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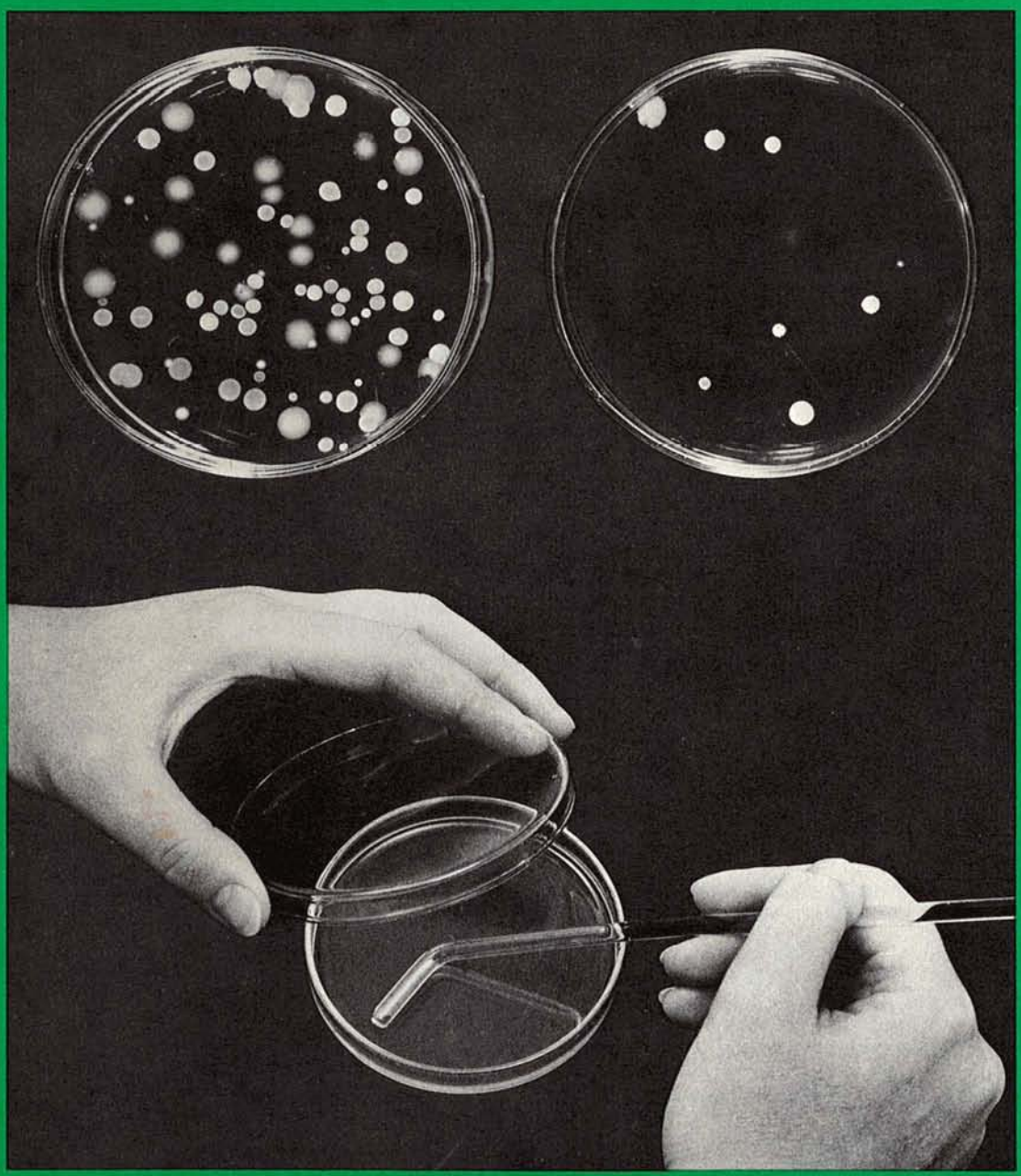

Cleaning in the food industry

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A guide to the selection of detergents and disinfectants,* and how to set up an effective cleaning program

Cleaning or the removal of unwanted material (dirt) from equipment and surroundings is one of the most common operations in the food industry—and one of the most important. Unless equipment and surroundings are properly cleaned and kept clean they will offer an ideal environment for microbial growth and may attract rodents and insects. The final step in the cleaning program should be to disinfect the area, thus reducing the number of microorganisms to a level which does not prejudice the production of safe wholesome food.

Although the food industry has seen a marked improvement in standards of hygiene, management all too often regards cleaning as a necessary but expensive burden which is difficult to relate to production. Spoilage, rejection of goods by the customer or an outbreak of food poisoning are among the factors that occasionally restore the matter to its proper perspective. The need to understand the problems associated with cleaning has been made more pressing by the rapid growth of the food industry and its increasing mechanization, as well as by the fact that the consumer is becoming more exacting in his demand for safer products.

The number of detergents and disinfectants (sanitizers) available for use in the food industry is enormous, but information on how they perform in a cleaning program is at present almost non-existent. However, a Commonwealth Advisory Laboratory on Dairy Detergents and Sanitizers has been established at Richmond, N.S.W., and it is expected that in addition to setting up standards for dairy detergents and disinfectants, this centre will develop standards for the meat-, chicken- and fish-processing industries and, ultimately, for the entire food industry. An account of the Laboratory is given in another article in this issue.

*The terms 'disinfectant' and 'sanitizer' are both used in the Australian food industry to refer to agents for reducing the numbers of microorganisms to a level which does not present a health hazard. This issue of the *Quarterly* follows the Draft British Standard Glossary (in press) in using 'disinfectant'.

Objectives of a cleaning program

The main objectives of a cleaning program should be to restrict microbial activity, to preserve the freshness and palatability of the product and to ensure that it is wholesome and free from pathogenic microorganisms. Thus a good cleaning and sanitation program will be profitable as it ensures that a product can be stored for some time and then eaten safely.

In order to put into operation an effective and successful cleaning program the following points should be considered.

- Is there an adequate supply of good quality water?

After a consideration of the properties, composition and function of detergents and disinfectants:

- What is the right detergent for the job?
- What is the right disinfectant?
- What are the best cleaning methods?

Water

The main function of any cleaning procedure is to make dirt soluble, so that it can be removed completely and effectively.

Although it is recognized that cleaning can only be carried out with adequate amounts of water, the quality of the water

is a factor frequently overlooked. In many cases the water is hard and contains excessive amounts of metallic ions, mostly calcium and magnesium. Hard water has several disadvantages—it neutralizes soap, detergents and disinfectants, and it forms scale on equipment, on the inside of water heaters and in steam boiler tubes, thus leading to reduced efficiency from heat transfer losses and clogging.

Hard water

Two types of water hardness due to the anionic components of calcium and magnesium compounds are generally recognized.

Temporary hardness. This is due to the presence of bicarbonate. When water which has temporary hardness is heated carbon dioxide is evolved, resulting in the precipitation of insoluble carbonates.

Permanent hardness. This is due to the presence of sulphates. When such water is heated there is no precipitation, but there is precipitation when alkaline detergents are used.

Although many detergents are designed to perform well in hard water, the efficiency of the detergent is generally reduced whenever the hardness exceeds 100 mg/l. The following simple test determines the suitability of a detergent for use with hard water.

1. Prepare a solution of the detergent with the water to be used in the cleaning operation at the recommended dilution.
2. Heat to boiling.
3. Observe whether a precipitate forms—if it does the detergent is unsuitable.

In many instances the solution will become cloudy on heating. Although this does not necessarily indicate that the detergent is unsuitable, its performance should be watched carefully as sometimes a grey-white deposit, which is particularly noticeable on stainless steel, can build up with time.

Commercial water-softening processes are expensive, but in the long term they may often prove to be economic.

The water used in a cleaning program should be of potable (drinkable) quality, and has to meet certain criteria laid down by the Australian Department of Agriculture (ADA)—formerly the Department of Primary Industry— or State authorities. Potable water is defined by the ADA as water which does not contain chemical substances or microorganisms in amounts that could be hazardous to health. The assessment of whether a particular water supply is microbiologically acceptable is often based on the U.K. Ministry of Health Bulletin 71, 'The Bacteriological Examination of Water Supplies'. It is management's responsibility to ensure that a water supply designated 'potable' really is of acceptable quality and that all necessary steps are taken to maintain this standard.

In recent years chlorination of industrial water has become a common practice in food-processing plants both in order to meet official requirements and as a means of improving plant hygiene.

When chlorine is added to water a small proportion, usually less than 1 mg/l, reacts with impurities in the water. The quantity that reacts depends on the amount and nature of the organic and inorganic pollutants present, the pH of the water, its temperature and the time required to produce the first persistent residuum. The difference between the amount of chlorine added to the water (the chlorine dosage) and the amount remaining after some chlorine has reacted with the impurities in the water is known as the 'chlorine demand' of the water. What remains after this demand has been satisfied is termed the 'total residual chlorine'. The residual chlorine in water exists as free available chlorine (Cl_2, HOCl and OCl^-) and combined available chlorine. A certain portion of the chlorine combines with ammonia and other nitrogenous compounds present in natural waters to form chloramines and/or N-chloro compounds, the latter often being responsible for the unpleasant smell and taste sometimes noticed in municipal water supplies. Chlorine in this form is termed 'combined residual chlorine'. Both free and combined forms may be present in water at the same time.

Further addition of chlorine results in an increase of free residual chlorine until it reaches a concentration, determined by the physical and chemical nature of the water, at which an oxidation reaction occurs between the free chlorine and the N-chloro compounds. The free chlorine residual is then decreased by the amount necessary to oxidize the N-chloro compounds completely. Further additions of chlorine

beyond this point will result in a proportional increase in the free chlorine concentration.

