Association of Public Analysts

Mastership in Chemical Analysis Examination

Training Guide

Food Complaints

ACKNOWLEDGEMENTS

This guide has been prepared by the Training Committee of the Association of Public Analysts. The Training Committee membership during preparation of, or at the time of publication of, this booklet was as follows :-

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Second Edition : April 2003

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The publication of this guide has been sponsored by the APA Educational Trust. The Trust (Registered Charity Number 328086) was established in 1988 "to advance training and education in the field of scientific analysis and examination".

Correspondence relating to this training guide should be sent to the committee secretary at the address given below. Further copies of the guide may be obtained from the same address. The charge per copy, including postage, is £25.00 and cheques should be made payable to the "APA Educational Trust".

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FOREWORD

The examination of food complaint samples is arguably one of the most important tasks for a public analyst. There are no clear pass or fail criteria as with additives or compositional standards which are laid down in regulations. The Public Analyst must use experience and knowledge to judge each individual case on its merits, and be in a position to argue that judgement in court if necessary.

This guide has been produced as an aid to the examination of food complaint specimens. It is not meant to be the definitive work on the subject but rather a guide on how to proceed and gives examples of the more common problems found. Other publications will be needed for more detailed information. When dealing with foreign matter in foodstuffs, although as this guide tries to emphasise, there are some possibilities more likely than others, the saying 'anything can be found in anything' is good advice.

Part A outlines a procedure for receiving and initially examining a complaint specimen. Part B looks at the more common faults found in various categories of food. Because of their varied nature and in order to simplify the presentation, the subject matter has been broken down into spoilage and contamination.

Part C gives some useful tests and information for the examination of food complaint specimens. It is not intended to be a complete list by any means and further guidance should be sought from the sources listed in Part D (Bibliography). The bibliography is again intended for guidance, and old editions can be very useful when dealing with complaint specimens. For this reason publication dates and ISBN numbers are not given. Sufficient information is given to allow the reference to be sourced through standard library procedures.

This study guide is one of a series produced by the Association's Training Committee for use in the profession. It is particularly directed at candidates preparing for the Mastership of Chemical Analysis (MChemA) examination. The Committee would welcome corrections to the text, if necessary, and constructive comment on ways of improving future editions. Correspondence should be sent to the secretary at the address given at the foot of the acknowledgements page.

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Training Committee Chairman
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PART A : EXAMINATION OF CONSUMER COMPLAINTS

1. Specimen Submission

The specimen should be accompanied by a submission form completed by the person who submitted the specimen. and which should detail relevant information regarding the history of the specimen. For example, how was the sample handled prior to submission, had it been washed, where and for how long had it been stored? It should be ascertained exactly what the complaint is before proceeding with tests, and whether the specimen has been cooked or otherwise treated by the complainant. The subject of the complaint may have to be referred to in the final report (even if the complaint is not justified).

2. Initial Examination

The specimen must be examined by a public analyst or an experienced member of staff under the direction of a public analyst. On receiving a complaint specimen it must be properly logged including information such as to how it was received, condition (frozen, fresh), time, date, mode of delivery, and name of person making the delivery .

3. Record of Specimen as Received

A written description of the specimen should be completed WITHOUT DELAY. If there is to be a delay, the specimen should be stored in such a way that deterioration and change in composition with respect to the complaint are prevented and a record of storage history maintained.

Describe the bag, envelope or other wrapping in which the specimen is submitted. Examine seals for faults or damage.

Describe and note the details on the label.

Weigh the specimen as received and prior to opening. Record the weight (see below).

Measure the dimensions of the specimen and wrappings, if relevant.

Peel off the wrapping, noting appropriate observations as the unwrapping proceeds (odour, texture, colour, cooked or uncooked). Unless the condition of the cap is giving cause for concern, cut around foil caps on bottles leaving edges sealed around bottle. Record any details of embossed characteristics on the cap prior to cutting. Similarly, cut into packaging or wrapping on other foods leaving seals, but ensuring that any damaged areas on the packaging are not touched.

Do not discard any wrappings and examine them for defects. Record all the product batch codes, date codes or indications of minimum durability as appropriate and include observation on whether the package was open or intact and whether it showed signs of insect damage, corrosion or physical damage.

Either weigh the removed food or measure the volume of liquids directly. If more appropriate, weigh the packaging to obtain the weight by difference, and record details. With liquid containers, marking the level prior to emptying can be easier and less disturbing to the nature of the complaint.

Weigh and/or measure parts of the specimen as relevant.

A colour photograph is advisable and consideration should be given to photography at all stages of examination (unopened packaging, actual food giving rise to complaint, extracted foreign matter). Include in photographs a ruler or other form of measurement to give a reference scale, the specimen number and date. A magnified photograph may be of benefit in some cases.

4. General Examination of Specimen

This stage will depend on what is wrong or suspected to be wrong with the specimen.

4.1 Odour and Taste

The odour of a food can give clues to the nature of the complaint (volatile substances, deterioration, chemical taints etc.) Food may be required to be tasted CAREFULLY at this point. Each laboratory will have a policy on the tasting of food complaint specimens. Consult the Public Analyst if in doubt.

A taste panel may be required to confirm or otherwise the presence of a taint etc. The panel should always taste the food without knowledge of the reason for the complaint and a normal specimen used for comparison. It is advisable to have a suitable antiseptic mouthwash available for use immediately after tasting.

4.2 Spoilage

The availability of a suitable antiseptic mouthwash for use immediately after tasting is particularly relevant where spoilage is suspected.

If the complaint is related to spoilage, then the spoilage criteria should be assessed as soon as possible, (TVN level, rancidity values, the culturing of moulds, microbiological tests).

4.3 Mouldy Food

Measure the area(s) of suspect mould as soon as possible and in three dimensions if applicable. Ensure that the dimensions and numbers of individual colonies are noted. Document a full description of the affected areas recording the types of colonies present, their colours and their textures.

If sufficient mould is present attempt an identification. If insufficient mould is available it may be necessary to allow the mould to grow further before re-examination, culturing and classification.

Culture the mould on suitable media (see later) (Czapeks Dox Medium, Malt Extract Agar, Corn Meal Agar). Let cultures grow until some fruiting bodies are present. Two moulds may be present with only one genus thriving. It is therefore necessary to look at both the specimen and the culture.

Also note from the culture whether the mould is viable or non-viable. This is important as it can indicate contamination of the food prior to heat treatment or bottle cleaning. Care should be taken in interpreting the results of non-viable growth of moulds since this could be due not only to the mould being non-viable, but also to the growth medium being unsuitable for the species (some Aspergillus species require Czapek Agar + 7% sodium chloride for plate growth). Similarly, the development of moulds at different temperatures may be of significant value in the interpretation of results.

