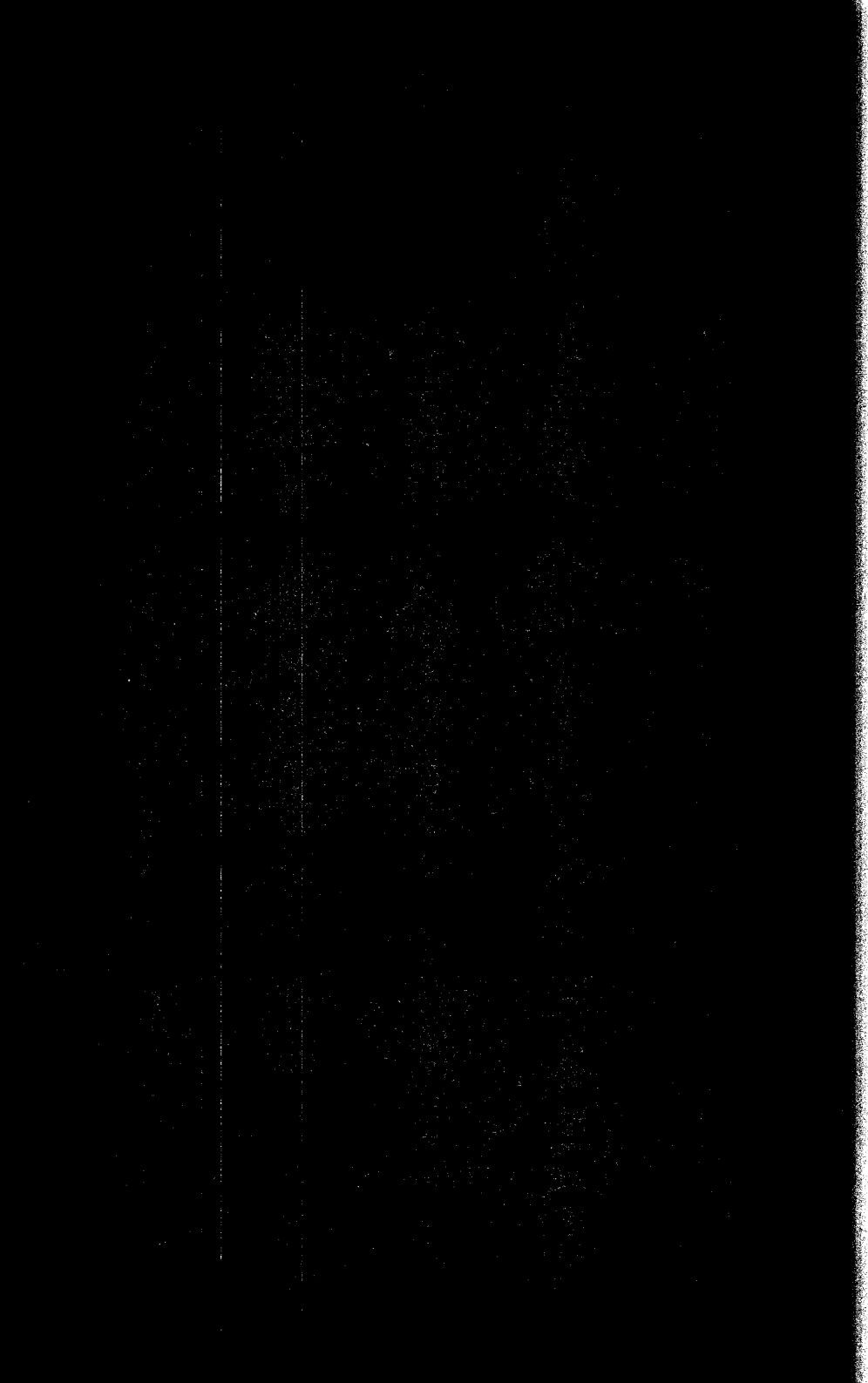

CONTENTS

The Cocoa, Chocolate and Confectionery Alliance is the national trade association of the manufacturers of cocoa, chocolate and sugar confectionery in the United Kingdom.

The Alliance Scientific Committee, which advises the Alliance Council on scientific and technical matters affecting the industry, felt that information on the control of infestation should be made more readily available to members of the industry. It therefore recommended that a special working party, including members with direct experience of infestation control and also representatives of the British Food Manufacturing Industries Research Association, should be set up to collate this information in a suitable form.

The Alliance Council accepted this recommendation, and the present booklet is the result. The booklet is published for the benefit of members of the industry and for the information of others who may be concerned.

CHAPTER I

INTRODUCTION

This booklet really needs no introduction to those concerned with this industry. We know that it is our job to produce and present to the public good, clean and wholesome foodstuffs, and out of something like 200 million units sold each week all but a very few are perfectly satisfactory. Perhaps the rarity with which insects are found in our products increases the abhorrence of a public which is much less concerned by the more frequent finding of a similar moth larva in an apple.

Nevertheless, there is no doubt that it is in the interests of the industry that consumers should be able to rely on the safety and wholesomeness of its products. The rare instances of contamination will have an effect out of proportion to their numbers in relation to the vast number of satisfactory products presented and they will impair the image of the industry as well as that of the manufacturer and the shopkeeper concerned.

There are, in addition, the following legal requirements:

Food and Drugs Act, 1955

SECTION 2: If a person sells to the prejudice of the purchaser any food which is not of the nature, or not of the substance, or not of the quality, of the food demanded by the purchaser, he shall be guilty of an offence.

SECTION 8: Any person who sells, or offers or exposes for sale, or has in his possession for the purpose of sale or of preparation for sale, any food intended for, but unfit for, human consumption shall be guilty of an offence.

Food Hygiene Regulations, 1960

SECTION 5: No food business shall be carried on in or at any insanitary premises, or at any premises, the use of which because of the situation, construction or condition thereof exposes food to the risk of contamination.

It is with the aim of reducing even further the rare occurrences of infestation that the industry has co-operated in attempting to bring together in this booklet some of the knowledge and experience of how to control infestation in the production and distribution of confectionery.

Many of the foodstuffs which are combined into the diversity of confectionery products are attractive to a wide variety of life in addition to the human beings for whom they are designed. Micro-organisms, i.e. bacteria, yeasts and moulds, require moist conditions and are of more significance on some raw materials and at intermediate stages of processing than they are on the finished products. They are outside the scope of this booklet, except that the hygienic significance of some pests is increased by their ability to contaminate food with harmful bacteria.

The Kinds of Pests

The insects, with their great variety, have evolved species which are all too well adapted to living on our foodstuffs in store, in the factory and even while they are being distributed to the consumer. A few species of small moths and about a dozen kinds of little beetles are the main so-called stored products insects which can live on normally dry foods. These insects are harmless in the sense that their feeding is largely restricted to dry food and they do not usually carry harmful bacteria. On the other hand, they can breed rapidly to produce enormous numbers of insects which are on occasions found feeding on confectionery by the consumer. Their presence at any stage of storage or manufacture is most undesirable.

Cockroaches are larger more mobile insects which flourish in warm conditions. They can be difficult to control in those factories where the construction provides numerous crevices, hollow walls, etc., in which they can hide during the day and come out at night to feed on and contaminate foods. Silverfish may be a nuisance, particularly where paper or board are stored. Flies and wasps generally breed outside the factory but can contaminate food by walking on it, and there is a danger of their bodies becoming incorporated in the food. The minute Pharaoh's ants form their nests in small cavities, and may walk some distance in search of food. Mites are even more minute relatives of the insects, differing in having four pairs of legs like spiders. They can feed on a variety of stored foods, producing a characteristic sour odour, but are limited in their occurrence by requiring particular conditions of humidity.

Rats and mice can be serious pests of food, causing damage directly by their feeding, and in addition by contaminating food with harmful bacteria. They are not deterred by normal packaging, and often use packaging materials, labels, etc., for nesting purposes. Birds, especially sparrows, can be a nuisance and present difficulties in control in this country. They do little damage directly, but can cause contamination, and their nests can harbour insects.

Principles of Control

The control of these various forms of infestation should be based on good hygiene in the broadest sense. It is not difficult to avoid infestation in a small, well constructed kitchen by regular attention to cleanliness. A food factory is essentially the same, but size does introduce difficulties in the maintenance of clean conditions. Fixed machinery involves crevices from which it is difficult to remove food residues and also places where pests can hide. Consequently, pest control in a food factory should depend less on superficial cleanliness all the time, and more on prevention of the entry of pests, avoidance of places where they can hide, and really thorough cleaning at intervals chosen to prevent their breeding.

There are few activities in the industry which are not involved either directly or indirectly with the maintenance of the desired hygienic conditions. Control of infestation is not merely a matter of organising a

spraying routine, but impinges to a varying extent upon all activities of the business. It is only by a truly co-operative approach, with a continual awareness of what is involved in the broader aspects of hygiene among the various different personnel at all levels, that effective infestation control can be attained.

Hygiene in this broad sense is not simply a matter of cleanliness in the handling of food. It requires a co-operative and conscious approach by all the diverse personnel concerned with the making of confectionery. The architect must design the building with the maintenance of hygienic conditions in mind, and the buildings must be maintained free from cracks and crevices and holes where rodents may enter. The engineers must install plant that can be kept clean. Buyers should seek to purchase ingredients as free from infestation as possible. Care must be taken to prevent infestation reaching ingredients, packing materials or products during transport or storage. Production personnel obviously have a big part to play in maintaining hygiene. Methods of manufacture should be adjusted wherever practicable to facilitate the maintenance of hygienic conditions. Packaging design should aim to prevent as far as possible the entry of insects.

It is the purpose of this booklet to indicate how hygiene in this broad sense can be applied to secure effective control of infestation, and how it can be supplemented by specific measures designed to eliminate any infestation which may be present. The primary purpose of hygienic measures is to prevent infestation being present, and consequently the more control can be based on such preventive hygienic measures the better. Nevertheless, under practical conditions there will be times when insects enter the factory, perhaps with ingredients, and rodents may find their way in. Methods of killing such infestation are therefore required, but caution is necessary in applying them. Many of the chemicals which could be used to control infestation are harmful to humans, and some cause tainting of food. Great care must be taken to ensure that the control of infestation does not involve any risk of harmful chemical contamination of food.

Conclusion

The primary aim of a food factory is to produce good wholesome foods. In the factory, where there is abundant food necessarily present, warmth, and large-scale continuous production plants make thorough cleaning difficult, the conditions are favourable to the pests. Nevertheless, it is essential to control infestation by methods which do not involve any risk of harmful chemical contamination.

In practice, infestation is kept down to a very low level in most factories, and infestation is usually absent in their finished product stores, which contain only wrapped food and where there is little risk of particles of food becoming lodged in cracks and corners. It is common experience that among the products which consumers return because of infestation only a very small proportion have become infested at the factory. The majority are infested during distribution, and some only a

long time after manufacture. While, therefore, the control of infestation in factories demands continual and costly measures, to achieve an appreciable reduction in the comparatively small number of infested products which reach the consumer, improved control during distribution is required. Relatively simple hygienic precautions should suffice, because the conditions involved in the distribution of packed confectionery are less favourable to the pests than those inherent in factory processing. However, the effective application of such precautions depends upon the many distributors, both wholesale and retail, who handle the products of this industry, and who have their own problems. These include the provision of suitable storage facilities, the achievement of a sufficiently rapid turnover of all the lines they handle, and the possibility of cross infestation from the various products other than confectionery which some distributors also handle.

CHAPTER II

INSECT CONTROL IN THE FACTORY

Production workrooms involve a wide range of conditions, but as mentioned in the previous chapter, in general the environment is favourable to the insect pests of food. There is necessarily abundant food present; processing of food almost always involves some spillage so that residues of food are usually present; processing requires machinery and equipment which provides surfaces to which food residues can adhere, and cracks and corners in which particles of food can collect and where insects can hide; in addition, temperatures are usually favourable for insect growth throughout the year, and in places are high enough, 70–80°F (21–27°C), for rapid insect development.

Prevention

The first aim should be to prevent any insects being present in the factory:

(*a*) Insects may enter the production workrooms with the ingredients. Means of controlling insects in ingredients are discussed in Chapter V, but complete protection for many ingredients can only be obtained by applying a fully effective insect killing treatment such as fumigation, high temperature treatment, or liquefaction, e.g. by the melting of fat or the solution of sugar in water, actually at the time of entry into the factory. In this way there is no opportunity either for reinfestation of the ingredient before entry, or for insects to escape into the factory prior to treatment.

(*b*) The production workrooms may contain a resident population of insects breeding there. It is the main purpose of this chapter to discuss how such resident population can be controlled and prevented from damaging the products being manufactured.

(*c*) Pests may enter the factory from outside. This is more probable with rodents and the common flying insects like flies and wasps. Their control, and especially means of proofing buildings against their entry, is discussed in Chapters III and IV. The insect pests of food are mostly derived from warmer regions of the world and do not normally live outside buildings in this country. However, the cocoa moth for example is capable of flying up to 150 yards under summer conditions, and could easily emerge from an ingredient store and fly into an adjacent factory workroom.

It is, therefore, essential to provide conditions in the factory which will control the insect pests of food. These so-called stored products insects require relatively dry foods which are not in liquid form, at least moderately warm conditions and, because they are comparatively immobile during the main stages of their life history when feeding and growth take place, they require their food to remain relatively undisturbed for a period of weeks. A single insect consumes only a very small quantity of food; for example, a moth larva is said to eat only about one third of a gram of chocolate throughout its life, so that relatively few particles of food remaining undisturbed in cracks are sufficient to maintain an infestation.

It is comparatively easy to eliminate insect infestation from the food products actually being processed except during the last stages of manufacture. Insects are readily destroyed by heat, temperatures in the region of 130°F (54°C) being lethal in a matter of 20 minutes, and much higher temperatures kill insects almost instantly. Roasting of cocoa beans and nuts is effective in destroying insects, and hot water treatments such as blanching of almonds will kill any insects present. Liquid fats destroy all stages of the insects including their eggs, apparently by a suffocating effect, so that chocolate is free from infestation up to the stage at which it is solidified. Much sugar confectionery and chocolate centre making involves boiling and other high temperature or liquid phases at an intermediate stage of manufacture, and these effectively eliminate insect infestation.

However, there is inevitably a period of varying duration when partly finished or fully finished products are held in the factory and will not subsequently receive an insect killing treatment. As a precaution this period, and particularly the period up to the packing stage prior to which the products are quite unprotected, should be kept as short as possible.

The risk of infestation taking place at this stage can be greatly increased by the use of trays, which are continually being re-used, for transporting or storing finished products prior to wrapping. Inevitably particles of food adhere to the trays and infestation can develop there. The insects may find their way on to the products even though the products only remain in the tray for a brief period. It is, therefore, essential that such trays are regularly and frequently washed, or otherwise treated to kill any insects which may be present.

When finished products are wrapped, they should be packed into outers and moved to the storeroom with a minimum of delay. The longer

the products remain in the production workrooms after the last processing which would destroy insects, the greater the likelihood that any stored products insects in the workrooms will infest them, and lead to complaints of infested goods from the public.

In addition, the chances of products becoming infested must be reduced as far as possible by eliminating insects from the production workrooms, and especially by preventing the development of a resident population of stored products insects there. This is difficult to achieve under factory conditions, where, as has already been indicated, the conditions are necessarily favourable to the insects and where the main objective is to secure economic production.

Cleaning

Essentially insect control should be based on cleaning. The cocoa moth would not be a problem if no food materials remained in the factory for more than six weeks. Obviously care should be taken that no products, including samples, sub-standard products, components of assortments surplus to requirements, etc., are held long enough both to become infested and to form a source of infestation. This period of six weeks is about the maximum which should be allowed. While such food which has been overlooked can develop into a massive local source of insects, it is the presence of food materials in the many cracks and crevices where insects can develop undisturbed which is the more usual cause of the maintenance of a resident population of insects in a factory workroom, and which is extremely difficult to eliminate entirely. It is the aim of the specialised cleaning for insect control to remove all food materials at sufficiently frequent intervals to prevent insect development.

It should not be forgotten that food which can support infestation may appear in unexpected places. To certain operatives an opening in an air-conditioning trunking is an invitation to practice accurate throwing. The design of the openings or the addition of wire mesh should prevent this possibility. Cupboards may prove to harbour foodstuffs, and infestation. Sometimes the food is lodged between the cupboard and the wall. As far as possible places where misguided employees can hide foodstuffs should be eliminated from the factory, and when insects are found in an area the possibility of such a hidden food supply should be remembered when searching for the source of the insects. Lift shafts can be a problem and it is remarkable the diversity of foodstuffs which are sometimes found at the bottom of these shafts. The eating of snacks by employees can also create difficulties, and the variety of food brought in for this purpose can encourage rodents particularly, because the normal confectionery foodstuffs provide them with a rather restricted diet. It is usually better to confine the eating of snacks to snackrooms, but even then it will often be found necessary to ensure that surplus food is properly disposed of.