The point at which the free chlorine is lowest after the complete oxidation of the N-chloro compounds is known as the 'break point' (Fig. 1). Beyond the break point the unpleasant odours and flavour are practically eliminated. Hence it is essential that sufficient chlorine be added to the water to ensure the presence of free available chlorine and the absence of chloramines and/or N-chloro compounds. Since the chemical reactions take time the available chlorine should be measured at least 20 min after the initial chlorine dosage.

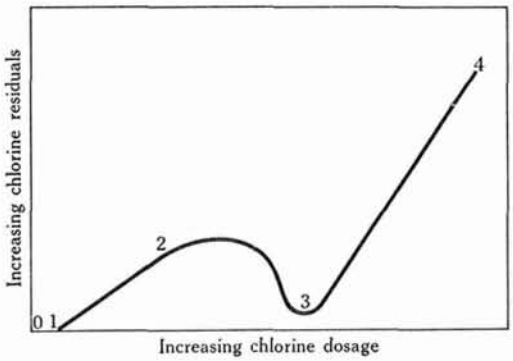


Fig. 1. Chlorination of water. 0–1, chlorine demand; 1–2, total residual chlorine; 2–3, oxidation of chloramines and N-chloro compounds; 3, break point; 3–4, free available chlorine.

Function and composition of detergents

To remove dirt, either work must be done or energy must be supplied. Work is usually done by mechanical and physicochemical energy (Jennings 1965). Any substance which, either alone or in a mixture, substitutes physicochemical energy for some of the mechanical energy required for removing dirt can be classed as a detergent. Thus detergents influence the amount of energy or work that must be put into a cleaning system.

In most cases water alone is not a very efficient cleaning substance owing to its high surface tension, which prevents intimate contact with dirt and equipment surfaces. Hence if it is used as the sole cleaning agent a considerable amount of mechanical energy is required. Detergents enable water to penetrate dirt by lowering the surface tension.

A good detergent should have the following properties. It should be:

- quickly and completely soluble,
- non-corrosive to metal surfaces and other factory surfaces,
- able to soften water completely,
- economical to use,
- non-poisonous and biodegradable.

It should have:

- good wetting or penetrating action,
- emulsifying action on fat,
- dissolving action on food solids,
- deflocculating, dispersing or suspending action,
- good rinsing properties,
- good scale- and rust-removing properties.

No detergent or cleaning compound has yet been developed that can be truly called an all-purpose detergent. None of the alkalis, acids or surface-active agents meets the requirements of a good detergent when used alone. However, certain mixtures of these chemicals will combine several properties in one product, each being effective for a particular cleaning operation. There are four types of chemical compounds commonly used to achieve the functions of cleaning described above.

1. Alkalis and alkaline salts

Sodium hydroxide (caustic soda) is the cheapest of the strong alkalis. It is a powerful detergent and is used to suspend protein and to convert fats to soap. However, it has no buffering action, severely corrodes aluminium and galvanized iron, strips paint, and presents a hazard to personnel using it. Because of its intense corrosive action, caustic soda is not recommended for cleaning equipment and utensils.

Sodium metasilicate is an effective detergent for many purposes. It is an excellent emulsifying and suspending agent and has reasonable wetting and rinsing properties. Another advantage is that it possesses anti-corrosive properties. Sodium metasilicate should not be used in water above 70°C, otherwise redeposition of soil–detergent mixture may occur.

Sodium carbonate (soda ash) is not a good cleaner, but it is a cheap source of alkalinity and has been used as a detergent

filler for a long time. It is corrosive to aluminium and galvanized iron, and in hard water forms a scale of calcium carbonate and other insoluble salts.

2. Phosphates

Phosphates are included in almost all detergents as they have several functions, but primarily they are used to prevent the formation of insoluble metallic salts by the interaction of hard water or dirt with the detergent. The amount of phosphate needed depends on the hardness of the water, the composition of the detergent and the composition of the dirt.

Sodium tripolyphosphate and sodium tetraphosphate are the two phosphates mainly used in detergent formulations. In addition to removing the minerals causing water hardness, they have varying functions in emulsification, protein peptization and dispersion.

3. Surface-active agents

Such agents are employed in a variety of cleaning applications as wetting, emulsifying and penetrating agents.

Anionic surface-active agents dissociate in solution to give a negatively charged surface-active ion and a small inactive cation. Most commercial surface-active detergents belong to this group. Several anionic surface-active agents are available, but the alkyl aryl sulphonates represent the principal synthetic surface-active agent.

Nonionic surface-active agents do not yield ions in aqueous solutions and are compatible with either cationic or anionic materials. These compounds are little affected by water hardness or by heavy metal salts. The fatty acid ethoxylates, in particular dodecanol ethoxylates, are commonly used in detergent formulations.

Mixtures of anionic and nonionic surface-active agents in a ratio of 2:1 in detergent formulations appear to be the most suitable for the food industry.

Cationic surface-active agents dissociate in solution to yield a positively charged surface-active ion and a small inactive anion. Their performance as detergents is only fair, but they exhibit anti-microbial activity and are sometimes used in detergent–sanitizer formulations.

4. Acids

Acids are an important group of chemicals having specific action against alkaline or mineral soiling. Phosphoric acid, sulphamic acid and sodium bisulphate are the most important acid detergents used in the food industry.

As acids are only effective in the removal of minerals and certain organic-mineral complexes that are resistant to alkali-type products, it is essential that fat and protein be removed with an alkaline detergent before acid cleaning. Acid detergents are very corrosive because they generate hydrogen ions, and corrosion inhibitors such as aryl-thioureas or heterocyclic nitrogen bases should always be incorporated. Even acids containing inhibitors are very corrosive to galvanized iron and aluminium; indeed, extreme care is needed in all uses of these acid detergents.

When galvanized iron has been cleaned with acid detergents an unsightly white film of zinc hydroxide/zinc carbonate will form upon drying. To mask this, a food-grade oil should be sprayed onto the surface immediately after acid cleaning.

Choice of detergent

The choice of detergent is determined by the chemical nature of the substances that have to be removed, the building materials and type of metal that are present in the area to be cleaned, and the kind of cleaning technique used.

The material that must be removed from a surface is usually composed of fat, carbohydrate, protein and minerals. The amount and type of each material varies from industry to industry, and it is necessary to know whether the dirt to be removed is water-, acid- or aklkali-soluble or soluble only in an organic solvent. Once this is known, selection of the detergent is simplified.

In many cases the type of metal and building materials (including paint) used in the area to be cleaned severely limits the choice of detergent. Aluminium and galvanized iron, which are frequently used, corrode rapidly in strongly alkaline or acid detergents. Although detergents can be formulated that will not corrode these metals, their effectiveness as cleaning agents is usually reduced. In addition, galvanized iron surfaces, being relatively rough, are

more difficult to clean than stainless steel surfaces.

Paint occurs commonly in 'wet' processing areas and is difficult to clean without damaging the surface. Indeed, it is often preferable to remove the paint and leave surfaces such as cement-rendered walls unpainted.

Where it is necessary to clean by hand only mild detergents can be used, whereas automated cleaning techniques enable the use of stronger detergents.

Thus in most instances the choice of a suitable detergent must be a compromise between the efficiency of the detergent and the need to protect metals, building materials and personnel.

It is perhaps somewhat surprising that the cost of the detergent is not a guide to its efficiency, and only actual tests with a particular detergent during the cleaning operation will give some indication of its efficiency. Because the range of detergents is unlimited and new ones are being introduced very frequently, the task of testing for efficiency is never-ending. The establishment of a central testing laboratory will be of considerable benefit to the food industry in overcoming this problem.

When and how to clean

Equipment surfaces inevitably become dirty during use, and a measure of work is essential to remove the dirt. It has been found that most of the dirt may be easily removed from the system until a monomolecular layer remains which may only be removed with a considerably higher energy input (Bourne and Jennings 1961). When the dirt is allowed to remain on a surface for some time a portion of the less tightly bound dirt 'ages' and becomes converted to the more tightly bound form which can be dislodged only slowly. Hence cleaning should be commenced without delay.

The following steps are essential in the cleaning procedure.

Dry cleaning. At the end of the day's production, or more frequently if necessary, gross contamination should be picked up and removed. This is very important since the amount of detergent required is determined by the quantity of dirt to be removed. Packaging materials and small utensils should be taken out of the area to be cleaned.

Wet all areas. Cold water should be used wherever protein is present. Hot water may coagulate protein, making it extremely difficult to remove.

Apply a detergent solution. A detergent solution reduces but does not eliminate the need for expending energy to remove dirt. Either elbow-grease or mechanical action is essential.

Rinse. All surfaces should be thoroughly rinsed to remove all traces of dirt and detergent. Remove excess moisture.

Where hard-water scale has to be removed, apply acid detergent, scrub, rinse and remove excess moisture. Small utensils can be soaked in hot acid solutions for 15 min and rinsed.

There are several ways a detergent can be used in the cleaning operation, but the following methods appear to be the most suitable where large areas have to be cleaned.

Foam cleaning

A foaming agent is added to a detergent solution and sprayed through special equipment to produce a white foamy layer of detergent like shaving cream (Fig. 2). This method uses detergents more efficiently than conventional cleaning and allows longer contact time between detergent and dirt. In addition, the foam–detergent mixture provides visual evidence of the areas covered (Fig. 3). It should be remembered that this method does not

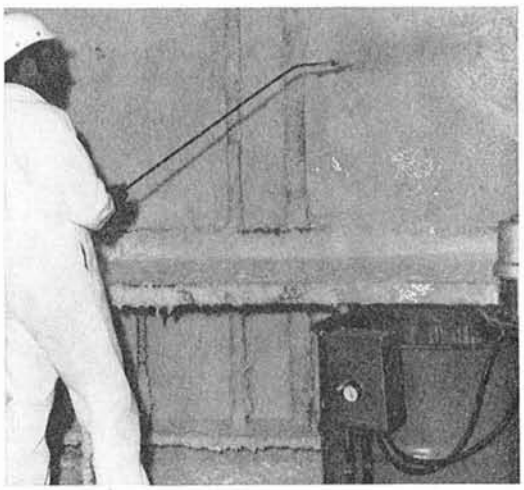


Fig. 2. Applying foam cleaner to a meat-preparation room.

