Foreign Bodies
Techniques for Investigation and Identification

White Paper

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Executive Summary

Foreign bodies are one of the biggest problems for food manufacturers to avoid and one of the biggest headaches when they occur. Thousands of tonnes of food production can be lost when a foreign body is discovered and the cost of a recall can run into millions if that is required.

Deciding on the best response to finding a foreign body begins with a proper identification, and the good news is that sophisticated laboratory techniques are now available that can help manufacturers make an accurate identification, not just of the foreign body itself, but of its most likely source. A simple investigation can therefore solve the immediate problem, and often prevent an expensive and frustrating recurrence.

This white paper gives an overview of the techniques that can be used to investigate foreign bodies, so that food executives and production managers can appreciate that there are actions they can take to limit the financial and reputational damage that a foreign body incident can engender.

Introduction

Most food and drink manufacturers will understand the potential damage that a foreign body incident can cause to the reputation of a food business, not to mention the potential harm that it can cause to the customer if ingested.

In these days of social media, a foreign body incident can be photographed and communicated to thousands of customers before the manufacturer is even aware of the problem, never mind having the potential to respond.

Yet respond they must. Every foreign body incident is worthy of investigation, because foreign bodies are not always what they seem to the naked eye. So a customer may report finding a stone, or a fragment of glass, or the bone from a rodent, and genuinely believe that this is what they have found. However, without proper investigation these 'discoveries' tell us nothing worthwhile.

Only a proper investigation can reveal whether the foreign body incident is what the customer claims it to be. This will determine whether this is a one-off incident, or perhaps indicative of a serious flaw in a manufacturer's processes or procedures, or indeed, whether the 'find' is due to customer fraud or accident in the customer's home. Ultimately, an investigation is the only way to satisfy the disappointed customer with a credible explanation for the incident, and provide information that helps prevent a recurrence, either by identifying a problem in manufacturing or distribution, or perhaps, some shortcomings with suppliers and/or specifications.

Foreign Body Types

Foreign bodies can be broadly classified as extrinsic or intrinsic, and neither have a place in a quality foodstuff.

Extrinsic

The former are materials that come from external sources either by deliberate or accidental means. They might include swarf from process machinery, insects or other animal body parts, fragments of material from packaging that is broken in the factory, or any other item. They can occur at any point in the supply chain, including during the harvesting, transport and storage of raw ingredients, and include acts of deliberate tamper as well as factory accident. Over many years of investigating foreign body incidents, the laboratories at RSSL have seen a truly astonishing array of extrinsic foreign bodies that have been reported by customers, or detected within the factory. They range from the bizarre to the obvious, and contribute to a database of many thousands of examples, which acts as a useful reference when it comes to investigating new cases.

Intrinsic

Intrinsic foreign bodies include ingredients such as bones and gristle in a meat product, a leaf or stalk in a pack of frozen vegetables, or an ingredient in an unusual/unexpected state (crystallised ingredients often present as glass to consumers). They might also include fragments of packaging or a blemish on an otherwise perfect surface, e.g. a smear of raspberry jam on a white iced cake.

If the last example seems trivial, the point, as noted above, is that when the foreign body is first noticed, it may not be at all obvious what it is. To one consumer, the red smear will be interpreted as jam and probably ignored. To another, it could look like blood, and when their complaint comes in, that is the complaint that has to be investigated, proved or disproved, and then dealt with. In any event, the smear of jam represents a failure of quality control, and may indicate inadequate clean down between different batches of production. In which case, the manufacturer should be asking, if there is a problem with jam, what about cross contamination of other ingredients, including allergens, and what about the implications for hygiene and product safety?

Why Bother to Investigate?

Some manufacturers might be tempted to deal with the apparent one-off complaint with a simple refund of purchase. This may be a mistake for several reasons; the complaint may not be genuine, or it may be the first of a series of incidents rather than a one-off, and therefore may be symptomatic of a bigger problem waiting to happen.