4.4 Insects etc.

In the following discussion the word ‘insect’ should be read as including all forms of creatures which can be associated with food complaints.

Examine packaging for signs of entry (boreholes) using a stereo-microscope or other magnification. Note whether the insects are alive or dead. Count them if possible or if too many, estimate the number from a proportion of the sample. An attempt should be made to identify the species present if possible. The insect may need to be sent to an outside body for identification.

Search the food thoroughly for insects, webbing, larvae and faecal matter. Describe the degree of infestation (light, moderate or heavy). Also search for insect species other than any which are specifically reported as being present by the complainant or the inspector.

If necessary, establish whether the insect has been heat treated by determining its alkaline phosphatase activity. The interpretation of the results of this test is not clear cut unless a strong positive colour change is evident i.e. there has been no heat treatment (but see below). However where no colour change occurs, this could be due to heat treatment of the insect, or it could be due to the following reasons :-

- Simply dipping an insect in the test solution may not be enough as alkaline phosphatase activity may not occur on the surface.
- The insect may be too small to contain sufficient phosphatase to produce the yellow coloration. (Reducing the amount of reagent to a few drops can help).
- The phosphatase may have been deactivated or neutralised by other means e.g. in acidic foods.

Misleading results can also occur where a yellow coloration is produced suggesting that no heat treatment has occurred, when in fact the insect has been subjected to heat treatment. This can occur where :-

- Moulds or bacteria have appeared in or on the insect following heat treatment.
- In large items, e.g. slugs, not all the phosphatase may be deactivated by the heating process.
- Colour may have been extracted from the food by the insect and colour the subsequent reaction mixture.

To be as sure as possible, the whole insect needs to be ground with sterile water. This means that the taking of photographs and the making of diagrams are absolutely vital. It is advisable to consult the submitting officer prior to destruction of any insect etc., (or <u>any</u> foreign object for that matter). A compromise is to disembowel, dissect or chop a piece off if possible but trying to leave recognisable parts intact, or, to open the insect without much damage, and expose the body contents to the buffer substrate.

If possible use a recently killed insect as a control to compare colour development. Heat treat half to give positive and negative reactions. Alternatively saliva or raw meat can be used as a control.

4.5 Foreign Matter (excluding moulds and insects)

Foreign matter in foods can take many forms, common examples being: metal, glass, plastic, vegetable matter (leaf, paper, stem material fibres), stains and marks. The approach to the identification of these will vary enormously depending on their nature. However certain general rules apply in all cases.

Measure the object or area affected in the food and describe it. If the submitting authority does not want it removed as may be the case with a leaf in a sealed bottle of wine then the description and identification will need to be done *in situ.*

Once satisfied that the area affected is completely logged in detail, an attempt can be made to remove it. Details should be recorded on how easily it was removed and whether food was adhering to it; also was it embedded, resting on the surface, or moulded into the substance? The resulting cavity in the food should also be examined for regularity as this can indicate whether or not the foreign matter was present during the manufacturing process.

After removal an analysis may be attempted. It is a good starting point to look at the item under a stereo-microscope as much information may be gained.

An analysis may then be attempted and this will largely depend on the observations and interpretations made following the microscopic examination.

5. General Approach

Part C of this document contains a number of qualitative tests which may be of use in the identification of foreign matter. The following is a non-exhaustive list of possible approaches :-

♦ animal matter structures by	faecal pellets, hairs, hide, offal. Identify physical microscopy using staining techniques where appropriate (phosphatase, trypsin?).
♦ crystalline matter	physical tests, chemical tests, microscopy, infra red.
♦ fibres	microscopy, chemical sorting tests, melting point, infra red.
♦ glass	RI or density, chemical tests (metals), x- ray diffraction, scanning electron microscopy.
♦ metals	qualitative tests, quantitative tests for alloys and amalgams, AAS, ICP.
♦ plastic	chemical sorting tests, infra red.
♦ stains	test for iron or other metals, mineral oil, blood, dyestuffs (both natural and synthetic).
♦ taints	taste panel, distillation, GC.
♦ vegetable matter	identify physical structures by microscopy using staining techniques where appropriate (lignified, starch ?).

A simple and useful test which can be carried out on a tiny piece of the foreign matter is to heat the item slowly in a small dish and observe any actions (heat resistance, melting) or odours (distinctive smell of burning protein), and then carry on heating further to an ash. This will give information on the nature of the material and the ash may also be tested to obtain further information e.g. the presence of sulphate. Direct heating in a flame can also give valuable information in terms of flame colour, the presence or absence of sootiness etc.

Thought should always be given to the often limited amount of foreign matter available for identification with complaint specimens. In these cases, notwithstanding the previous comments made regarding the desirability of retaining the foreign matter as evidence, non-destructive tests and observations are preferable to destructive ones. Where destructive testing is carried out, tests should be done in a sequential manner to maximise the information generated. For example, determine moisture, fat, mineral oil, fatty acid profile in that order.

PART B : FOODSTUFFS AND POTENTIAL PROBLEMS

1. Cereals and Cereal Products

1.1 Spoilage

Bread is a very suitable medium for the growth of moulds especially when wrapped. Those most commonly found are Penicillium (greyish-green) species and Cladosporium (dark green/khaki). Occasionally Aspergillus niger (greenish brown with yellow pigment diffusing into the bread) is also found. Rhizopus nigricans (white with large black sporing heads) and Mucor species (rather similar to Rhizopus) are more rare. Alternaria tenuis (brown septate mycelium) is sometimes found but is more commonly found on puff pastry.

Monilia (red bread mould) causes a powdery salmon pink growth on the bread, which together with an odour of over-ripe fruit, is easily recognisable. It is particularly prevalent in hot weather, spreading rapidly and becoming a serious problem in bakeries.

Bacterial infection of bread is less common and the well documented conditions known as ‘bleeding bread’ and ‘ropy bread’ are occasionally found.

Yeast in bakery products can produce ethyl acetate through the alcohol produced being esterified by acetic acid.

High fat flour confectionery products such as shortbread may develop rancidity, either through poor storage conditions or extended shelf life.

1.2 Contamination

The most frequent cause of contamination in bread is by lubricants containing extraneous iron from moving machinery parts soiling the dough and producing black particles and streaks. This effect can sometimes be mistaken for rodent excreta or mould. One method of identification is to extract the oily matter from the bread with petroleum ether and test for mineral oil by examining the extract under UV light; mineral oil shows a definite purplish fluorescence. This can then be confirmed by Holde’s test, or more conclusively by GC. (NB lubricants may be mineral or vegetable based with the vegetable base now more common.)