Fig. 3. Foam cleaning leaves visual evidence of the areas covered.

eliminate the need for mechanical action and is only designed to use detergents more efficiently.

Foaming equipment ranges from the inexpensive venturi-type air–water foamers, to expensive equipment which uses air-driven pressure pumps together with venturi-type foamers. A more recent development is the use of pressure-operated systems in which the detergent–foam solution is pressurized by means of special equipment. Each system has advantages and disadvantages, but where the mains pressure is constant the use of venturi-type air–water foamers is recommended.

Gel cleaning

A gelling agent is added to a detergent solution and sprayed with the aid of a pressurized chamber (Fig. 4). The gel–detergent mixture sticks on the dirty surfaces thus allowing the detergent to remain in contact with the dirt for a longer time. The mixture can be removed easily with water. This method appears to use detergent most efficiently, but as in foam cleaning the need for mechanical action remains.

High pressure cleaning

Cleaning with pressure sprays may be successful, but this method is time consuming. The most suitable equipment is a high-pressure, large-volume spray equipped with a detergent-feed system. The main disadvantage of the method is that it easily damages painted surfaces, cement-rendered walls and concrete, and may force water into machinery and electrical fittings.

A combination of foam or gel cleaning and high pressure rinsing is probably the most effective cleaning method to date.

'Clean-in-place' (CIP) methods

CIP methods or methods which clean automatically should be used wherever possible and are ideal for cleaning large storage tanks and pipelines. Some precautions are necessary—proper equipment must be used, *all* surfaces must be cleaned, and detergent concentrations and temperatures must be carefully controlled.

Thoughtfully designed equipment and processing areas permit easy and adequate cleaning. Thus provision should be made wherever possible for self draining and for inspection of inaccessible areas. Components in the equipment that are not cleaned routinely should also be of an appropriate design.

Disinfection

As has been pointed out previously the main objective of a cleaning program is to control microbial activity. As a first step towards this goal cleaning removes from the

system any source of food for microorganisms. Although an adequate cleaning program will get rid of nearly all the dirt present, it will not destroy or remove all the microorganisms. This requires a second step, namely effective disinfection.

Disinfection as defined by the British standard glossary of terms relating to disinfectants (in press) means 'the destruction of microorganisms, but not usually bacterial spores; this does not necessarily involve killing all microorganisms, but reducing them to a level not normally harmful to health. The term is applicable in a commercial context solely to the treatment of inanimate objects and materials.'

This definition does not take into account the fact that the types of microorganisms present are probably as important as the total number when their effect on the quality of the end product is considered. However, it is usually assumed that where total numbers of survivors are small, undesirable types such as pathogens are less likely to be present in significant numbers.

Traditionally, non-chemical methods of disinfection have been used almost exclusively and will be considered briefly.

Non-chemical disinfection methods

Heat. Hot water or steam is generally used either at atmospheric pressure (101·325 kPa) or under pressure, usually at two atmospheres. Combinations of hot water and steam may also be used.

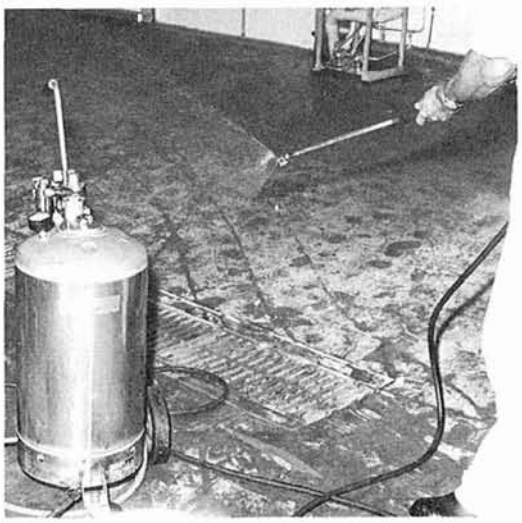


Fig. 4. Gel cleaning.

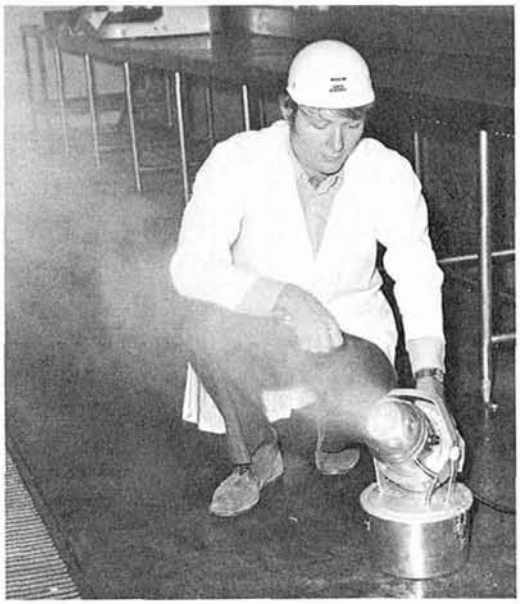


Fig. 5. Disinfection using fogging equipment.

Although in many cases steam is a very good means of disinfection, it may be inconvenient or impractical on any of the following grounds. Steam may be expensive and may cause materials to deteriorate and equipment to distort; use of steam means that a considerable time must elapse before equipment is heated and cooled; it causes the baking-on of food and other residues; it reduces visibility in the environment thus reducing the effectiveness of the sanitizing procedure; it leads to condensation problems. Finally, the use of steam as a disinfectant selects heat-resistant bacteria which will be difficult to eliminate on subsequent heat treatments. Moreover, inefficient heating may result in the incubation of microorganisms in inaccessible parts of the equipment.

Ultraviolet radiation. The major application of ultraviolet radiation in the food industry has been for disinfecting the air. As some ozone is produced, oxidative rancidity may be induced in fatty foods, thus making the method unsuitable for many industries. Ultraviolet radiation can also be used with some success for disinfecting water.

Chemical disinfectants — advantages and disadvantages

	Corrosion	Stability	Factors controlling efficiency of disinfectant	Effect of hard water	pH	Comments
Chlorine-releasing compounds:						
(*a*) Hypochlorite	Very corrosive on most common metals	Unstable	pH, organic matter, temperature, available chlorine	None	Use at pH 8·5	Cheap and effective
(*b*) Organic chlorine-releasing compounds	Corrosive on galvanized iron and aluminium	Stable in powder form	Same as (*a*)	None, but could result in white precipitate on surfaces	Most effective below pH 8·0, most stable above pH 10	Usually combined with detergents and inorganic salts
(*c*) Halogenated	Same as (*b*)	Same as (*b*)	Same as (*a*)	Same as (*b*)	Effective over wide range	Can be mixed with non-ionic surface-active agents
Quaternary amonium compounds	Slight corrosion on galvanized iron	Stable	Hard water, pH, ferric and ferrous ions, organic matter	Hard water decreases efficiency	Effective above pH 6	Can be mixed with non-ionic detergent
Ampholytic compounds	Same as above	Stable		Not affected to the same extent as Quats	Effective over wide range	Expensive, disinfecting power limited
Iodophors	Corrosive to galvanized iron and aluminium	Stable	Organic matter, pH	None	Effective below pH 4	Can be mixed with non-ionic detergents—good scale remover
Phenolics	Slight corrosion	Stable	Organic matter	None	Effective over wide range	Good sanitizer

Chemical disinfection methods (see table)

As none of the non-chemical disinfection methods is completely effective for routine use, chemical disinfectants should also be used (Fig. 5).

The first essential for an effective chemical disinfection program is a clean surface—no chemical disinfectant available to date can disinfect a dirty surface. Consequently, to achieve microbial control the two programs, cleaning and disinfection, must be thorough, compatible and totally effective. To put it briefly, a disinfectant will not cover up faulty cleaning practices. Moreover, it is advisable to change the class of disinfectant being used at least once a month in order to prevent a possible build up of resistant microorganisms.

The choice of chemical disinfectants for use in processing areas is determined by the following considerations.

- Public health regulations.
- Possibility of odour from the disinfectant being absorbed into the foodstuff or being produced by reaction with the foodstuff.
- Possibility of colour from the disinfectant tainting the foodstuff.
- Corrosive properties.
- Effect of hard water.
- Concentration necessary to achieve satisfactory results.
- Type of surface to be disinfected.
- Presence or absence of organic matter.
- Spectrum of effectiveness, i.e. ability to kill many types of microorganisms.

Despite the fact that manufacturers offer a large number of disinfectants, each claimed to be the best on the market, the only ones suitable for the food industry contain chemicals of one of the following groups: chlorine and chlorine-releasing compounds, iodophors, quaternary ammonium compounds, ampholytic or amphoteric compounds, or phenolic compounds.

Chlorine and chlorine-releasing compounds. Chlorine is the cheapest and most effective disinfectant available. Although it has a decided smell, the odour is not persistent and with proper control need not present any risk of tainting.

The *hypochlorites* (calcium and sodium) have been used for many years in water purification processes and in many instances have replaced steam and hot-water sterilization. Their characteristic smell is produced by free hypochlorous acid which is considered to be the germicidally active form of chlorine. This acid is very unstable and decomposes rapidly. To reduce the rate of breakdown during storage, the hypochlorite solution should be maintained at pH 9–11.

The disinfectant properties of the hypochlorites depend on a number of factors, e.g.

- Concentration of available chlorine, which for equipment should be 200–300 mg/l.
- pH of the solution.
- Temperature. The disinfectant is made more efficient if the concentration and temperature are raised and/or the pH is lowered ($< 8{\cdot}3$).
- Absence of organic material. Organic material consumes available chlorine and reduces the disinfecting capacity.

