Campden BRI
Station Road
Chipping Campden
Gloucestershire
GL55 6LD, UK

Tel: +44 (0)1386 842000
Fax: +44 (0)1386 842100
www.campdenbri.co.uk

Campden BRI
food and drink innovation

Identification of physical contaminants ("foreign bodies")

Rapid and accurate identification of foreign body material found in food is essential in identifying the source of contamination and implementing measures to handle the incident and prevent recurrences. Pinpointing the stage in the food chain at which contamination took place can require skilled detective work. Information may be required on: country of origin; whether contamination occurred before or after processing, in the factory or during storage and distribution, or at retail point of sale; whether contamination was due to the consumer and if so, was it deliberate or accidental? An assessment may also be needed on the likelihood of the problem being restricted to one product or batch, or whether it is more widespread.

Ultimately a company or enforcement authority has to decide whether they are handling a safety issue with product recall implications, or a quality issue related to consumer perception or fair trading.

A useful working definition of a foreign body is "an object which can be seen by the unaided eye or felt in the mouth, and which the consumer perceives as being alien to the food". This will therefore include not only items that are obviously foreign, such as insects, stone or glass, but also materials that are connected with the food, such as bits of stalk or apple core and burnt product. Foreign bodies may get into the food product at any point between growth of the raw materials and the consumer's mouth.

Systems should be in place to remove any foreign bodies from the product at various points in the manufacturing chain (see Campden BRI Guideline No. 5 Foreign Bodies in Foods: Guidelines for the Prevention Control and Detection) or to highlight their presence and trigger appropriate intervention. However, the consumer's own home is another common source of foreign bodies. In any foreign body investigation it is important to accept that something has gone wrong and to suspend disbelief, implying that the foreign body could have come from almost anywhere. At the same time, it is also important to remember that experience shows that there are many well known, recurring sources of foreign bodies.

This sheet focuses on identification of foreign bodies once they are found. The examples given in this fact sheet are based on information given in Campden BRI's Guidelines for the Identification of Foreign Bodies Reported from Food (Guideline No. 4). No single laboratory is likely to be able to perform all of the types of analyses discussed, but for further information and details of the identification services available from Campden BRI contact Kathryn Hope on +44(0)1386 842017 Kathryn.hope@campdenbri.co.uk and at www.campdenbri.co.uk/services/contaminants.php.

Campden BRI, Registered no. 510618, Incorporated in England & Wales
Registered Office: Station Road, Chipping Campden, Gloucestershire. GL55 6LD
Part of Campden BRI Group

ISO 9001 CERTIFIED

Introduction

In the case of a foreign body found in the product by a consumer, it is essential that the details of each consumer complaint are properly recorded and kept on file. Regular reviews of these data will provide information on any patterns emerging from complaints. Initial information recorded may depend on the retailer or enforcement officer, over whose systems the foreign body identification laboratory may have little or no control, but the fullest information obtained at this time will save much time and wasted effort later. Where the foreign body could have originated from the packaging (e.g. glass, metal, plastic), try to obtain the packaging from the product both for comparison and to determine whether or not any portion is missing, or whether tears, holes or other damage may be present.

In the case of foreign bodies found at the factory, the time, date and specific place the material was found should be recorded, together with details of the person reporting the find. Where appropriate, the product involved, its batch number and the sources of raw materials in use at the time should also be recorded. Again, it is essential that each complaint is properly recorded and kept on file. Regular reviews of these data will provide valuable information on factory performance and is increasingly important as part of a Due Diligence defence and in fulfilling the requirements of Quality Management systems.

It is important that, when receiving the complaint, the foreign body is handled in such a way to minimise cross contamination and reduce the risk of disturbing deposits, where this is likely to be of significance.

Analytical methods

A whole range of analytical techniques are used for identification of foreign bodies: microscopy techniques such as light microscopy, scanning electron microscopy, infra-red and atomic absorption spectroscopy, Micro CT, thin-layer, gas and liquid chromatography, mass spectrometry, DNA-based methods and -conventional wet chemistry methods.

