Campden BRI
food and drink innovation

Practical microbiology training

Needs of the food and drink manufacturing and retail sectors

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Campden BRI is the UK's largest independent membership-based organisation carrying out research and development for the food and drinks industry worldwide. It is committed to providing industry with the research, technical, advisory and knowledge transfer services needed to ensure product safety and quality, process efficiency and product and process innovation. With a largely industrial membership of over 2000 companies it is ideally placed to establish the scientific and technical needs of industry and provide a centre of excellence in knowledge, skills and continuing professional development.

Purpose

This document identifies the key areas of microbiological training required by industry personnel to fulfil their tasks across the diverse range of roles within food manufacture and retailing.

Devised in close collaboration with industry representatives, the document will be used

- by Campden BRI to inform the development of training provision and related continuing professional development (CPD) for industry
- to promote industry's training needs to other training promoters and relevant organisations that support training and continuing professional development.

We are grateful to the companies that gave their time, energy and experience in the development of this document.

Preface

The food industry relies upon the skills of its employees to develop and manufacture products that meet the attributes demanded by the consumer. The most fundamental and non-negotiable attribute that must be assured is product safety.

One of the greatest threats to food safety is the growth of pathogenic organisms. In addition product spoilage is a major contributor to product wastage and financial loss. Microbiology is accordingly an essential area in which the sector must be able to source high level practical skills and knowledge. There is a suggestion, from our members, that the level of practical experience of newly qualified and even some established microbiologists, technologists and managers is not sufficient to satisfy the changing and ever more demanding needs of the food and drink sector.

This document identifies the key areas of microbiological training required by staff to fulfil their tasks across the diverse range of roles within food manufacture and retailing.

The skills and training requirements presented here were compiled as an output from a dedicated workshop convened in April 2013 and through further consultation with our members, through a discussion group at Campden BRI's Rapid Methods Conference the following June. The April event had the specific objective of

identifying key roles within the industry and the associated skills and knowledge needed. The June workshop refined and developed these considerations.

The document has two main functions. First, it will be used by Campden BRI to ensure that our training services in microbiology meet the needs of our members and other clients. Second, it promotes the needs of the sector more widely to other training providers, including academic institutions, and to agencies that fund skills and training development nationally and internationally.

Introduction

An understanding of the hazards and risks associated with microbial agents is essential in providing assurance in product, process and pack innovation. Changes in the use and storage of food materials, together with global sourcing and the impact of climate change mitigation, are all placing additional challenges on the control of microbiological risks in the food and drink supply chain.

Understanding how raw materials, the product, pack, process, storage and distribution interact to influence microbiological stability and safety is paramount in building safety into the product and deciding what to do to ensure that microbiological risks remain under control.

Equally important to the knowledge and understanding of microbiological risks is the availability of reliable data which is representative of what is being considered. Good technique in sampling, whether product or environment, and in the selection of media, methods and/or culture conditions, to reflect the prevailing environment, is essential. Finally good laboratory practice and practical skills ensure that there can be confidence in the data produced and the information on which crucial judgements may be made.

Through its ongoing contacts with member food companies and food chain stakeholders Campden BRI identified a concern that much of the applied industrial microbiological skills base was being lost from the industry. Experienced food and drink microbiologists were leaving or retiring from the industry, or their roles were being diluted by other areas of responsibility. New staff coming in often lack the appropriate knowledge and skills required. As a result, Campden BRI undertook a consultation with its members, through various means, and convened a special workshop to explore the areas in which training is required.

Microbiology is at the heart of food safety and quality

Consultation

A primary method used in the consultation was a workshop to consider the training needs. The workshop held in April 2013 developed a matrix of training needs by analysing the job roles within the food manufacture and retail industries. These roles were those which contained some element of microbiological responsibility and spanned technician level through to senior manager level. Workshop participants then highlighted the areas of microbiology in which the job holder would need to be competent and the level at which competence is needed. An additional discussion group was convened at the Rapid Microbiology Methods conference in June 2013 at Campden BRI. The results of the workshop and discussion group and consideration of comments from interested parties outside the events have informed the debate and enabled this summary document to be produced and training matrices to be developed. The matrices are presented in the appendix to this document.