The *organic chloramines* may be produced by the reaction of HOCl on an amine, amide, imine or imide. They include chloramine T and the chloroisocyanurates.

The disinfectant properties of chloramine T are affected by pH, concentration and temperature in the same way as the hypochlorites. Chloramine T has some advantages over the hypochlorites in that it is more stable in solution as well as being stable in powder form. Moreover, it does not react as rapidly with organic material and it is less irritating and slightly less corrosive. However, in general, chloramine T solutions should only be used where long exposure is practicable as its bactericidal activity is slow.

The *chloroisocyanurates* are used as disinfectants or as detergent sanitizers when combined with detergents. They will give satisfactory results provided that soiling is not excessive and the products are used at the right concentration.

Chloroisocyanurates are unstable both in solution and in the presence of nonionic surface-active agents. Hence it is important that all traces of detergent should be removed before the disinfecting process is commenced. The effect of pH on their usefulness is the same as in the case of hypochlorites.

A relatively new disinfectant is a halogen mixture consisting of chlorine-containing compounds mixed with small amounts of bromine. This product, it is claimed, is exceptionally effective over a wide bacterial spectrum, is stable in solution and is not affected by hard water (Russon 1970).

Other organic chloramines are not generally used for disinfecting.

Iodophors. Iodophors are acidic solutions of iodine complexed with a nonionic surface-active agent. They possess a broad spectrum of antibacterial activity and high fungicidal and virucidal activity.

The phosphoric acid in the iodophors lowers the pH sufficiently to prevent precipitation of calcium and magnesium salts in hard water and makes them good removers of hard-water scale. For efficient use the pH should be maintained between 2·0 and 4·5. It is also essential that the acid content should be high enough to compensate for water hardness and suspended soil. Most of the iodophors are effective in cold and warm solutions, but the temperature must not exceed 43°C as iodine sublimes above this point. Iodophors are corrosive to galvanized iron and aluminium and should be used with extreme care.

Under working conditions iodophors often prove to be unsatisfactory as disinfectants and they are generally not used in food processing plants such as poultry and meat works which employ alkaline detergents for cleaning. Although the explanation of their poor performance is not clear, it is believed that the alkaline detergents used in the cleaning step are not completely removed during rinsing. The detergent remaining is sufficient to raise the pH of the iodophor and make it ineffective, particularly in situations where unbuffered solutions are used.

Quaternary ammonium compounds. The cationic synthetic surface-active agents or quaternary ammonium compounds (Quats) are excellent disinfectants, but they are poor detergents (Parker and Litchfield 1962).

The Quats are free of odour and colour, are highly stable and have little corrosive action on metals when used in recommended concentrations. They are effective against Gram-positive and Gram-negative bacteria and are more active in the presence of small amounts of organic matter than any other class of disinfectant (Parker and Litchfield 1962). The pH should be above 6·0 for optimum results.

Quats are inactivated by soaps, anionic detergents, pine oils and inorganic polyphosphates. Calcium and magnesium ions in hard water and ferrous and ferric ions reduce their bactericidal effectiveness (Lawrence 1968).

Since toxic effects have been observed in humans and in warm-blooded animals when Quats are taken internally, utensils and equipment should be thoroughly rinsed after applying these compounds in disinfecting operations.

Amphoteric (ampholytic) compounds. Amphoteric and ampholytic compounds are essentially alkyl or acyl amino acids. They have several advantages in that they combine detergent and disinfectant properties and are of low toxicity; they are compatible in all forms with anionic, nonionic and cationic agents; they are not affected by hard water, are non-corrosive, and are effective against both Gram-positive and Gram-negative bacteria.

The amphoterics are not very powerful as disinfectants and they are expensive, but their freedom from the disadvantages of the strongly alkaline or acid detergent–disinfectants makes them very suitable for certain purposes (Davis 1968).

Phenolic compounds. Phenolic compounds are not generally suitable for use in the food industry, but some halogenated phenol derivatives can be used in meat works. These derivatives are stable and can be used in solution at any temperature. They are effective against spores, viruses, moulds, Gram-positive and Gram-negative bacteria, and they remain effective in hard water. They are less affected than the chlorine compounds by the presence of organic matter. However, they can cause skin irritation and they are corrosive, particularly if used in concentrations higher than those recommended.

Phenolic compounds should be sprayed onto dry surfaces to avoid dilution, and should be left on for at least 15 min. All traces must be removed with potable water before production starts.

Quality control

Since cleaning is a costly operation some form of quality control is essential. Appraisal of results should be carried out on a routine basis as part of the daily housekeeping inspection. The following criteria may be used.

- General appearance—no contamination should be visible under good lighting conditions.
- Work surfaces should not feel greasy or rough when rubbed with the fingers.
- A clean white tissue should not be discoloured when rubbed over the surface of cleaned stainless steel—this test is not applicable with aluminium or galvanized material.
- Objectionable smells should not be noticeable.
- Cleaned surfaces should not show signs of excessive water break when wetted.
- Cleaned, disinfected work surfaces should have a microbial population below a set maximum number, the number depending upon the product, its stage in processing and its required storage life.

The first five tests are easily performed and can be carried out on a routine basis. They do not, however, give any indication of the microbial populations on the cleaned surfaces. There are several methods of assessing the approximate number of bacteria, yeasts and moulds on cleaned surfaces.

Replica methods

Replica methods reproduce the pattern of distribution of microorganisms present on the surface.

Rodac plates. These are small, specially designed plastic dishes about 5 cm in diameter. The centre well of the dish is filled with the growth medium of choice so that the meniscus extends above the edge of the dish. The lid is then replaced on the dish and the medium is cooled and allowed to set.

To test a cleaned surface, remove the lid and press the medium on to the surface, replace the lid and incubate the dish at a chosen temperature for a period of time depending mainly on the temperature. After incubation, count the number of colonies.

Agar syringe. Cut the tip off the barrel of a standard 50-ml glass or polypropylene hypodermic syringe. Sterilize syringe and plunger by autoclaving at 121°C. Assemble the syringe, fill with a suitable medium containing 2% agar, and seal the opening of the syringe with aluminium foil. Allow the medium to cool and set.

To test a surface, first sterilize a knife by wiping with methylated spirits and passing through a flame to burn off excess alcohol. The medium in the syringe is advanced by gently pressing the plunger until the medium is about 3 mm past the end of the barrel. Cut off the medium extending past the barrel of the syringe with the sterile knife and discard. Advance the medium again and gently press the exposed surface on to the surface to be tested. Cut the slice and place it on the bottom of a sterile plastic dish with the contacted surface facing upwards. Throughout the operation the slice of medium should be touched only with sterile equipment. The slices are then incubated at a suitable temperature.

Agar sausage. This method is basically the same as the syringe method. The agar medium is formed into a sausage in a heat-shrinkable casing. Agar sausages are commercially available from Oxoid (Ageroids).

Cellulose tape. This method involves rolling a sterile adhesive strip over the surface to be sampled, and then rolling the tape over the surface of a sterile agar medium (cellulose-tape dispensers: Birko Chemicals, U.S.A.).

All these methods will give an indication of the spread of contamination over a surface and the number of microorganisms present. A count of less than 100 colonies per 6·5 cm^2 is, in most cases, considered a satisfactory result. The main disadvantage of such methods is that they are not suitable for sampling in corners, cracks or curves.

Swab methods

These involve the removal of a proportion of the bacteria from a known area by means of sterile swabs.

The swab is moistened with sterile 0·1% peptone solution and rubbed over the surface to be tested. It can be streaked directly over the surface of a poured, dried agar medium or it can be placed in a

known volume of sterile dilution fluid (0·1% peptone). Direct streaking, by the following method, has been used successfully in the meat industry.

Prepare Plate Count Agar (Oxoid) or any other suitable medium according to the manufacturer's directions. When the agar has cooled to about 45°C pour a small amount (15 ml) into a sterile Petri dish, replace the lid, and allow the agar to cool completely. When the agar has set the surface can be dried by placing the dish in an oven in an inverted position with the lid partially removed; drying at 37°C for 30 min should be sufficient. Replace the lid and store the dish in a plastic bag in the refrigerator (or use within 2 days).

Moisten a sterile swab with sterile fluid such as 0·1% peptone and rub over the surface to be tested in two directions (North to South; East to West). The area rubbed should be approximately 51·6 cm^2 (the size of a standard Petri dish). Then rub the swab over the agar surface. Incubate the Petri dish in an inverted position at a suitable temperature (e.g. 20°C for 3 days) and count the number of colonies.

The result will indicate the effectiveness of the cleaning program.

Although standards will vary between industries the following rough guidelines can be given:

> 300 colonies/51·6 cm^2—unsatisfactory;

< 300 colonies/51·6 cm^2—satisfactory;

< 100 colonies/51·6 cm^2—excellent.

Conclusions

Cleaning in the food industry is important in ensuring that the end product is free from undesirable microorganisms and has a reasonable storage life.

Water used for cleaning should preferably be soft, but where this is not possible special precautions should be taken, e.g. the use of detergents containing sufficient sequestering agents. In addition, the water should be potable and of good microbiological quality. Detergents reduce the amount of energy required in cleaning and should be incorporated wherever possible. The choice of detergent is governed by the type of dirt present. After the food processing area has been thoroughly cleaned a disinfectant should be used to eliminate undesirable microorganisms and to reduce the total number of microorganisms to an acceptable level.

In order to prevent corrosion caused by the action of detergents or disinfectants, recommendations as specified by the manufacturer should be strictly adhered to; in general, it is preferable to change the detergent or disinfectant rather than to increase the concentration.

The effectiveness of the cleaning program should always be examined by visual and microbiological methods.

A complete cleaning program is as follows.