Light Microscopy

Light microscopy is used routinely for the examination of the structure of samples, and this can provide useful evidence in their identification. It can help identify the type of a biological material such as plant stem or bone. More specifically, the examination of samples in polarised light, for example, is one of the most powerful yet neglected analytical methods available to the analyst. The refractive index of many crystalline materials can be used in their identification. Some specimens, including some artificial fibres and asbestos, have different refractive indices at different orientations to the plane of polarised light.

Scanning Electron Microscopy and X-ray Microanalysis

The Scanning Electron Microscope (SEM) gives pseudo-three dimensional images with higher magnification and greater depth of focus than the light microscope. Samples can be relatively easily prepared and quickly examined in the SEM, making it an invaluable tool for the rapid examination of the three-dimensional structure of many samples.

More detailed microanalysis of SEM samples may be carried out using an energy-dispersive X-ray microanalyser. The energies of the X-rays given off by a sample irradiated with an electron beam are characteristic of the elements present in the sample, and so the X-ray microanalyser can be used to give a quick non-destructive elemental analysis of the sample. The primary application of the method in foreign body identifications is in the analysis of inorganic objects such as glass, metal and stone; it can also rapidly identify samples erroneously reported as glass such as struvite (magnesium ammonium phosphate), salt and silica minerals.

Identification strategies and aims

The two primary questions that the analyst is seeking to answer are: what is the foreign body? and how did it get into the product? The latter is often very difficult to achieve. It is important not to destroy evidence that could answer one question while answering the other.

The initial approach to the examination of a foreign body should be made with great care, to avoid disturbing the sample and possibly destroying vital evidence. Notes should be made, possibly using a light stereomicroscope, and photographs may be taken. If the sample is still embedded in the food product, consider how it might have become embedded before removing it. If fragments of food material are still attached to the surface, these can be examined to see if they support the reported circumstances of the discovery. A major question that most clients would like answering is: was the foreign body processed with the product? Unfortunately, this is often very difficult to determine.

Some foreign body samples will be so familiar as to be readily identifiable on sight. They may be intact manufactured items, and the shape of such objects is particularly important in their recognition. These may include nuts, bolts and screws, staples, matchsticks, buttons and other everyday objects. In these cases the more important information will come from surface deposits, scratches or staining which may provide clues as to how and when the object got into the food.

Types of foreign bodies

Animal tissue

Animal tissue may include pieces of mis-formed food material, pieces of the animal which should have been excluded from the food, such as skin, bone, cartilage, etc., and animal products such as faeces. Animal tissue may sometimes change in appearance as a result of processing or drying, so that, for example, dried muscle tissue can look very different from fresh meat. Spots of blood on the surface of things like bread or packaging often give rise to concern in the consumer's mind because of a perceived health risk. Similarly, the presence of material which looks like meat in a vegetarian product can give rise to complaints.

Plant tissues

One of the distinguishing features of plants is their ability to manufacture their own food from carbon dioxide and water, for which they need the green pigment chlorophyll, contained in chloroplasts. Another is the presence of a definite cell wall around each cell. This is usually made of cellulose, but may consist of lignin (e.g. wood) or other materials.

Identification of the plant structure from which a sample comes is based on the recognition of cell types present, as seen under the compound microscope, and by comparison with published drawings, anatomical texts and known reference samples. The likelihood of an identification will depend on many factors including, the size of the sample, which part of the plant the sample originates from, the presence of any characteristic features and the condition of the sample. Certain structures are more resistant to cooking and processing than others and are more likely to be present in highly processed foods. For example, the cells and hairs from the bran layers of wheat can still be seen even in a highly processed product, such as puffed wheat, whereas the structural features of other cells will be completely destroyed during processing.