If the amount of soiled dough is considerable, the extraction can be made quantitatively by separation of the unsaponifiable matter by column chromatography and comparison with the fat extracted from a piece of clean dough from the same loaf. A microscopical examination and a test for iron are also helpful. A simple test for both mineral oil and iron is to remove the contaminated area, dry thoroughly and grind to a powder. Place the powder in a flat dish or small watch glass, add petroleum ether and allow this to evaporate. The mineral oil migrates to the circumference. The re-dried residue can be tested for magnetic activity.

Charred particles and specks of burnt dough are also encountered, their black and shiny microscopical appearance distinguishing them from true foreign matter. Iodine gives a reddish colour with completely dextrinised particles caused by over heating. Brown flour can also be found within white bread as brown patches and is harmless. Iron salts, vitamins and *creta preparata* (chalk) added as a master mix and the brown fat extender lecithin, if not properly mixed, may also give rise to brown patches. Portions of partially cooked dough sometimes form tough strands which may be found in bread.

Of all foods, cereals and cereal products are the most frequently infested with insect pests. Commonly found species are: -

♦ Beetles	Tenebrio molitor (Mealworm beetle) Stegobium paniceum (Biscuit beetle) Ptinus tectus (Australian spider beetle) Tribolium castaneum (Red rust flour beetle) Sitophilus granaria (Grain weevil) Sitophilus oryzae (Rice weevil)
♦ Lice	Psocids (Book lice mainly from packaging).
♦ Mites	Only in flour when it contains more than 14% moisture, but common in stale cereal products.
♦ Moths	Ephestia species Plodia interpunctella (Indian meal moth - particularly larvae, excreta and webbing).

Other contaminants occasionally found in flour and confectionery products include the following :-

- Localised concentrations of sodium bicarbonate in buns giving white specks and a soapy alkaline taste. Effervescence is visible microscopically when a few spots of strong acid are placed on a portion of the affected food on a slide.

- Metal fragments such as nails, or from machinery. Checking the food for localised heating or scorch marks can give a clue as to when the metal gained access to the food.

- Rodent, bat and bird excreta when present, are mostly found in cereal products from the use of contaminated flour and can be studied using microscopy, uric acid, phosphatase and trypsin tests and hair/feather examinations.

- Sacking fibres (jute, hemp, cotton).

- Stains found on biscuits can be due to drips of condensation moisture, sometimes containing dissolved copper or iron.

- Stones can be carried over from vine fruit harvesting.

- Sugar crystals in cakes and fillings and which look like glass can be identified by solubility in water, Fehling's test and Molisch's test. IR may also be useful.

- Wood splinters -possibly from trays and bakery equipment - can be identified by microscopy and staining tests. Wood identification may be needed to exclude or confirm specific sources of wood.

2. Sugar and Sugar Products

2.1 Spoilage

Sugar itself and solutions of high concentration (greater than 65%) are inhibitors of both fungal and microbial attack. However, complaints of mould growth on jam are encountered where the surface concentration of sugar has been reduced by condensation from the lid, or, with home-made, low sugar or dietetic jams, the sugar content may be low throughout. Moulds normally associated with sugary, acid products include Penicillium and Aspergillus species.

Yeasts, particularly osmophilic types such as Saccharomyces rouxii are the cause of fermentation in sugar products such as fruit drinks and jam Swiss rolls. These may be identified microscopically, although biochemical tests are usually required for confirmation. Methylene blue distinguishes live cells from dead ones, by staining only the latter. Lime water in a fermentation lock will give evidence of the evolution of carbon dioxide.

Although not true spoilage, crystallisation of the sugars in jam and honey due to long storage can occur and give rise to complaints.

Deterioration of sugar confectionery is mainly due to the following :-

- Bloom occurs on chocolate products as a whitish surface film of fat or sugar, and is due to incorrect storage. Fat bloom is caused by fluctuating temperatures whereas sugar bloom is due to condensation.

- Some flavouring solutions used in confectionery deteriorate with time, particularly orange, giving an unpleasant taste, as do artificial sweeteners, especially aspartame.

- Staling is due to chocolate products readily acquiring stale taints on long storage mainly from the packaging materials.

2.2 Contamination

Sugar itself is relatively free from contamination from other sources, but the following foreign and suspicious matter has been found :-

- Clumps of brown sugar crystals in white sugar.

- Infestation of sugar can be due to mites, mainly in brown sugar, and Psocids straying into white sugar. Ephestia moth species can attack chocolate, the larvae causing tunnelling and contamination with webbing and excreta. These must be identified down to the species if the problem is to be fully assessed. Other common food beetle pests can also be found in sugar products.

- Packaging materials such as fragments of blue sugar bags and string. Glass from storage containers can also find its way into the final product. Where possible compare the glass with that of the original containers.

- Stones in soft brown sugar, usually due to the agglomeration and compression of powdered brown sugar, forming hard, smooth, pebble-like lumps, which can be mistaken for real pebbles.

3 Meat, Meat Products and Seafood

3.1 Spoilage

The main cause of spoilage in meat and fish is protein breakdown, aided by bacteria, with the production of volatile amines and ammonia. These are simply assessed by the Total Volatile Nitrogen determination, thus giving an indication of the condition of the meat. It is less meaningful when applied to cooked meat since cooking raises the TVN level considerably, but may still be useful as a guide. The total surface area of the meat specimen also influences the level of TVN. Thus the TVN level of minced steak will be higher than the equivalent steak as a single unit due to the higher total surface area of the mince.

Care must be exercised however, with some high TVN results being due to naturally high levels in some products such as rock salmon and skate. It is desirable to compare TVN results from complaint specimens with those of control samples of known history.

The pH value of fresh meat (steak) is about 5.5 but rises to around 8.0 with a corresponding increase in the free ammonia level after storage at room temperature for 48 hours. At low temperatures (3°- 6°C) pH is still below 7 after 3 days storage and in general terms meat keeps 3-4 times longer under refrigerated conditions, than at ambient temperature.

Another effect of long or poor storage is development of fat rancidity. Tests for the evidence of the various forms can be carried out such as Free Fatty Acids, Peroxide value and Kreis test.

The commonest mould found associated with meat products is Penicillium, particularly on the filling of meat pies, closely followed by Rhizopus and Cladosporium, the latter of which develops more readily than others at low temperatures. Microbiological examination can also be useful when assessing spoilage.

High levels of histamine in fish are caused by the action of bacterial decarboxylase enzymes on the amino acid histidine and are indicative of prolonged storage at elevated temperatures. Histamine poisoning is also known as scromboid poisoning because of the frequent association of the illness with the consumption of spoiled spiny-finned fish of the family Scombridae which includes tuna, bonito, skipjack and mackerel. However sardines, anchovies, herring and pilchards have also been associated with histamine poisoning.