In a food factory, a great deal of cleaning must be done at frequent intervals, and the specialised cleaning for insect control should be superimposed on this normal cleaning and be directed to secure the removal

of all food residues at intervals of not more than six weeks. Even to approach such an ideal in many workrooms, it is essential that both the buildings and machinery and equipment are designed and installed as indicated in Chapter IV to facilitate such thorough cleaning. The layout and organisation of work are important in securing effective cleaning, which is much easier to organise in a tidy workroom with adequate space round machines, etc., than in a cramped workroom where access is further impeded by stacks of trays and other clutter. Idle machinery poses a special problem; many infestations have been traced to food residues hidden in machines which are not in use. If only temporarily out of use, a machine should be cleaned thoroughly shortly after it stops working, despite any reluctance to spend time on unproductive equipment. If no longer required, it should be removed from the workroom, the various holes, etc., in the structure of the building being made good, and the machinery thoroughly cleaned and greased before putting into store.

The increasing mechanisation in the industry is altering the balance between so-called productive work and cleaning. Large and complex plants may require only a few men to run them, but will often involve many man-hours for effective cleaning, and their complexity may demand a higher level of skill for cleaning than has sufficed in the past.

A variety of methods should be employed. In general it is better to avoid the use of water for cleaning fixed machinery because of the difficulty of drying thoroughly. Damp patches will allow moulds to grow, encouraging the beetles which feed on mould, and will provide a suitable source of water for cocoa moths which require some to enable the full 200 viable eggs to be laid. Where the food residues are dry, vacuum cleaners are useful and can suck loose material out of cracks. Stiff brushes can be helpful in dislodging particles. Where the food materials are more adherent, such as chocolate which has melted, special tools will be needed to scrape out corners and cracks. Machinery will often have to be partly dismantled and guards, etc., removed to allow thorough cleaning. Some parts of the machine will then be more easily cleaned by washing followed by thorough drying.

Water is usually required for cleaning the floor and it is important to dry thoroughly afterwards, and especially in the various corners. Equipment such as trays which can be dried thoroughly is best washed to secure effective removal of food residues and the killing of any insects which may be present. Some fixed machinery is designed for regular cleaning by washing down, using jets of hot water, and this can be very effective in maintaining an infestation-free condition.

Cleaning practice must be adapted to the particular conditions in the factory, and it is scarcely possible here to do more than indicate the ideals to be aimed at in this specialised cleaning for insect control. It must be done regularly at intervals of about six weeks to break the life cycle of the cocoa moth. In places where the temperature is in the region of 85°F (29°C) even shorter intervals may be necessary. Alternatively, where a factory workroom is virtually free from infestation, a longer interval may

suffice. It is most important that all areas are covered, and indeed special attention may be necessary in the relatively clean places where only occasional particles of food find their way into cracks as compared with the places where substantial spillage occurs and more frequent removal is a matter of necessity. It must, however, be stressed that the six-week cycle of thorough cleaning should be the general aim, and effective insect control cannot be expected from thorough cleaning only during the annual holiday.

Methods of Killing Insects in Production Workrooms

The effectiveness of cleaning in eliminating insects can be supplemented in several ways. One of the most useful supplements is the use of insecticides. These and other techniques for killing insects are discussed in more detail in Appendix II. After a machine with many cracks or crevices, or other difficult areas, has been cleaned as thoroughly as possible and the greater part of the food debris removed, a comparatively heavy surface spray of insecticide can be most useful in eliminating any insects which may have survived the cleaning. But such a use of insecticide is no substitute for cleaning because food residues will protect many of the crawling insects, including moth larva and beetles, from the spray.

Heat can similarly be used, but again any substantial food residues can greatly impede the penetration of the heat. Suitable machines can be equipped with means of heating so that at appropriate intervals they can be heated sufficiently to destroy insects.

The organisation of such specialised cleaning and supplementary insect killing can be a matter of some difficulty, not least because it will often involve stopping production. It is probably best to have specially trained staff attached to specific workrooms, who can become familiar with the various machines, equipment, etc., learning the vulnerable areas where food residues are liable to accumulate unnoticed. Arrangements must be made so that machines are available for cleaning at the appropriate intervals.

Various forms of moth traps are available. The simplest, which is effective in rooms which are not unduly dusty, consists of a tray containing a liquid which may be water, oil or sugar syrup. The moths are attracted to the shiny surface and are trapped on alighting. Such traps are of little use in controlling the cocoa moth, because many of the moths will only be caught after they have laid most of their eggs. They can, however, provide a useful guide to the presence of infestation. With regular recording of the numbers caught, it is at once apparent that special attention is needed in an area where the numbers increase.

Insecticide sprays can be used, as described in Appendix II, to provide a mist which will kill all moths in a room. This can be a useful technique if the infestation is heavy, but must be carried out at frequent intervals, preferably every 24 hours, otherwise sufficient of the moths will have laid their eggs to maintain the infestation before they are killed by the mist spraying. Moreover, moths which have been knocked down by the

spray may actually deposit viable eggs before they die. The cocoa moth is more efficiently controlled by cleaning followed by spraying designed to prevent the larva reaching the moth stage.

As discussed in Appendix II, fumigation using a poisonous gas can be employed to kill all the insects in a whole room, or in a particular machine which would be covered with gas-proof sheeting. Such techniques can be extremely useful, especially in securing control rapidly in an area containing an excessive number of insects. It is, however, expensive and re-infestation can take place from outside the area fumigated quite rapidly. Alternatively, areas can be heated quite quickly by powerful mobile electric heaters to a temperature which will kill any insects present. If suitable equipment is available, this heat treatment, which obviates the risks involved in using a poisonous gas in the factory and can readily be applied to individual machines under a suitable screen, can be most useful but similarly provides no protection against subsequent re-infection.

So far, this discussion of infestation control in production workrooms has been primarily concerned with the Ephestia moths. There are several stored products beetles, described in Appendix I, which can infest confectionery factories. However, in general the hygiene methods described will also control these beetles effectively, although—because the beetles are more mobile than the moth larva—rather more emphasis needs to be given to heavy surface spraying with insecticide after cleaning in the areas in which they are found. In addition, greater care is necessary to ensure that the food residues cleaned out are disposed of by burning or other means without allowing any opportunity for the beetles to escape to cause further infestation.

There are several other pests which may be found in the factory and are of considerable hygienic significance, although they are not usually found in the finished products. Their habits and methods of control are detailed in Chapter III, but in general the necessary spraying and other control measures should be carried out by the same specialised staff as are employed for the control of the stored product pests.

Types of Workroom

The problems of securing effective insect control differ significantly in the various types of production workrooms involved in confectionery manufacture. Advantage should be taken of the varying ease of control, by arranging so far as possible that the different operations are separated, with the object of keeping infestation to a minimum at the most vulnerable stages, i.e. after the products have passed the last stage at which the processing will kill any insects present. Special care should be taken to keep the packing rooms as free from insects as possible, and storerooms for finished goods should be isolated as far as possible from the possibility of moths flying in.

Cocoa and chocolate manufacturing rooms are most liable to have moth infestations. The machinery involved is often difficult to clean properly and both spillage and food dust are difficult to avoid. Chocolate moulding and enrobing machinery is complex and often difficult to clean,

and temperatures are usually fairly high. Where the chocolate remains liquid there is no danger of insects, but this is only the case on limited parts of the machines. After the chocolate is set in the cooler, some advantage is obtained from the lower temperature. However, even in the coolers there are usually areas where chocolate dust collects and the temperature is high enough for slow development of cocoa moth larvae. It is desirable to screen the packing area from the moulding section to prevent moths flying into the packing section, and again although insect development may be slower there is a real danger from particles of chocolate accumulating in hidden places on packing machines, etc. The use of light lubricating oil on the moving parts of packing machines can be helpful in discouraging moth larvae.

Sugar confectionery manufacturing rooms can attract a variety of insects, depending on the ingredients used, but particular difficulty is likely to be experienced with cockroaches, which flourish in the warm and wet conditions found near boiling pans. Because these insects are much more mobile than the stored product moth larvae and beetles, their control requires somewhat specialised techniques, which are discussed in Chapter III. Where nuts are used, moths are likely to present similar difficulties of control as in chocolate manufacturing rooms, and in fact these moths are often associated with nuts. The use of flour for dusting purposes tends to encourage some of the small beetles.

In general, therefore, the production rooms offer the greatest difficulties in infestation control because the complexity of the machinery provides numerous places where food residues can collect and insects can develop undisturbed. This is especially true of the earlier stages of processing, when the products are usually not subject to risks of live infestation because the processes are lethal to insects. On the other hand, it is important to exclude insect bodies from the products; and, if there is an appreciable resident population of insects in these workrooms, it is very difficult to prevent them finding their way into the rooms where the later stages of manufacture and packing are carried out and the products are then very vulnerable to infestation. In addition to the danger of moths flying, there is a very real risk of infestation being present on trays and being carried on the equipment used to transport the products. Trays are a special danger, because partly grown moth larvae or beetles which have been feeding on residues in the corners of the trays can crawl on to the products in the trays, and can result in the product being infested with larvae which may develop to the breeding stage even during the time the product is held in the storeroom.

While, therefore, good buildings without holes in walls, etc., which allow pests, including rodents, to pass from one room to another, and suitable segregation of the more vulnerable manufacturing processes from the finishing and packing area are all important precautions in the continual problem of pest control, it is essential that control is exercised at all stages. The objective must be to keep the insects down to the lowest possible level at all stages of manufacture, and real success in infestation control requires the complete elimination of the pests, and the maintenance of precautions so that they cannot re-appear.

CHAPTER III

CONTROL OF PESTS OTHER THAN THE STORED PRODUCTS INSECTS

This booklet is primarily concerned with the so-called stored products insects. These are the moths and a few beetles which are adapted to living on relatively dry foodstuffs and which can, under suitable conditions, multiply on food to produce enormous numbers and cause serious losses. They can also feed on confectionery products and can result in products which appeared perfectly satisfactory when they were packed becoming spoilt in appearance and rendered most distasteful during their distribution. There are several other pests which may be encountered and which require somewhat different control measures because of their different habits. These are discussed in this chapter, but it should be noticed that, with the exception of mites, they differ from the stored products insects in being unable to feed and develop inside confectionery product packets which superficially appear to be undamaged.

Cockroaches

These are relatively large insects, often known as black beetles, black clocks or steam flies. They can run rapidly over considerable distances, as compared with the relatively immobile stored products insects. Cockroaches are primarily nocturnal, and spend the day hidden in cracks, behind cupboards, etc., their flattened bodies enabling even large cockroaches to use quite narrow cracks. They require warmth and access to moisture and food, but their mobility enables them to live an appreciable distance from their food supply. It is therefore impractical in a food factory to control cockroaches by the frequent removal of food and food residues, which is the basis of the control of the much less mobile stored products insects. Cockroaches rarely come out of their hiding places except at night when nobody is about, and it is easy for moderately heavy infestations to remain unnoticed. A heavy infestation produces a characteristic stale sweetish odour, and cockroaches are particularly objectionable because they are liable to contaminate the food they walk over, although it is rare to see obvious evidence of their feeding.

The main preventive measure is to eliminate the cracks and narrow gaps where cockroaches can hide. Well-finished solid construction of buildings without gaps below skirting boards, absence of cupboards with their backs close to the wall, and the mounting of machines, etc., well clear of the wall or the floor will make it difficult for cockroaches to become established. As already mentioned they prefer warm and damp conditions, and may become established some distance from any apparent food source. Boiler houses are often infested, damaged lagging on steam pipes may provide the insects with cover and they are often found under and behind sinks and in the neighbourhood of steam pans.

Cockroaches are readily killed by insecticide sprays. (For details see Appendix II, but for spraying against cockroaches in production rooms the pyrethrum type sprays are suitable and effective.) If an

infestation is found, the spray should be directed into all the apparent hiding places, and particularly upwards under sinks, tables, etc. It is preferable to use at least two electric sprayers which can maintain a steady spray and can approach from two directions. The spray causes cockroaches to run out of their hiding places, and there is a danger that they will scatter so rapidly that many will escape without receiving a lethal dose. In addition, cockroach eggs are laid in capsules, each containing about 15–40 eggs, depending on the species, and these are carried at the rear of the body of the female at first. These capsules are very resistant to the spray and even though the adult is killed the capsule may be shed and the young cockroaches hatch out subsequently. For these reasons, it is essential to be persistent in controlling an infestation of cockroaches. If many adults appear to have escaped, the area should be sprayed weekly until no more cockroaches are seen to be disturbed by the spray. Then the area should be sprayed at 4–6 week intervals to ensure that the newly hatched young cockroaches are killed. Otherwise the infestation can rapidly be re-established. In areas particularly liable to cockroach infestations, spraying should be carried out as a routine every 2 months to prevent re-establishment and to provide warning of their presence. Owing to their habit of avoiding light, it is possible for an appreciable number to remain unnoticed in an area with plenty of hiding places, and a pyrethrum spray is a useful means of checking whether they are present because it causes the cockroaches to run out of their hiding places. After spraying, all dead cockroaches should be swept up and burnt to destroy egg capsules.

Alternatively, insecticidal dusts can be used for cockroach control. These can be pumped into crevices or spaces in the fabric of the building and pyrethrum in the form of a dust will have a much more persistent effect in killing cockroaches than the spray. However, dusts present a greater hazard from the point of view of contaminating ingredients or products and must only be used where there is no possibility of contamination.

A continuous control of cockroaches can be provided by means of bands on suitable parts of the wall, floor or even in machines, which are coated with a persistent insecticide. This can be done by painting bands of insecticidal lacquer or by careful spraying of suitable insecticide. Unfortunately, the insecticides like dieldrin which are effective in this application have a high mammalian toxicity, although a more recently introduced insecticide, aprocarb, is less hazardous. Such bands must therefore be applied with great care in a food factory to ensure that there is no risk of contamination, such as by workers touching the surface. Applied to a suitable non-absorbent surface, these lacquers slowly exude the insecticide on to their surface, and this is picked up by cockroaches walking on the band so that they subsequently die.

The aim of this method of control is to provide sufficient bands of insecticide so that any cockroaches which find their way into the area are killed before they can start an infestation. The difficulty is to find sufficient areas which can safely be treated to maintain freedom from

cockroaches. Certainly, if an infestation becomes established the most rapid and safe way of eliminating it is by means of the pyrethrum type sprays.

Silverfish and Firebrats

These are two primitive, wingless insects which, although much smaller than cockroaches, can run rapidly over short distances. The silverfish requires moderately damp conditions and the firebrat considerable warmth. Neither are usually serious pests, but they can be a nuisance and are difficult to eliminate because they continue reproducing over a long life and any which escape treatment will maintain the infestation.

The firebrat is confined to hot areas, such as around ovens, and will feed on flour and crumbs. Silverfish are not found in really dry rooms and are more often met with in paper stores and sometimes in offices. They will feed on paper and especially on glues and pastes such as are used in bookbindings or for wallpaper. Silverfish commonly hide in cracks and under skirting boards during the day and emerge at night to feed.

Good construction of buildings, etc., to eliminate cracks where insects can hide, and cleanliness to avoid a plentiful supply of food particles are the best preventive measures, coupled with the avoidance of slightly damp conditions to discourage silverfish. Infestations can be dealt with by repeated pyrethrum spraying, and where they can be used safely, dusts or insecticidal lacquers could provide longer-lasting control.

Flies and Wasps

A variety of flying insects may enter the factory buildings. Few, if any of them, will breed inside the factory but some, including wasps at the end of the summer and flies, may be looking for food. The main danger is that such flying insects may become trapped in the food which is being processed and lead to contamination of the product with the dead insect. They cannot remain feeding on confectionery to produce an infested product as can the stored product insects.

Flies breed in damp and usually decaying vegetable or animal matter. Their numbers can be reduced by keeping the area round the factory free from damp refuse, and it should be noted that certain small flies can breed in dirty external drains. Maintenance of a high level of hygiene around the factory can, therefore, reduce the number of flies. If there are rubbish tips in the vicinity, they can be treated with insecticide to curtail the breeding of flies. Suitable representations should be made to the local authority.