Insects and other invertebrates

Insect and invertebrate contamination is a recurring problem within the food industry as these types of foreign body are often difficult to remove and hard to detect. They can also arouse strong feelings of revulsion in the consumer and in such cases it is essential that the invertebrate species in question is accurately identified and the point at which contamination of the product occurred is determined. If possible, action should then be taken to prevent a recurrence of the event.

Identification to species level of the insect or invertebrate involved in the contamination issue will often provide essential information such as geographical distribution, life cycle and food preferences. This information can then be used to determine where in the food chain contamination of the product occurred.

The identification of insects and other invertebrates is often a specialised task reserved for an experienced entomologist. There are many thousands of invertebrate species present in the UK, and on a worldwide scale the number of species is in the millions. This large number of potential species may seem daunting at first but with a little knowledge and experience it is possible to identify some of the more common groups and species of insects and other invertebrates associated with food products.

Microorganisms

Microorganisms, particularly fungal and mould growths, can often give rise to foreign body complaints. Fungi (moulds and yeasts) are probably the main causes. In one case a mould pellicle (a growth of mould as a mat on the top of a semi-liquid product), became folded up into a cone shape and was reported by the complainant as a “mouse’s head”. The principal feature identifying such material as fungal matter is that under the microscope it is seen to be composed of many fine, branching, tube-like structures or hyphae. The more advanced fungi are identified by the presence of cross-walls in the hyphae, absent in the more primitive types, but individual genera and species are usually identified by the form of the spores and the hyphae on which they grow.

In contrast to moulds, yeasts are fungi existing as groups of single cells rather than branching structures and are identified as such by the presence of many round or oval cells, often seen "budding" or in chains. Yeasts are generally seen as a surface film, smear or spots on the surface of a food product, or as a cloud or haze in the liquid product, rather than as a solid body.

Metals

Despite the widespread use of metal detectors on production lines in the food industry, metal fragments still represent an important source of foreign body complaints. Metal fragments may originate with the raw materials, they may derive from food processing or they may have been introduced by the consumer. The accurate identification of the metal composition (e.g. by X-ray microanalysis) is often an important factor in the correct identification of the source of the problem.

Metal fragments in food may be from a number of possible sources, such as tramp metal in raw materials, tinplate from a can, stainless steel from a factory pump or scraped surface heat exchanger, steel wool cleaning pads or chrome or nickel plating, or dental fillings from the complainant themselves. Stainless steels are widely used in the food industry and so metal foreign bodies can originate from food machinery.

Larger fragments of metal present few identification problems, as their metallic nature is usually readily apparent from familiar physical characteristics. When clean, metals or alloys such as copper, brass and bronze have characteristic colours. Careful examination with a stereomicroscope will show evidence of coatings such as galvanising, tinning or plating, and will also show signs of wear, rusting or other surface changes.

The shape of the specimen is often of considerable value. Fragments from saw blades, cutters and stirrers have a characteristic shape. Wire has a characteristic cylindrical shape, whilst steel wool cleaning pads such as "Brillo" have a flattened, ribbon-like shape.

Glass and ceramics

Glass fragments arising from consumer complaints are amongst the most significant foreign bodies that have to be identified because of the public perception of glass as a particularly dangerous type of foreign body. It is therefore particularly important to be able to identify glass fragments as accurately and as precisely as possible. Glass fragments may come from a wide variety of sources, and it is important to bear all of these in mind when examining a sample. Most modern food factories operate a "no glass" policy in food production areas, but there may still be glass inspection ports, dial covers, fluorescent lighting tubes and windows, and glass sampling equipment from the quality control laboratory must also be considered. On-line breakages, particularly at the filler, are a potential hazard when food products are being packed in glass. However, we have found that many of the glass fragments reported from food originate, whether by accident or design, from the consumer's own home. A particularly common foreign body example is a glass fragment from the bottom corner of a jar. These are produced when the last remaining contents of the jar are being scraped out with a metal spoon or knife, and excess pressure causes a small hole to be punched in the bottom corner of the jar.