3.2 Contamination

Unpleasant taints detected by taste alone include ‘Bone taint’ and Boar (Pork) taint, for which there are no chemical tests. A TCP chlorphenolic (disinfectant) taint in chickens can be very distinctive. It can be caused by uptake of pentachlorophenol preservative from wood shavings used as litter. This taint can also get into cattle via this chicken litter, as it is used as a type of cattle feed.

The presence of naturally occurring taints can occasionally give rise to complaints. Urine taint in kidneys is associated with elevated urea levels. Animals under stress retain urine which increases the urea content and can be caused by poor husbandry at the abattoir.

Dye from the marking of raw meat can find its way into final products due to incomplete dressing of the carcasses. Currently permitted colouring agents are Brown HT, Brilliant Blue FCF and Allura Red AC.

Infestation of meat products is limited mainly to the blowfly (Calliphora erythrocephala or Calliphora vomitoria) whose eggs and larvae are easily recognised on meat and sausages.

Some naturally occurring structures which can lead to complaints of foreign matter, and which can usefully be identified using histological techniques, are :-

- Animal hairs and hide -especially in comminuted meat products, e.g. corned beef.
- Bone fragments.
- Blood clots - almost black.
- Fish scales and skin in fish fingers and fish cakes.
- Gristle and connective tissue (wavy fibres seen microscopically).
- Kidney stones in steak and kidney pie.
- Lymph nodes and cysts - both whitish in appearance.
- Papillated tissues in prepared meat products.
- Tubules, blood vessels and other ducts which are sometimes mistaken for parasite worms.

Nematode worms in fish are unsegmented parasitic worms creamy white in colour, pointed at both ends and about 2-3 cm in length. They can cause alarm when found embedded in the flesh of white fish, particularly cod. They are often alive in the uncooked fish. The two species most commonly found are Filaria bicolar (the codworm) and Porrocaccum decipiens.

Canned fish occasionally contains transparent crystals of “struvite” (magnesium ammonium phosphate), sometimes mistaken for glass. Positive test results for magnesium, ammonium and phosphate and solubility in water should be sufficient to allay doubts.

The green slime sometimes found amongst canned sardines and other small fish is usually the remains of gut contents not properly removed by the cleaning and washing process. Microscopy reveals the presence of algae, diatoms and other phytoplankton typical of the fish’s food.

Other miscellaneous natural causes of complaints which should be included in this group are the iridescence sometimes seen on meat, particularly ham, due to the angle of cut; the white patches (freezer burn) found on frozen chickens; and white spot on sausages, an oxidative condition of the fat prevented by the addition of vitamin C. Similarly photobacterium spp. present on fish can cause the fish to glow in the dark. These are part of the natural microbial sea flora, are heat labile and are not a health hazard.

4. Milk and Dairy Products

4.1 Spoilage

The souring of pasteurised milk is usually caused by the bacteria Streptococcus lactis and Lactobacilli spp. with a consequent increase in acidity. 10 ml of fresh milk require 1.7 ml of 0.1M NaOH for neutralisation, corresponding to 0.15 % acidity as lactic acid. A sour taste is noticeable when the level reaches 0.25% and separation occurs around 0.6% of lactic acid. UHT Milk on spoilage develops a bitter taste without titratable acidity increasing due to the change in the microbial flora. This bitter taste may be due to gram positive sporing rods.

The most commonly found moulds associated with milk residues are Alternaria tenuis, Rhizopus, Cladosporium, Geotrichum candidium and sometimes Mucor. Algal growths are also sometimes found.

Cream displays similar defects at approximately the same levels of acidity. Specimens containing up to 0.6% of lactic acid have been submitted with a complaint of sour taste.

Butter complaints have arisen with free fatty acid levels of between 0.3 - 0.5% as oleic acid from certain butters due merely to their fuller flavour and which may seem 'off' to a person who is used to a bland tasting butter. Imported butter has occasionally been found to have a high free fatty acid content (FFA) in excess of the normal figure of 0.3% of oleic acid, probably due to long storage in transit. Values above 0.7% give the butter an unpleasant rancid taste. Unsuitable storage conditions for a shorter time can also produce the same effect. Exposure of butter to sunlight and oxidation can cause the yellow colour to fade or intensify in the surface area, leading to complaints. The determination of peroxide value is a useful indicator of rancidity.

Mould contamination in butter (and margarine) is more likely in unsalted varieties and is usually confined to Alternaria tenuis which appears as a smoky brown growth in the surface layers. It is difficult to culture mould from fat rich butter on standard laboratory growth medium. Other moulds such as Cladosporium, Candida, Dematium spp. sometimes grow on the surface, often in condensation water.

Butter can develop fruity odours due to the presence of Pseudomonas fragi and Pseudomonas fluorescens. Pseudomonas nigrifaciens can produce black coloration while Streptococcus lactis produces a malty flavour which persists after pasteurisation. Only staphylococci will grow in margarine, the salt level and water content being inhibitory to other organisms.

Cheese spoilage by Bacillus proteolytium has been known, causing an objectionable sulphide smell due to the production of hydrogen sulphide gas. This is due to the action of the organisms on sulphur containing proteins such as cystine. The TVN level can show if Camembert has deteriorated. (satisfactory at 100 - 120 mgN/lOOg but unsatisfactory at 300 mg N/lOOg.) Among the moulds that grow on cheese are Penicillium spp., and Cladosporium herbarium.

Dried milk has a normal moisture level in the region of 3%. A figure in excess of 5% (the legal maximum) indicates that the product has been incorrectly stored and may result in a high acidity and general deterioration. Usually the acidity is less than 1% as lactic acid, but when this exceeds 1.8% a definite sour taste and smell becomes detectable. These high values are most commonly met in spray-dried skimmed milk powders. It should be noted that the protein becomes less soluble on long storage.

4.2 Contamination

Milk contaminating matter originates from extraneous material not being removed from the bottle before filling. Some of the most common foreign matter found includes :-

- Cement, sand and inorganic earthy matter, sometimes caused by empty bottles being left on building sites etc., and windborne cement dust, or plaster and sand solidifying in the bottle. Addition of dilute hydrochloric acid, in the case of cement, causes effervescence and the resulting solution can be tested for calcium and iron. While natural limestone will also give the same reaction, its presence in milk bottles is much less likely. A positive test for sulphate in the acid solution indicates the presence of plaster. Cement, while also containing sulphate, gives a weaker positive result.

- Drosophila (fruit fly species), Phoridae, and other fly pupae and larvae. The fly pupae adhere very firmly to the glass and are often not removed by the hot caustic wash. They resemble brown 'seeds' in a full bottle of milk and are easily identified by the tracheal tubules protruding from the chitinous case. Other fly larvae are less commonly found.