Hence, rewarding the fraudulent customer with a ‘no-questions asked’ refund merely helps to encourage a repeat occurrence, whereas a relatively straightforward identification/investigation can challenge a customer’s account of how they ‘found’ an item in their food. Similarly, identifying the root cause of the initial problem, can help to avoid many more similar incidents occurring in future.

This is why it is always sensible to investigate the incident thoroughly, and to determine the precise nature of the contaminant, to discover its likely causes, and to act to resolve any issues and prevent a recurrence. Moreover, a thorough investigation demonstrates a commitment to ‘due diligence’ and should help in restoring consumer confidence when the customer’s report is genuine.

What Can Be Investigated?

The microscopy team at Reading Scientific Services Ltd (RSSL) investigates approximately 1000 foreign body incidents every year, providing identification of the contaminant, possible explanations for how it came about, and consultancy on resolving specific issues. Broader help is also available in training and consultancy on risk assessment, HACCP and related disciplines, which are designed to prevent incidents from occurring in the first place.

A broad spectrum of technologies is routinely used in foreign body investigations, reflecting the diverse nature of potential contaminants. However, relatively simple light microscopy is often the starting point of any investigation, as it can be used to determine features that are typical or characteristic of the likely candidates, thereby directing the scientists to the more sophisticated methods that will provide ultimate confirmation.

Thereafter, different techniques are required for different types of contaminant and an indication of what can be achieved is given below.

What Techniques are Appropriate for Different Contaminants?

Glass Fragments

In truth, glass fragments are not as common these days as was the case twenty years ago, not least because many manufacturers have removed glass from their production lines and factories. That said, glass packaging is still popular for certain food items, and is a feature of many homes, meaning that it does still emerge as a foreign body with some regularity. Customers do not always relate finding a glass fragment in a mixing bowl, for example, to them breaking a similar item at home some days previously.

Microscopy of any original surfaces of a glass fragment can provide important information on its mode of manufacture, whether for example the original glass article was moulded (e.g. milk bottle) or spun manufactured (e.g. light bulb). Surface interferometry gives information on the curvature of a fragment, distinguishing between flat glass (e.g. window) or curved glass (e.g. tumbler, milk bottle). Using this technique it is possible to estimate the radius of curvature of a minute glass fragment and thus form a conclusion about the diameter of the region of the item from which it originated.

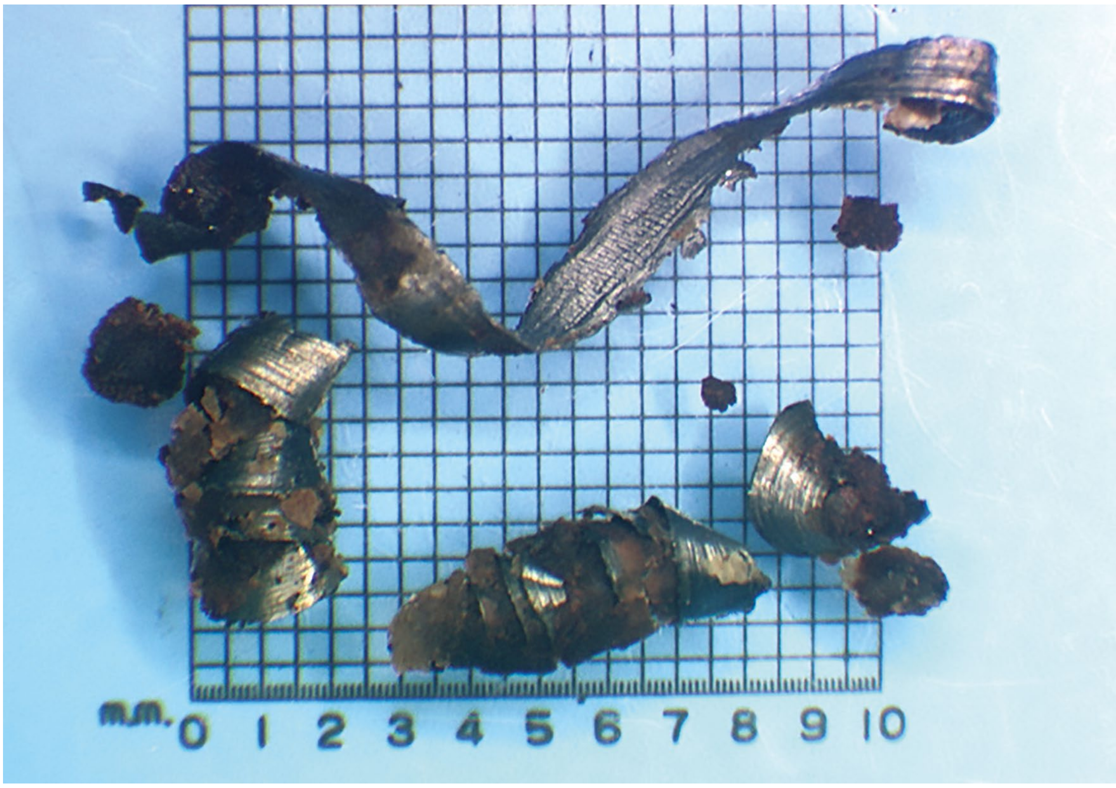
More information is available from X-ray microanalysis, a technique used in conjunction with scanning electron microscopy.