Wasps are only a problem during the late summer and early autumn, when the 'worker' wasps are produced in vast numbers and feed on sugary materials. Most wasps nest in holes in the ground, but some make their nests on such places as the rafters of a roof, among piles of timber or on small trees and bushes. Since they forage as much as half a mile from the nest, it is difficult to effect control by finding and destroying the nests, although it can be useful to eliminate nests in the immediate

vicinity of the factory. This can be done by pouring 4 fl. oz. of carbon tetrachloride or tetrachloroethylene into the entrance hole to the nest in the ground and then plugging it with turf or soil, or, if in a building, by the liberal application of an insecticidal powder to the nest entrance where the wasps land.

Ideally, flying insects should be kept out of the factory by screening windows. Wasps are excluded by a one-eighth inch mesh, and in a large building such a mesh can most usefully be applied to rooms which are particularly attractive to wasps. However, it is virtually impossible to keep them out of a factory altogether, especially where there is syrup to attract them close to doors which must constantly be opened, although the provision of a screened vestibule and a second set of mesh doors will reduce the number still further. The ideal arrangement is to have forced ventilation drawing air through filters and exhausting at a distance from the room.

Flying insects are readily killed by the pyrethrum type sprays and the aerosols are convenient to use. Unfortunately, however, any such insecticidal treatment raises the problem of the dead bodies. There may be occasions when considerable numbers need to be dealt with by spraying and then all foodstuffs and containers must be covered and the bodies swept up. Systems such as the aerosols which automatically discharge a puff of insecticide every 15 minutes, or the hanging strips of plastic containing dichlorvos, would be attractive for controlling flying insects. But in addition to the undesirability of having even small traces of insecticide regularly present in the air, this problem of ensuring that the dead bodies do not fall into the foodstuffs being processed will usually prevent such systems being used. Further, such systems are not effective in rooms where powerful extractor fans maintain a rapid change of air.

The units which attract the insects by black light fluorescent tubes and kill them by electrocution, such that the bodies fall into a trough, overcome this difficulty of the dead bodies. They provide a useful means of reducing the numbers of flying insects but usually do not destroy more than a proportion of those entering, and cannot be used in dusty areas where there is an explosion hazard.

Wasps can be trapped in containers of syrup, with a small opening designed so that the wasps fall into the liquid. However, while considerable numbers may be caught in such traps, they rarely make any significant reduction in the numbers of insects present, most of which will feed on the sugary foods present in preference to entering the traps.

Bees can present a similar problem of control to wasps and less can be done to destroy their nests. Unless local beekeepers can be persuaded to site their hives at a greater distance from the factory, control must be based primarily on screening to prevent their entering the factory.

The control of flying insects in factories is difficult to achieve. Flies should not appear in appreciable numbers, and if they do then breeding places should be found and suitably treated. While all flies require damp situations for their larvae, the various different kinds of flies, ranging from fruit flies to blue-bottles, have different preferences and identifica-

tion of the type of fly can assist the search for their breeding sites. All the flying insects are more common in summer, and particularly the late summer and early autumn, and wasps are confined to quite a short season. Screening, provided it can be done effectively, is the best preventive measure in the factory and it is unfortunate that it is mainly required at the time of year when restriction of ventilation is least acceptable.

Pharoah's Ants

The various garden ants rarely penetrate far into buildings and will not usually require any control measures in factories, but there are two ants of tropical origin which are adapted to living in warm buildings. These are the minute Pharoah's ants, which are now very widely distributed in buildings in this country, and the somewhat larger Argentine ant, which has a characteristic and most active movement, but is only occasionally encountered.

These ants live in nests, which are usually hidden in the fabric of the building, and such small cavities as light switches have been used. Worker ants radiate for considerable distances in search of food and water. Pharoah's ants can use almost any edible material, and when they start feeding on a piece of food it becomes surrounded by numerous ants and there is a trail of ants taking food back to the nest as well as ants coming out from the nest to the food. In spite of their small size, the many ants can remove an appreciable amount of food and, for example, a box of chocolates left near to a nest can be largely eaten out by these ants. They often prefer the centres to the chocolate coating, with the result that in time the chocolates can be left with a small hole through the coating and the centre completely hollowed out. The ants cannot continue living as a colony if separated from their nest, so that if the box of chocolates is removed the many ants inside will gradually leave the box in trying to find their way back to the nest, and after a day or two there may be nothing left inside the box to indicate what has hollowed out the chocolates.

If ants are found in the factory, and it is usually the trail of ants moving in both directions along a band up to $\frac{3}{4}$ inch wide that is noticed, the only real control is to destroy the nest. As with wasps, the 'worker' insects are produced in such large numbers that even when very many of the workers are killed more will be produced in the nest and will maintain the infestation.

Nevertheless, some measure of control can be maintained by repeated spraying with pyrethrum of any ant trails that are seen, especially if this is coupled with maintaining the building in good condition without cavities in the walls, behind tiles, etc., in which the ants can nest. It is often possible to trace the trails back to the locality of the nest and sometimes it is sufficiently accessible to be destroyed.

A better method of eliminating the ants, which must be applied with special care because it involves the use of relatively poisonous insecticides, is to attempt to surround the nests with bands of persistent insecticides. The dieldrin lacquers are suitable for painting on non-porous surfaces,

or either this insecticide or aprocarb can also be sprayed, preferably from an aerosol. The object is to place the bands on the walls, etc., such that the ants' trails must cross them in order to reach their food, and the ants are then killed by the insecticide which they pick up in crossing the bands. Such bands of insecticide can remain active for about a year, and if sufficient suitably sited bands are placed the ants can be eliminated. However, the placing of the bands must be restricted by the need to avoid any danger of contaminating the products, even by the possibility of operatives touching the band and then handling the products.

A useful method of determining the extent of infestation by Pharoah's ants is to place a number of baits in the area. Scraps of raw meat or liver are suitable in a confectionery factory. The number of baits with ants clustered around after 24 hours will provide a clear guide to the extent of infestation, and observation of the trails extending from them will provide guidance as to the locality of the nests and where the control treatments should be applied. The numbers of ants can be reduced by plunging the baits with the adherent ants into boiling water. It is also possible to use baits which have been poisoned, but this method is not suitable for use in a food factory except possibly where the most stringent precautions can be taken against product contamination.

Mites

These pests, more closely related to spiders than to insects, are almost too small to see without a lens, but can be detected by the slightly brownish powdery deposit which may be seen when they are present in large numbers and which can often be seen to be moving due to the presence of live mites. They are primarily a pest of cereals, flour and products like custard powder, but may also attack a wide variety of foods including milk powder. They produce a characteristic sour odour and, for example, products made from mitey flour have an off flavour and may not rise properly.

Mites are rarely a problem in the confectionery industry, because they require moderately damp conditions with relative humidities between 75% and 85%. However, some ingredients may during storage provide the conditions in which a few mites can multiply to produce a significant infestation. If a mite infestation is found, it is important to deal with it immediately and to take precautions against spreading the infestation. Heavily infested ingredients should be burnt, the affected area carefully swept and the sweepings burnt, and then the whole area should be sprayed with a pyrethrum insecticide of the type containing piperonyl butoxide, since the synergist is even more effective than the pyrethrum against mites. Lightly infested ingredients, especially if the mites are only superficial, can be used through a suitable process provided there is no adverse effect upon flavour, but it would be desirable to fumigate the ingredient to avoid any danger of mites escaping in the production department.

Rodents

Rats and mice are objectionable in food factories and stores because of the physical damage which they can do, and even more because there is a real risk that they contaminate food with their excreta and with

harmful bacteria, which may include food poisoning bacteria. Rodent control must be applied continuously, because the danger of rodents entering the factory is always present. Brown rats are ubiquitous and especially in autumn attempt to find their way into buildings. The abundance of food in confectionery factories and stores is attractive to them. Black rats, which are more dangerous as carriers of disease, are more restricted in their distribution in this country, but because of their even greater climbing ability than brown rats they can be more difficult to exclude and to control once they have gained entry. Mice also are found everywhere but are less mobile than rats, and they are probably more often brought into factories with ingredients, packing materials and machinery. Their habits make them even more difficult to control than rats and they will be discussed separately.

The main preventive measure against rodents is the maintenance of all the buildings in a rodent-proof condition, as indicated in Chapter IV. It is essential to restrict the ease of entry of rodents in order to be able to make the control measures applied within the buildings sufficiently effective. Clearly, however, the factory and stores cannot remain closed all the time, but fortunately rodents do not move about much during the day and hence, provided doors are effectively closed at night, comparatively few should find their way into well-built and maintained premises.

Rat Control

Rats are comparatively large animals and move about freely. They are dependent on having a source of water which they can drink. Consequently, if a store can be closed at night so that rats are unable to enter or leave, and all water in the building is made unavailable to them, rats will not remain in the building. But it is sometimes very difficult to find and close the hole through which they go out to drink after feeding within the building.

In production rooms, it may be more difficult to eliminate available water, and particularly in larger buildings, which it is impractical to maintain in a fully rodent-proof condition for a variety of reasons, including the need for doors to be open for access, it is essential to maintain precautions against the occasional rat which may find its way in.

This can be done by maintaining rat traps at strategic positions near to probable entry points. Break-back traps are suitable and should be baited with a different type of food from that which is available in quantity. Rats are not especially attracted to most confectionery ingredients or products although they do like nuts, and a food like cheese will generally draw them to the traps. It is essential that the traps are set carefully and placed in the positions where experience has shown that rats tend to walk, and that the traps are maintained daily. The cheese baits should be replaced before they become dried out and hard. If there is any evidence of rats being present, and this can take the form of observation of droppings, damage to goods, and actual sighting by workers, then additional

traps should be set in the area until they have all been eliminated. Flour dusted on to the floor, or french chalk, can be used to see by the footmarks where they are running. Rats tend to continue to use the same paths and this information can assist the siting of traps and the finding of any entry points. However, traps should not be moved continually because rats are wary of new objects. Instead, the existing traps should be left in position and additional traps placed in the pathways. If trapping is unsuccessful, care should be taken to ensure that the traps are set sufficiently delicately to spring easily and different baits should be tried, including pieces of kipper, sausage rusk and even such things as fresh tomato. But in general reasonably fresh cheese is the more reliable bait for both rats and mice. If a rat is successfully avoiding the traps, it can often be caught by a sticky board coated with rat varnish, especially where it is known to be passing through a doorway and the board can be placed across the opening.

These trapping methods have the great advantage that they do not involve the introduction of poisonous materials into the factory and stores, with the attendant risks of contamination. When applied with skill and regularly maintained in a reasonably rodent-proofed building, trapping methods can be extremely successful, even in large factories, in maintaining freedom from rats.

The alternative method is the use of poison baits. Rats in most areas are readily killed by an anti-coagulant poison known as warfarin. If they eat this bait regularly for about a week, their blood loses its ability to coagulate and they die from haemorrhage. Although warfarin has a similar effect on other animals and on humans, the danger to them is reduced because they are unlikely to continue eating on successive days a sufficient quantity of accidentally contaminated food. For this reason warfarin has been regarded as a relatively safe rodenticide and, particularly in stores, baits containing warfarin can be placed for any rodents which may find their way in. Regular inspection of the baits enables the extent of the infestation to be judged from the amount of bait taken.

Warfarin poisoning can be an effective means of controlling rats, and has the advantage that the bait is continually available without the need for almost daily inspection which is necessary for effective trapping. It can be applied by less skilled personnel, but it does not prevent the rat causing damage during the few days before the poison takes effect, and problems may arise from the rat dying in an inaccessible place. The risk of contaminating foodstuffs can be reduced by placing the bait in specially designed baiting boxes instead of open trays. It must be recognised that the rodents themselves are liable to scatter the bait. Warfarin baits can now be obtained in small plastic sachets which rats appear to accept as readily as the bait itself. The use of these sachets much reduces the risk of accidental scattering of the poison and obviates the need for the operator to handle the bait.

In some areas, rats have developed resistance to warfarin. Where this has occurred it is especially desirable that trapping methods are employed in food factories, otherwise control would have to be based on the use of acute poisons which are much more dangerous to humans. Such poisons are discussed in the literature cited in Appendix III and should only be used with the strictest precautions to avoid any possibility of contamination of food.

In addition to maintaining control measures in the factory and stores designed to deal with the occasional rat which finds its way in, and also to provide warning that rats have succeeded in entering, it is desirable to maintain control outside the factory and especially in such places as river banks where brown rats are likely to breed. The objective is to kill all rats before they can reach the factory or stores. While suitably sited traps can be effective outside the buildings, in such positions where the danger of contaminating food does not exist freer use of warfarin and of the various other more dangerous poisons can be made. It should also be noted that, where rats are breeding on land outside the factory area, the co-operation of the local authority can be sought to obtain control.

In the last few years, it has been claimed that ultra-sonic noise is disliked by rats, and various units are available which are designed to produce this noise in buildings and thereby prevent rat infestations developing. A difficulty in stores is that the stacks of ingredients themselves provide a shield against the vibrations, but practical experience has demonstrated that rats in some areas at least are quite undeterred by the ultra-sonic vibrations even where there is no question of any shielding effect.

Mouse Control

Mice are considerably smaller than rats, are less dangerous as carriers of disease, although they can be carriers of food poisoning bacteria, and are much more restricted in their area of movement. Largely because of this, they are much more difficult to control in food factories and stores than are rats. They are much less dependent on an available source of drinking water, and appear to be able to obtain sufficient moisture even from apparently dry foods. They are able to live inside stacks of many ingredients, feeding and breeding there without coming outside the stack. This means that in a store, or even in a factory where there is a lot of cover in the form of trays, idle machinery, etc., a serious mouse infestation can build up before their presence is realised.

Proofing of buildings is desirable in mouse control, although gaps must be even narrower to exclude mice than will suffice for rats, but perhaps of greater importance is the soundness of the building construction, without cavities and spaces under the floor boards, and the elimination as far as possible of cover for mice. Even complete rodent proofing will not in practice exclude mice, because they are liable to be brought in with ingredients, packing materials, machinery,

returned containers, etc. Hence it is particularly important to limit as far as possible the places where they can hide. Mice can find cover among equipment, stacks of trays, etc., which are in use, but it is the material which is not being turned over at all frequently that is the more serious danger, since there is time for breeding and infestations may develop to serious proportions before they are noticed.

The best method of controlling mice, once they have got into a building, is by trapping. As for rats, the recommended type is the break-back trap baited with cheese, although other baits can be tried but should be different from the food available to them. Moist baits may be especially attractive, since mice living on dry foodstuffs will have difficulty in obtaining sufficient water. And it is especially important to set the traps accurately so that a slight pressure will release them.

Some traps should be maintained, and inspected at least every second day, in all vulnerable areas. Wherever signs of mice are seen, the numbers of traps should be greatly increased. Because of the very restricted movement of mice, traps should be as close as a yard apart for an intensive treatment of an area, and then it is sometimes found that the bait is unnecessary, as many mice being trapped in unbaited as in baited traps. The siting of the traps is a matter of considerable importance, both from the point of view of placing the traps where they will be noticed by the mice and of avoiding the traps being damaged by the normal work. It is, of course, desirable to secure the co-operation of those working in the area and in some cases the main trapping may have to be done at week-ends.

It must be recognised that even this intensive trapping with large numbers of traps may have to be continued for some time to eliminate an infestation where the mice have plenty of cover. Many will not come out of stacks of ingredients and will not, therefore, be exposed to the traps. It will sometimes be necessary to move the stack of ingredient in which mice are living, or the equipment which is providing cover, in order to bring an infestation under control reasonably rapidly. When the cover is being removed, as much of the adjacent space as possible should be cleared and the escaping mice dealt with. Such localised infestations can also be eliminated by fumigating the room, or the stack of ingredients under gas-proof sheeting, in the same manner as is done for insect infestations.

The sticky boards coated with rat varnish which were mentioned under rat control are particularly useful against mice. An infested stack can be surrounded with the boards, both to prevent the mice moving away and to reduce their numbers Suitably placed sticky boards can be a useful supplement to traps in eliminating the occasional mouse which has gained entry. Particularly in dusty areas, the surface must be renewed at intervals to maintain its effectiveness.

The poison, warfarin, can also be used against mice but is less effective in controlling mice than rats. Mice are less sensitive to warfarin, and because it is their habit to nibble a little food here and

there they often do not eat sufficient of the bait on successive days for the poison to act, whereas this habit of feeding increases their vulnerability to traps. Nevertheless, the convenience of attempting control by the placing of numerous poison baits results in the method being used especially in stores, but precautions must always be taken to prevent contamination of food. Moreover, there is the advantage that, with regular inspection of the baits, warning of the presence of mice is obtained by the disappearance of some of the bait.