- Slugs, snails, and their excreta and slime. These molluscs sometimes stray into bottles on doorsteps. They may be found whole in the bottle or leave trails of slime or excreta on the glass - the latter having the form of greenish-brown rods of macerated plant material. Molluscs are particularly resistant to heat and may pass through a bottle washing plant without losing all of the phosphatase enzyme. A positive reaction to phenolphthalein of a section of the mollusc may indicate its presence at the time of bottle washing due to contact with the alkali wash solution.

- Miscellaneous matter such as glass fragments, bottle tops, paper, plastic material, paper clips, drinking straws, somatic cells, algae, bird excrement, varnish and vegetable debris have all been found in milk bottles.

- Chemical taints may be caused by contamination of the milk with disinfectant fluids such as hypochlorite, phenolic types and black fluid disinfectant used in byres, occasionally combining to give a medicinal or TCP odour and taste. Dairy disinfecting fluids contain 0.7% chlorate in the hypochlorite solution as a marker. Dairy cleaning fluids are generally caustic alkali silicates, metaphosphates, quaternary ammonium compounds or iodophores. Milk produced from cows during prolonged periods of wet grazing conditions can have a malty taste due to the presence of Streptococcus lactis maltigenes causing the production of 3- methyl butanal.

Other dairy products can also give rise to complaints such as brown and black specks in dried milk specimens, especially spray dried, due to localised scorching during manufacture. Dried milk can also be contaminated through the use of scooping utensils used previously for other foods such as coffee granules.

Taints are readily absorbed by fine powders such as dried skimmed milk and custard powder, giving rise to complaints of various tastes and odours such as 'cardboard' from packaging, 'fusty' from prolonged storage or 'soapy' from other household goods stored in close proximity.

5. Canned Foods

5.1 Spoilage

Blown cans can be caused by chemical or biological action producing gas. The action of acid contents on the metal of the can releases hydrogen, the bacterial action of micro-organisms produces carbon dioxide and hydrogen whereas yeasts produce only carbon dioxide. The gas can be collected and tested using a simple displacement apparatus.

Pin holes in the can cause serious spoilage due to loss of vacuum and subsequent infection by bacteria and mould spores. With fruit in particular extensive mould growth can occur as a pellicle on the surface of the contents. Furthermore in the case of canned meats, dehydration can occur together with a loss of colour due to the oxidation of the blood pigments. With suspect canned pork the presence of clostridium botulinum should be considered.

5.2 Contamination

Brown to black corrosion stains found on canned meats can be due to iron sulphide formed from the solder in the can after the tin coating has been attacked in localised areas. With acidic fruit products this attack can be seen as etching of the can surface (feathering). Contamination by lead can be picked up from the can seams giving black spots of lead sulphide or raised lead levels in the food.

The larvae of the Tomato Pin-Worm (Heliothis zea) moth have been found in canned tomatoes as have those of the house-fly, Musca domestica. Small, round, ball shaped, green coloured caterpillars have been found in peas, their size and shape allowing their passage through screening processes.

Pea pod and plant structures are occasionally encountered in canned peas as compacted fragments of vegetable matter. Microscopical examination is a useful aid to identification.

Stones, small rodents/birds (or parts thereof), slivers of wood and machinery parts have all found their way into caIU1ed goods from various stages of the harvesting and manufacturing process.

Crystalline material has also been the subject of foreign matter complaints, the colourless ones being mistaken for glass. Some are natural to the product but are evident due to insufficient care during the manufacturing process. Common examples are :-

- Calcium ditartrate in canned cherries.
- Hesperidin crystals can be found in canned oranges.
- Magnesium ammonium phosphate (struvite) in salmon.
- Naringin - small pale creamy-yellow spheres up to 2 mm across found in canned grapefruit products are in fact crystal aggregates of this natural bitter glycoside.
- Potassium hydrogen tartrate (argol) in canned grapes.
- Quercetin crystals in pickled onions.

6. Beverages and Soft Drinks

6.1 Spoilage

Fermentation of sugar in soft drinks by stray yeast can lead to cloudiness and an alcoholic taste in the drink. Pressure can build up in the container due to carbon dioxide production. Aspartame has a limited life in the acidic medium of soft drinks, leading to complaints of unusual tastes in out-of-date products. Some flavouring components can also break down giving an unpleasant taste.

The most common moulds associated with soft drinks are Penicillium and Aspergillus species. If mould is present, check the drink for the presence of preservative since it may be unintentionally absent through poor production control leading to shorter than anticipated shelf life.

Dried beverages such as tea and coffee can develop mould and yeast growth under poor storage conditions. Cocoa is similarly affected with a well stored batch routinely being found to contain less than 50 spores/gram. Cocoa has also been known to be spoiled by Bacillus spp. and salmonella. Rancidity can also be a problem with this product due to the relatively high fat content.

6.2 Contamination

Re-usable glass bottles can lead to contamination due to their use as receptacles prior to being returned. Building materials such as cement, plaster, sand, resinous glues, varnish and white spirit have all been found in soft drinks. Other material from various sources such as paper, plastic, vegetable debris, insect material, cigarette ends and drinking straws have also been found.

Chemical taints can occur due to disinfectant fluids or soluble metal such as copper from manufacturing utensils.

7. Wines and Alcoholic Drinks

7.1 Spoilage

Microbial action on corks can cause cork taint in wine due to waste products diffusing into the wine. Grass-like taints in wine are caused by hexanal compounds forming during the juice extraction. Yeasts can also cause spoilage in the form of vinegary and off-tastes with gas production. Oxidation within the product constituents may alter the colour or produce rancid flavours. Cloudiness is caused by colloidal complexes involving a number of cations. Wines containing an excess of 0.6 mg of copper/l or 10 mg of iron/l may be susceptible to this form of cloudiness.

Butter-like tastes in beer are caused by the formation of diacetyl during fermentation. Yeasts, moulds, and bacteria in beer can also cause cloudiness due to colloidal complexes (usually removed in fermentation, fining and filtration), sourness, vinegary tastes and hydrogen sulphide formation.

Flavour defects due to microbial contamination during production or storage include the following :-

- Acetic acid bacteria — determined by microbiological examination causes an increase in volatile acidity and loss of alcohol content.

- ♦ Enterobacter — produces sulphur off-flavours.
- ♦ Extraneous yeasts — produce various esters and phenolic odours. Kloeckera apiculata, which produces a typical ethyl acetate odour, can be identified microscopically, but most yeasts are determined by physiological tests.
- ♦ Hafnia protea — a common contaminant, usually producing little odour.
- ♦ Lactobacillus spp. — produce lactic acid and diacetyl in beer.
- ♦ Pedicoccus — produces lactic acid in beer.
- ♦ Zymononas — produces acetaldehyde and sometimes hydrogen sulphide.

