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Fish Canning

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INTRODUCTION

The succesful development of a fish canning industry is dependent upon several factors, including the choice of appropriate sites for the canneries, the establment of suitable buildings and canning facilities, and the availability of fish suitable for canning. Needless to say, the canned fish and other fish products must be of sufficiently good quality to be acceptable to the consumer, and must be profitable enough to render the enterprise worth while.

Proximity to the source of fish may seem an obvious requirement for a fish cannery, but other factors such as availability of labour, water supply, and transport facilities have also to be considered. Continuity of supply of raw material is a factor which can have a significant influence on the success of the enterprise, since longer canning seasons lower overhead expenses and induce cannery workers to remain in the area, thus ensuring the availability of a core of skilled workers, essential for efficiency. It may therefore be preferable to select a site close to an area where several species of fish suitable for canning can be caught at different seasons of the year, even though the quantity of any one species is not really large. Alternatively, a location may be chosen where plentiful supplies of particular species are available only for limited periods each year if the expense of freezing preservation in order to prolong the canning season is warranted.

CANNERY CONSTRUCTION AND EQUIPMENT

The Building

One of the principal faults in fish cannery construction is failure to allow sufficient space for efficient operation. Jarvis (1943) recommends that the space needed for proper placing of the equipment be decided upon and the building then planned around this equipment. He also suggests that the approximate floor space required for operating one line of machinery to deal with several different products throughout the year should be at least 2400 square feet, to permit of a daily production of 20,000 cans. In addition to this essential space for actual canning equipment and facilities, further space is required for storing empty cans, filled cans, and for the boiler room and a machine shop.

Wiegand (1950) emphasizes the need for a good layout such that all materials flow in one direction from the receiving end and thence in a straight, more or less continuous line, without bottle-necks. He advocates a mechanized transport system, since it is cheapest to handle material as little as possible. In recommending the use of one-floor buildings he lists the following advantages:

- They are less expensive to build and maintain.
- A better supervision of operation with less effort is possible.
- Removal of dust, fumes, and steam is simplified.
- More essential space is provided since there is no need for heavy columns.
- Unit transport systems can be used and elevators eliminated.

* Earlier articles in this series appeared in *C.S.I.R.O. Food Preservation Quarterly*, Vol. 18 (1958) pp. 6–11, 35–8, 76–8; Vol. 19 (1959) pp. 2–9, 42–8; Vol. 20 (1960) pp. 9–12.

The most economical type of building is usually of steel and wood framework with asbestos cement walls and roofing. A "saw-tooth" roof is light, in addition to providing good ventilation and facilitating the escape of steam. Good lighting favours efficient workmanship and makes cleaning and inspection easier. Plenty of large windows and roof skylights enable the maximum amount of daylight to be obtained.

Reinforced concrete floors, preferably waterproofed, are the most suitable and practical. Special reinforcement should be provided where machinery is to be placed. Wooden floors, when used, should be waterproofed. To facilitate good drainage, all floors should have a slope of $\frac{1}{4}$ in. to the foot where mechanized conveyors are used, and $\frac{1}{8}$ in. to the foot where wheel carts are used. Gutters should preferably run lengthwise to the plant and parallel to the canning line, with no section of the floor more than about 16 ft from a gutter. Gutters should open into floor holes fitted with drain pipes connecting with the sewer, if available, or to a central drain discharging at some distance into a channel with a good tidal flow.

Equipment

Various types of cannery equipment, some of which are described later, are used for the operations of fish cleaning and dressing, pre-cooking, can filling, heat exhausting, addition of substances such as salt and sauces, can closing, steam pressure cooking, can cooling, labelling, and packing. These should be in efficient working order, and so designed as to permit of easy cleaning.

Steam Supply

According to Jarvis (1943) the average steam requirements to allow for heat processing (exhausting and retorting) and for cleaning purposes may be calculated as $\frac{1}{2}$ boiler-horsepower per case of production. On this basis 500 boiler-horsepower would be required for a daily cannery output of 1000 cases or 48,000 1-lb cans. By installing two boilers, each of sufficient size to supply the average daily steam requirements, the cannery could continue to be run in the event of a boiler breakdown.

Conveyance of Fish and Products

Mechanization of fish and products movement into and through the cannery will serve to reduce labour costs and to increase the rate of output, but the costs of equipment for such mechanized operations must be considered in relation to the overall economy of production. Where the daily production is comparatively low, e.g. about 10,000 cans, the installation of expensive and extensive conveyor systems may not be warranted. In such cases the labour required to operate the canning machinery could also be used to do the work performed by conveyors in larger canneries.