Like rats, in some areas mice have developed resistance against warfarin. An alternative poison is alphachloralose, which is also used for narcotising birds. This poison acts by reducing the body temperature of the animal and if sufficient is eaten mice can be killed. However, it is only effective under cool conditions and is virtually useless against mice in rooms where the temperature is above 70°F (21°C). While alphachloralose is a less dangerous poison than the acute inorganic poisons, it must only be used with strict precautions against the possibility of contaminating food.

Rodent control should, therefore, be based on prevention in the sense of providing buildings and equipment which prevent as far as possible the entry of rodents, and of making the surroundings as unattractive as possible by limiting the availability of water and providing a minimum of cover and potential breeding places. Food is necessarily available in abundance, but because the foodstuffs in confectionery provide a somewhat restricted diet, the foods brought in for employees' snacks can be particularly attractive to rodents. Care should, therefore, be taken that any remains are properly disposed of and are not allowed to become an attraction for rodents. In addition, continual control must be applied in all vulnerable areas, to ensure that warning of the presence of rodents is obtained as early as possible. Wherever rodents are known to be present, intensive measures must be taken to eliminate them.

While these animals are intelligent, and some skill and experience is required for their control, too much attention should not be paid to stories of their cunning. Most will behave in a predictable manner, and the rat finding its way into a building is likely to be caught easily in a well placed trap, especially if it is a young rat. Mice also are readily trapped, provided they move far enough to come to where the traps are placed. There is little or no evidence that special care is needed to use clean traps which have been handled with gloves, except for protection of the operator. The use of poisons is an easier way of attempting to control rodents than is trapping, which requires more frequent attention, but all poisons are undesirable in a food factory. Further, poisoning and fumigation involve the problem of the dead bodies of the rodents, which may die in inaccessible places and become a source of insects, including flies, and of unpleasant odours. In practice, poisoning is a less effective method of eliminating mouse infestations than the intensive use of trapping, and the control of rats should not present much difficulty in reasonably well maintained buildings.

Birds

Birds, particularly sparrows, may enter buildings to feed or for nesting and roosting purposes. Obviously they are undesirable in a food factory; their droppings, as well as being unsightly, can contain food poisoning bacteria, and their nests can harbour stored products insects. Unfortunately, once they become accustomed to entering a building they can be very persistent and it can be difficult to exclude them—lofty rooms, and especially stores, encourage birds and where the doors are high and kept open much of the day, as is usual in stores, there is nothing to hinder their entry.

The best preventive measure against birds is to close all the entry points. Windows can be screened with $\frac{1}{2}$–$\frac{3}{4}$ inch mesh, all holes in the walls must be closed and the gap which used often to be left in stores between the roof and the top of the walls needs to be sealed. Closing of entry points must be thorough, because sparrows will continue to enter through quite small openings, such as through ventilators. Doors constitute a greater problem because of the need to open them during the day when birds are active. Double doors can prevent them flying through, and an air curtain or hanging strips of plastic across the doorway can greatly discourage them. It may be possible to close the upper part of lofty doorways and this will discourage entry.

Where proofing against entry is impracticable, it is difficult to take effective measures against birds. Their ease of entry should be reduced as much as possible and they can be further discouraged by preventing nesting within the building. This involves preventing access to horizontal ledges and to hollow spaces behind false ceilings, etc. Often in stores the rafters provide suitable ledges, particularly at the eaves, which can be enclosed or made unsuitable by filling in with sheet metal or plywood at an angle of 45°. In addition, possible perching sites should be reduced, although in stores, for example, the ingredients themselves are likely to provide plenty of resting places. The elimination of nest sites is particularly important, and better than the necessity to remove nests regularly, because birds can be extremely persistent in continuing to go to their nests, and will overcome a degree of proofing which would deter them from starting to enter. Moreover, it is probable that the young reared in the nests will continue to return to the building even after they leave the nest.

Scaring devices are of very little use in buildings. Birds very rapidly become accustomed to most types, especially those which are suitable for use in a building. Ultrasonic scarers have been advocated, but many users have observed sparrows merely using the units as additional perches. Some very limited success has been claimed for revolving amber lights. The use of bird distress calls has little effect on sparrows.

Temporary relief can be obtained by using narcotic baits. This can only be done under licence from the Ministry of Agriculture, Fisheries and Food, although some servicing companies are licensed to carry out the treatment. The narcotised birds are collected, the protected species released, preferably at a distance, and the species officially classified as

pests destroyed. However, unless the proofing against entry is considerably improved, more birds are likely to have returned within three or four months. It must also be recognised that the bait is poisonous, considerable numbers of baits will have to be exposed and will be liable to be scattered by the birds. Stringent precautions would have to be taken to avoid any danger of contaminating food.

Birds can also be trapped and the pest species destroyed, but where they have easy entry into the building it is difficult to reduce the numbers sufficiently by this means. Moreover, trapping arouses resistance from employees, especially because trapped sparrows become vicious and attack one another.

The widespread liking for birds makes their control particularly difficult. Employees will often encourage birds to come to the vicinity and even into buildings by feeding them, and will sometimes attempt to frustrate any apparently cruel methods of control.

It is, therefore, best to base bird control on the preventive measure of proofing buildings against entry and, where this cannot be made fully effective, by eliminating nesting sites rather than by destroying the nests as they are built. In stores, it may be necessary to protect ingredients by covering stacks with moderately heavy gauge polythene or other suitable sheeting.

CHAPTER IV

BUILDINGS AND MACHINERY DESIGN AND INSTALLATION

Infestation should be controlled by the application of hygienic measures based essentially on cleaning. Especially in production workrooms, such measures are much more difficult to carry out effectively and more expensive unless the buildings and the machinery are designed to facilitate the necessary cleaning, and to eliminate as far as possible the hidden cracks and corners where food can lodge and infestation can develop unnoticed. The physical surroundings play a big part in infestation control, and even in existing factories there is a great deal that can be done in the way of modifications to facilitate effective cleaning.

It is proposed in this chapter to indicate the ideals which should be aimed at, and which would, if attained in practice, greatly simplify the task of infestation control. While it is hoped that the main principles will be made clear, it is not intended to point to every detail of construction and machinery design. As regards machinery and factory equipment, two useful booklets going into considerable detail are available from BFMIRA, entitled *The Design of Machinery and Plant in Relation to the Control of Insect Pests* and *The Installation of Machinery etc. in Relation to the Control of Insect Pests.*

Buildings

The design and construction of buildings should avoid all cavities, within walls, floors and ceilings. Such cavities provide hiding places for pests, especially rodents and cockroaches. If in the course of time foodstuffs find their way in, these cavities can provide a breeding ground for insects which it is almost impossible to reach by any means short of a major building operation in order to secure control. Walls and floors should therefore be of solid construction, and if impervious facings are required, such as tiles or sheet metal guards, they must be firmly seated without any spaces underneath. Tiled walls appear superficially to be most hygienic and can readily be cleaned down, but in practice often cover small cavities in which the minute Pharoah's ant can nest and from which it can be extremely difficult to eradicate.

Horizontal ledges should be reduced to an absolute minimum, and should be made accessible for regular vacuum cleaning. In larger buildings such as stores, where birds are liable to enter, it is important that there should be no ledges on which sparrows can build their nests.

All buildings should be made proof against rodent entry. This involves eliminating all gaps wider than a quarter of an inch which are accessible to rodents, suitable sealing of the roof at the eaves, and suitable design of drains. Specialised advice on rodent-proof construction is available in the literature cited in Appendix III. Maintenance is important in this connection, and all holes in walls made for pipes, etc., must be properly sealed.

Corners should all be rounded. For example, right angle joins between the wall and the floor are difficult to clean properly.

Surfaces should all be smooth and free from holes and cracks where dirt can collect and insects can hide. The surface should be of suitable material for the wear it will receive, so that it will remain smooth and non-porous, and where appropriate should withstand washing.

Suitable screening of windows and the provision of double doors or an air curtain system will be desirable in some instances to exclude birds and also flying insects such as wasps and flies.

Fixtures such as sinks, pipes, electric wiring, switches, etc., should ideally be fitted flush to the wall such that they remain sealed and no gap develops. Alternatively, they must be offset a few inches so that the space between the fixture and the wall can be effectively cleaned.

Maintenance of buildings requires continual attention. Alterations and movement of machines result in holes and crevices, etc., which need to be promptly filled in and the surface finished smoothly.

Machinery

It is comparatively easy to specify what is required of machinery design, but much less easy to obtain many of the specialised types of machines in which the designers have paid as much attention to the requirements of hygiene as they have to the performance and output of the machine. Because the machines are actually handling the foodstuffs,

it is particularly important for the effectiveness of infestation control that they should not cause undue spillage, splashing or dusting of food and that they should be readily cleanable. Ideally, there should be a minimum of spillage, ready accessibility to every part, and a minimum of ledges on which food residues can collect and an absence of crevices in the machine or between the machine and the floor. There are few machines which cannot be improved in these respects and some which leave a great deal to be desired.

As far as possible all surfaces should be rounded. Tubular metal, provided the ends are sealed, is preferable to angle iron. A good welded joint is always easier to clean than one clamped by nuts and bolts. Where ledges and bolts are essential in castings they should be on the outside where they can be cleaned readily and the less accessible inner surface should be smooth. Crevices in joints between metal members should be avoided. The ends of conveyor rollers should be sealed.

Chocolate machinery which operates at a sufficient temperature to keep the chocolate liquid will not be a problem for infestation, but there are usually outlying parts where the temperature is low enough for rapid insect development. At the other end of the scale, chocolate coolers are cold enough to discourage insects. But there are usually places near the periphery of the cooler where the temperature is high enough for insect development and which are reached by the particles of chocolate which always become dislodged in coolers. The old fashioned construction of cool boxes from tongued and grooved boarding was particularly dangerous because effective cleaning of the innumerable crevices was almost impossible. Such equipment should be made with smooth surfaced panels which are readily removed to allow full access to the conveyor machinery and really effective cleaning.

It is helpful if gearing can be completely enclosed to prevent the entry of food residues. In addition, the use of oil mist lubrication is an effective way of preventing insect breeding.

The use of light colours is advantageous in enabling the presence of food residues to be seen easily, particularly in the less accessible parts of machinery.

Special attention needs to be paid to the mounting of machinery and electric motors, etc. The equipment should either be sealed down so that there is no space, not even a crack, below or else should be mounted on rounded legs sufficiently high that there is free access for cleaning right under the machine.

The design of electrical equipment, including motors, starters and even light fittings, is most important, because food residues accumulate in any spaces and can support insects.

As well as reducing as far as possible the spaces and ledges where food can collect, and eliminating the crevices which are virtually impossible to clean properly, the aim of machinery design and installation should be to provide easy accessibility to all parts of the machine. Guards should be designed so that they can be removed readily when the machine is stopped for cleaning, so that the cleaning personnel can do an effective

cleaning job and are not dependent on having a fitter in attendance. As well as providing accessibility, machines should be designed so that the food residues can be effectively removed. It is not sufficient to be able to reach the bottom of a cool box, if there are angled corners from which it is virtually impossible to remove the chocolate residues.

Fittings

Cupboards are undesirable in having corners which are difficult to clean, and perhaps more important because things tend to be overlooked in cupboards, and forgotten foodstuffs may form a focus of infestation. Supervision is facilitated by the use of open mesh doors which allow easy inspection, but as far as possible the cupboards should be replaced by racks or shelves whose construction is as open as possible, providing few or no places where food can collect. Racks, consisting simply of a framework on which equipment can be placed, are preferable to shelves. The latter should be designed to avoid corners which are difficult to keep clean and should be placed so that there is a space between the shelf and the wall.

Tables should be of clean construction, avoiding hidden ledges. The old fashioned metal covered wooden table is a particular danger because food tends to find its way between the metal and the wood. Cockroaches are particularly well adapted to living in such tables.

Trays are another source of danger. The wooden types always have corners or crevices out of which it is impossible to remove food debris, and which provide breeding sites for insects. Trays should be of one-piece metal or plastic construction with rounded corners so that they can be readily cleaned effectively.

Trolleys and bogies are liable to include corners and spaces where dirt collects. They should be designed for easy cleaning.

In practice, factory buildings, machinery and fittings vary a great deal in the extent that they approach these ideals. It is found that the more the places where foodstuffs can lodge and are difficult to clean can be reduced, and many can be eliminated by relatively simple modifications, the easier it is to maintain control of infestation and the more effective the control. There is no way, apart from frequent room fumigation or heat treatment, whereby insects can be reached in some of the inaccessible corners where foodstuffs collect in poorly designed or mounted machinery. Insecticidal spraying will only affect some of the insects near the surface. Consequently, design and maintenance of buildings and equipment is an essential factor in infestation control; however carefully the plant is cleaned and sprayed to control insects, the physical surroundings will exert an important influence on the level of control which can be obtained. It is most desirable, therefore, that the problems of infestation control are fully taken into account at the design stage, and that those concerned with this control have an effective means of securing modifications, improvements and repairs, the need for which will continually be becoming apparent to them, in order to enable control to be more effective.

CHAPTER V

HANDLING AND STORAGE OF INGREDIENTS AND PACKING MATERIALS

The confectionery industry uses a wide range of raw materials, many of which are attractive to insects and other pests, and some of which, while not providing food, offer suitable harbourage for pests. Some raw materials may be brought from almost every part of the world, and are liable to be exposed to a variety of types of infestation before they reach the manufacturer. While the aim should be to receive all the raw materials in an infestation-free condition, and to protect them from infestation during storage, so that the factory can be supplied with its raw materials free from infestation, this ideal is not yet possible for many commodities. Consequently, while the control of infestation in raw materials should be based on hygiene, such methods alone are not always sufficient. For example, cleanliness alone cannot eliminate the insects which are already present in a consignment of many tons of nuts. While the aim should be to buy raw materials in an insect-free condition, and this can be obtained with some commodities, the handling and storage of many raw materials must be based on the expectation that they will contain infestation.

Purchasing

Every effort should be made by buyers to obtain raw materials which are free from infestation. Appropriate specifications and representations to suppliers will assist, but it will in some cases be desirable to investigate the conditions of production and transport of raw materials and make appropriate recommendations. Care is, however, necessary that, in attempting to control infestation, suppliers do not make unsuitable use of chemical control, and there may be circumstances where it is better to accept some degree of infestation, which is in general harmless to health, in preference to subjecting the raw materials to chemical treatments which may involve a risk of leaving harmful residues.

Many raw materials are vulnerable to infestation at various stages between their initial production and their arrival at the factory. Some, such as nuts, can start to become infested as soon as they are harvested, others, such as cocoa beans, during the drying on the farm after the primary processing or fermentation which is carried out by the grower. The bags in which such produce is packed constitute another possible source of infestation, which can be controlled by the use of new or recently sterilised bags. The stores in the country of origin are liable to harbour infestation, which should be controlled by good hygiene and suitable insecticidal treatments, especially when the store is empty of food materials. Shipping involves a serious risk. Holds should be cleaned and treated to kill all infestation prior to loading, but even when this is done there is often a serious danger of cross-infestation resulting from insects migrating from other commodities which are being carried. After unloading in this country, infestation may take place from barges or vehicles used for transport, or during storage.

There are many possible stages at which raw materials can become infested, and in making effective representations to suppliers it is often necessary to attempt to determine where the fault lies. Small samples such as are normally provided for buying purposes will not usually reveal the extent of any infestation present, and it is essential that consignments are inspected for signs of infestation both on the surface of the bags and in the foodstuff as early as possible, preferably prior to delivery, and not later than the stage at which the raw material is being taken into the manufacturer's warehouse. The kinds of insect present, their ages and distribution can reveal a good deal about the source of the infestation.

It is necessary to carry out such an examination of all consignments of raw materials, not only to enable appropriate representations to be made, but also so that suitable precautions can be taken to prevent infestation brought in with ingredients forming a source of infestation in the store or causing deterioration of the ingredients.

It is, of course, difficult to control infestation in large stacks of raw materials which are held in store for many months. Such stacks provide excellent harbourage for rodents, and even a few insects which might not be detected in the examination on receipt can under suitable conditions multiply to form a significant infestation. The buying policy can, therefore, make a further contribution to infestation control by keeping the stocks in store as small as is practicable and endeavouring to avoid storing the commodity for as long as the life cycle of its main pests. Such a policy can usually be applied effectively for ingredients such as flour, which is produced by the millers throughout the year, but may be less effective with seasonal commodities like nuts or cocoa beans. It should in most instances be better, from the aspect of infestation control, for such ingredients which have to be stored for up to twelve months to be stored under the control of the manufacturer rather than that the necessary infestation control be left to the supplier. Nevertheless, the aim of purchasing should be to avoid unnecessarily long holding of stocks, and it should be recognised that excessive buying when prices are low may not be economic if the materials have to be held in store for so long that they deteriorate.