Another frequently encountered glass fragment occurring as a result of accidental breakage in the home is a sliver of glass from the rim of a heat resistant casserole or bowl. These pieces are usually sharply pointed at both ends and may be quite large.

Rocks and minerals

This group of foreign bodies ranges from grains of sand to larger stones. They commonly originate from the soil, and are harvested with a field crop. It is important to be able to recognise them for what they are, to avoid confusion with foreign bodies from other sources such as lime scale. In many cases the item may be a very common material such as sand, quartz or limestone. Nevertheless, this may still be useful in narrowing down the range of possible origins for the sample.

The principal distinction to be made is that between rocks and minerals. A mineral is a single chemical substance such as quartz (silicon dioxide, SiO_2). A rock may be made up of a number of different minerals, for example granite.

The precise identification of many stones requires either detailed microscope examination of thin sections of material, or accurate elemental analysis, which generally require sophisticated laboratory tests. There are, however, a number of simpler tests that can be carried out, and will enable many materials to be identified.

Plastics

Plastics have a wide range of uses in packaging, machinery and instrumentation, and in many domestic applications. The wide range of uses means that they are amongst the commonest foreign bodies to be reported. This is exacerbated by the fact that, because of their physical characteristics, plastics are generally rather hard to detect within a food product, so it is often difficult to remove such foreign bodies on-line.

In some cases, the shape of the piece of plastic can give an indication of its likely source. However, in many cases the laboratory is asked to examine a small fragment that has broken off a much larger object, and in cases like these, the shape of the sample may not be particularly helpful. Colour can sometimes be useful: the presence of bright or multiple colours can sometimes be an indication that one is dealing with a consumer item rather than a piece of factory machinery, but this is not always the case. Different plastics are suitable for different purposes, so the chemical identification of the plastic will often lead to a more limited range of possible applications

Fibres and hairs

This group of foreign bodies includes six main classes of materials:

- Animal fibres (including human hairs)
- Insect fibres – silk and webbing from caterpillars (and spiders)
- Plant fibres and plant hairs, including cotton, linen, rape and sacking
- Artificial fibres (including synthetics and regenerated fibres, and glass fibres)
- Mineral fibres (asbestos, asbestos-like materials and carbon fibres)
- Metals

Other than animal hairs, the majority of fibres encountered in foreign body identification work are from textiles or rope and twine. They may be found as single strands, twisted or spun fibres or yarn, or as part of a structural material such as cloth or paper. The six main classes may be distinguished by their structure as seen under the light microscope and a range of techniques can then be applied to identify the sample more precisely within one of these six main classes. Animal fibres, insect fibres and plant fibres are usually identified by light microscopy: animal hairs may be foreign bodies in their own right, or may be present in droppings, when they can be used to identify the animal responsible, such as rodents, rabbits and bats. Artificial hairs are often identified by infra red spectroscopy, whilst x-ray analysis can be useful for mineral and metal fibres.

Drugs

The apparent contamination of food products with tablets or capsules is concerning for the consumer. Whilst the material may be a prescribed medicine, it may equally be something as innocuous as an artificial sweetener tablet or a vitamin supplement. Tablets and capsules may get into the food as a result of deliberate contamination or by accidental introduction, for instance by an absent-minded or unwell consumer.

Tablets and capsules will often not survive most food processing operations. Most tablets and capsules are designed to dissolve, so any prolonged contact with anything moist will result in either complete dissolution or at least a very substantial change in appearance. Consequently, it is unusual for contamination during the manufacturing operation to result in a physical contaminant being detected by the consumer.

Naturally occurring materials reported as foreign bodies

A number of substances naturally present in food may be reported as foreign material. These may include items such as fish bones in fish products, extraneous vegetable matter (EVM) in fruit and vegetables, indeterminate lumps of various kinds, and crystalline materials of different types. Lumps of material may often contain carbohydrates such as starch or inulin, proteins or lipids, and their identification can go a long way towards determining the cause of the problem. Crystals are often of particular concern, as they may be mistaken for glass fragments when found by the consumer

Some of these materials may be described as ergastic substances: organic and inorganic end products of metabolism, which do not participate in the building of the cell (e.g. mucilages, gums, latex), and are found in the cytoplasm or in the vacuoles. Reserve food materials such as starch grains, aleurone grains, inulin and oils may be present in solution or as solid particles. Some of these, such as starch, are important as food materials, and others are important either as foreign materials in their own right, or as evidence for the identification of foreign bodies.