1. Dry clean the area by removing all packaging materials and small utensils.
2. Wet the area with potable water at a temperature not exceeding 50°C.
3. Apply a detergent solution and leave on surfaces for about 10 min.
4. Scrub to loosen and remove dirt.
5. Rinse thoroughly with potable water at a temperature below 70°C. If scale has to be removed (i) apply acid detergent, (ii) scrub, (iii) rinse thoroughly, and (iv) remove excess water.
6. Remove excess moisture with a clean squeegee or paper towels.
7. Disinfect, leaving the disinfectant on surfaces for at least 10 min.
8. Rinse thoroughly with potable water.
9. Dry all surfaces.
10. Wash and clean small utensils separately.
11. Examine cleaned areas and take swabs to estimate the number of microorganisms.

References

Bourne M. C., and Jennings, W. G. (1961). Some physicochemical relationships in cleaning hard surfaces. *Food Technol.* **15,** 495–9.

Davis, J. G. (1968). Chemical sterilization. *Prog. Ind. Microbiol.* **8,** 141–208.

Jennings, W. G. (1965). Theory and practice of hard-surface cleaning. *Adv. Food Res.* **14,** 325–458.

Lawrence, C. A. (1968). Quaternary ammonium surface-active disinfectants. *In* 'Disinfection, Sterilization, and Preservation', eds. C. A. Lawrence and S. S. Block. Ch. 26, 430–52. (Lea and Febiger: Philadelphia.)

Parker, M. E., and Litchfield, J. H. (1962). 'Food Plant Sanitation.' (Reinhold Publishing Corp: New York.)

Russon, J. H. (1970). Sanitisers in the food industry. *Aust. Food Manuf.* **39**(6), 16, 18.

Further reading

Bensink, J. C., and Brownlie, L. E. (1970). An evaluation of foaming equipment and foam-additives. CSIRO Div. Food Res., Meat Res. Lab., Indust. Sect., Tech. Rep. 2/70.

Bensink, J. C. (1971). An evaluation of detergents. CSIRO Div. Food Res., Meat Res. Lab., Indust. Sect., Tech. Rep. 2/71.

Bensink, J. C., and Muhl, G. J. (1972). An evaluation of sanitizers. CSIRO Div. Food Res., Meat Res. Lab., Indust. Sect., Tech. Rep. 4/72.

Foods and heart disease

By M. V. Tracey

CSIRO Division of Food Research, North Ryde, N.S.W.

Is there a contribution that the food technologist could make towards reducing the incidence of heart disease? An article based on a talk given earlier this year at a National Heart Foundation Symposium, 'Foods, Fats and Heart Disease'.

Except in childhood, prison, hospital or the armed services, the consumer is the arbiter of what he buys and eats, and although he may be influenced by advice from his doctor or some other source, the final choice of foods, whether good or bad, will remain with him. The food technologist, however, can increase the options open to the consumer by altering the nature and quality of the food on offer. This article will discuss some of the changes which could be introduced in order to allow the consumer greater freedom to modify his diet in a way that may seem to him to be desirable if he is to reduce the risk of heart disease.

Let me make some initial assumptions and then see how it could be made easier for the consumer to modify his diet as he might wish. First, ruminants' fats (beef, sheep, goat and deer) have a low ratio of polyunsaturated fatty acid to the C_{12-16} saturated fat. (I shall refer to this in future as a low P/S ratio.) Secondly, leaf and fruit fat have a high P/S ratio. Thirdly, seed fats or oils often have a high P/S ratio; and fourthly, there is no cholesterol in plant products though other sterols are present. These are sweeping statements of observable fact. Similarly on general medical grounds it may be said that it is desirable—certainly for some individuals—to increase the P/S ratio of the diet, to reduce the proportion of fat in the diet to below 30% of the total calories, and to decrease the dietary cholesterol content. Finally, we must be aware of a sociological observation—people like some foods better than others and will often find it difficult to make major changes in their eating habits, even when strongly advised to do so on health grounds. This means that in changing the chemical composition of customary items in the diet it will be important not to disturb the make-up of currently acceptable meals.

Possible approaches

Change dietary habits

Let me now survey the ways in which the P/S ratio of a diet may be increased and its fat and cholesterol contents diminished. The simplest method for the individual is to eat only that part of a normal mixed diet which has high P/S ratios and a low

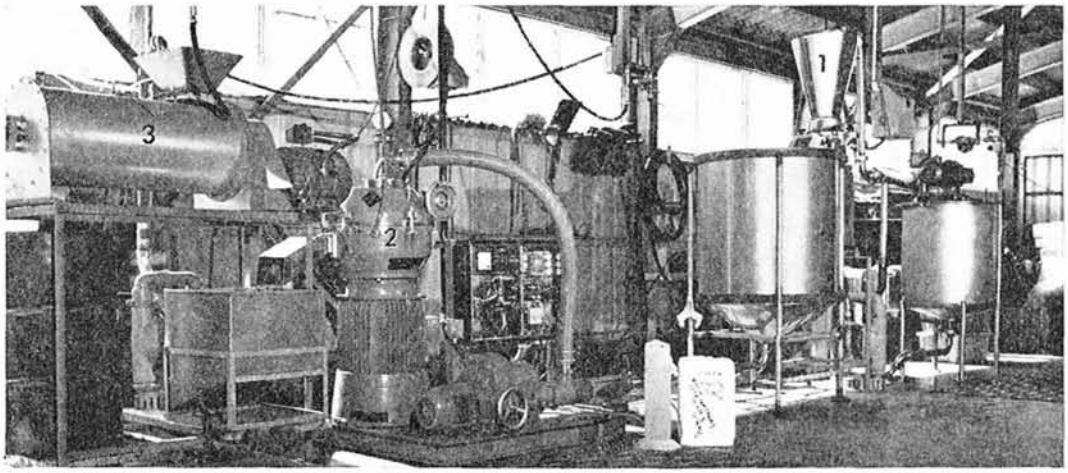


Fig. 1. 'Controlling the diet, not of the consumer, but of the consumed': plant for preparation of protected lipid food supplements. 1, Platemill for initial comminution of oilseed; 2, carborundum-stone mill for fine homogenization and emulsification of the oil–protein homogenate; 3, mixer used for introducing the formalin for protein protection.

cholesterol content. This results in essentially a vegetarian diet with the addition of fish. It would be easy, inexpensive, but quite unacceptable to many people in our present society. A more widely acceptable alternative would be to admit into the diet some items with a low P/S ratio but compensate by the addition of unusual components with a very high P/S ratio such as some of the seed oils. This must be done without unduly increasing the total fat content of the diet. Many diets of this nature have been recommended, but again there is the disadvantage that they are not very widely acceptable, and some people find it difficult or impossible to stick to them for long periods. Both these methods depend on changing the make-up of the diet by substituting some kinds of foods for others. It may be more acceptable to change the composition of the individual items in the diet, leaving it apparently unchanged in terms of its recognizable components.

Change composition of items of diet

Reduce proportion of fat. A first step is to reduce the proportion of fat in all those items of the diet which have a low P/S ratio. This will also reduce cholesterol intake. Among the methods that might be used are to market meat from animals raised in such a way that they will have a lower fat content at slaughter. This would mean encouraging the slaughter of animals of existing breeds at an age before the rate of fat deposition overtakes muscle deposition. The development of breeds designed to come to slaughter in a lean condition is a possibility as is the use of unusual breeds or species of ruminants, for example, the water buffalo, the cow-buffalo hybrid ('beefalo'), which has just been produced in the U.S.A., or domesticated game, either African or Australian in origin. As a supplementary measure to marketing low-fat animals, the proportion of fat in ruminant products can be reduced by processing. Meat can be trimmed before sale, low-fat milk can be sold as an alternative to full-fat milk, and efforts could be made to reduce the amount of fat traditionally used in many processed foods such as pastries, pies, sausages, and canned or comminuted meats. In some instances, fat with a high P/S ratio might be used in the preparation of such foods. These measures would also reduce cholesterol intake.

Increase P/S ratio. Another measure, which would reinforce these, would involve increasing the P/S ratio in individual items of the diet—particularly the animal products. This can be done by controlling

the diet, not of the consumer, but of the consumed—an attractive proposition to most of us. The composition of the fat of the chicken and pig can be influenced by the composition of the fat in their diets (just as that of our own fat can), but this is not so for the ruminants.

It is now clear that the fats, i.e. the triacylglycerides of the ruminants are not only very low in linoleic acid content when compared with those of non-ruminants (or monogastric animals), but that the microorganisms in the rumen constitute an almost insuperable barrier to altering this composition by a simple increase in the polyunsaturated fat content of the feed. In fact, the polyunsaturated fat content of their feed is already high, but it is largely abolished by the activities of the rumen organisms. Until 1970 the position was clear: it was possible by dietary manipulation to influence the P/S ratio in the fats of most animals, but it was not feasible to influence that of the ruminants.

Importance of ruminant products

To assess the importance of the rumen barrier, it is necessary to have some idea of the quantitative importance of ruminant products in the Australian diet. The dry weight of all foods supplied for consumption in Australia in 1971–72 amounted to 690 g per head per day. Of this, 67% or two-thirds was of plant origin and only one-third came from animals. However, the proportion of plant to animal fat provided per head is remarkably different. One-sixth of the total dry matter per head was fat, i.e. about one-third of the energy content of the diet was derived from fat. While we eat twice as much plant dry matter as animal dry matter, the proportion of fat in animal foods is so high that of all the fat consumed —86% or more than five-sixths—came from animal food. Of this by far the largest amount came not from animal seafoods with a high polyunsaturated fat content or from the flesh of animals such as the pig and chicken whose fat composition can be varied simply by dietary means, but from the ruminants with their efficient saturating mechanisms. In fact, five-sixths of it came from ruminants in the form of meat and dairy products. Thus, though we eat twice as much plant than animal matter on a dry weight basis, nearly three-quarters of the fat we consume comes from ruminants, while the remainder is split almost evenly between plant and non-ruminant animal origins.