A further point which should be watched is that, if relatively small quantities of special grades of raw materials are required, it can be easy for an excessive stock position to be reached. This can lead to small stacks remaining in the stores for an excessive time, and these are liable to develop into dangerous sources of infestation for the main commodities which are being stored for a reasonably short period.

Storage Conditions

Raw material stores should be soundly constructed buildings, built and maintained according to the principles detailed in Chapter IV. In particular, the buildings should prevent any entry of dampness either from rain or through the floor, and there should be a minimum of cracks and crevices. Special attention should be paid to preventing the entry of rodents, and the presence of any water which they can use for drinking should be eliminated. The construction should prevent the entry of birds,

and because such stores often require their relatively large doors to be open much of the day, it is particularly important to avoid the presence of possible nesting sites in the roof. Once sparrows start entering a store for the purpose of nesting, it is extremely difficult to keep them out.

The floors of ingredient stores should be swept regularly to keep them clean, and whenever a stack is removed the floor area should be thoroughly cleaned and if necessary sprayed to eliminate any residual infestation before fresh ingredients are brought in. Washing is in general undesirable in an ingredient store, and if it is necessary great care must be taken that the bases of adjacent stacks are not wetted and the area is thoroughly dried out. Cracks in floors are a special danger, because food particles are liable to be brushed into them and allow insects to breed there even when the store is empty. Where there are cracks and ledges in the store, vacuum cleaners should be used to remove dust and debris.

Raw materials should, from the point of view of infestation control, be stored at as low a temperature as possible. In general this means, in this country, storage in unheated buildings. Winter temperatures, particularly in the northern half of the country, are sufficiently low to inhibit the activity of most insects, and can cause some of the tropical insects to die out in commodities like cocoa beans. For some purposes, stores which can be heated will be required, usually in order to control the humidity or to prevent condensation when the materials are brought from the store into the warm factory. Although the maintenance of very dry conditions can exercise considerable control on the development of infestation, in general it is more economic to heat ingredient stores to only a limited extent, and if temperatures between 55°F (13°C) and 60°F (16°C) are maintained the rate of insect development will not be unduly rapid. It is then better to use heating systems such as hot water pipes or low voltage electric strip heaters where a relatively large surface is maintained at a moderate temperature, rather than the fan heater system where air is blown over a small high temperature surface. The latter system is liable to result in greater variation in temperature, with hotter areas where insects may breed more rapidly.

Containers and Stacking

Many foodstuffs are received in sacks. In the past jute sacks have been most commonly used and still are for cocoa beans. They have advantages for stacking and sampling and will withstand rough handling. But they encourage rather than discourage infestation. Insects can readily pass through the bags, rodents use the fibres for nesting, and insects often pupate on the sacks. However, it is comparatively easy to see whether infestation is present in a consignment packed in jute sacks. In addition, fumigation is effective through jute.

The comparable more hygienic containers made of paper or plastic are difficult to stack safely to similar heights, but offer a considerable barrier to the entry of insects and fumigants. However, their effectiveness as a barrier to insect entry depends on their sealing. The heat sealing of plastic can be effective, but insects can enter through the holes made

when closing by stitching. Moreover, while a sealed bag provides useful protection against cross-infestation, it cannot prevent insects which entered with the ingredient from developing. Further, fully grown larvae moving away to pupate and also some beetles can penetrate most papers and plastics. All bagged produce is vulnerable to rodents, which are able to gnaw their way into all such containers, and the spaces between the stacked bags afford convenient hiding places for the rodents.

Cartons are rarely proof against insects or rodents and the corrugations in cardboard afford ideal sites for insect pupation. Tins are proof against rodents, but are rarely entirely effective against insects; on the other hand, drums are usually well sealed.

All materials should be stored in stacks which are not unduly large and with gangways which allow access all round the stack. Preferably these should not be less than 18 inches wide. No goods should be stacked against walls.

It is preferable not to use stillages or battens because they allow easy access for rodents to the centre of the stack, and provide further sites for insect pupation or where insects can remain on the stillage ready to infest the next stack built on to them. If porous or damp floors are unavoidable, sheets of heavy gauge polythene can be used to prevent damp entering the material, but they must be carefully cleaned after use to remove any insects.

Types of Raw Materials

The commodities most subject to infestation are those which provide a reasonable balance of nutrients. Nuts in bags are most prone to infestation because they are attractive to a variety of insects and to rodents, and many come from temperate and sub-tropical regions where they may be infested with insects better able to survive in our climate than the insects from the tropics. Nuts are also particularly vulnerable to infestation because they are often used whole and any appreciable insect feeding can seriously reduce their quality, even if they can be effectively cleaned. Because nuts are both attractive to insects and provide a suitable source of food, infestations can develop rapidly on them, causing serious damage as well as being a dangerous source of infestation for other commodities in the store.

Cocoa beans are liable to carry a wide variety of insects, but because many of them are of tropical origin these tend to die out in unheated stores in the winter, especially if located in the northern part of the country. However, they may also become infested with insects better adapted to the conditions, and cocoa beans must therefore be treated as being vulnerable to infestation and as a potential source of cross-infestation. Rodents are less attracted to cocoa beans and do not usually feed on them unless they have become contaminated with palm kernels or palm oil. They will readily use the bags and the cover provided by the stacks for nesting.

Sugar and fats are rarely used as food by pests because they do not provide adequate nutrition. But the containers may provide harbourage

for insects or nesting materials for rodents. For example, cardboard boxes containing blocks of cocoa butter have been known to contain many beetles, which were not apparent on the outside of the container but were present in considerable numbers between the wrappings.

Flour and milk powder are both extremely attractive to insects and can support a variety of beetles and moth larvae. However, these semi-manufactured materials should be virtually free from infestation when produced and, provided their storage time is restricted to a few weeks, there should be no opportunity for the development of infestation.

Ingredients like dried fruit and desiccated coconut can support a variety of insects. Because of the difficulty of cleaning such foodstuffs to remove any insects present, it is particularly important to purchase them in an insect-free condition and to store them in such a way that they will not become infested.

Some raw materials like gum arabic are not in themselves attractive to infestation but may be contaminated with seeds or other materials which do form a suitable food supply. In this way, such materials which do not attract infestation can both bring infestation into the stores and be a source of cross-infestation.

Liquid ingredients such as sugar syrup, condensed milk and fruit juices do not provide suitable conditions for the stored products insects, and because they need to be transported in sealed containers they are not exposed to infestation. However, if spillage or leaking occurs, a variety of pests, including flies and wasps, may be attracted. It is, therefore, important to clean away any such spillage.

Packaging materials are, of course, less attractive to infestation than are foodstuffs. Nevertheless, some insects such as silverfish are sometimes found on paper and board, and mice can be brought in the containers with packaging materials. Inspection on delivery is therefore desirable, and because in general packaging materials are used on the finished goods without any treatment which will eliminate insects, it is most important to ensure that no stored products insects can find their way on to or into packaging materials while they are held in store. Consequently, packaging materials should be stored quite separately from ingredients and preferably in different stores, which should be more like the finished goods store than the ingredient store for cleanliness and freedom from infestation.

Further, it should not be forgotten that equipment like crated machinery which is brought into the factory is a further possible source of infestation. Rodents, and particularly mice, are not infrequently brought into factories in incoming goods, and machinery crates usually provide plenty of space. Previously used machinery which still contains food residues is, of course, a dangerous source of insects, and should always be carefully inspected before bringing into the factory.

Control of Infestation in the Store

The operation of raw material stores to control infestation begins with the inspection of all incoming goods to determine the extent of

infestation on them. Provided there is no significant indication of infestation, the consignment can be suitably stacked in an already cleaned area. It is desirable to store similar types of raw materials together, and to keep as separate as possible ingredients like cocoa beans which are rarely entirely free from insects, and those like dried fruit or desiccated coconut where the presence of any insects is particularly undesirable.

If a moderate level of infestation is found, steps should be taken to minimise both the damage to the ingredient and the possibility of the insects infesting other goods or becoming established in the store. If there are appreciable insects on the surface of the bags or other containers, these should be brushed to remove the insects before they are brought into the store. The ingredients should be stacked as far away as is practicable from the other more vulnerable ingredients, with adequate space all round the stack. Crawling insects can be prevented from reaching other goods by surrounding the stack with a suitable barrier consisting of an insecticidal band which can be in the form of a powder, or a band of sticky material can be used, provided it will not become coated with a layer of dust which would render it ineffective. Some measure of control of moths can be obtained by regular spraying with a suitable insecticide (see Appendix II), directing the spray in between the bags. This will make a contribution by killing some of the insects which emerge on to the surface of the bags, but will do little to control the insects within the bags. Probably the best method of dealing with an odd consignment of moderately infested goods is to use it immediately through a process which will involve cleaning and insect killing, and thus avoid the problems of preventing cross-infestation and further damage to the ingredient.

When a heavy degree of infestation is found, consideration should be given to the possibility of rejection of the consignment. Where this cannot be done, it will usually be necessary to fumigate the consignment, preferably before it is brought into the store, or alternatively the stack should, as soon as it is built, be covered with gas proof sheeting and fumigated *in situ*. Fumigation is the only method whereby insects inside a consignment of materials like nuts or cocoa beans can be killed without taking them out of the bags. The only alternative is to use off the consignment immediately through a process which will effectively deal with the insects.

While it is always necessary to take precautions against cross-infestation when a consignment showing signs of infestation is received, and this will be particularly necessary when the insects are on a relatively unattractive commodity which they will readily leave, the level of infestation at which immediate usage or fumigation is necessary will depend on the commodity involved. Nuts which are to be used whole must be dealt with to prevent loss of quality, whereas a moderate level of infestation will have relatively less adverse effect on cocoa beans. Again, commodities like desiccated coconut which cannot be cleaned to remove small insect bodies must be specially protected against infestation.

The operation of the store should be directed to maintaining cleanliness, removing food debris from cracks and crevices, and avoiding any

accumulations of materials including surplus packing materials and odd rejected bags of ingredients in which infestation can hide and multiply.

Rodent control must be exercised continually, whether there is any sign of rodents or not, and desirably must be maintained outside the store as well as inside. Details of rodent control methods are given in Chapter III, but when warfarin baits are used, if these are examined monthly on a hot plate they will also provide an indication of the presence of insects.

A raw material store inevitably contains large quantities of foodstuffs which remain undisturbed for considerable periods. These are the conditions which favour infestation and especially rodents. Precautions must, therefore, be maintained continually in order to prevent infestations developing. It can be extremely difficult to bring under control an infestation which has developed in an ingredient store. In addition to the inspection of goods on receipt, there should be a regular inspection of all ingredients at intervals during their storage, and appropriate action should be taken whenever undue signs of infestation are seen.

Finally, precautions should be taken to avoid infestations or other contamination being brought into the factory with the raw materials. Bags or other containers should be inspected and if necessary brushed before delivery to the factory. Any damaged bags should be checked for the presence of rodents or their nests.

Bulk Handling

The handling of ingredients in bulk involves some additional considerations in infestation control. In general, the problem of cross-infestation is reduced or eliminated when the material is transported in sealed containers. Rodents also should not present any problem in suitably designed bulk handling systems. On the other hand, large quantities of material are handled together and if there is a failure in control the damage may be proportionately large. For example, the development of a heavy infestation in a large storage silo may damage a large quantity of material, and could be extremely difficult to control unless the silo was designed for fumigation.

Liquids such as sugar syrup and fats present few difficulties, although care is necessary to ensure cleanliness of the inlet pipes, etc. Flour and other powdery materials can with advantage be handled in bulk, but freedom from infestation depends largely upon the standard of hygiene of the suppliers. Effective inspection is more difficult than with bagged materials, and the presence of infestation may only be found after the use of the consignment is started. Suitable sieving arrangements are essential.

If bulk storage of raw materials which are liable to carry infestation like cocoa beans or nuts is adopted, it would seem necessary to fumigate prior to storage or to design the silos for fumigation *in situ*.

In general, bulk handling should simplify the problems of infestation control, but because of the increase in the quantities of material at risk and the reduction in the scope for inspection and the adoption of simple ameliorative measures, special care should be taken both in the design of bulk handling systems and their operation to prevent the possibility of infestations developing.

CHAPTER VI

HANDLING OF FINISHED GOODS

The precautions outlined in the previous chapters, and particularly in Chapter II, should result in the products being free from infestation. As has already been pointed out, it is important to wrap the products as soon as possible after completing their manufacture, and to move the wrapped goods into the storeroom with a minimum of delay. This is to reduce the risk of any infestation which may be present in the production rooms from reaching the finished products. At this and subsequent stages they are especially vulnerable to infestation in the sense that there is no treatment, apart from prolonged storage at 45°F (7°C) and the rather expensive procedure of fumigation, neither of which is fully effective in all the circumstances, which can be used to prevent insects that succeed in reaching the products from feeding and growing on them to give rise to a justifiable complaint from the consumer who purchases the product.

It is, therefore, vitally important that the conditions in the storeroom and during subsequent distribution are kept free of infestation in order to prevent infested products reaching the consumer. This is the stage when instances of infestation are most serious in their consequences. The only additional precaution which can be taken is to provide wrappings which prevent the entry of insects to the product.

Storeroom Conditions

It is relatively easier to maintain the storeroom for finished goods in an insect-free condition than ingredient stores or production workrooms. No infestation should be brought in with the products, and because they are all packed there should be no danger of particles of food finding their way into cracks and crevices to support a resident infestation. Nevertheless, active precautions should be taken to maintain this position.

The storeroom and its fittings should be designed and constructed in accordance with the principles outlined in Chapter IV to allow effective cleaning and the elimination of places where foodstuffs can accumulate. The possibility of the operatives hiding the remains of products which have been sampled should not be forgotten.

The storeroom should be isolated from the factory and ingredient stores to prevent insects finding their way in. Screening of windows or air inlets might be needed where the storeroom could not be placed at a sufficient distance.

A low temperature is advantageous in retarding insect growth and activity, and at temperatures of about 45°F (7°C) very little insect growth takes place, and some insects, such as the moths, will not survive more than a few weeks. However, such a low temperature is expensive to maintain and may not be suitable for all products, and may require care to avoid condensation on the products when they are taken out of the store. While temperatures as low as 45°F (7°C) may not be desirable for other reasons, any reduction in temperature will assist insect control.

Foods should not be held in the storeroom for unduly long periods, such as would allow a moth larva which found its way on to a product in the production workroom to complete its development and infest other products. Goods should be despatched in date order, and special care should be taken to avoid overlooking any products, or the holding in store of remnants of discontinued lines for long periods pending decisions as to their disposal.

The storeroom should be kept clean and free from any accumulations of materials on which insects could develop or in which rodents, particularly mice, could hide.

Moth traps of the syrup or water tray type can be useful as indicators of the presence of moths in any locality of the storeroom. They should remain entirely free of moths. If any moths are found, an intensive search should be made in the area to locate the source of infestation. All goods suspected of being affected should be removed from the storeroom.

Routine spraying with insecticide should not be required in finished goods storerooms. However, if any infestation is found, and especially if beetle infestation develops, surface spraying of the affected area would be an added precaution after thorough cleaning had been carried out. If the construction of the storeroom leaves cracks, etc., which have collected food debris that cannot be cleaned out, then regular spraying could be a useful precaution.

No returned goods of any type, including advertising material and empties, should be brought into the storeroom. There is always a danger that such material may carry infestation.

In short, the storeroom should be constructed to facilitate real cleanliness, and should be so operated that no infestation is brought in to it, and no foods remain long enough for infestation to develop to become a source of insects which can attack other goods. Because of the relative ease with which a room used only for packed goods can be kept clean and free from particles of food in cracks, etc., and because no infestation should be brought in with the products which are stored, it ought to be possible to keep the storeroom free from infestation. It is especially important to achieve this aim, because products which become infested at this stage will be distributed to the consumer in this condition.

Insect-Proof Wrappings

Protection against infestation of finished goods can be provided by suitable wrappings which cannot be penetrated by insects, and such protection has the great advantage of being effective until the product is unwrapped. If this protection can be given by the actual wrapping of the unit which is sold to the consumer, then full protection is provided until the product is opened by the consumer.

However, in practice it is not easy to make the normal wrapping of confectionery proof against insect entry. Insects are able to eat their way through most papers and packaging films. The newly-hatched larvae of moths and beetles are very small indeed and are remarkably active. They are capable of finding their way through the most minute holes. It has

been demonstrated that the young moth larva can pass through a hole which is only seven-thousandths of an inch in diameter. They are capable of entering even round tins by passing up the small groove left by the seam. They can find their way along the minute passages which are most difficult to avoid in the angle of the fold of many papers and films even when care is taken to seal the folds as fully as possible.

