a wide variety of flavours, have been developed by one manufacturer from chicken and vegetable scraps and spent grain.

A UK supermarket is using packaging from tomato leaves and recycled cardboard as punnets for tomatoes, as well as boxes partly made from pulses for some of its pasta products.

The outer layers of coffee cherries, which house the green beans, have been highlighted as a key area of potential nutritive value, with high levels of fibre and polyphenols.

Chitin is another example. It is widely available in mushrooms as well as in insects and shellfish and is being advocated as a potential alternative to traditional plastic packaging.

These innovative applications are just the beginning of a move towards repurposing materials that were previously considered waste, but we should not forget that using by-products successfully in food manufacturing has been around for several decades – Marmite is made from yeast from the brewing industry.

Just consider the volume of autolysed yeast used to make it and the twin benefits of a value-added ingredient and reduced costs of biomass disposal – and don't forget the environmental benefits.

Challenges

But there are challenges. Using 'waste' materials – whether it be potato peelings, spent grain, avocado stones or the flesh of coffee cherries – demands creative and innovative thinking.

Different solutions usually have to be found for different materials. And this creates technical hurdles – from ingredient characterisation, product development or reformulation, process modification and optimisation, safety assessment and shelf-life trials, consumer and sensory tests, and labelling and regulatory support.

For example, a previously discarded material which is rich in nutrients or fibre might have no history of consumption and be deemed a novel food – requiring a dossier of information addressing its suitability for use as or in products.

However, the incentives and the prize make it worth the effort. Even a relatively small increase in the proportion of a material used can, for a high-volume product with extended product runs, result in significant savings over time.

Direct financial incentives are also available. In the UK, aside from the aforementioned benefits of reduced disposal costs, funding is available through Innovate UK to explore new applications. Other governments, no doubt, also offer similar schemes. ■

You can learn more about food waste from Dan Hall via email dan.hall@campdenbri.co.uk

Number 5

FOCUSING on global standards for packaging

by Anna Kiryla, Packaging Technologist, Campden BRI. www.campdenbri.co.uk

The BRC Global Standard for Packaging and Packaging Materials was the first packaging standard to be recognised by the Global Food Safety Initiative (GFSI). Many food and drink manufacturers and retailers require certification to the standard as a pre-requisite from suppliers, so it is widely used in the UK and worldwide.

Packaging suppliers are also keen to comply with the standard as it can provide a competitive advantage when securing supply contracts in the food and drink supply chain.

On 1st August the new BRC standard, Issue 6, was published. Auditing against the new standard will begin from 1st February 2020. So, if you are a manufacturer or retailer who requires certification, BRC has allowed a six-month transition period to meet its requirements.

To help you prepare for implementation and auditing against the new standard, here is an overview of the main changes in Issue 6.

What is new?

The most obvious change to the standard is the merging of two hygiene categories to provide just one set of requirements for all packaging manufacturers.

Additionally, there are two more optional sections regarding 'traded product requirements' and 'pellet, flake and powder control'.

The latter was developed with the British Plastics Federation and is based on Operation Clean Sweep. It was included to minimise the risk of pellet, flake or powder polymers littering the environment, and is only applicable to sites that will use these as raw materials for future packaging.

The new standard focuses more on product quality and not just product safety. As a consequence, hazard analysis risk assessment (HARA) will be used more broadly, not just to assess product safety risks but also to determine quality hazards. This may result in quality control points even if the company does not have any critical control points.

Product security

In section one, senior management must be committed to the development of product safety and quality culture. This requires senior management to develop a plan that allows continual improvement which can be reviewed and audited against measurable objectives.

The plan should encourage employee communication and ownership from the bottom to the top. Development of the plan should be supported by departments such as HR, marketing, IT and procurement as they might also have an impact on product quality and safety.

Changes within this section highlight the importance of product security and defence systems, from raw material to finished product. It covers this with the implementation of review processes and ensuring the effectiveness of hazard and risk management systems.

New clauses

Section three of the standard is enriched with clauses. Clause 3.6 'Corrective and preventative action' requires information from a non-conformity to be analysed to allow the necessary corrective and preventative action to be put in place. Clause 3.8 'Product authenticity, claims and chains' was introduced to minimise the risk of purchasing fake raw materials. There is also more focus on cyber security, product defence, internal audits and supplier approval.

Campden BRI will be hosting a briefing on Issue 6 of BRC Global Standard for Packaging and Packaging Materials on 15th October. The event is targeted at packaging manufacturers, auditors within the packaging industry and food and beverage manufacturers as a tool to manage their packaging suppliers.

For further information contact Anna Kiryla:
anna.kiryla@campdenbri.co.uk

Product quality

In section five there is a continued emphasis on product quality. The standard increases stringency for the documentation of line clearance (the process of clearing a production line/work area) by including the roles of persons involved, areas where materials can become trapped, validation of line clearance and a sign-off section for continuing production. It also expands the requirements for testing methodologies.

Training

In section six, training requirements are extended to product defence for all staff performing tasks affecting product safety, legality and quality. This section also makes the rules of personal hygiene clearer and more detailed.