CONTAINERS

Canning of fish and marine products involves filling the raw material into suitable containers and subjecting them to the usual treatments applied to canned foods. In some cases the raw material is given a preliminary cooking, and it may be pre-heated by special methods to minimize objectionable changes occurring during later heat sterilization in the containers.

Types of Container

Glass, and tinplate made up of 98·5–99% steel base (iron) and the remainder tin coating, are the two principal materials used for making containers for heat-processed fish products, but aluminium is also used. By far the larger proportion of such products is packed in tinplate containers for commercial purposes. During recent years electrolytic tinplate with tin coatings as low as 0·5 lb/base box* has been used with some fish products, but at this reduced level it is necessary in some cases to provide additional protection by means of suitable internal lacquers to minimize the dangers of staining of the can.

Lacquered Cans.—Can lacquers or enamels are of three types, namely, acid resisting, sulphur resisting, and "general purpose". Acid staining is generally more severe with electrolytic tinplate than with hot-dipped tinplate. However, the type of tinplate has little effect on the amount

* Base box is the trade unit for measurement of area of tinplate, and consists of 112 sheets each 20 by 14 in., with a total surface area (both sides) of 62,720 sq. in.

of sulphur staining in a can. Fish packs are generally non-acidic, but certain types of pack contain added acid, as in packs with vinegar, mustard sauce, etc. It is important that lacquers selected for fish packs should be resistant to oils in the pack.

Aluminium Cans.—Aluminium food cans have for many years been used for canned fish products in Scandinavia. At the present time Norway is producing cans from continuously anodized and lacquered aluminium alloy strip more cheaply than from tin-coated steel. An aluminium-magnesium alloy, anodized and lacquered, gives cans almost as strong mechanically as any competitive material for use in sardine cans.

Glass Containers.—Glass containers are sometimes used for the purpose of displaying the contents, but this is advantageous only for attractively coloured or pigmented products. Extreme care is required in retorting and cooling glass containers to avoid breakages, and when exposed to light there is a tendency for the product to fade in colour.

PREPARATION FOR CANNING

Thawing

Frozen raw material requires thawing to enable proper handling prior to canning and to ensure that the selected cooking conditions during retorting are adequate to sterilize the can contents. In fish such as tuna, which are usually pre-cooked before putting in the cans, incompletely thawed fish tend to develop a honeycomb-like structure during pre-cooking.

Large fish such as tuna are often frozen at sea, and in some circumstances it is possible to commence thawing some of the fish in sea water some time before reaching port, so that thawed or partially thawed material is immediately available for canning purposes. Thawing fish by immersion in running water is one of the quickest and most effective methods for obtaining uniformly thawed material. Very slow air thawing of large fish may lead to spoilage of thinner areas of flesh while the deeper layers still remain frozen. Conditions during thawing should be regulated so that flesh temperatures do not exceed about 75°F at any time.

Thawed fish should be held at the lowest practicable temperature while awaiting canning if there is likely to be a delay of longer than 4 or 5 hr.

Cleaning and Dressing

Although the flesh of fish, shellfish, and crustaceans may be prepared by simple hand operations in readiness for canning, it is sometimes more convenient and economic to use machine equipment for some of the stages in handling.

Washing

Washing and cleaning is necessary for some raw material before other operations are commenced. In other cases it is essential only during and after dressing, prior to canning.

Shellfish are frequently contaminated on the outside of the shells by mud, sand, and seaweed on arrival at the cannery. Effective removal of these requires water applied at high pressure, usually by spraying. The shellfish may be carried on conveyors through the sprays or into a drum-type rotary washing machine set in a tank of water in which they are whirled about and rinsed under strong water pressure. If the contamination is not too great it is possible to clean the shells by immersion in running water for short periods, or by simple hosing. Either sea water or fresh water may be used for washing—bacteriological purity is not as important here as it is for water which is to be used during fish-dressing operations or for cleaning the flesh after removal from the shells.

In the washing of the flesh, which may be contaminated by viscera, blood, slime, and dirt, generous quantities of water of good bacteriological purity are essential. Simple washing by immersion in tanks of water is usually effective in removing blood, but the water must be changed frequently to keep down bacterial contamination to a minimum. Over-soaking in water tends to soften the flesh, but this can be avoided by adding about 1% salt to the water.

The efficiency of washing is increased by agitation of the water, as in a rapidly moving current in a flume conveyor or by rapid pump circulation. Alternatively, drums revolving in tanks of water or strong jets or sprays may achieve the same result. The use of revolving drums in combination with high-pressure water sprays is effective for some types of fish which must also be scaled. One of the most efficient types of agitation washer, used for the removal of shell fragments from oyster meat, makes use of compressed air for agitation of the water.