Crystals are also formed as end products of metabolism. They are of differing compositions and are found in many kinds of plants. These can be seen in the cells when examined microscopically. Calcium salts are the most common, especially calcium oxalate. The shape of the crystals is variable and they may be solitary, rhomboidal, octahedral or elongated. Elongated crystals can occur as massive solitary crystals such as the styloids in Iris and in bundles, or raphides, as in pineapple. They can also be found as crystal masses.

One particular crystal that is often mistaken for glass is struvite (magnesium ammonium phosphate), which is occasionally found in fish products after canning. As a result, struvite is probably most commonly reported in tuna sandwiches. Its presence is believed to be related to a complex interaction of the nutritional components present in the product during processing and the precise conditions of the temperature and pressure being used. The crystals are formed in regular shaped prisms with straight edges, unlike glass, which fractures with irregular edges. Struvite crystals are softer than glass, they can be scratched with a scalpel and also dissolve in warm solutions of dilute vinegar or lemon juice (and more slowly in water).

Effects of processing on foreign bodies

When identifying foreign bodies and their origins, it is important to consider the potential effects of processing on the object. Processing may change the appearance of the contaminant, and the nature of the change may suggest what type of processing it has been subjected to. The foreign body identification laboratory is frequently asked to determine whether a sample was processed with the food product, in an attempt to determine at what point in the food chain the contamination occurred.

Alkaline phosphatase test

The alkaline phosphatase test has long been used as a presumptive indication as to whether or not an insect has been heat-treated with a food product. This enzyme is present in virtually all living organisms, and remains active for a long period after death. However, enzyme activity is destroyed by heat treatment. It is therefore assumed that alkaline phosphatase enzymes will remain active in an insect long after its death, unless that insect is heat-treated; hence the test is widely used to indicate whether an insect has been heat-treated. This test is not as 'exact' as it would at first appear, and careful interpretation of results is essential. This is discussed in more detail in R&D Report 217: *The alkaline phosphatase test: improvements and limitations.*

A more detailed explanation of the effects of processing on a wide range of foreign bodies can be found in two Campden BRI publications, both based on a series of experiments in which foreign bodies were processed with different foods:

- Effect of food processing on foreign bodies - a case study on baking Review No.13
- The effect of food processing on foreign bodies - a case study with in-container heat processing Review No. 16

Effects of Chewing

Chewing of a foreign body by the complainant at the time of discovery may result in considerable damage, which may make the task of identification that much more difficult. However, chewing may produce some characteristic teeth marks on more durable materials such as plastic, which may help to substantiate the complainant's account of events.

If a foreign body is received with a claim that it injured the complainant's mouth, it may be possible to find evidence that the object has been in the mouth. Microscopic examination may reveal the presence of blood or epithelial cells from the mouth lining. Presumptive tests can also be carried out to detect the presence of blood.

Conclusions

The range of items that occur in food as physical contaminants is wide. Identifying precisely what they are and how they might have got into the food requires an array of techniques and much knowledge and experience. Sometimes, all that is possible is to eliminate some options: e.g. an item could not have gained access at a certain point.

Some items reported as foreign bodies are, in fact, natural constituents of the food (although sometimes not desirable natural constituents). It is important that companies treat all such complaints seriously, and have the nature of the contaminant fully investigated when appropriate.

If you have a physical contaminant issue, contact Kathryn Hope in our Microscopy Section - on +44(0)1386 842017 kathryn.hope@campdenbri.co.uk to see how we can help.

Revised October 2015