Environmental monitoring

An additional risk-based clause 4.8.5 has also been included. It requires packaging manufacturers to perform microbiological environmental monitoring.

The programme that they are expected to put in place should verify that control measures are suitable for keeping a product safe throughout the manufacturing process.

The manufacturing site must identify any contamination hazards and vectors and will need to define sampling locations, frequency and target organisms. These can be sampled in numerous ways, such as with settle plates, swabs or handheld air samplers.

The results will then need to be monitored and reviewed at least annually – more frequently if they show an increase in microbial detection levels.

Position statement number P558 is available on the BRC website to support this new clause.

What else?

In addition to the above high-level changes, there are other additional updates which include:

- Ensuring procedures for inspection of goods on arrival and acceptance of raw materials, are in place.
- Control of elevated walkways to minimise the risk of contamination.
- Ensuring procedures for unavoidable use of glass, ceramic and brittle plastic are in place.
- Controlling usage and storage of sharps and metal.
- Assessing suitable pest management programs.
- Changes to equipment settings (which are critical to product safety and legality) are performed only by trained and authorised staff.
- Ensuring procedure to address the transfer of client requirements to the site's own system is in place.
- Ensuring procedure for dispatch transport of goods is in place. ■

Number 6

FOCUSING on thermal process validation

by David Whittaker, Campden BRI. www.campdenbri.co.uk

If you are a manufacturer applying heat to food in order to reduce its microbiological levels, then that process is a crucial step towards producing a safe product. It will need to be governed by a critical control point within a HACCP plan, requiring both verification and validation to provide evidence of its safety.

A thermal process validation is a practical study which provides evidence of the effectiveness and the repeatability of a thermal process, for food and beverages in pasteurisers, retorts, ovens, kettles and everything else in between.

It provides the evidence that ensures your thermal process is effective, repeatable and consistently produces safe products.

Verification is the continuous monitoring of temperature levels, for example temperature checks of every batch, during production. Regular verification and a robust thermal validation combine to deliver evidence of safe thermal processing.

In my experience, validation is often undertaken without a true understanding of why it is done and how to do it robustly. Anyone who approaches it without a proper understanding risks the safety of the process and creates the potential for missed opportunities to optimise.

Here are six key points to consider when validating a process:

1. Understand what the process target is

Technical staff will often be targeting a specific temperature for a specific time. This will often be the minimum level of heat treatment to achieve a specific log reduction of a target organism plus extra heating to give a margin of safety.

We recommend understanding and challenging:

- The heat resistance of the organism targeted.
- The margin of safety specified.

With this understanding there could be opportunities to reduce processing time or to experiment with time/temperature combinations that could be better suited to your product.

2. Use the appropriate validation technique

Temperature measurement is the most common method to validate a thermal process and there are a variety of different sensors and probes/thermocouples which can be used depending on the product type and the heating environment.

These methods are often quite simple and practical, and with the correct equipment there is no issue with trained in-house staff undertaking the validation work, enabling many studies to be undertaken. Data loggers can be wireless – ideal for using inside packs (pouches or cans) – or wired.

Some processes are very difficult to validate using conventional data loggers, for example when extremely high temperatures are used.

In these cases, you can validate using a 'log reduction' method with inoculation of a surrogate organism which mimics the log reduction of the target pathogen. Alternatively, enzymes, which similarly mimic the death kinetics of target organisms through a process, can be used.

3. Establish probe and product sample positions

The exact point in the product where temperature measurement is being recorded is crucial, as heating rates can often vary within a pack or within a unit of product – for example, in a chicken drumstick heating rates near the bone are different to those in the flesh.

It is a similar case with the positioning of validation samples within the heating system, for example in a retort the top layer of a crate may heat very differently to the bottom layer, or racks of product by the oven door may heat at a different rate to those away from the door.

Extra testing is often required to fully understand these crucial points, so that during the validation tests we know all worst-case conditions have been accounted for.

4. Understand and control 'worst-case' variables

When undertaking validation test runs, you need to understand how the amount of heat applied to your product may vary from day to day. This could be due to variations within the product, packaging or the cooking vessel, for example the fill level of bottles, or the heating performance of a retort. These variables need to be controlled and set to replicate worst-case heating conditions during the validation run to ensure that every single time during normal production an absolute minimum level of heat treatment will always be applied.

5. Interpreting validation data

A large amount of data is generated during a robust thermal validation. When analysing the data to calculate minimum P or F0 values, several questions can crop up:

- Which part of the cook program or cycle can be used to calculate the lethality?
- If different areas of the retort or cooker give large differences in temperature, what level of difference is acceptable?
- The P/ F0 values are extremely variable; how can I be sure they will always be high enough?
- Would it be sensible to apply a safety factor and over process the product? If so, by how much?

These are all frequently asked questions which can typically be addressed by a thermal processing expert in-house or through a third-party thermal processing authority.

6. Presenting the findings

While making the effort of ensuring a robust validation study is worthwhile, there is little point if the evidence is not clearly presented. A short report summarising the methodology and analysis of results with a clear conclusion should suffice. It would need to be sufficiently detailed to be used as evidence of a successful and safe thermal process and ensure that the key points are clear for customers and external auditors. ■