This technique relies on the fact that different elements emit X-rays of characteristic energies and wavelengths when irradiated with an electron beam. Detection of the emitted X-rays reveals the elemental composition of the glass fragment and allows it to be compared with reference samples, either from the factory, or from our own database of many hundreds of samples. Using this technique, it is possible to differentiate between sheet glass, lighting glass, containers (bottles and jars), lead glass, borosilicate (i.e. heat resistant glass) and domestic glass (tumblers, dishes etc.).

Metal

Like glass, metal fragments and objects may arise from a variety of sources such as factory machinery, packaging (laminated foil), even dental fillings. Most factories do have metal detection facilities on-line which helps limit the problem of metal fragments reaching the consumer but none of this equipment guarantees an end to the issue.

The origin of a tiny metal fragment or dust can only be determined once its elemental composition is known. This is achieved by X-ray microanalysis, which allows distinctions to be made between different base metals, steels and other alloys. The same analysis can be used to determine any match between samples and reference materials supplied from the factory.



Plastics

Polymers and plastics have replaced metals and glass in many applications. As a result, plastics present an increasingly common foreign body problem.

A combination of microscopy and spectroscopy techniques can be used to identify these materials. Fourier Transform Infra-Red (FT-IR) spectroscopy can be used to characterise the chemical structure of the sample, with the spectrum obtained by FT-IR being compared against reference spectra from RSSL's own plastics database, or an extensive polymer library.

A second technique, known as Differential Scanning Calorimetry (DSC) can also be used to characterise plastics in terms of their melting point, degree of crystallinity and glass transition temperature. In some cases, this will differentiate between different forms of the same polymer.

Others

There are many other potential foreign bodies, such as hairs and fibres, insect parts, animal droppings, all of which can be investigated using a combination of microscopy, microbiology and chemistry techniques.

Deposits and hazes, for example, often arise from natural deposition or settling out of ingredients, breakdown of filtration systems, or by chemical contamination causing precipitation of ingredients (e.g. accidental addition of cleaning fluids to milk). Occasionally they develop post-manufacture as a result of microbiological or enzymic activity.

Hence an obvious foreign body problem may have a very obscure origin and considerable detective work may be needed to identify its cause. In the case of insect infestation, for example, this can occur at any point in the supply chain and is especially distressing for consumers. RSSL is experienced in insect identification and can usually determine the species or family of insect, its country of origin and association with specific raw materials. From the manufacturer's point of view, it is worth knowing whether the infestation occurred in the raw materials, during processing, or after processing. It is sometimes possible to use a test to determine the activity of the phosphatase enzyme, which is found in insects, to verify whether the insect has been heat-treated during processing, or whether it gained access to the product after processing had finished. The enzyme is heat sensitive and loses its activity on heating.

Even with foreign bodies not from live sources, it is sometimes possible to tell whether it has been processed alongside the food, added afterwards, or come into contact with any other ingredient or item that might indicate where it came from and how it got into the product.