Can we change the composition of ruminant fats?

The implication is obvious. If we are to alter materially the composition of the fat we consume we must either drastically reduce the amount of ruminant fat in our diet or alter its composition in a major way. And this means finding some way of evading the saturating activity of the rumen microorganisms. Two methods of achieving this are available, neither of which involve surgery.

In the first we persuade the ruminant animal to swallow its food in such a way as to bypass the rumen. Ruminants at the suckling stage have a mechanism for doing this. A reflex muscular action in the suckling lamb or calf causes milk or other liquids to pass directly into the abomasum. With careful management and the use of liquid diets the reflex can be maintained, and polyunsaturated fat can be fed in this way without being subjected to saturation in the rumen. By means of this method research workers in Ireland have recently been able to increase the linoleic acid content of lamb meat to a level of 15–18%.

The second method was developed in the CSIRO Divisions of Animal Physiology and Food Research (Figs 1 and 2). It involves feeding a supplement of highly polyunsaturated seed oil, such as that of sunflower, in a protected form. Microscopic globules of the seed oil are coated with protein from the seed by a process of fine grinding. At this stage other protein such as casein or soya bean protein may be added. The protein is then lightly tanned by the addition of small quantities of formaldehyde. The result is a feed supplement in which the polyunsaturated fat component is unavailable to the rumen microorganisms because the tanned protein coating of the droplets does not break down in the rumen. When it reaches the more acid conditions of the abomasum, however, it breaks down into its components and digestion of the oil proceeds normally as in any monogastric animal. The component fatty acids are not saturated before absorption and there is a consequent increase in the polyunsaturated content of the depot fat and milk fat of the ruminant.

Fig. 2. Flash drier used in the last step of preparing protected lipid food supplements—drying the formaldehyde-treated oilseed homogenate.

The process was patented by CSIRO and has been licensed to Dalgety Agri-Lines Pty Ltd. It is being intensively developed by the Company and its associates, and the supplement is being produced in Australia, New Zealand and the U.S.A. Exploitation of the product is likely to begin in other countries in the near future. By its use, ruminant products can now be produced in an almost routine way in which the linoleic acid content of the fats is at least 20%, and there seems little doubt that they will be marketed in a number of countries at a reasonable price in the next year or two. This development is, I believe, of the greatest importance, since it offers, at last, a method of modifying all ruminant products and thereby altering the nutrition of the typical Australian without affecting his dietary habits.

This stratagem of modifying the ruminant-based foods of man is sufficiently important to warrant a little further discussion of its pros and cons. An obvious disadvantage is that the process is incomplete in its effect as it results in no reduction in cholesterol content, though of course the increased P/S ratio would be expected to mitigate the effect of the cholesterol. In some products, particularly dairy products, an antioxidant might have to be added, as in margarine, to ensure stability during storage. Fortunately, it appears that the storage properties of polyunsaturated meats are as good as those of pork. Finally, the products will certainly have an added cost. The advantages of the products include their acceptability with no necessity to alter the gross make-up of the diet, the fact that they involve no economic upheaval by a swing from the traditional sources of animal foods, and that their use in no way reduces the possibility of the application of other useful measures already discussed, such as reducing the total fat content of the products before consumption.

Other dietary components

Increasing the P/S ratio in ruminant products is of major importance because of their central role in the normal pattern of diet, but there are also possibilities for increasing the ratio in other dietary components. Although the P/S ratio in the fats of plant seeds is generally high, it is also quite variable in single species. It is clear, therefore, that there is room for improvement through breeding, and most plants of agricultural importance have the advantage that the individuals are smaller than domestic animals: to raise 10 000 individual plants to reproductive age and examine their progeny not only requires much less space, but is often quicker, than it would be with sheep or cattle. Although there is little fat in the wheat seed, it is worth some consideration in that wheat fat from white flour accounts for a seventh of our intake of plant fat, and contains more than 50% linoleic acid. Unfortunately, the palmitic content is high. Wheat varieties with lower palmitic levels might well be a worth-while aim of future breeding programs.

The processor

The two possibilities I have just discussed affect the producer rather than the processor, but there is much that the processor could do to increase the P/S ratio in individual items of the diet.

It has long been possible to increase the P/S ratio of margarines, and such products are already available on the market in limited amounts. No problems appear to exist, other than legislative, either in the production of cooking margarines with a high P/S ratio or in the production of butter blends with an improved P/S ratio; indeed the blended butters may well have an added appeal in that they can be made more easily spreadable at low temperatures. Much could also be done to increase the P/S ratio in the normal processing of many baked products and processed meats.

New foods

Manoeuvres such as these shade into the subject of producing new foods which closely simulate the old foods. Margarine is, of course, an outstandingly successful example of this approach, but it is by no means the only one. Products simulating milk and meat have already been developed and marketed. Milk simulants may be made entirely from plant products or they may be composed of the non-fat portion of milk with added plant fats free of cholesterol and with a P/S ratio controllable by choice of the vegetable oil used. Obviously, if coconut oil is used the ratio will be low, but high ratios can be achieved with many seed oils. Meat extenders in the form of structured vegetable protein are already available. When these are used as a diluent in manufactured meat products they reduce the amount of cholesterol (since they contain none), and can be a vehicle for the addition of polyunsaturated fats. More sophisticated and more expensive meat-like products are also available. They are made from seed protein spun into fibres cemented together with a protein such as egg albumen, and their fat content can be an oil with a suitable P/S ratio. They are cholesterol-free.

Outlook

I have briefly surveyed the options that are open in an advanced technological society if we wish to alter the P/S ratio of the diet of some or perhaps all of the population. It is clear that many alternatives exist covering the whole spectrum from a diet that would be quite strange in its make-up to diets that would be almost indistinguishable from those presently eaten, except perhaps in cost. If the demand exists, I have no doubt that the food processing industry has, or will shortly have, all the means available for supplying any of these alternative diets.

New patents

A new occasional feature introducing processes or devices developed within the Division for which patent applications have been made

Debittering citrus fruit juice

Fresh chilled orange juice may be available in supermarkets, restaurants and corner stores almost all the year round if a new process for removing limonin bitterness, present in certain citrus fruit juices, proves successful commercially. So far, the process has been demonstrated only on a laboratory scale at the Food Research Laboratory, North Ryde, but it is relatively straightforward and appears economically feasible.

The process is not concerned with the mild bitterness of Seville orange marmalade or fresh grapefruit. Rather, it is designed to remove limonin, a compound which turns some citrus juices intolerably bitter after they have been processed or allowed

Debittering orange juice on a laboratory scale. Dr R. L. Johnson (left) is filling the juice reservoir while Dr B. V. Chandler withdraws a sample of juice for analysis after it has passed through the gel bead column. Adsorbent beads of the type used for packing are displayed at the base of the stand.

to stand. Limonin bitterness is a universal problem which restricts the processing of a number of varieties of citrus fruit, particularly the seedless ones such as navel oranges, which have a high limonin content. It is an economic problem not only in Australia, but also in California, Israel, Spain, Greece, Morocco, Japan and in all countries where seedless oranges form a high proportion of the orange crop.

In the absence of an effective method for removing the bitterness, fresh chilled orange juice—for which there is a large and growing public demand—can only be made available commercially in Australia during the harvesting season of Valencia oranges (which do not have a bitterness problem) from September to March. However, if the new debittering process proves successful on a commercial scale, fresh orange juice could also be extracted from navel oranges, which are harvested from May to August. Moreover, this period covers the winter months when people are more conscious of the need for vitamin C, of which oranges are an important source.

The new process is based on the discovery by a research team led by Dr B. V. Chandler that cellulose esters—materials not previously regarded as adsorbents—are good adsorbents of limonin from fruit juice.

After extraction and screening by conventional equipment, the juice is either flash pasteurized or chilled for a short period to ensure that the limonin is in an adsorbable form. It is then passed through a column containing cellulose ester material in gel-bead form. This material removes the limonin, and therefore the bitterness, by adsorption. The juice may then be processed or treated for distribution and storage by conventional methods.

The cellulose acetate gel beads may be readily made from cellulose acetate powder by a process also developed at North Ryde. This source material is made locally and is freely available and relatively cheap. The process uses acetic acid and medicinal paraffin, which are permitted food additives. Since cellulose acetate is given the maximum marking for non-toxicity by the British Plastics Federation and is permitted for use in the lining of food packages by the U.S. Food and Drug Administration, the debittering process should not result in any contamination of the juice by toxic chemicals.

The bitter principle is preferentially removed from the juice, leaving the appearance, colour, aromatic flavour and vitamin C content virtually unchanged. Although the adsorbent has a strong affinity for limonin, its activity can be restored simply by washing with warm water.

The cellulose ester process appears to offer an effective solution to the bitterness problem and CSIRO has applied for a patent.

A precision pipette

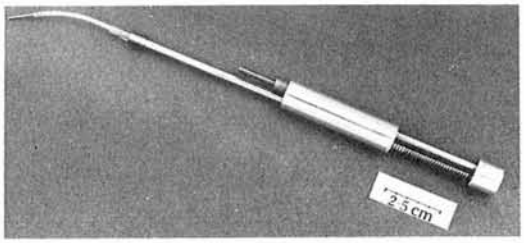
A semi-automatic pipette designed for the precise and rapid measurement of liquids, particularly viscous liquids, has been invented by Mr P. B. H. O'Connell of the Plant Physiology Unit.

The pipette differs from similar devices in that it has a small dead space relative to the delivered volume. This enhances the precision of displacement of aliquots of viscous liquids. Such liquids may be

polymer solutions or extracts of biological samples rich in biopolymers, e.g. extracts of many fruit tissues which have a high pectin content.