In practice, it is impossible to achieve completely insect-proof wrapping on all the units packed in any acceptable type of confectionery wrapping applied in an economic manner with modern wrapping machines. But while perfection may be unattainable, a great deal of protection can be obtained from packaging. In general terms, the more wrapping and the better the sealing of the wrappings, the greater the difficulty which will be experienced by insects in entering, and this will be reflected in a reduction in the number of packages entered by insects under similar conditions of exposure to infestation.

While it would not be appropriate to attempt to discuss the technology of packaging here, it may be noted that the heavier heat-sealed foils and some of the compound films are virtually proof against insect penetration and, provided the package can be fully sealed, a high degree of protection against infestation can be obtained. Such wrapping is more suited to the various bars which are produced, but will not always be appropriate on grounds of appearance or cost. Cartons and boxes are more difficult to protect in a satisfactory manner, and the transparent films are relatively easily penetrated by insects. Nevertheless, it is found that a well sealed transparent film wrap on a rectangular box does in practice result in a substantial reduction in the number of boxes entered by insects. It is possible to improve the sealing of tins by means of adhesive tape, but because of the difficulty of avoiding slight folds in the tape, it is doubtful whether in practice the slight improvement in resistance to insect entry justifies the additional cost.

In general, it is found that all measures to increase the effectiveness of sealing, either by heat sealing or by the use of adhesives, contribute to proofing against insects, but completely effective proofing against insect entry is virtually impossible to achieve in all the packages. A comparatively recent development offers protection in another way. Insecticidal coatings based on pyrethrins can be added to paper or board. These remain effective for some months so that any insect walking over the coated surface is killed. These coatings are relatively expensive but can offer another means of obtaining a degree of protection, although it cannot be claimed that they will under all circumstances prevent insect entry.

Transport

Finished products must be transported from the storeroom to depots and wholesalers and thence to the retailers. Similar considerations apply to the vehicles, either road or rail vehicles, which are used for this transport as to the storeroom itself. It is essential that they do not provide a source of infestation for the products which they are carrying, and by attention

to cleanliness it should be possible to achieve this. Certainly there should be no danger of goods being overlooked for months in the corner of a vehicle.

On the other hand, there are practical difficulties in ensuring cleanliness and freedom from insects in vehicles, the main function of which is to load and transport with a minimum of delay. It is desirable that both the road and rail vehicles are used solely for the transport of finished packed goods. They should be inspected carefully, before they are taken into service, for cleanliness and suitability, and while in use should be cleaned regularly and desirably sprayed thoroughly or fumigated once or twice a year. They should not be used for returns, and if this is necessary the returned materials, empties, etc., should be placed in one corner which is cleaned after each use. This area should be sprayed more frequently.

Railway wagons are often of unsuitable construction from the infestation point of view. Wooden floors above a metal shell may allow foodstuffs to enter the space between. It may be virtually impossible to clean this space, and if the wagon has previously been used for comparatively poorly packed food material such as animal feeding-stuffs, this space may be a dangerous source of a variety of insects. Linings to the sides of the wagon may also enclose spaces where infestation can develop unnoticed.

If it is essential to use vehicles which may be used for other purposes, outside the control of the manufacturer, there is an even greater need to inspect the vehicle carefully before it is loaded and if necessary to clean and spray it thoroughly before loading with finished goods. The vehicles used for distribution of finished goods should never be used for the transport of ingredients, unless they can be really thoroughly cleaned before being used again for finished goods.

Distributors

Wholesalers and retailers provide the last stages in the distribution of confectionery to the consumer. Lack of care in insect control at these stages can undo all the care and expense of the manufacturer in producing insect-free products, if it results in the confectionery under the control of the distributors being allowed to become infested before it reaches the consumer. The principles discussed for the design and operation of the storeroom apply to both the wholesaler's store and the retailer. However, it is appreciated that there will often be circumstances where it is more difficult for the distributors to attain the desired practice to secure freedom from infestation. The following are the main points to which attention should be directed:

1. The warehouse or stockroom, and the retail shop, should be designed and constructed to facilitate easy cleaning, and to avoid as far as possible cracks and crevices, particularly in the floor or on shelves, etc., where food particles can lodge.

   Cupboards are difficult to keep effectively clean, and steel shelving with a minimum of joints, etc., is preferable to wood. Shelving is

better placed in the middle of the room with gangways all round. If it must be placed near the walls, a gap should be arranged so that no stock touches the wall, and there is a space for any debris to fall from the back of the shelf to the floor where it can easily be removed by sweeping or preferably with a vacuum cleaner.

Floors should be smooth without cracks, such as are found between wooden boards, to allow easy and effective cleaning.

Shopfittings and counter display units should be designed and placed so that there are no cracks or crevices where particles of food can collect and allow insects to breed.

2. The temperature of the storeroom should be kept as low and as even as possible. While some heating is desirable to avoid excessively high humidities in winter, it should be designed to avoid unduly hot spots close to the heaters, and combustion stoves like paraffin heaters are undesirable because they actually increase the humidity. It is much easier to maintain even conditions in a storeroom which is a part of a larger building and without any of its walls or roof exposed to the weather.

3. The aim should be to achieve a rapid turn-over of stock with the shortest practicable storage time. Obviously this will be difficult to achieve with varying rates of sale of the different lines held. Nevertheless, great care should be taken to rotate the stocks carefully, always using the oldest stock first. Special attention is necessary to ensure that a few boxes do not always remain at the back of the shelf while the new stock is placed at the front. If insects find their way into such confectionery that is overlooked, perhaps for many months, they can breed there and form a source from which the newer stock becomes infested.

   If stock of particular lines is found to be stored for an abnormally long time, it should be inspected carefully at intervals for signs of deterioration, and it would be wise to take special measures to dispose of it while it is still in a satisfactory condition. It is better to take precautions to prevent stock which is out of condition reaching the consumer than to have to offer replacements to dissatisfied customers.

4. The rooms where confectionery is held should be cleaned regularly and thoroughly. Vacuum cleaners are better than sweeping, and special attention should be paid to cracks and corners where it may be necessary to use stiff brushes or scrapers to dislodge the dirt. In the retail shop, special attention should be paid at frequent intervals to the area around the weighing scale and anywhere else where loose sweets are handled. The danger there is that particles of food are liable to be broken off and accumulate in any cracks or crevices where insects might then be able to breed. Indeed, the conditions here are more akin to those in the factory in that it is impossible to avoid some particles of food being available, and consequently the conditions are more favourable for insects, and the precautions against them need to be more rigorous than in areas where only packed goods are handled.

5. Care should be taken to keep all returned goods in a separate area, and to dispose of them as soon as is possible. If returns are known to be infested, special care should be taken to prevent the insects leaving the returned goods and reaching the stock.
6. If any signs of infestation are found in stock, it is essential to clear the whole area which is affected. Infested stock should be disposed of by burning or appropriate return as soon as possible, and the whole area cleaned very thoroughly. Where practicable, washing can be more effective in destroying infestation than vacuum cleaning, but care must be taken to dry the area thoroughly. Cleaning may also be supplemented by insecticidal spraying, but great care must be taken to use a safe insecticide which will not contaminate other stock in any way. Details of suitable insecticides are given in Appendix II. Following such an outbreak of infestation, other stock which was apparently not affected should be examined at intervals for signs of insects to ensure that the outbreak has not spread more widely than was at first thought.
7. Special problems will arise in the case of distributors who handle other foods as well as confectionery. Many of the stored products insects are at times found on various different foods, and infestations which develop on other foods may spread to attack confectionery which is stored nearby or which is placed on the shelves from which the other food has recently been removed.

   It is probable that this happens comparatively often in the case of spider beetles, which prefer powdery foods like flour, soup powders, semolina, etc., and rarely present any difficulty in confectionery factories. There has been an increasing tendency for chocolate products damaged by this beetle to be returned by consumers, and the products affected have usually been an abnormally long time in distribution.

APPENDIX I

NOTES ON THE BIOLOGY OF THE MAIN INSECT PESTS

1. The Moths

In common with many insects, moths pass through four stages during their life history. These are the egg, the larva, the pupa and the adult moth. The minute rounded pale coloured eggs hatch out to produce larvae about a week to a fortnight after they are laid. The larval stage is the only one in which food is eaten. These moth larvae are soft bodied, creamy coloured, cylindrical grubs with three pairs of legs towards the head end and four pairs of fleshy prolegs nearer the hinder end. Their droppings, technically known as fras, are characteristically shaped as little cylindrical pellets coloured by the food being eaten, and the larvae also produce silken threads, which may coat much of the food being eaten, and often result in a typical appearance of droppings dangling

from the threads. The full grown larva spins a cocoon, similar to the silkworm's cocoon although much smaller and less complete, in which it changes into the pupal stage where the transformation takes place into the adult moth. The moth can emerge about a fortnight later.

The moths do not feed and are quite short lived. They are capable of flying and their function is to mate and distribute their eggs which are usually laid within about 10 days after they emerge from the pupal case. Although moths do not feed, they take some water, if it is available in the form of a wet surface rather than liquid water which traps those that alight on it, and the availability of water allows a higher proportion of their eggs to be capable of hatching.

The Cocoa Moths

Two different kinds of moth which look very alike are generally known in the confectionery industry by the name cocoa moth, although one of them is also known in another industry as the tobacco moth. These are *Ephestia elutella* to which the name cocoa moth is sometimes restricted and *Ephestia cautella*. More recently it has been suggested that *E. elutella* which is found mainly in the temperate regions should be called the warehouse moth, and *E. cautella* which is found on cocoa beans arriving from the tropics should be called the tropical warehouse moth. In view of this difference in the occurrence of the two cocoa moths it is not surprising that there is evidence that the warehouse moth is more often found at the distribution stage of the industry in wholesale and retail premises, whereas the tropical warehouse moth is more characteristic of cocoa bean stores and chocolate factories.

Both the cocoa moths are small grey coloured moths, a little larger than the common clothes moth, and with two zigzag bars across the forewings which are not always easy to see. They live for only about 10 days, mate very soon after emerging from the pupal case, are most active in flying around dawn and dusk, and dislike draughts. The females lay up to about 200 eggs, usually in groups of a dozen or so, and prefer rough surfaces and draught free conditions. Most of the eggs are laid within a week of the moth emerging. While there is some evidence that the moths are attracted by the smell of chocolate, it is also true that eggs are laid indiscriminately and have even been seen scattered across the tops of biscuit tins as though shaken from a pepper pot. Under natural conditions the minute pale coloured eggs are extremely difficult to find.

Between a week and a fortnight later, under warm conditions the time is shorter, minute larvae hatch from the eggs and begin to wander actively. This wandering is initially quite instinctive and may result in the larvae leaving a suitable source of food. Nevertheless, this is the stage at which the larvae, often emerging from eggs laid a little distance from a source of food, must find their way to a suitable source of food if they are to survive. It often seems that the larvae of these moths are attracted to such foods as chocolate and especially to nuts, and in practice some larvae do succeed in finding their way through quite well sealed packages to reach suitable foods, although

no doubt many fail to do so. The newly hatched larvae can live for some 56 hours before starting to feed, and do not seem to start feeding during the first 30 hours even if food is available to them. They can wander as much as 3 feet from the egg and their heads, the only hard part, measure 7/1,000ths inch across. It has been shown that they can get through holes of this size.

While a considerable proportion of newly hatched larvae die from desiccation, especially in draughty areas, or from starvation because they fail to find a suitable food supply during this first wandering phase, those that do succeed then start feeding and growing and remain relatively immobile. If undisturbed on cocoa beans or chocolate and under summer conditions of temperature, the larvae feed and grow for about 8 to 10 weeks until they are about $\frac{3}{8}$ inch long. At this stage the characteristic black spots on the abdominal segments are easily seen at the base of the sparse hairs. The presence of these larvae on food can also be recognised by the characteristic mixture of silken threads and fras (the insect droppings) which they leave behind.

The fully grown larva ceases to feed and starts to wander again, usually in an upward direction, in search of a suitable crevice in which to spin its cocoon and turn into the pupal stage or chrysalis from which the moth will later emerge. These larvae are now able to chew their way through paper and foil, and even cardboard, to leave their feeding site, and have been known to climb as much as 60 feet to find a suitable crevice in which to pupate. A variety of sites may be used including corrugated cardboard, the neck of sacks, and in shops a common site is in shelving or at the top of the wall where it meets the ceiling. In the cocoon, the larva changes into the pupal stage in which the transformation into the moth takes place. Under summer conditions, the moth can emerge to mate and lay eggs to continue the cycle in about a week to ten days, but at lower temperatures the larva can remain dormant in the cocoon for a period which may be as long as several months in winter temperatures, and does not change to the pupal stage until it is warm enough.

In unheated premises, there are usually two generations during the summer with the main emergence of moths over a short period during May, but in heated rooms breeding is continuous, and under ideal conditions of temperature and food, for example nuts promote more rapid development than chocolate, the whole life cycle can be as short as eight weeks.

The Mediterranean Flour Moth (Ephestia kuhniella)

This moth closely resembles the two previous ones but is somewhat larger. It is primarily a pest of flour mills where the copious production of silken webbing by the larvae can cause difficulties. It is comparatively rarely encountered in the confectionery industry but is commonly associated with cereal products and nuts on which its larvae develop twice as quickly as they do on chocolate. Their habits and development are also similar to those of the cocoa moths.

The Rice Moth (*Corcyra cephalonica*)

This moth is sometimes brought into premises on goods from general warehouses and may become a nuisance on nuts or grain products in heated storerooms. It does not survive in an unheated store through the English winter. Its size is similar to that of the Mediterranean flour moth but it is much lighter in colour.

The Dried Fruit Moth (*Plodia interpunctella*)

This is a handsome moth about the same size as the cocoa moths but with the areas near the tips of the forewings reddish brown in colour. The larvae are yellow rather than white and do not have the spots at the base of the hairs. They grow to about the same length as the cocoa moth larvae but are much slimmer. They are normally associated with dried fruits and nuts but will feed on chocolate when these are not available.

The Brown House Moth (*Hofmannophila pseudospretella*)

This moth is also roughly the same size as the cocoa moths but it has speckled brown wings. Its larvae have a characteristic semi-transparent appearance with a large light brown head. This moth is cosmopolitan and will breed out of doors. It will infest grain products but requires a higher moisture content than is normally present in confectionery materials. It can, however, be of considerable inconvenience in food premises where a high standard of hygiene is not maintained.

It will be apparent from the much more detailed account given of the cocoa, or more accurately the warehouse, moths that they are the main moths likely to be encountered in the confectionery industry. However, the other four moths have somewhat similar life histories and habits, although they differ in details, and are likely to be met with from time to time. In addition, there are several other moths which may be encountered but are sufficiently rare that they do not warrant description here, and information about them can be obtained from the advisory organisations or from the literature.

2. Beetles

These insects have the same four stages of their life history as the moths, but they differ in that the adult beetle stage is a considerably harder bodied insect than the moths, and whereas the moth is short lived and does not feed, the adult beetle may live for months or even years and does feed. The larvae also differ in lacking the fleshy prolegs at the hinder end. Beetle infestations can be distinguished from moth infestations even in the absence of the insect because beetles and their larvae produce powdery droppings (fras) giving a dusty appearance, whereas the moth larvae produce characteristically shaped pellets and silken webbing. Most adult beetles have wings and are capable of flying but unlike the moths they only rarely fly at the temperatures encountered in this country.

There are a number of different beetles and their appearance and habits are more diverse than those of the moths. Only those which are likely to be met with more often are discussed here.

Spider Beetles

Australian spider beetle (*Ptinus tectus*)

White marked spider beetle (*Ptinus fur*)

Golden spider beetle (*Niptus hololeucus*)

Spider beetles, as their name implies, can easily be mistaken for small spiders. They are small brown beetles and are common warehouse pests, feeding on the food debris which collects in cracks in the floor, etc. *Ptinus tectus* is said to be the commonest beetle pest of warehouses in Britain, and this insect is tending to become more commonly seen infesting food products including confectionery although it is usually confined to those which have been abnormally long in distribution. Heavily infested food develops an unpleasant, characteristic sour odour. These beetles are very resistant to adverse conditions and can survive in very dry conditions or at temperatures below freezing point.

The female Australian spider beetle lays about a hundred eggs over a period of several weeks and these hatch into larvae which are initially very active, but on finding a suitable foodstuff they tend to burrow into it and remain feeding and growing there. The larvae are pale in colour, covered with short hairs and slightly curled. If taken from the foodstuff they generally curl into a ball and remain motionless. After about 7–10 weeks feeding, the larva is fully grown and usually comes to the surface of its food or the outside of sacks or boxes to form its rounded cocoon in which it pupates and turns into the adult beetle. The beetles tend to avoid light and wander about at night.