7.2 Contamination

Metals such as copper and zinc originating from taps and dispensing equipment can be found in these products, as can alkaline or ionic detergents used as sterilants. Rinse water from filling lines can also contain traces of sterilant. The presence of iron or copper in beer from production containers causes cloudiness, due to their catalysing effect on the reaction between polypeptides and polyphenols, forming an insoluble condensation polymer.

Moulds resulting from cracked bottles, imperfect seals, or improperly cleaned reusable bottles are not unknown. Diatoms from filter breakdown, possibly associated with finings have also been found.

As with any foodstuff, insects can be present. However Drosophila spp. (fruit fly) are most commonly found in fermented liquors.

Where glass is found, the determination of refractive index, density and composition may be required to identify or compare it with the container. Normally, a glass fragment having an identical density to the third decimal place as the container bottle can be considered likely to be from the same batch of bottles.

Tartrate deposits in red wine cause complaints of contamination but are a natural sign of wine ageing, with deposition being accelerated by chilling. Usually wine is cold stabilised prior to bottling, followed by filtration before the wine rises in temperature. Sometimes tartrate is formed after prolonged storage in uncoated concrete tanks. The dark brown scale sometimes encountered in wine bottles, particularly sherry, is usually a deposit of either tartrates or more often tannin. Microscopic spherical ‘cells’ from degenerated cork have also been found in brown deposits.

8. Confectionery

8.1 Spoilage

Confectionery with a high sugar content is protected from fungal and microbial attack. However complaints of mould growth can occur where the surface concentration of sugar is reduced due to fluctuating storage temperatures and/or prolonged storage times. Penicillium and Aspergillus are frequently associated with sugary products.

Chocolate is susceptible to sugar bloom, whereby sugar crystallises out on the surface, and is due to prolonged storage periods. Similarly, fat bloom occurs where fat rises to the surface of the chocolate and is caused by prolonged storage at elevated temperatures.

Taints can develop from packaging materials and are often associated with the presence of Chloroanisoles, giving a musty taint, and also from flavouring component deterioration during prolonged storage.

8.2 Contamination

Numerous foreign bodies have been reported in confectionery products and can arise from the variety of ingredients or manufacturing processes :-

- ♦ container materials — sacking, cardboard, paper, wood.
- ♦ insects — the wide variety which can gain access to foodstuffs at any stage.
- ♦ malicious intent — staples, pins, glass, cigarettes, matches, metals.
- ♦ personal hygiene material — medical plasters, finger stalls, bandages.
- ♦ process materials — plastic, pieces of metal implements, conveyer belt material.

9. Fruit and Vegetables

9.1 Spoilage

Mould and rot are the main spoilers of fresh fruit and vegetables (blights, leaf spots, wilts). Saprophytic moulds develop on damaged tissue and in conditions of prolonged and/or poor storage. Bacteria cause soft rots in storage (Coliforms, Erwinia, some Pseudomonads).

Watercress may carry bacterial pathogens from polluted streams, while salad vegetables may accumulate pathogens from land on which sewage sludge is used.

A bitterness can develop in citrus fruits through the formation of limonin and a medicinal taste in lemon juice due to the presence of high levels of thymol.

Legumes (soya beans, lentils, etc.) can develop off-tastes (grassy, beany, rancid) due to the action of the enzyme lipoxygenase.

Canned products may be spoiled by Bacillus cereus, Bacillus coagulans, Bacillus stearothermophilus, Clostridium botulinum, Clostridium perfringens, Clostridium nigrificiens (sulphides) and the food blackens in the presence of iron. The mould Byssochlamys fulva is a spoilage organism in canned as well as bottled fruits. Other moulds are normally the result of imperfect seals or subsequent damage and are usually one of the common saprophytes.

Dried fruits such as dates and particularly prepacked fruits are susceptible to yeast attack. However microscopical identification is necessary to avoid confusion with sugar efflorescences.

In fruit juices, moulds and yeasts are the most frequent spoilage organisms, producing alcohol and esters.

9.2 Contamination

Watercress may be contaminated by the snail, Limnaea trunculata, which is the host for part of the life cycle of the Liver Fluke and has been known to transmit this parasite to humans. Insects can often be present on fresh vegetables (aphids on cauliflower). Caterpillars can be trapped in ripening figs and be carried through to the final product undetected.

Pesticide/fungicide residues are seldom sufficient to be seen or tasted on fresh fruit and vegetables but accumulations do occur occasionally. Residues of copper-based fungicides are often found on grapes. Herbicides on the other hand may be the cause of various leaf abnormalities which are best diagnosed visually, since the cause of the abnormality usually occurs long before the effects are noticed. These abnormalities may be confused with plant deficiency disease symptoms.

With dried fruit products and dates, infestation is mainly by moths such as Plodia and Ephestia species with their larvae, webbing and excreta commonly found in such cases. Mites if present are usually alive, while beetle pests include Ptinus tectus, Ptinus fur, Oryzaephilus surinamonsis and Calandra granaria.

Metabisulphite salts can contaminate the surface of grapes through contact with this preservative which is placed in the bottom of containers in protective packs which can be punctured or otherwise damaged.

Detergents have been found in complaint fruit juices, as has mercury in fresh oranges through tampering.

10. Oils and Fats

10.1 Spoilage

In general, pure oils are less easily spoiled than emulsions, and water-in-oil emulsions are less easily spoiled than oil-in-water emulsions, where for example the salt and preservative levels are less concentrated in the aqueous phase.

Oxidative spoilage of oils and fats is accelerated by exposure to air and by agitation. Detection and quantification is achieved through the use of Kreis test and the peroxide value respectively. Hydrolytic rancidity on the other hand develops slowly as the product ages, but rapidly under microbiological activity. The free fatty acid level quantifies the extent of this spoilage.

The interpretation of results of these tests is best done using of a reference material. In general with most oils rancidity begins to be noticeable to the palate when the free fatty acids (as oleic) reaches the range 0.5 to 1.5%. Similarly a peroxide value of less than 10 meq O_2/kg is considered to be satisfactory, while values greater than 20 meq O_2/kg are considered to indicate rancidity. Between these two figures fats and oils can be reported as “incipiently rancid”.

Coconut oil is subject to a particular type of rancidity known as ‘perfume’ or ‘ketone’ rancidity which is caused by the action of micro-organisms and encouraged by moisture. It can be detected by distillation followed by a colour reaction with salicylaldehyde (see Bolton).