Spring-loaded retraction of the plunger to a position predetermined by adjustment of the control rod permits rapid sequential one-handed operation of the device. The non-disposable Teflon extension and stainless steel tip are easily and completely washable.

The pipette has been used for sampling supernatants derived from fruit-tissue homogenates in experiments designed to measure incorporation of carbon-14 and tritium-labelled amino acids into protein. No cross contamination of radioactivity between samples has been observed during these experiments.



News from the Division

Retirements

Richard Atkins

When the present headquarters laboratories of the Division of Food Research were being built at North Ryde, one of the mechanical engineers of the Department of Works who supervised the project was Dick Atkins. Subsequently, in 1963, he joined the Division as Divisional Engineer.

Dick Atkins was born in London and served an engineering apprenticeship there, obtaining a Diploma in Mechanical Engineering from the London Polytechnic and becoming a member of the Institute of Mechanical Engineers. During World War II he served in the RAOC/REME in the United Kingdom and India and rose to the rank of major. He had a number of years experience in industry before coming to Australia and joining the Department of Works. In serving the Division he has made extensive use of his varied experience.

The principal responsibility of the Divisional Engineer is to provide and maintain the buildings and equipment of the Division. This involves the supervision of construction and maintenance activities, and control of the workshops which build and service specialized scientific equipment. No tribute to Dick would be complete without mention of his almost uncanny ability to obtain, where others had failed, the means to finance important works in the Division; he never took 'No' for an

answer if the need was serious enough. Among major projects in which he was concerned with design and construction were the Meat Research Laboratory at Cannon Hill, Qld and the new Fruit Disinfestation Laboratory at Gosford, N.S.W.

In addition to conscientious attention to these duties, Dick Atkins has maintained a keen special interest in the design and construction of cool stores for fruit, especially controlled atmosphere stores. He has contributed new ideas in this area, published several papers, and advised numerous inquirers.

Dick Atkins retired from the Division on, as he said, 'his Independence Day', 4 July 1974. He has made many friends in CSIRO and will be missed for his friendship as well as in his official capacity. Outside the Division he has been a keen member of the Agricultural Engineering Section of the Institute of Engineers and of the Australian Institute of Refrigeration, Air Conditioning and Heating. Dick is an active member of a group of engineers who are using their skills to assist incapacitated people in a very practical way; and he is also actively interested in local affairs at Berowra where he lives.

Now Dick Atkins may even have time to indulge his hobby, the building and running of scale-model steam railway locomotives.

E. G. H., J. F. K., G. F.

E. G. Hall

There is no name more widely known in the Australian fruit-growing industry than that of Eric Hall. From the time of his graduation as B.Sc.Agr.(Hons) from the University of Sydney in 1934, when he was appointed a fruit research officer with the New South Wales Department of Agriculture, Eric Hall immersed himself in the problems of the fresh fruit industry. His initial work included studies on the storage of apples, pears and stone fruit, and he was also committed to Australia-wide investigations on the handling and export of citrus fruit conducted under the auspices of the Citrus Preservation Technical Advisory Committee. It was in this connection that he first became associated with what was then the C.S.I.R. Section of Food Preservation and Transport. When the Section established its headquarters at Homebush in 1938, C.S.I.R. and the Department of Agriculture agreed to work jointly on fruit storage research and Eric Hall was seconded for this purpose. In 1946 Eric became an officer of C.S.I.R. with a continuing responsibility for research on the cool storage of fruits and vegetables, until at the time of his retirement on 4 July 1974, he was a Principal Research Scientist and Leader of the Fruit and Vegetable Storage Section. Throughout the years he fostered close relations with his former Department, and his duties included supervision of programs at the jointly operated Citrus Wastage Research Laboratory at Gosford. Indeed, Eric Hall has worked assiduously to encourage cooperation between all the State Departments of Agriculture, and he has been one of the most active supporters of the Committee for the Coordination of Fruit and Vegetable Storage Research which brings together research workers from all parts of Australia and New Zealand.

In addition to continuing his earlier interest in the storage of pome, stone and citrus fruits, he extended his investigations to the handling and transport of bananas, and played a prominent part in the establishment of the Banana Research Advisory Committee. In the period 1955–70, an increasing part of his work concerned the use of controlled atmospheres in the storage of apples and pears. As a result, C.A. storage of apples and pears is

now widely used in Australia by orchardists and food packers, and consumers receive the benefit in better quality fruit.

As his reputation grew as a leading expert in his field, Eric's services were increasingly sought by bodies outside the Division. In 1952 he was seconded to the Department of Commerce and Agriculture to work for some months as Australian Fruit Officer in London. In 1962 he visited the United Kingdom and Europe in connection with research on the overseas carriage of fruit. The advent of shipping containers for the carriage of fresh fruit brought many new problems and Eric's wide knowledge and experience have been frequently called upon by shippers and the shipping industry. In 1969 he accompanied the first shipment of Australian fruit to travel to Britain by I.S.O. container. At the invitation of the International Institute of Refrigeration and FAO, he visited India and Turkey in 1974 to provide instruction and advice on the storage and distribution of perishable foods.

Eric Hall is a man who dedicated himself completely to the service of the fresh fruit industry. He held strong views about the best courses of action for the welfare of the industry and he promoted his views with sincerity and vigour, by visits to growers in the field, by tireless committee work and by prolific writing about his specialty. He is perhaps best known to *Quarterly* readers as author of the series, 'Storage and Market Diseases of Fruit'. Most recently he has worked with the CSIRO Film Unit to produce a film entitled 'Tree-fresh Oranges' which demonstrates good practice in the handling and distribution of citrus fruits. Eric has retired from active research before reaching the statutory age, but he intends to make himself available to the industry as a consultant so that he may continue to share his knowledge and experience.

J.R.V., J.F.K., G.F.

Philip Read Maguire

After a lifetime of service to science as a biological technician and specialist photographer, P.R. Maguire ('Maggie' or 'Mig') retired from the Division of Food Research in March 1974 upon reaching the statutory age. Within 24 hours he was recalled to serve for some three months more.

Philip Maguire started work in 1925, a few days before his sixteenth birthday, as a junior laboratory assistant in the Biology Branch of the New South Wales Department of Agriculture. In May 1938 he joined the then Section of Food Preservation and Transport of C.S.I.R., and was one of the first people to work in the new headquarters of the Section located in the State Abattoirs at Homebush Bay, Sydney. For many years he was a Technical Officer in the Microbiology Section specializing in mycology, and he also acted as scientific photographer for the laboratory. When the headquarters of what by then was the Division of Food Preservation moved to North Ryde in 1961, he was confirmed in the role of Divisional Photographer and took immense delight in vastly improved facilities.

Maggie built up a reputation for painstaking skill both in microbiological techniques and in scientific photography. During his career he prepared thousands of prints in black and white to illustrate scientific papers and hundreds of colour transparencies for talks and lectures by research staff. The series of photographs on 'Storage and Market Diseases of Fruit' in Kodachrome colour which has appeared in the *Quarterly* during the past five years demonstrates the excellence of his work, although he would claim 'it was the process, not the photographer.' He regularly worked long hours because his work was his life, he was proud to be of service, and nothing was too much trouble for him.

Outside his professional area, Maggie is well known for his sustained curiosity about biology, medicine, natural phenomena, and all things scientific, and for his lifetime interest in semasiology, orthography, and lexicology.

His ability to remember dates was almost legendary and he assumed the role of the Division's demographer 'who prefers, as always, to remain anonymous'. His continuing liking for anonymity prevents us, even now, from publishing a photo of him. Older members of the staff at North Ryde will know of his penchant for bestowing humorously apt honorific titles on his colleagues. All will remember his tremendous, immediate reaction in Homeric laughter to a good joke.

But above all, P.R. Maguire remains a humane man and a true friend. We wish him a long and happy retirement and success in his new activities.

E.G.H., J.F.K.

Visit by President of Burma

The Food Research Laboratory was visited on 3 June by President Ne Win of Burma and his entourage of 30. The President was shown work on controlled atmosphere storage of fruits, biochemistry of eggs, identification of flavour volatiles, flame sterilization of canned foods and the production of foods from structured vegetable protein.

Appointments

Miss A. D. Hocking, B.Sc., has been appointed to the Microbiology Section at FRL to work with Dr J. I. Pitt on the mycology of foodstuffs, and Dr J. M. K. Snowden, formerly of the Biomechanics Unit at Imperial College, London, has been appointed to MRL to investigate the role of proteoglycan in connective tissue.

Mr Ian Stafford is the new Divisional Engineer. He transferred to CSIRO from the National Standards Commission where his work was with the Pattern Approval Laboratory. Mr Stafford received his Diploma in Mechanical Engineering from Sydney Technical College in 1943 and the degree of B.E. (Engineering Technology) from the University of Sydney in 1946.

Work overseas

Dr J. H. B. Christian, Associate Chief, visited Switzerland in June and July to act as a WHO consultant on food microbiology. He was also a member of the Australian delegation at the Codex Alimentarius Commission on Food Hygiene in the U.S.A.

Mr Eric Hall visited India and Turkey recently to advise their Governments on post-harvest handling of fruit and vegetables. In India he also gave lectures at a joint International Institute of Refrigeration/ FAO course on this topic.

MRL's Extension Officer in Perth, Mr Dennis Roberts, has left for Kuwait and Iran to supervise, on behalf of Westralian Farmers' Coop. Ltd, a trial shipment of vacuum-packed chilled sheep meats.

Visiting worker

Professor Reiner Hamm of the German Federal Institute of Meat Research at Kulmbach was a guest worker for three months in MRL's Meat Science and Technology Section. Since 1963 Professor Hamm has been Director of the Institute of Chemistry which is an integral part of the Institute of Meat Research. He is also head of the whole institution every fourth year. The author of over 200 scientific papers and of a book on the colloid chemistry of meat, he was awarded the Distinguished Meat Research Award of the American Meat Research Association in 1973. During his stay at MRL, Professor Hamm participated in investigations into the effects of rapid post-mortem glycolysis on meat quality.