Salt brines of various strengths may also be used to wash the raw material. These aid in the removal of blood or slime and they also serve to firm the flesh and make it easier to handle. It is possible to adjust the strength of the brine so that the uptake of salt by the flesh is in the vicinity of 1%, thus obviating the need to add any more salt to the product for flavouring purposes.

Scaling

One machine commonly used for scaling small fish such as pilchards and herring consists of an inclined, revolving, wire-mesh drum, with a perforated pipe along the axis, and with longitudinal baffles of angle iron at intervals around the inner circumference. While the drum revolves in a tank of water the fish are simultaneously washed and scaled. If water is plentiful it may be sprayed on the fish from the perforated pipe, thereby washing the scales away as they are loosened.

Metal cylinders of bronze or steel, fitted with knurled faces or blunt blades and rotated by flexible drives from electric motors, may be used as scalers by running them over the surface of the fish with the same action as in shearing sheep. This type of machine scaler has been used for fish such as Australian salmon, but in some canneries it has been replaced by modified potato peelers operating at low speed, the scales being removed by friction against "Carborundum" surfaces.

Shelling

Crabs are usually shelled alive for best results. Cooked crab meat deteriorates much more rapidly than uncooked meat and is more likely to become discoloured in processing. It is also more difficult to clean than uncooked meat. Shrimps and prawns are also shelled before the tail flesh is prepared for canning. Removal of the tail flesh is made easier by pre-cooling, peeling being done either by hand, or by machines recently devised for this purpose. If pre-cooked before the shell is removed, the flesh is more susceptible to sulphide staining during heating in the can.

While it is possible to remove the raw flesh by hand from oysters, mussels, clams, and other shellfish, it is customary to pre-heat the live fish to open the shells and to partially cook the meats in order that they can be more easily and cleanly cut and separated from the shells. Pre-heating of clams, oysters, and mussels is usually done by steaming, and of lobsters and crayfish by immersion in boiling water, although steaming is sometimes used for these species also. Steam chests capable of withstanding a pressure up to 12 lb/sq. in. (245°F) are usually rectangular, horizontal retorts of sheet iron, with doors at each end. Continuous pre-cooking in steam may also be achieved by using long, cylindrical or rectangular, insulated cookers. The raw material is carried through these on slat conveyors and is thus exposed to steam at about 210°F for times sufficient to open the shells. Steaming times range from 1 to 30 min at 212°F, and may be as long as 15 min at 245°F, depending on the species being processed. A more intense heating is given when it is desired to obtain maximum yields of liquor (suitable for soup making) from the heated meats.

With most species of clams, oysters, and mussels it is necessary to cut the muscle attaching the pre-cooked meat to the shell to enable it to be removed. It is, however, possible to shake out the pre-cooked flesh of the razor clam (*Siliqua patula* Dixon) after a preliminary steaming or water blanching for 1 min at about 210°F. The clams are carried on a slightly inclined metal screen divided on the surface into a series of saw-tooth ridges. Because of a shaking motion imparted to the screen by means of a cam mechanism, the clams advance from ridge to ridge and the meat is shaken free from the opened shells.

Gutting

In some cases it is not necessary to gut fish before canning. Fish such as pilchards, anchovies, and small herring may be held alive a few days or longer in nets, traps, or enclosures, in sheltered sections of bays or estuaries. This allows emptying of the gut to take place.

Fish to be canned are frequently gutted by hand, but vacuum machines are sometimes used for removal by suction of the gut from headed pilchards. In another method the fish are carried past a revolving, circular blade which severs the backbone and cuts the head off, leaving it attached to a thin strip of belly flesh. In the next step the fish on a conveyor pass a whirling paddle which completes the heading operation, pulling out the entrails attached to the head, with a strip of belly flesh. In another type of machine the head is completely removed and a revolving burr is plunged into the body cavity to ream out the viscera. This burr is perforated, and water at high pressure is forced through to flush out the cavity.

Several other types of mechanical devices are used for gutting fish such as herring. Eviscerating equipment for handling smaller, more delicate, fish has recently been developed in Europe and Canada. With these smaller fish, prior grading into sizes facilitates evisceration.

The intestinal tracts of raw prawns and shrimps, or of crayfish and lobster tails, are sometimes removed in order to prevent discoloration of the flesh in these areas. In prawns and shrimps the tracts may be removed by hand, or by the cutting blades of machines. The operation applied to crayfish and lobster tails consists of cutting round the anal end of the tract with a specially designed knife and pulling it out. It is also possible to cut out the tracts after precooking and splitting the whole crustaceans before canning.