Themes

The training matrix contains eighteen aspects of competence which spanned the thirteen job roles identified. These roles cover the spectrum of authority and responsibility - from laboratory operatives to Technical Managers. The consequence of this was that not only was there a need for training in different aspects of food microbiology, but it is likely that it will need to be provided at different levels:

- "Foundation" (giving a basic awareness of issues and familiarity with concepts)
- "Specialist" (providing information in key areas to develop good understanding)
- "Advanced" (imparting detailed understanding in key areas to enable extrapolation of knowledge and self-initiated development/research)

Further consideration of this matrix grouped the aspects into four key training themes. Each of these themes is considered in more details within this document, with specific areas highlighted.

The four key training themes are:

- **Building safety in** - which covers understanding how the raw material quality, product type, process, production environment, packaging, storage and distribution interact to influence microbiological status and stability and product compliance. It considers the behaviour of micro-organisms, in relation to growth and death, the effectiveness or validation of controls in ensuring safety and inherent microbiological stability and the prevention of subsequent cross contamination prior to sale. It is particularly relevant to the new product development (NPD) process.

- **Understanding microbiology** - which includes understanding how microbiological safety and stability are maintained. It incorporates basic theoretical microbiology and focuses on how risk assessment, audit and testing regimes assure ongoing product safety. It also includes what actions may be appropriate based on the findings of these control tools and how microbiological investigations should be carried out.

- **Practical microbiology** - which covers practical aspects of environmental and food material sampling, and microbiology laboratory techniques. Aspects of laboratory quality assurance and the role of testing in product assurance are also included. The correct selection of techniques and media,

based on the objectives of the test, is of great importance and constitutes a significant element of this theme.

- **When things go wrong** - which considers how things can go wrong and how audits and testing can be used to detect non-compliance and non-conformance. It also covers what immediate steps need to be taken and what further investigations might be appropriate and how these should be planned and conducted.

Linking themes to courses

These themes could form the basis of courses aimed at addressing the areas of competence across the roles identified. The following four sections indicate the likely components of training required to support the achievement of the necessary knowledge and skills and contribute to continuing professional development programmes.

It should be noted, however, that this document identifies the needs for training, i.e. the areas in which competence is needed, and not the methods by which training should be provided. The following sections are not prescriptive in course content or how courses should be constructed.

The same general areas often appear in more than one theme. The specific focus and level of training in these areas is likely to vary and the extent of overlap between the themes is likely to be less than it appears. However, training providers should consider how best to manage this or how any modular system of training, cutting across themes, may be established.