Investigating Foreign Bodies In-situ

There are occasions when it can be useful to investigate the foreign body in-situ, perhaps without disturbing packaging, or without disturbing spatial relationships between a multitude of foreign bodies. It may be that the manufacturer wants to examine the inside of a product without destroying it. For example, it can help to know whether the metal fragments that a consumer reports in a meat pie are located internally or externally in relation to the pie, whether the contaminant is part of the pastry topping or sides, whether associated more closely with the meat or with the pastry, or indeed, with the packaging.

X-ray tomography is ideal for this kind of investigation, and uses technology similar to that employed in a hospital CAT scanner. The key difference is that the high resolution X-ray CT (Computed Tomography) used in the food laboratory is able to resolve details down to a few tens of microns, whereas the medical CAT scanner has much lower resolution.

The two technologies are otherwise the same. Both involve taking a sequential set of images through a sample, to which a specialised algorithm is applied, to create a three-dimensional representation within the computer. The image is considered as being built up of voxels (volume elements) as distinct from pixels (picture elements) more familiar to users of digital photography. Essentially, the technique recreates the fine detail of a sample's internal and external microstructural features, by layering multiple images together, and the sample remains intact.

X-ray tomography can provide imagery and data reflecting both the structure of the material and the distribution of its individual constituents. Since X-ray tomography presents a clear picture of what is happening across the whole sample, it also helps the microscopist to decide where to focus use of the SEM in a foreign body investigation, rather than requiring them to work 'blind'.

The Benefit of Reference Materials

A key resource in identifying contaminants is the availability of reference materials against which to check the sample provided. This applies to all kinds of foreign bodies.

RSSL's own databases are a useful resource in this respect, as are the reference spectra that are supplied with instruments such as FT-IR and EDX. However, these reference materials/spectra only tell us so much. The crucial next step is to identify which, if any, of the several potential sources in the factory have perished to create the contaminant.

Many manufacturers now take a proactive approach to this issue by compiling their own databases of all materials held and used in the factory. This might include the chemical composition of cleaning materials (not a foreign body issue, but relevant to the wider issue of contamination), the composition of metals and plastic used on the factory line, and the protective clothing, including sticking plasters, provided to staff.

Case Studies

The sheer variety of foreign body incidents means it is impossible to talk in much detail about the specifics of investigations. For the analytical laboratory the response to finding something that looks like glass in a can of peas, is very different from finding something that looks like part of a dead rat, or a pharmaceutical product, or a razor blade. The analysis and the repercussions are going to be very different in every case.

The following case studies cast a little more light on the approaches that might be taken to an investigation, and the variety of circumstances that lead to foreign bodies being discovered.

Sharp Practices

A family complained of finding a blade inside a pack of cooking fat, involving the police and trading standards in the process. Investigations by RSSL demonstrated that there was a blade in the product, but there was no damage to the packaging, and crucially, internal 'scarring' of the product consistent with the blade being inserted after the block of fat had been formed. This indicated the blade had not entered the product during manufacture. Presented with this finding, the complainant admitted to having inserted the blade herself in an attempt to win compensation.

Staple Diet

On-line metal detectors picked up on several products that contained metal pieces. Investigations by RSSL identified the fragments as being office staples. Regular markings on the staple body indicated that all had been issued from the same machine (rather as firearms experts can identify bullets fired from the same gun). A thorough check was made of every stapler within the factory site. Once the stapler was identified, it did not take long for a disgruntled employee to admit to firing a few staples into one of the factory's small mixers.