There are several other spider beetles in addition to the Australian spider beetle which is the one most commonly met with and which is described in the preceding paragraph. The others are generally similar, although they differ in details of the appearance of the beetles and their rates of development. Two other spider beetles which are quite common are listed above and some other kinds of this group of beetles may occasionally be encountered.

Flour Beetles

Confused flour beetle (*Tribolium confusum*)

Rust-red flour beetle (*Tribolium castaneum*)

These are small elongated beetles which may be found in a wide range of commodities, although they are more serious pests of cereal products and especially flour. The rust-red flour beetle is more often found on imported tropical produce, while the confused flour beetle is more likely to be found in warehouses in this country, and can feed on milk chocolate crumb. These two species of *Tribolium* are

rather alike in appearance, both being chestnut brown in colour, but the antennae of *T. castaneum* are distinctly clubbed at the end, whereas those of *T. confusum* widen continuously from the base to the tip.

Both the adults and the rather slim long larvae are likely to be found feeding in the same foodstuffs. The female may lay as many as 450 eggs over a period of many months, and the minute larvae which hatch out grow over a period of about 8 weeks until they are as long as the adults, i.e. about 3/16th inch. The pupae, in which the fully grown larvae change into the beetles, remain in the foodstuffs without the formation of any cocoon. While the beetles can live as long as two years, they may not survive the cold normally experienced in winter in this country.

Saw Toothed Grain Beetle (*Oryzaephilus surinamensis*)

This is an even smaller and slimmer beetle than the *Tribolium* beetles and has a similar slim larva. The name is derived from the serrated edge of the thorax, the section behind the head. It is so small that it is easy to overlook but it can be a troublesome pest of cocoa and chocolate under slightly damp conditions, of flour and starch dust, and of packaged food. The beetles are somewhat flattened and remarkably active and they are capable of penetrating many food packages. While they are not often found in confectionery distributed in this country, probably because they do not breed at temperatures below about 68°F (20°C), they are one of the commonest insects attacking confectionery exported to warmer regions. The saw toothed grain beetle is not primarily a pest of confectionery and is more often associated with cereal products. It is a comparatively rapidly developing pest with a larval period which may be as little as four weeks so that infestations with numerous larvae and adults can develop quite rapidly. The adult beetles are long lived like the *Tribolium* beetles which they resemble quite closely in their life history.

The Biscuit Beetle or *Drug Store Beetle* (*Stegobium paniceum*)

Another small beetle, but distinctly broader than the two described above and with a slightly curled larva, the biscuit beetle is closely related to the common furniture beetle. This may well be the reason for the characteristic appearance of round holes bored into the product which is seen on the rare occasions when this beetle attacks chocolate. It is more usually found on cereal products or, as is suggested by the alternative common name, on drugs.

Dried Fruit Beetles (*Carpophilus hemipterus* and *C. dimidiatus*)

These again are small beetles distinguished by their wing cases being slightly shorter so that the last two abdominal segments protrude behind, and the larvae which grow to be rather longer than the adult beetle have two harder brown processes called urogomphi at the rear end. They are usually found on dried fruit especially when it is sufficiently damp to allow slight mould growth. Their life history can be unusually short with a larval period of only 10 days.

Weevils

This is a large group of beetles distinguished by a snout-like prolongation of the head between the eyes and by larvae without any legs at all. Most of the weevils feed on growing plants but a few are important pests of grain. These include the two small grain weevils, *Sitophilus granarius* and *S. oryzae*, but they are rarely seen in the confectionery industry.

The Hide Beetles

Bacon beetle (*Dermestes lardarius*)

Khapra beetle (*Trogoderma granarium*)

This group of beetles prefers animal to vegetable food and requires a relatively high protein content. They are distinctly oval or rounded in shape, and their larvae are markedly hairy and usually have a tuft of long hairs at the tail end. The *Dermestid* beetles, of which the bacon beetle is most often seen, are relatively large, about 3/8 inch long, and on the rare occasions when it and its larvae infest chocolates they produce a very characteristic appearance with the transversely striped cast skins of the larvae and their peculiar fras in the form of long thin rods which readily break up into dust.

The *Khapra* beetle is rather smaller and is primarily a pest of grain. However, the beetles and their larvae belonging to this group may on occasions be found feeding on nuts, chocolate, etc., and one frequent source of these insects consists of birds' nests which they often infest. The larvae have the habit of boring into materials like wood for pupation.

The Mould Feeders

The Plaster Beetle (*Enicmus minutus*)

Cryptophagidae

Book lice (*Psocoptera*)

The first two mould feeders listed are small brown beetles which can be a nuisance where mould even in traces is available to them as a foodstuff. Damp cardboard, the glue on freshly made boxes, or even empty tins in store can support them. The *Cryptophagidae* include small brown insects which may be found occasionally in damp dried fruit, whereas the plaster beetle is more common on slightly damp packaging materials.

The book lice are included here because of their similar habits. They are not beetles and are a group of minute soft bodied insects little more than 1/16th inch long and without a larval stage. They are not uncommonly found on paper and board kept under slightly damp conditions.

3. Cockroaches

These are much larger more robust insects which are well adapted to living in warm buildings and can be serious pests of food factories. They

belong to one of the more primitive groups of insects, and have not evolved the quite distinct larval and adult stages shown by the moths and beetles. The eggs hatch into minute replicas of the adults known as nymphs which feed and grow, shedding their hard skins at intervals to replace them with a larger size. The adults differ in developing wings and it is only at this stage that they can breed.

The cockroaches differ from the above stored products insects in being highly mobile. They generally hide in cracks, behind cupboards, etc., for which their flattened bodies are well adapted, and only come out at night to feed on any sort of food material which may be available. Consequently, they are not usually found on foods and do not live in packaged foods, but if present in a room will emerge at night to nibble any food which they find.

There are two kinds of cockroaches commonly found in this country and a third cockroach which is said to be more common in ships and is occasionally brought in with raw materials.

Black Beetles or *Black Clocks* (*Blatta orientalis*)

This is a dark brown shiny insect about 1 inch long and $\frac{1}{2}$ inch broad when adult. The body is flattened and it does not climb well on relatively smooth surfaces so that it is more often found in crevices at floor level. As with all cockroaches, it has long powerful legs and long antennae. The adult female carries her eggs in an egg case (ootheca) which protrudes from the tail end of the abdomen. After it has its full complement of about 16 eggs, the case is dropped in a warm crevice where the eggs hatch into minute whitish replicas of the adult. Their skins soon harden and turn brown. These nymphs grow, moulting at intervals, until they reach the adult stage. Only the adult males have wings and they do not fly properly but may open their wings and use them more like a parachute.

The black beetle has a comparatively long life history with the nymphal stages lasting about a year, although under warm conditions this may be reduced to about six months, so that infestations of this cockroach build up comparatively slowly.

The German Cockroach or *Steam Fly* (*Blattella germanica*)

This is a distinctly smaller and slimmer insect, the adult being about $\frac{3}{4}$ inch long, and the colour a lighter more yellowish brown. They are extremely active and climb readily even on smooth surfaces and will often be found in crevices on walls or in ceilings. They are better adapted to living in modern centrally heated buildings although they require water and are often found around boiling pans.

The life cycle is similar to that of the black beetle but is distinctly shorter. At temperatures in the region of 86°F (30°C) the nymphal stage may last only six weeks, and with the several egg capsules, each containing some 40 eggs, which can be produced by every female, this means that infestations can build up to serious proportions quite rapidly.

The American Cockroach (*Periplaneta americana*)

This is a distinctly larger cockroach, about $1\frac{1}{2}$ inches long, which is said to be more common on ships but is only occasionally seen in this country. It appears to require rather warmer conditions.

The House Cricket

These are comparatively large insects somewhat similar in life history to the cockroaches and distantly related to them. They are rarely pests of factories but often live in refuse tips and may occasionally invade cellars and warm places like boiler houses. They are nuisances rather than food pests and can be controlled by pyrethrum spraying.

4. Silverfish

The Firebrat (*Thermobia domestica*)

The Silverfish (*Lepisma saccharina*)

These belong to another group of primitive wingless insects and do not have a separate larval stage. Their bodies are almost torpedo shaped, although somewhat flattened facilitating their hiding in cracks, and they grow to about $\frac{1}{2}$ inch in length. They can run very rapidly over short distances and generally hide during the day and come out to feed at night.

The firebrat requires very warm conditions and is darker brown and less shiny. It tends to be restricted to the neighbourhood of ovens. The silverfish is paler and shiny and requires damp conditions and can tolerate lower temperatures, although it will develop more rapidly under warm conditions provided they are not too dry. They can feed on predominantly carbohydrate food and the silverfish is often found feeding largely on paper and the glue of bookbindings or the paste used for wallpaper. As a result of their tolerance of lower temperatures, silverfish may be found in birds' nests.

These insects are long lived, up to a year or two, and may breed over a considerable period of their lives.

5. Ants

Pharaoh's Ant (*Monomorium pharaonis*)

Argentine Ant (*Iridomyrex humilis*)

Ants are a highly specialised group of insects. They form nests like bees and wasps in which the larger queen insect lays eggs which hatch into larvae. These are tended in the nest by the worker insects which collect food outside the nest. It is only the workers which are seen foraging, and since these are produced in large numbers it is possible to kill a great many of them without weakening the nest sufficiently to eliminate the infestation.

It is only these two kinds of ants which originated in more tropical regions which are at all common as pests in buildings in this country and they both require warmth. Pharaoh's ant is a minute sandy coloured insect less than an $\frac{1}{8}$ inch in length and is now quite common in heated buildings in this country and is very difficult to eradicate. The nests are often made behind tiles or metal facings and even in electric switches.

The worker ants radiate outwards from the nest in well defined trails and can carry fragments of food quite as big as themselves back to the nest. They can use almost any kind of food, but they do require warmth and some moisture.

The Argentine ant is somewhat larger and darker in colour and the worker ants show a characteristic bobbing movement. This ant is much less common than the Pharaoh's ant, requiring both warmth and rather damper conditions.

6. Mites

These are not insects but are more nearly related to spiders, having eight legs. They are minute in size requiring a lens to see them, and are primarily pests of cereals in which they require a moisture content of at least 12%. They require a moderately high humidity and thrive between 75 and 85% R.H. and can only tolerate a comparatively small deviation from this range.

There are a considerable number of different kinds of mites but only a relatively few species are pests of food. While they are more often found on cereal products they can feed on a variety of foods, and there are some species of mite which feed on other mites and others which are capable of causing dermatitis.

Mites are so small that the presence of a few would pass unnoticed and would be of little significance, but they are capable of forming an inactive hypopus stage which is resistant to adverse conditions. When the humidity and other conditions become favourable, mites can multiply rapidly and the large numbers produce a characteristic powdery dust which can readily be seen and can also be observed to be moving. For example, a hollow made with the finger in heavily infested flour will be seen to be filled up with the mites. They also produce a sour odour.

APPENDIX II

TECHNIQUES OF INSECT CONTROL

The application of hygiene methods to control insects has been explained in the appropriate chapters of this booklet. The purpose of this appendix is to explain the technical details of the use of the various methods whereby insects can be killed and which can be used to supplement the procedures which can broadly be described under the heading of good housekeeping. These supplementary methods have their place in the control of infestation, but if reliance were placed upon them in the absence of good hygiene they would be found to be both expensive and relatively ineffective.

1. Insecticides

One of the most useful supplements to cleaning is the use of insecticides. These are chemicals, usually in solution in oil, which kill insects with which they are brought into contact. After a machine with many

cracks and crevices has been cleaned, and the greater part of the food debris removed, a surface spray of insecticide can be most useful in eliminating any insects which have survived the cleaning. But such a use of insecticide is no substitute for cleaning, because food residues can protect any crawling insects present from the spray.

A wide range of insecticides is available, but most of the more recently developed insecticides are unsuitable for general use in a food factory because they were selected for their persistence. They are all poisonous to varying degrees, and persistence as insecticides means that their poisonous character may be retained in the foods. Fortunately one of the older insecticides, pyrethrum, which is a plant extract, has a powerful 'knock-down' activity and is not persistent under most conditions. Moreover, its poisonous properties are destroyed in warm blooded animals' stomachs, and consequently it is in practice a non-poisonous insecticide. Pyrethrum is therefore the insecticide used as a spray wherever possible in the food industry. A cheaper version containing piperonyl butoxide is claimed to be equally effective and to give better residual action. It is generally considered to be equally safe. These insecticides are normally used in solution in an odourless and tasteless mineral oil, but water-based emulsions can be obtained. In spite of their harmless nature, the insecticides should not be sprayed directly on to foodstuffs or on to the surfaces with which food products come into contact.

Equipment for Applying Insecticides

There are two different methods of using insecticidal sprays. They can be applied comparatively heavily to the vulnerable places as a surface spray designed to kill larvae and other crawling insects. This can be most valuable when used after thorough cleaning, and a paint brush can often secure the best application to the right spots. Alternatively, they can be sprayed as a mist to fill the air of a room. Such a mist will do little more than kill any flying insects and to be effective as a control measure needs to be repeated at very frequent intervals, preferably daily.

Spraying of small areas can be carried out using a hand operated sprayer. Suitable types include those where the pump is operated to produce the spray directly, or those which are pumped up in advance and the spray is released by means of a valve. Such hand sprayers can be adjusted for the fineness of the spray and can be used either for surface application or for very localised mist spraying. However, they are very laborious to operate for long periods, and are not suitable for large areas or where rapid spraying is required. For somewhat more extensive spraying and particularly for localised application of surface sprays, small portable electric sprayers are suitable. These generally consist of a small compressor unit feeding a spray gun by means of a flexible pressure tube. If mist spraying of larger volumes of air is required, the machines which produce a fine spray by means of a rapidly rotating disc are convenient, and for large scale spraying compressors and spray guns of the kind used for paint spraying can be used for both surface and mist spraying. In these sprayers, it is desirable to maintain an air pressure of at least 60 lb. per sq. in. in order to secure a fine spray, and in practical

application it is useful if the spray is carried on a moderately powerful draught of air to secure penetration into gaps, etc., out of the direct reach of the spray gun.

There are also the aerosol sprayers which are very convenient for local application, and especially for controlling the odd fly or wasp, but expensive for large scale use. Care must be taken to avoid using those containing a perfume which is likely to taint foodstuffs, whereas the smell of pyrethrum is not absorbed.

Other Methods of Applying Insecticides

Insecticides may be used in a variety of ways other than as a spray. Insecticide powders can be useful against crawling insects and particularly against cockroaches, but, even if the insecticide is restricted to pyrethrum, powders are less suitable for factory use because of the danger of contaminating food. One precaution is to colour the powder a distinctive colour such as blue, and care should be taken to remove all the powder after it has served its purpose.

Varnishes and paints can be applied containing insecticides which are gradually extruded on to the surface and remain toxic to any insects which walk over the surface. Persistent insecticides must be used for this purpose and the main one employed is dieldrin which has rather a high mammalian toxicity. More recently, the somewhat less toxic aprocarb has become available for this purpose. These are often used in the so-called two pot resin varnishes, and the theory is that while the surface remains toxic to insects the small quantity of insecticide which can be rubbed off would be harmless to man. The practice has been to apply these lacquers in bands designed to run across places where Pharaoh's ants or cockroaches move, and also to place them underneath machines, but always well away from any direct contact with foods. In such uses, lacquers containing dieldrin or aprocarb can be very effective in controlling crawling insects for periods of up to two years. It is, however, essential that the lacquer be applied to a suitable non-porous surface, and its use should be carefully controlled because of the toxicity of these persistent insecticides. A similar but less persistent film of insecticide can be obtained by applying these types of insecticide from an aerosol. This can be a convenient means of controlling these crawling insects over limited areas.

Other insecticides such as DDT and lindane have also been added to paints with the aim of making the whole painted surface toxic to insects. Many of these insecticidal paints have been ineffective due either to inactivation of the insecticide or failure to secure its extrusion, but recently claims have been made for a paint containing a very small percentage of lindane which could prove to be useful in some circumstances. The use of such an insecticidal paint on walls and ceilings could control flying insects like flies and possibly also wasps but may introduce a risk of contaminating the products with the dead insects. Moreover, care must be taken that there is no risk of the insecticide, which is both poisonous and persistent, reaching the product. Obviously the wide-

spread use of such paints which may subsequently peel or flake, increases the risk of contamination with insecticide; hence their use should be restricted at least to those areas where they serve a useful purpose, and they should not be used generally for decorative purposes.