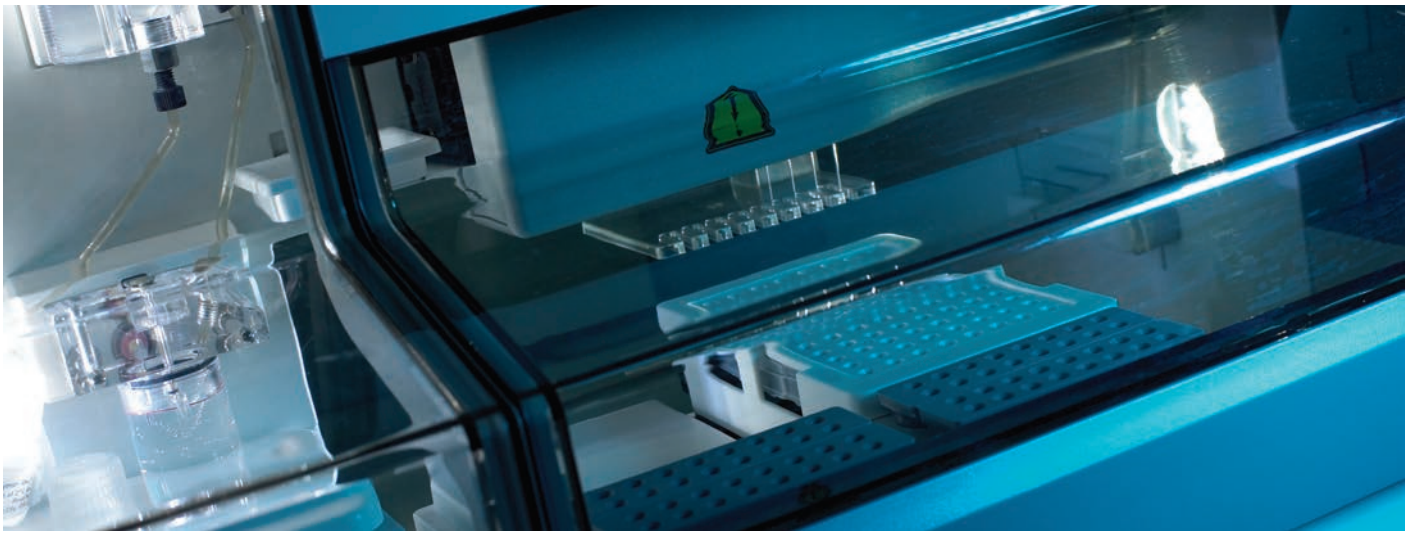
Training themes

Building safety in

The key to *building safety in* to a product is to understand what makes it safe from a microbiological point of view. To this end, the ingredient quality, processing, intrinsic (e.g. water activity, pH) and extrinsic (e.g. temperature, gas content of the headspace) properties of the food, packaging, and shelf life parameters need to be understood and formulated appropriately.

Microbiological Risk Assessment and process validation are appropriate tools to use to justify and understand why the foodstuff is microbiologically safe, and this links in with systems, such as Hazard Analysis and Critical Control Points (HACCP) and Good Manufacturing Practice, which are used to manage food safety and quality. The influence of cross-contamination from the processing environment has also to be considered, particularly associated with the selection of the appropriate hygiene zones that are necessary for food manufacture.

Microbiological testing is carried out to verify that the control systems designed to manage safety and quality in the production of the product are working correctly. But there is a need to understand what tests are necessary and how the results should be interpreted. This module of training would be aimed at those involved in product development and would provide an understanding at an advanced level. It is a critical part of the job role and will allow them to understand how their needs to develop novel products must be tempered by the absolute need to produce safe and stable products.



Those fulfilling other job roles will need to understand this but not necessarily at the advanced level. It would be expected that company microbiologists would need to have specialist knowledge, whereas those in retail technology, auditing, technical management and senior management would be expected to have a foundation understanding.

This training module could include:

- Risk Assessment - the basics of assessing risk in production of a food product, where do risks arise, what magnitude, how can they be reduced to the lowest level. This will dovetail with the sections on intrinsic and extrinsic factors, safe product design, and process validation.
- Effects of intrinsic and extrinsic factors on microbial survival and growth- discussions on pH, A_W, gas mixes, package type, preservatives, storage temperatures and processing.
- Safe product design - shelf life, storage requirements, potential contamination, manufacturing conditions, food matrix, formulation, pack type.
- Process validation - what validation is for, how to validate, what types of validation to use, discussions on process verification.
- Safe production environment - an awareness of the significance of zoning, building design and equipment design on product safety
- Maintenance of a safe production environment - personnel hygiene, cleaning and disinfection, maintenance.
- When to test - how testing at various times gives different results, and what those results can mean
- What to test - discussions of how testing different matrices can lead to different results and what these mean
- How to sample - correct sampling of ingredients, foods and environmental samples
- How to test - how to select the most appropriate test method and the advantages and disadvantages of different methods
- Verification (role of testing) - what value test results give to companies, how to use testing and test results within a risk management programme.
- Interpretation of microbiological results - discussion of test results, what they mean, how to interpret them and draw valid conclusions
- Knowledge of microbiology legislation - what legislation exists, the importance of knowing and understanding legislation.

Practical microbiology

One of the concerns expressed from the consultation with industry is that new graduates do not have adequate practical microbiological skills to fulfil roles in the food industry. These may be in a testing laboratory, but also extend to sampling (foodstuffs and manufacturing environment) as well as knowing what to look for when monitoring suppliers and working with customers.

The focus of the **Practical Microbiology** course would be to train delegates in basic manipulative and aseptic skills, as well as in carrying out testing for the most common food microorganisms.

Also covered would be the theory behind sampling and knowing what to test for and when to apply testing - both for foodstuffs and the manufacturing environment.

This module is designed for practicing laboratory microbiologists and others who may be undertaking environmental microbiological sampling such as QC and Hygiene staff. The training will help these job holders to develop knowledge in the practical application of microbiological testing.

It would be expected that laboratory managers would require training at an advanced level. Active bench microbiologists would benefit from specialist training. New recruits into the laboratory would need foundation level training.