FRL was host to Mr Jamshid Raoufian, food technologist of the Sherkat Sahami Dashte Morghab Company, Teheran, Iran, for about six weeks.

A former member of the Division returned to Australia for a stay of several weeks. He is Professor R. A. Gallop, Head of the Department of Food Science at the University of Manitoba in Winnipeg, Canada. During his time in Sydney, Professor Gallop gave a seminar on 'Food processing without pollution', under the joint sponsorship of the University of New South Wales, CSIRO and the Australian Institute of Food Science and Technology (AIFST).

The Plant Physiology Unit is host to Professor Takao Murata of the Laboratory for Post-Harvest Physiology and Preservation of Fruit and Vegetables at Shiguoka University, Japan. His main interest is the study of the secondary events following chilling injury in plants.

Awards

At the annual convention of the AIFST held in Sydney in June, the Chief of the Division, Mr M. V. Tracey, was given the Institute's Award of Merit for 1974. Mr Tracey has also been appointed chairman of the CSIRO Medical Research Liaison Committee. Members of this committee serve in an individual capacity, not as representatives of their organizations.

Mr R. W. Sleigh of FRL's Physical Biochemistry Section has taken up a Dairying Research Commonwealth Scholarship at the University of New South Wales. Dr R. J. Steele, a member of the Food Technology Section at FRL, has been awarded the degree of Master of Business Administration by the same university.

Specialist courses

At the request of the Australian Department of Agriculture, a short course for meat canning inspectors was organized at FRL. Further courses are to be run at Hawkesbury Agricultural College.

The proceedings of the seminar on Gouda cheese, held at DRL in May, have been published and copies are available from the Librarian, DRL.

Conferences

MRL proposes to hold a series of conferences every two or three years on the general subject of 'Advances in meat science and technology'. The first of the series has been planned for 13–14 November 1974, in Brisbane. A preliminary program has been arranged under the theme of meat chilling and handling, with sessions on the design and construction of chillers, problems and advances in operating chillers, microbiology of chilled meat and transport of chilled meat. Further details can be obtained from Mr P. L. Thomas, Liaison Officer, MRL.

The next World Dairy Congress will be held in New Delhi, India, commencing on 7 December 1974. In the week before the congress, there will be a meeting of the International Dairy Federation, also in New Delhi.

Selected publications of the Division

A reprint of most of the papers listed below can be supplied by the Librarian of the laboratory from which it was published.

From the Dairy Research Laboratory

Buchanan, R. A., and Rogers, W. P. (1973). Manufacture of butter high in linoleic acid. *Aust. J. Dairy Technol.* **28,** 175–8.

Conochie, J., and Sutherland, B. J. (1973). Pressing, packaging, transport and storage of Cheddar cheese in fibreboard drums. *Aust. J. Dairy Technol.* **28,** 11–16.

Harrap, B. S. (1973). Recent developments in the production of dairy products with increased levels of polyunsaturation. *Aust. J. Dairy Technol.* **28,** 101–4.

Henderson, J. O., and Buchanan, R. A. (1973). Manufacture of CFI: a sterilized dairy-based carbohydrate-free infant food. *Aust. J. Dairy Technol.* **28,** 7–11.

Kieseker, F. G., and Zadow, J. G. (1973). Factors influencing the preparation of U.H.T. whipping cream. *Aust. J. Dairy Technol.* **28,** 165–9.

Kieseker, F. G., and Zadow, J. G. (1973). The whipping properties of homogenized and sterilized cream. *Aust. J. Dairy Technol.* **28,** 108–13.

Keogh, B. P. (1973). The setting of microbiological standards for foodstuffs. *Food Technol. Aust.* **25,** 21.

Lloyd, G. T., and Pont, E. G. (1973). The production of concentrated starters by batch culture. *Aust. J. Dairy Technol.* **28,** 104–8.

Muller, L. L. (1972). Metric conversion: some practical aspects for dairy factories. *Aust. J. Dairy Technol.* **27,** 113–16.

From the Food Research Laboratory

Davis, E. G., and Rooney, M. L. (1972). Rigidity of polycarbonate in the presence of sulphur dioxide. *J. Polym. Sci.: Polym. Phys. Ed.* **10,** 2325–31.

Greenfield, P. F. (1973). An example of simulation applied to food engineering. *Food Technol. Aust.* **25,** 502–7.

Harper, K. A., Beattie, B. B.,* and Best, D. J.* (1973). Texture changes in canned apricots. II. Study of infection with *Rhizopus stolonifer* under commercial conditions. *J. Sci. Food Agric.* **24,** 527–31.

Kefford, J. F. (1973). Citrus fruits and processed citrus products in human nutrition. *World Rev. Nutr. Diet.* **18,** 60–120.

Looney, N. E.,* McGlasson, W. B., and Coombe, B. G.* (1974). Control of fruit ripening in peach, *Prunus persica:* action of succinic acid-2, 2-dimethylhydrazide and (2-chloroethyl) phosphonic acid. *Aust. J. Plant Physiol.* **1,** 77–86.

McBean, D. McG., Coote, G. G.,* and Christie, Elizabeth M. (1973). Quality tests of some new and standard potato varieties. CSIRO Aust. Div. Food Res. Tech. Pap. No. 37.

Marshall, B. J., Coote, G. G.,* and Scott, W. J. (1973). Effects of various gases on the survival of dried bacteria during storage. *Appl. Microbiol.* **26,** 206–10.

Mitchell, R. S., and Rutledge, P. J. (1973). Control of colour in potato crisps by water treatment before frying. *J. Food Technol.* **8,** 133–7.

Mitchell, R. S., and Rutledge, P. J. (1973). Determination of a blanching treatment for potatoes for freezing. *J. Food Technol.* **8,** 89–96.

Pitt, J. I. (1973). An appraisal of identification methods for *Penicillium* species: novel taxonomic criteria based on temperature and water relations. *Mycologia* **65,** 1135–57.

Pitt, J. I. (1973). Mycotoxins. *Food Technol. Aust.* **25,** 291–4.

Powers, M. J.,* and Board, P. W. (1973). Apparatus for measuring time to breadkown of heated fleshy plant tissues. *J. Texture Stud.* **4,** 278–83.

Rooney, M. L., Best, D. J.,* and Davis, E. G. (1973). Molecular complexes of sulfur dioxide with organic carbonates. *J. Polym. Sci: Polym. Chem. Ed.* **11,** 2601–13.

Ruello, J. H., and McBride, R. L. (1973). Consumer acceptability of the royal red prawn (*Hymenopenaeus sibogae*). *Fisherman (Syd.)* **4**(9), 4–8.

Scott, K. J.,* and Wills, R. B. H.* (1974). Reduction of brown heart in pears by adsorption of ethylene from the storage atmosphere. *Aust. J. Exp. Agric. Anim. Husb.* **14,** 266–8.

Sleigh, R. W., Melrose, G. J. H.,* and Smith, M. B. (1973). Isolation and characterisation of hen egg white ovomucin. *Biochim. Biophys. Acta* **310,** 453–60.

Wills, R. B. H.* (1973). Relationship between hexanol levels in apples, and the development of soft scald. *J. Hortic. Sci.* **48,** 165–8.

Wills, R. B. H.,* Scott, K. J.,* and Campbell, J. E.* (1973). Effect of preharvest application of gibberellic acid (GA_3) on storage breakdown of apples. *HortScience* **8,** 395.

From the Food Research Unit, Hobart

Thrower, S. J., and Eustace, I. J. (1973). Heavy metal accumulation in oysters grown in Tasmanian waters. *Food Technol. Aust.* **25,** 546–7, 549, 551–3.

Young, F., James, D. G., Olley, J., and Doe, P. E.* (1973–74). Studies on the processing of abalone. IV & V. Dried abalone. VI. The effect of brine composition on the quality and yield of canned abalone. *Food. Technol. Aust.* **25,** 142–9, 189–95; **26,** 96–107.

From the Meat Research Laboratory

Bouton, P. E., Carroll, F. D.,* Fisher, A. L., Harris, P. V. and Shorthose, W. R. (1973). Effect of altering ultimate pH on bovine muscle tenderness. *J. Food. Sci.* **38,** 816–20.

Bouton, P. E., Carroll, F. D.,* Harris, P. V., and Shorthose, W. R. (1973). Influence of pH and fiber contraction state upon factors affecting the tenderness of bovine muscle. *J. Food. Sci.* **38,** 404–7.

Bouton, P. E., Fisher, A. L., Harris, P. V., and Baxter, R. I.* (1973). A comparison of the effects of some post-slaughter treatments on the tenderness of beef. *J. Food Technol.*. **8,** 39–49.

Bouton, P. E., Harris, P. V., Shorthose, W. R., and Baxter, R. I.* (1973). A comparison of the effects of aging, conditioning and skeletal restraint on the tenderness of mutton. *J. Food. Sci.* **38,** 932–7.

Graham, A. (1973). Meat freezing. *Aust. Refrig. Air Condit. Heat.* **27**(7), 18–22.

Kaess, G., and Weidemann, J. F. (1973). Effect of ultraviolet irradiation on the growth of micro-organisms on chilled beef slices. *J. Food. Technol.* **8,** 59–69.

Macfarlane, J. J., Harris, P. V., and Shorthose, W. R. (1973). Manipulation of meat quality, particularly tenderness, by the processor. *Proc. Aust. Soc. Anim. Prod.* **10,** 219–26.

Smith, M. G., and Grau, F. H. (1973). Occurrence of salmonellas on the hides and fleeces of cattle and sheep at slaughter. *Aust. Vet. J.* **49,** 218–19.

*Not a member of the Division.