Obvious Foreign Body, Less Obvious Outcome

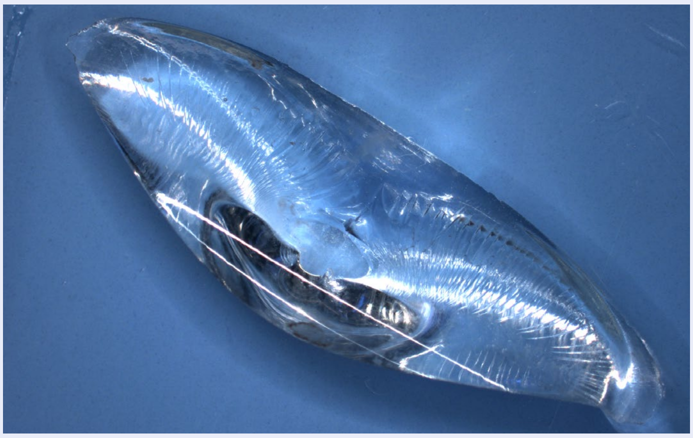
When the maintenance team realised that one of its tools had been mislaid, the obvious conclusion was to question where the team had been working in previous weeks. One location that had to be checked was a silo, in which the item was duly found. Identifying the foreign body was simple enough, but now the manufacturer needed to know if and how it might have contaminated batches that were waiting to be sent out. RSSL did a full toxicology check on the item, and a full assessment of potential for taints, and was able to conclude on this occasion that the product was safe for release.

Onsite Investigation

A factory metal detector located metal filings and caused a complete shutdown of production. Analysis in the laboratory revealed the metal to be chromium rich, and not of the common 316 grade stainless steel thought to be in use throughout the factory. Using the handheld X-ray microfluorescence (XRF) device, RSSL was able to locate one piece of factory equipment where the unusual metal had been used and repairs were carried out as a consequence.

Suspected Glass

A consumer complained that a tin of fish contained several fragments of glass. When the pieces were sent to RSSL it was quickly shown that the fragments were actually crystals of struvite, which can be formed during the canning process from a reaction between naturally occurring ingredients.



Insects/Rodents/Reptiles

A whole lizard was found in a food product, and using a biochemical method, RSSL was able to demonstrate that it had probably been processed and cooked along with all the other ingredients. Using external, specialist expertise, RSSL was further able to propose a species and country of origin, allowing the manufacturer to strengthen specifications and audits on a particular supplier.

Black Bits

Some black marks were appearing on a white iced sweet. A number of possible causes were mooted, such as oil splashes from lubricants, printer inks, factory dirt and so on. Using X-ray microanalysis on the scanning electron microscope, RSSL identified the elemental composition of the black bits and showed that it was likely to be metal dust from a particular piece of production equipment. Maintenance procedures were tightened as a consequence.

Conclusion

There is a truly bewildering number of foreign body possibilities that 'lie in wait' for food manufacturers. RSSL's own rogue's gallery of incidents includes examples that are both bizarre and bewildering, often exposing practices on the factory floor that no-one had ever anticipated nor thought it was necessary to control against.

This observation is arguably the single biggest reason for investigating every foreign body incident, because it is not enough to identify the foreign body and to respond to that individual incident. Rather, every incident should be used as an opportunity to learn about vulnerabilities in processes and procedures, and to dictate how improvements should be brought about.

RSSL is widely acknowledged as a world leader in foreign body identification. Our microscopy laboratory has over 100 years of expertise in this area, and has built up a database containing thousands of reference samples, which supports our work in analysing new incidents. We use highly sophisticated microscopy and spectroscopic techniques to identify contaminants and promise rapid turnaround in urgent cases. We provide guidance on how to send samples for testing, and also advise on preventing foreign body incidents, as well as offering a pre-screening service that is useful for identifying sources of metal swarf should these arise in factory equipment. To find out more about our contamination identification services please contact us on:
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About Reading Scientific Services Ltd (RSSL)

RSSL is firmly established as a trusted partner in the provision of analytical, investigational, consultancy and product development training services to clients in the food, consumer goods, pharmaceutical, biopharmaceutical and healthcare sectors.

Our chemical, physical, biochemical, biological and microbiological services are wide ranging, and provide support through the full product lifecycle. RSSL is routinely inspected by the MHRA, FDA and UKAS which ensures that our analytical services meet the needs of industry. We are trusted by industry to provide a solution with scientific excellence, outstanding customer service and professionalism.

Contact us to find out more about our expertise and how we can support you:

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