This training module could include:

- Practical laboratory microbiology - how to work in an analytical microbiology laboratory, hygiene, aseptic technique, procedures and working practices.
- How to sample (factory/environment) - taking samples for microbiological testing from the factory environment (ingredients, finished product, process intermediates and environment samples).
- How to sample (food) - testing in the laboratory, how to effectively sample food products (representative sampling).
- How to test - how to select the most appropriate test method and the advantages and disadvantages of different methods
- When to test - how testing at various times gives different results and what those results can mean
- What to test - discussions of how testing different matrices can lead to different results and what these mean
- Interpretation of results - discussion of test results, what they mean, how to interpret them and draw valid conclusions
- Accuracy - understanding the concept of accuracy and uncertainty in microbiological testing
- Verification (role of testing) - what value test results give to companies, how to use testing and test results within a risk management programme.
- Process validation - what validation is for, how to validate, what types of validation to use, discussions on process verification. Basic practical process validation - how to do it.
- Maintenance of a safe production environment - personnel hygiene, cleaning and disinfection, maintenance.
- Management of services/contracts - provision of external services, how to know what you need, how to get what you need. Contracts with clients, what they need to cover.
- Incident management - what happens when things go wrong. How to deal with non-conforming work within the laboratory. Consideration of effects on results, informing clients and potentially dealing with claims

Understanding microbiology

Many of the aspects covered in **Building Safety In** will also be covered in the **Understanding Microbiology** course. However, the delegates attending will be given more relevant information regarding individual microorganisms which can give rise to food safety and quality issues.

It will also focus on how theoretical and practical microbiology can be brought together both in the laboratory and, more importantly, in the food manufacturing environment.

This module would support a range of job roles within a company. Those operating as company microbiologists and laboratory managers may be expected to require this knowledge at an advanced level. Bench microbiologists those involved in new product development, and hygiene, retail and technical managers would have needs at specialist and foundation levels. In addition those in senior management would benefit from this knowledge at a foundation level.

This training module could include:

- Microorganisms - what they are and what they do - basics of different types of microorganisms, pathogens, spoilage organisms, indicators.
- Microorganisms in the processing environment - sources, survival, growth, biofilms, persistence, personnel
- Microorganisms in the processing environment - vectors such as air, water, personnel and processing aids
- Risk Assessment - the basics of assessing risk in production of a food product, where risks arise, their magnitude, how they can be reduced to the lowest level. This will dovetail with the sections on intrinsic and extrinsic factors, safe product design, and process validation.
- Safe product design - shelf life, storage requirements, potential contamination, manufacturing conditions, food matrix, formulation, pack type.
- Process validation - what validation is for, how to validate, what types of validation to use, discussions on process verification. Basic practical process validation - how to do it
- Safe environment - consideration on the importance of cleaning/hygiene/equipment design
- Practical laboratory microbiology - how to work in an analytical microbiology laboratory, hygiene, aseptic technique, procedures and working practices.
- How to sample (factory) - taking samples for microbiological testing from the factory environment (ingredients, finished product, process intermediates and environment samples).
- How to sample (food) - testing in the laboratory - how to effectively sample food products (representative sampling).
- When to test - how testing at various times gives different results and what those results can mean
- What to test - discussions of how testing different matrices can lead to different results and what these mean
- How to test - how to select the most appropriate test method and the advantages and disadvantages of different methods
- Interpretation of results - discussion of test results, what they mean, how to interpret them and draw valid conclusions
- Accuracy - understanding the concept of accuracy and uncertainty in microbiological testing
- Knowledge of microbiology legislation - what legislation exists, the importance of knowing and understanding legislation.
- Verification (role of testing) - what do test results give to companies, how to use testing and test results within a risk management programme.
- Investigation and root cause analysis (RCA) - what happens when things go wrong - drawing valid conclusions, taking action, escalation, recording actions, finding route cause and implementing corrective actions.
- Incident management - what happens when things go wrong. How to deal with non-conforming work within the laboratory. Consideration of effects on results, informing clients and potentially dealing with claims
- Management of services/contracts - provision of external services, how to know what you need, how to get what you need. Contracts with clients, what they need to cover.

When things go wrong

As with the other courses, delegates on this course will receive a grounding in what makes food safe. Built upon those foundations will be an understanding of what can go wrong, and what to do when that happens. One of the key requirements for **when things go wrong** is to have a plan of action ("crisis management") for when such an eventuality arises. It would be expected that this module would be relevant, at an advanced level, to company microbiologists, those involved in technical and retail management and senior management. Laboratory managers and those working in hygiene management would require specialist knowledge and bench microbiologists and new product developers would need foundation level awareness.