The acidity of extracted fat from fresh meat is less than 1.2% as oleic and an acidity in excess of 2% is indicative of significant fat breakdown. Mayonnaise and salad dressings should have a pH value of less than 4.1 and an acidity in the aqueous phase of at least 1.4% (as acetic acid) to prevent microbiological development.

Principal spoilage organisms in mayonnaise and salad dressings are yeasts and Lactobacilli spp., particularly Lactobacillus fructivorans which may be difficult to culture unless a Lactobacillus selective agar is used. If the pH is above 4.1, Salmonella spp. and Staphylococcus aureus may develop.

10.2 Contamination

Most oils and fats are seldom contaminated as they are essentially non-corrosive towards plastic and metal containers and in addition can be filtered prior to packing. Subsequently, the most likely contaminants are extraneous mineral and natural fats. These can be evaluated through the standard fat/oil analysis techniques of GLC of methyl esters, iodine value, refractive index, saponification value, together with, if necessary, classic tests such as Baudoin's (sesame oil) and Halphen's (cotton seed oil).

Fullers Earth from deodorising filters and tailings can carry over into bottles of oil and settle to the bottom. Cold polymerisation of oils may occur during use, particularly around the neck of bottles. This may build up to give a resinous substance which may cause complaint if it enters the product.

Meaty protein matter present in home produced dripping in the form of traces of gravy accelerates bacterial spoilage and may give rise to complaints.
Contamination of emulsions may be more varied and could include fragments of metal, plastic and insects.

11. Spices and Herbs

11.1 Spoilage

Fungal spoilage can occur either in the field prior to drying or in subsequent unsatisfactory storage. Identification of the fungal organism may indicate which of these is relevant and culture of the fungus is advisable, bearing in mind that many plant pathogenic fungi are not amenable to laboratory culture. There may be other clues, such as accumulations of the fungal growth and possibly associated moisture in parts of the sample which would indicate spoilage after packing. Some fungi are mycotoxin producers and this aspect may be investigated by chemical analysis.

Bacterial spoilage is uncommon, but spices in particular may contain pathogens. Spore-forming organisms such as Clostridium perfringens and Bacillus cereus may cause problems in foodstuffs. Peppercorns have been known to contain Salmonella spp.

Bacterial spoilage of emulsions of essential oils sometimes occurs, but adjustment of the emulsion to pH 4 with lactic acid usually eliminates this hazard.

11.2 Contamination

Extraneous herbs can be problematic and microscopical examination is essential for determining the purity of the product. Dried herbs for domestic and for medicinal use are often imported and mistakes can occur, sometimes with serious results. For

example, a sample of dried comfrey, which caused alarming symptoms to the complainant, was found to contain Atropa belladonna. The atropine content, estimated chemically, indicated that the contaminant amounted to approximately 20% of the dried herb. Red lead has also been reported present in paprika.

Siliceous matter is normally present in herbs and spices to a limited extent, but sometimes can be present in unsatisfactorily high amounts as to be the subject of complaint. It is normally associated with the more primitive methods of drying.

Fibres can sometimes be present, possibly from bagging material or sieves or gaining access at the harvesting stage prior to drying. Rodent or other animal hairs and excrement may also be present due to lax hygiene regimes.

12. Miscellaneous Foods

12.1 Eggs

Queries as to the freshness of eggs are sometimes received. On ageing, the egg is attacked by moulds and bacteria which cause offensive odours and general decomposition. There are two simple tests which can readily give an indication of age :-

- When cracked on to a plate, the yolk of a fresh egg is tall and compact and stands centrally in a thick layer of colourless albumen. A thin pool of albumen surrounding a flattened yolk indicates a lower quality egg.

- The pH of the white of a newly laid egg is about 7.8. After three days this rises to 9.3 due to the loss of carbon dioxide by diffusion.

Blood spots in eggs are caused by minor haemorrhages in the hen's reproductive system as yolks are ovulated. Meat spots are either small pieces of tissue from the oviduct wall or small pieces of egg material fragmented during formation of the egg. They have the appearance of dark meat such as liver. These inclusions are unsightly but harmless.

PART C : TESTING AND EXAMINATION OF FOREIGN BODIES

1. Chemical Tests

1.1 Aluminium

Dissolve the metal in 10% hydrochloric acid and add one drop to an ashless filter paper impregnated with a solution containing 0.1% aluminon and 1% ammonium acetate. The paper is developed over concentrated ammonia where the production of a red lake confirms the presence of aluminium. The ammonia is needed to decompose red lakes formed by other metal ions.

1.2 Blood

To prepare Leuco Malachite Green reagent, gently boil 0.5g of malachite green, 50ml of glacial acetic acid, 75ml of water and 1g of powdered zinc until decolourised (grey solution). Filter this solution prior to using for the test. Rub the suspected blood stains on to a filter paper and add 1 drop of the reagent followed by 1 drop of 5vol hydrogen peroxide. The development of a deep green colour indicates blood.

It is usually advisable to confirm this result using the Glister test which uses phenolphthalein instead of malachite green. The reagent is prepared by adding 1g of phenolphthalein to 10g of potassium hydroxide and 50ml of water. It is decolourised using 10g of zinc powder.

1.3 Calcium

To a solution of the material made alkaline with ammonia and then just acidic to pH 5 with acetic acid, add an excess of saturated ammonium oxalate solution. A white cloudy precipitate indicates calcium.

1.4 Citric Acid

Mix 20ml of concentrated sulphuric acid with 100ml of water and dissolve 5g of mercuric oxide in the hot solution to produce Denige's reagent. To 5ml of the test solution add 3ml of the reagent and bring to the boil. Add 0.1N potassium permanganate drop by drop until a permanent pink colour persists. A white precipitate indicates citric acid.

1.5 Iron

To a cold nitric acid solution add one or two crystals of potassium thiocyanate. A deep red colour confirms the presence of iron.

1.6 Lead

Add one drop of concentrated nitric acid on to the suspected metal and heat to dryness. Add one drop of 5% potassium iodide, when the development of a strong yellow colour of lead iodide confirms the presence of lead.

1.7 Phosphatase

The presence of phosphatase in an insect can indicate whether or not heat treatment has taken place. Pierce or macerate the abdomen of the insect or other animal foreign matter in about 2ml of distilled water in a clean hard glass tube and add about 5mls of reagent (disodium paranitrophenylphosphate in a sodium carbonate/bicarbonate buffer

solution). A yellow colour appearing after incubation at 37°C for 2 hours indicates the presence of enzyme phosphatase. (With larger unheated insects the colour development can be almost instantaneous.) Comparison with a blank is normally advisable.