There are also various means of securing what effectively amounts to a vapour of insecticide in the air. Automatic dispensers for pyrethrum aerosols are available and produce a puff of insecticide at intervals. These can control flying insects effectively and the insecticide is relatively safe. Means have been developed of vapourising DDT or lindane by little electric heaters, but it is now recognised that these lead to the possibility of undesirably heavy contamination. More recently plastic strips have become available which continuously release a relatively new insecticide, dichlorvos, into the air. These can be effective in killing insects but the desirability of work people constantly inhaling an insecticide or of the inevitable product contamination remains a little doubtful although it is claimed that they are safe to use.

Lastly, there are the various smoke generator methods of dispensing insecticide which are sometimes used in stores. Again the insecticide is one of the persistent chemicals, necessarily resistant to the heat involved in burning the smoke generator, and it is doubtful whether they have any advantage beyond some economy on the labour of application over the use of an insecticide spraying machine which can use the safe insecticide pyrethrum, and also has the advantage that the insecticide can be directed into the areas where it is required. It is often suggested that smoke generators can be used in place of fumigation because the fine particles of the smoke can penetrate into all the corners of the room. However, in practice the smoke does not penetrate appreciably into bagged produce such as cocoa beans, nor into the spaces inside and under machinery, as can the fumigant gases. In addition, it is found even after a room has been most impressively filled with the smoke that the particles tend to settle out downwards, and it is only on the horizontal surfaces that an insecticidal film is produced while walls and ceilings do not receive sufficient of the insecticide to have a useful killing effect.

The Uses of Insecticidal Sprays

Insecticides can, and indeed must, be chosen such that they do not constitute a toxic hazard either to workers in the factory or the consumers of the food products and that they do not cause any effect on the flavour of the food products in the way in which they are used. They constitute one of the best relatively simple means of supplementing hygienic methods of insect control.

Pyrethrum or pyrethrum plus piperonyl butoxide sprays are the most suitable insecticides for general use in food factories. While some precautionary spraying in vulnerable areas may be desirable, in general the aim should be to restrict spraying to the locations where there are insects to be killed. In stores, spraying should follow cleaning and sweeping to remove dust and spillage, and should be applied particularly to cracks and crevices to destroy insects which may be present in the fabric of the building. It must be recognised that sprays are of

little use for killing insects which are present in commodities like cocoa beans or nuts. However, spraying can effect some control of cross infestation if the surface of the bags is sprayed at intervals of a week or two. A sprayer which produces a considerable blast of air is helpful because the insecticide can then be carried down the spaces between the bags to reach surfaces that would not otherwise be accessible without breaking down the stack of bags.

In the factory, the main use of insecticide should be to follow the cleaning of difficult areas where particles of food are liable to remain in cracks, etc., and underneath machines like melangeurs. The aim should be to obtain an even but relatively heavy surface film of the pyrethrum insecticide on those areas which are liable to harbour insects and with which the products do not come into contact. When spraying is producing an appreciable mist in the air, surfaces over which the foodstuffs pass, such as refiner rollers and conveyor belts, should be covered to prevent contamination when production re-starts.

The other method of using insecticidal sprays to control moths is to fill the air of the room with a fine mist of the spray. Something like a pint of insecticide for 20,000 cubic feet is required, and in a reasonably warm room the insecticide stimulates moths into flight when the insect will pick up sufficient insecticide to kill it. However, such a mist spray, although it looks impressive, will not usually produce a sufficient film on surfaces to kill the larvae or other crawling insects. Consequently, to effect control mist spraying must be carried out frequently, preferably every 24 hours, since the moths usually commence egg laying about a day after emerging from their pupae. The effectiveness of this control is further reduced because the moths can actually lay viable eggs as they are being killed by the spray. Such mist spraying can therefore be useful as a supplementary measure if numerous moths are emerging, but is rarely an effective control even when repeated at very frequent intervals.

Pyrethrum sprays are also useful in cockroach control, where a moderately heavy spray needs to be applied rapidly into any cavities or cracks where the insects hide, and under sinks, etc. It is important to have sufficient spraying capacity so that a considerable volume of spray is applied, otherwise cockroaches are liable to run ahead of the spray and escape.

In finished goods stores and in shops, there should be few occasions when insecticide spraying is indicated. However, if infestation is found to be present, again pyrethrum type sprays are the most suitable, and after removing the products from the area concerned and cleaning, a moderately heavy surface film of insecticide may be applied to the areas where there are cracks, corners, etc., which cannot be made perfectly clean.

Insecticide sprays, therefore, afford a valuable supplement to cleaning in controlling insects. In a food business, the chemicals should be confined to the safe insecticides like pyrethrum, apart from some limited use of other types of insecticides more suited to the specialised applications which have been outlined above. The pyrethrum type sprays are

suitable for localised use, and do not necessitate long interruptions to production. While it is preferable to arrange for spraying to take place after production has stopped, it is possible to carry out localised surface spraying of a machine in the same room as others which are working, provided there is sufficient distance to prevent contamination with the mist produced. In general, there is little residual insecticidal activity a few hours after pyrethrum sprays have been applied under factory conditions, although in cooler and darker situations, such as in stores, a surface film may remain active for days and even weeks.

2. The Use of Heat for Killing Insects

Insects are killed fairly easily by heat. They will not survive at a temperature of 140°F (60°C) for more than a few minutes, and few will withstand 125°F (52°C) maintained for an hour or two. This affords another method of localised killing of insects, which has the advantage of not introducing any risk of chemical contamination. However, there is no residual effect against re-infestation after the area has cooled, and it is difficult to secure adequate heat penetration into cracks. As with insecticides, heat treatment should be applied after cleaning, because a layer of dusty material half an inch thick will protect any insects at the bottom for a considerable time. However, heat does have the advantage of melting fatty materials like chocolate, when the suffocating effect of the liquid fat will reinforce the direct effect of the heat.

Heat treatment can be applied to individual machines such as enrober coolers which can be fitted with steam heating pipes. At intervals, desirably of the order of 6–8 weeks, the machine can then be heated over a period of some hours when it is out of production. Alternatively the heat can be supplied by high powered mobile electric fan heaters. A disadvantage of this method of insect killing is that there is a considerable time when the area is out of production while it is being heated up and allowed to cool before production can re-commence.

Insects can be killed by heat applied to single machines enclosed in a temporary structure such as can be made using a metal frame and builder's board, or to whole workrooms. The structure must be reasonably air tight, and a powerful source of heat together with a fan to distribute the heat placed within the structure. Suitably designed electrical heaters are available consisting of 40 kilowatt heaters with a fan driven by a 5 h.p. motor. Four such units would be required for a room of 50,000 cubic feet and would take about 18 hours to raise the temperature throughout to 125–135°F (52–57°C), and this temperature should be maintained for a further 6 hours. At least 12 hours should be allowed for cooling, although this will be accelerated by running the fans with the windows and doors open.

Such treatment can be considerably cheaper than gas fumigation, but is less reliable in killing insects in cracks and in materials which are poor conductors of heat. All heavy deposits should be removed prior to treatment, and of course all materials liable to be affected by the heat. In addition, care must be taken to remove equipment like liquid fire

extinguishers which might be damaged by the heat. Prior to starting production, machinery will require oiling and the heat expansion of materials can cause difficulties, such as the lifting of tiled floors.

Nevertheless, disinfestation by means of heat is a useful technique, which approaches fumigation in effectiveness when properly applied, can be distinctly cheaper, and introduces no problems of chemical residues.

3. Fumigation

This involves the use of a poisonous gas which can kill all insects, rodents and humans. It can be a most effective method of insect control, and is the only way of killing insects in stored commodities, such as nuts and cocoa beans while they are still in bags, and in finished products. There is no residual action against re-infestation after the gas is removed, and the treatment necessarily takes some hours or days. Because of the dangers involved in using a poisonous gas, fumigation should only be carried out by experts, and servicing companies are available. Expert advice is also necessary on the concentration of gas and the time of exposure needed to kill all stages of the insects under the particular conditions. Most fumigants are liable to leave some chemical residue in the commodity being treated, and while a single treatment may be harmless from this point of view, there is a danger that raw materials may be fumigated on several occasions leading to a greater build up of residues.

There are three main ways in which fumigation can be applied:

(*a*) *Room Fumigation*

Whole rooms, or a group of rooms, can be sealed and the fumigant gas released to kill insects and rodents within the area. This can be a very useful method by which infestation that has been allowed to get out of control can be effectively dealt with. Alternatively it can be used at intervals to control infestation in a room which is extremely difficult to clean adequately for insect control. Fumigation is one of the few methods which does not normally depend on a thorough cleaning first. On the other hand, substantial depths of powdery materials like flour or cocoa powder, or even solidified chocolate, can protect insects since gases penetrate only very slowly into fine powders and solidified materials.

However, with the time needed for effective sealing which often involves building special screens, the taping of windows, etc., and a relatively long exposure to the gas of some 24 hours coupled with the necessary airing time, room fumigation involves an interruption to the use of the room for at least two days and usually somewhat longer. It is also relatively expensive. Consequently, it is rarely economic to rely on frequent room fumigations to maintain control since treatment about every 4 months would be desirable. However, in some circumstances an annual fumigation, coupled with routine precautions against infestation during the rest of the year, can be the best method of controlling some rooms which are difficult to keep free of infestation, and the procedure can be valuable for bringing an infestation under control rapidly. There is also the advantage that movable

equipment like trays and tank bogies, even when containing food materials, can be placed within the area to be fumigated to ensure that they are disinfested and do not bring insects back to the treated area when production re-commences.

(*b*) *The Use of Fumigation Chambers*

For the regular disinfestation of ingredients, etc., fumigation chambers can be designed which can be operated by suitably trained factory personnel. Goods are loaded into the chambers, with suitable stacking to allow gas penetration, the gas introduced into the sealed chamber, and after the appropriate time the gas is vented and the chamber aired. This is an effective method of killing insects in bagged commodities like cocoa beans and nuts, and also in cartons. However, it must be remembered that the gas will not penetrate into fine powders nor through most films.

Fumigation chambers can be operated at atmospheric pressure when an exposure time of about 14 hours is required. Vacuum fumigation chambers are also available, and have some advantage from the point of view of safety in operation and effective penetration of the gas. While they are more expensive, the use of the pressure changes enables very rapid and complete penetration of the gas to be obtained even into powdery materials, and allows the exposure time to be reduced to a few hours. However, reduction in pressure can cause bursting of some products. Particularly where space is limited, the advantages can outweigh the relatively greater cost.

(*c*) *Localised Fumigation*

This can include several procedures. Stacks of ingredients can be fumigated in a warehouse under gas proof sheeting. This is essentially a more localised form of room fumigation and should also be entrusted to experts. The same technique, using gas proof sheeting, can be applied to particular machines in a workroom Or ingredients can be fumigated in barges. All of these localised fumigations require about two days during which careful precautions must be taken to avoid the possibility of accidents to personnel in the surrounding area.

Alternatively, localised fumigation can be carried out using much less toxic gases than the usual fumigants with only moderately careful sheeting to contain the gas. Carbon tetrachloride has been used for this purpose, but as well as being somewhat toxic to humans it is much less effective against insects, and the results of such local fumigations are usually rather unreliable. They are not recommended.

There are three gases which are commonly used for the fumigation of foodstuffs in this country. These are ethylene oxide, methyl bromide and hydrogen cyanide.

Ethylene oxide has the advantage that it has never been found in its use against insects to produce foreign flavours in foods. While it can be

an effective fumigant, it has less penetrative power than methyl bromide and tends to be absorbed to a greater extent on to materials. It must only be used by experienced operators because it is highly explosive, and all possible sources of ignition must be eliminated even when, as is customary, it is mixed with carbon dioxide to reduce the explosion risk. There is no definite evidence of undesirable residues in the food after umigation at the concentrations required to kill insects.

Methyl bromide is a most effective fumigant, having excellent penetrative properties, and involves no risk of explosions. While it is the cheapest fumigant, it is the most dangerous to use because there is no warning smell unless a small percentage of chloropicrin is added for this purpose. Its use does result in an increase in the bromine content of many foods but this is generally recognised to be within acceptable limits provided the food is not repeatedly fumigated. The main objection to methyl bromide is that it can cause tainting of a variety of foods, particularly those in a finely divided form.

Hydrogen cyanide is another effective fumigant which is dangerous to use and subject to special regulations. It is less used in the food industry than the above two fumigants.

4. Mechanical Devices

Equipment under this heading is concerned mainly with flying insects, such as flies and wasps, and also with moths. The former breed outside and consequently the best protection is obtained by preventing their entry. Windows can be screened with fine mesh, either of wire or of plastic, and the usefulness of such screening can be increased by spraying with pyrethrum which has some repellent effect. It is more difficult to prevent insects flying through doors, but self closing double doors are useful and air curtains can discourage entry.

For use inside buildings, equipment is available which attracts wasps and flies to a black light fluorescent source and electrocutes them on a charged grid. This has the advantage of collecting the bodies in a trough but obviously must not be used in dusty areas where there is a possible explosion hazard. Such equipment certainly kills insects and, while it is not so strongly attractive to them that it prevents wasps, for example, from going to sugary foodstuffs, it is claimed that the siting of sufficient of these units near the points where the insects enter can greatly reduce the numbers of wasps in the room.

Moths can also be killed by these electrocuting units, but it is doubtful whether cocoa moths are attracted to these units and it is unlikely that a sufficient control of a moth infestation could be obtained in this way. There are other machines designed to trap moths which depend on the supposed attractive effect of a light and incorporate a fan to draw these relatively weakly flying moths into the machine. However, for moths, the simple use of a shiny liquid surface can be employed in rooms which are not dusty to attract and trap moths in trays. Such trays containing water, sugar syrup or light oil are cheap and can be placed out of the

reach of workers in some numbers. While they may contribute little to control, since many of the moths they catch will already have laid eggs, regular inspection enables a continual assessment to be made of the level of infestation in the room and provides warning of any locality where infestation is increasing and requires the special attention of the insect control personnel.

There is a machine which is capable of killing any insects in powdery materials by centrifugal force. Such machines are widely used in the flour industry but have few applications in the confectionery field.

5. Low Temperature Storage

Insect activity is reduced at lower temperatures, and consequently reduction in temperature will reduce the rate at which infestations develop. At about 55°F (13°C) there is very little insect activity and a temperature of 45°F (7°C) is likely over a period of weeks to kill many of the stored products insects, and particularly the moths. However, the spider beetles are very resistant to low temperatures.

It should be noted, moreover, that rodents and particularly mice are not adversely affected by cold. Mice can adapt themselves by developing longer fur to living and breeding in cold stores.

In general, infestation control is assisted by storage at temperatures below 60°F (16°C) and in the case of the moths temperatures of 45°F (7°C) for some weeks will actually have a killing effect. But low temperature alone will not prevent rodent infestations, and some insects like the spider beetles simply remain dormant at the low temperature and resume their feeding activity when the conditions become warmer.

APPENDIX III

SOURCES OF ADDITIONAL INFORMATION

1. *Detailed information, particularly on possible suppliers of equipment and insecticides and on servicing companies, is available on application to:*

   The Cocoa, Chocolate and Confectionery Alliance, 11 Green Street, London, W1Y 3RF.

2. *Technical advice may be obtained from:*

   British Food Manufacturing Industries Research Association, Randalls Road, Leatherhead, Surrey.

   Regional Pests Officers, Ministry of Agriculture, Fisheries and Food Regional Offices, or in Scotland the Department of Agriculture and Fisheries Infestation Control Offices in Edinburgh, Glasgow or Perth.

   Infestation Control Laboratory of the Ministry of Agriculture, Fisheries and Food, Hook Rise South, Tolworth, Surbiton, Surrey.

   Agricultural Scientific Services, East Craigs, Edinburgh, 12.

   Pest Infestation Laboratory, Slough, a station of the Agricultural Research Council, for research problems.

   Industrial Pest Control Association, Alembic House, 94 Albert Embankment, London, S.W.1, can advise on availability of commercial pest control services.

3. *Further sources of information:*

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Safe and Efficient Fumigation Practice: Code of practice for the fumigation of commodities under gas-proof sheets with methyl bromide. M.A.F.F. May 1968.

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Thompson, R. H. (1966). J. Stored Product Research 1. 353–376. *A review of the properties and usage of methyl bromide as a fumigant.*

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Bills, G. T. *Equipment for Indoor Pest Control.* International Pest Control, July and September, 1966. Vol. 8. Nos. 4 and 5, pp. 6–11 and 15–21.

FURTHER SOURCES OF DETAILED INFORMATION ON INSECTS, ETC.

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