This training module could include:

- Microorganisms - what they are and what they do - basics of different types of microorganisms, pathogens, spoilage organisms, indicators.
- Interpretation of results - discussion of test results, what they mean, how to interpret them and draw valid conclusions
- Accuracy - understanding the concept of accuracy and uncertainty in microbiological testing
- Investigation (RCA) - what happens when things go wrong - drawing valid conclusions, taking action, escalation, recording actions, finding route cause and implementing corrective actions.
- Risk Assessment - the basics of assessing risk in production of a food product, where risks arise, their magnitude, how they can be reduced to the lowest level. This will dovetail with the sections on intrinsic and extrinsic factors, safe product design, and process validation.
- Safe product design - shelf life, storage requirements, potential contamination, manufacturing conditions, food matrix, formulation, pack type.
- Process validation/verification - what validation is for, how to validate, what types of validation to use, discussions on process verification. Basic practical process validation - how to do it. What happens when verification indicates there is a problem.
- Safe environment - consideration of the importance of cleaning/hygiene/equipment design
- Knowledge of microbiology legislation - what legislation exists, the importance of knowing and understanding legislation, responsibilities within legislation, what to do if you consider you are outside of legislation.
- Management of services/contracts - provision of external services, how to know what you need, how to get what you need. Contracts with clients, what they need to cover.
- Practical laboratory microbiology - how to work in an analytical microbiology laboratory, hygiene, aseptic technique, procedures and working practices. How to decide if the practical laboratory work is being done correctly and is giving 'correct' results.
- Incident management (claims procedures) - what happens when things go wrong. How to deal with non-conforming work. Consideration of effects on results, informing clients, competent authorities and potentially dealing with claims.
- Tracing microbiological contamination - raw materials, processes not operating correctly, environmental cross-contamination
- Decontamination - how to decontaminate processing areas following environmental cross-contamination
- Sampling - the relevance of enhanced product and environmental sampling during incidents and returning to routine sampling.

APPENDIX Figure 1. Matrix of job roles and the relevant areas of competence

Key: 1 = highly relevant, 2 relevant, blank less relevant

	Job role												
Area of microbiological competence	Auditing	Training	Technical Man'ment	QA Man' ment	Technical Admin	Hygiene Man'ment	NPD	Labor'ory function	Technical opera'ns	Specialist roles	General opera'ns	Food Tech'gy	Comm'ial
Role of testing in verification	2		1	1			1			1		1	2
When to test	2		1	1			1			1		1	2
Meaning of results	1		1	1	2			1		1		1	2
Significance of accuracy			1	1	2			1		1		1	2
What to test	2		1	1			1			1		1	2
How to sample food		1	1	1			1	1		1	2	2	2
How to sample the environment		1	1	1		1	1	1		1	2	2	2
How to test	2		2	2				1		1		1	2
Investigation (RCA)			1	1		1			2	1		1	2
Microbiological risk assessment	1		1	1			1		2	1		1	2
Safe product design (shelf life, matrix, formulation)	1		1	1			1	1		1		1	2
Process validation	1		1	1			1		1	1		1	2
Safe environment (cleaning, hygiene, design)	1		1	1		1			1	1		1	2
Legislation	1	1	1	1				2		1		1	2
Management of contract services	1		1	1		1				1			2
Practical laboratory work			2	2				1		1		2	
Incident management and claims			1	1		2			1	1		1	2
Factory auditing and audits	1		1	1						1		1	2

APPENDIX Figure 2. Matrix of areas of competence in relation to course themes.
Key: ✓ relevant

	Course theme			
Area of microbiological competence	Building safety in	Understanding microbiology	Practical microbiology	When things go wrong
Role of testing in verification	✓	✓	✓	
When to test	✓	✓	✓	
Meaning of results	✓	✓	✓	✓
Significance of accuracy	✓	✓	✓	✓
What to test	✓	✓	✓	
How to sample food	✓	✓	✓	
How to sample the environment	✓	✓	✓	
How to test	✓	✓	✓	
Investigation (RCA)		✓		✓
Microbiological risk assessment	✓	✓		✓
Safe product design (shelf life, matrix, formulation)	✓	✓	✓	✓
Process validation	✓	✓	✓	✓
Safe environment (cleaning, hygiene, design)	✓	✓	✓	✓
Legislation	✓			✓
Management of contract services		✓	✓	✓
Practical laboratory work		✓	✓	✓
Incident management and claims		✓	✓	✓
Factory auditing and audits	✓	✓		✓

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