Phosphatase is destroyed more readily as the temperature rises. 96% is inactivated by holding at 63- 65°C for 15 mins, at 70°C for 3 mins, and at 75°C the deactivation is almost instantaneous.

1.8 Phosphate

To a moderately strong nitric acid solution of the ash, add solid ammonium nitrate crystals, followed by an excess of 10% ammonium molybdate. A canary yellow precipitate formed on warming to 70°C confirms the presence of phosphate. This test is useful in distinguishing between a finger nail, which contains phosphorus, and the carpel of apple with which it is sometimes confused. In general, bone, nails and horn contain large amounts of phosphate (and protein) whereas plant materials do not.

1.9 Protein

Heat a portion of suspected proteinaceous matter with concentrated nitric acid. A yellow colour (xanthoproteic reaction) which changes to orange on making alkaline with ammonia confirms the presence of protein.

1.10 Silica

Any insoluble matter left after hydrochloric acid treatment of the ash is probably silica. However when dealing with foreign matter the possibility of aluminosilicate (soluble in hydrofluoric acid), or titanium dioxide (turns yellow when heated strongly) cannot be ruled out.

1.11 Tannins

These are readily soluble in water to give solutions with an astringent taste. With ferric chloride they give intense blue/black colours.

1.12 Tartaric Acid

To 2 ml of concentrated sulphuric acid in a porcelain dish add a few mg of resorcinol and a drop or two of the test solution. Heat to 140° C when a violet-red colour indicates tartaric acid.

1.13 Uric Acid

This is a useful test for excreta when used together with phosphatase tests. Moisten a portion of the matter with concentrated nitric acid and evaporate to dryness. Add concentrated ammonia when a violet colour indicates a positive reaction.

1.14 Urine

Urine can be tested for through the reaction of xanthydrol with the urea component. Mix 5ml of a well diluted sample with 5ml of glacial acetic acid in a large tube. Add 0.5ml of 7% w/v xanthydrol in glacial acetic acid. Mix and allow to stand. A turbidity or precipitate confirms urea as xanthydrylurea.

For confirmation a urease test can be carried out. To a water extract of the specimen, add a urease solution. The evolution of ammonia gas, confirmed by turning moist red litmus paper blue, confirms the presence of urea.

2. Microscopy Stains

2.1 Cellulose

Soak the specimen with 0.05N iodine solution for 2-3 minutes. Remove the excess solution with a tissue and add 2 drops of 66% v/v sulphuric acid. A brilliant deep blue solution is obtained with cellulose tissues.

2.2 Lignin

Soak the specimen on a microscope slide with a solution consisting of 1% phloroglucinol in 90% alcohol for 2 -3 minutes. Blot off the excess reagent with a tissue and add two drops of concentrated hydrochloric acid. Lignified plant tissue stains pink or purplish-pink.

2.3 Starch

Dilute 0.1N iodine solution four times with water. This stains all starches blue and dextrin reddish-orange.

2.4 Textured Vegetable Protein

There is no spot test for TVP and the best identification is by microscopic staining following various treatments with acetone, periodic acid, Schiff's reagent, Light green counter stain, alcohol, xylene and water. When mounted in Canada Balsam, carbohydrates stain magenta, proteins stain green and where these overlap a blue colour is produced. In TVP the palisade cells and hour glass cells of soya stain magenta and can be picked out. The presence of soya can be confirmed by birefringence with polariser. The cotyledon cells, found in soya flour, appear as green cells (protein containing) in a magenta network of cellulose. The full procedure is described by M. Coomaraswamy and F.O. Flint in The Analyst, 1973, Volume 98, pages 542-545.

3. Microscopy of Fibres

Many fibres encountered as foreign bodies have identifying characteristics which can be found in the relevant references in the Bibliography at the end of this study guide. The following is a brief summary of the more common features :-

3.1 Cotton

Fine hollow tubular trichomes flattened and twisted.

3.2 Hemp and Jute

These both contain lignin and cellulose. They consist of bundles of phloem fibres bound and containing a lumen which is straight sided in hemp and partially constricted along its length in jute. Hemp also shows transverse striations, which are absent in jute.

3.3 Man-made fibres

These are structureless but some have a stippled appearance microscopically. They cannot easily be identified microscopically although phase contrast, polarised light and cross sectional examination can help. A combination of solubility in various solvents, together with IR spectroscopy is usually required.

3.4 Wool and Animal Hairs

Most hairs and bristles of animal origin have a scaly surface, particularly evident in wool. Human hair is generally finer, having both a lumen and scales. These scale patterns can be quite distinctive (rodent hairs) as can the transverse section. Hairs can be cleaned in a solvent mixture such as ether and alcohol, and cleared with oil of turpentine. Where the scale pattern cannot be distinguished directly, a surface cast of the fibre using gelatine can be made. Being of a protein nature, animal hairs dissolve in hot IN sodium hydroxide, a distinction from plant fibres. A characteristic smell and appearance is noticeable on incineration of animal hairs which can be checked by burning a piece of genuine wool or hair.

4. Insect Classification

Insect food pests can be divided into the following main groups. All true insects have six legs and a body divided into head, thorax and abdomen.

- Bees, Wasps and Ants (Hymenoptera) — These are all familiar insects, normally with two pairs of linked wings, although some ants have none.
- Beetles and Weevils (Coleoptera) — In this group the fore-wings form a horny wing case (the elytra) covering the hind wings, which can be used for flight. It is the largest group of food infestors.
- Cockroaches and Crickets (Orthoptera) — Larger insects with long many segmented antennae and two pairs of wings. The front wings overlap in rest, but show a distinct network of veins distinguishing them from beetles.
- Moths (Lepidoptera) — Characteristically scale-winged, four winged insects with long antennae.
- True Flies (Diptera) — Insects with only two wings, the venation of which is useful in identification.

Other insect type bodies found in foods which are not included in the above groups are :-

- Insect larvae — These can be commonly found in food and can be divided into three groups by their general morphology :-
  - Beetle larvae — These have a head, six feeble thoracic legs and a soft body, sometimes segmented and sometimes comma shaped.

- Fly larvae — These are the headless, legless ‘maggots’ found in meat and dustbins. They are wedge shaped, tapering towards the front.
- Lepidoptera — This is the familiar caterpillar, having a head, six thoracic legs and eight prolegs on the third to sixth abdominal segments. The microscopical details of the eighth abdominal segment can be used in classification and identification.

- Psocoptera — ery small soft bodied, wingless book and dust lice with large eyes.
- Spiders and Mites (Arachnidae) — These are eight legged, have no wings nor antennae. The body is divided into head and cephalothorax only. They are not true insects.
- Thysanura — Primitive wingless insects with scales, having a fish-like appearance.

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