In some species of clams it is customary to remove the dark body mass or stomach after the shells are opened: at the same time the siphons or necks are cut away.

Cutting and Filleting

Cutting and filleting the dressed fish to provide suitable material for filling the containers may be done by hand or with the aid of machines. Gang knives or cutters adjusted to cut the fish transversely into pieces of the correct length for the can may be operated by hand or mechanically. Machines have been developed for cutting fish flesh such as herring fillets or precooked tuna into small pieces, but they have not proved suitable for handling small pilchards, sprats, or silds.

PRE-COOKING AND FILLING

When the material is suitably cleaned and prepared it is ready for filling into the cans or containers. Many products are precooked lightly, either before or after filling, and procedures vary according to which method is adopted.

Pre-cooking Before Filling

In commercial practice it has been found that pre-cooking the raw material before placing in the containers has certain advantages. With most species of tuna the flavour is more attractive than when the raw flesh is packed straight into the cans. A prior light cooking of lobsters and crayfish simplifies the removal of the flesh from the shell. The short heat treatments applied to whole shellfish to facilitate opening the shells are usually sufficient to produce some precooking of the flesh.

During pre-cooking, exudation of muscle juices begins when the flesh temperature rises above about 160°F, and the loss of liquid may reach 20–25% of the raw weight if heating is sufficiently prolonged. In the case of tuna the loss of liquid during normal pre-cooking is usually so large that no further liquid exudes from the flesh during subsequent heating in the can. The flesh of more lightly pre-cooked flesh, whether of fish, shellfish, or crustaceans, usually loses some further liquid during cooking in the can.

Another advantage of pre-cooking is that there is less likelihood of undue dilution of any sauces that might subsequently be added to the containers in order to produce certain flavours in the canned products. The appearance of the oils commonly added to tuna meat is also adversely affected by even small quantities of juice exuding from the fish meat in the can.

Pre-cooking of tuna is usually carried out by exposing the gutted fish to steam at about 216°F. In France a more common practice is to cut the fish into pieces and cook in a weak salt brine at boiling point. In another procedure the tuna flesh is enclosed in cylindrical moulds in which cooking is done in steam.

The tail flesh of shrimps and prawns to be canned is pre-cooked without the shells for 5–7 min in boiling brine containing about 1 lb of salt per gallon of water. The meats curl during this blanching operation and take on their characteristic pink colour. It is not possible to develop the proper degree of curl by cooking the raw meats in the container.

Filling

The prepared flesh may be transferred to containers by hand or by means of various filling devices. Very small fish are usually hand packed, but the flesh of larger fish is less likely to suffer damage through the use of machines for packing. Increasing use is being made of cylindrical pack shapers in which pre-cooked tuna flesh is moulded and cut by rotating knives to can length size before being forced by means of plungers into the containers. Fillers for relatively small-sized portions of flesh are operated automatically. In most cases the flesh of shellfish and crustaceans is hand packed.

Pre-cooking After Filling

Pre-cooking of the contents of the containers after filling is commonly practised in the process of "heat exhaust", a process designed to produce a vacuum in the containers after completion of canning. In some cases pre-cooking is done as a preliminary to the removal of portion of the muscle juice from the fish, thereby reducing the extent of exudation of liquid during retorting. This is especially important when sauces are to be added to the containers just before closing. A reduction of the free liquid in the contents is claimed to minimize the degree of softening and disintegration of the flesh during subsequent handling of the cans.

Various mechanical devices are used to enable the pre-heated cans to be inverted, to permit most of the exuded liquid to drain from the can without losing the flesh.

CAN CLOSING

It is not intended in this article to deal at length with can closing machines, methods of operation, etc., details of which may be found in a report by Jarvis (1943).

It is important to have a vacuum in the can, as this keeps the can ends collapsed, prevents strain on the container during processing, and reduces chemical activity. Air may be exhausted from the container by heat, or mechanically. The oldest method of exhaust, still used to some extent, is to fill the cans with hot pre-cooked product and to seal immediately. There must be no delay between filling and sealing. Although steam exhaust boxes are still used to some extent, they are now being replaced by vacuum can-sealing machines.

ADDITIVES

Brines, oils, sauces, and other ingredients may be added to the can before closing in order to impart certain flavours to the product, but such additives also serve other purposes. They may, for instance, shorten the processing time by facilitating the heat transfer—as in "wet packs"—or by lowering the hydrogen ion concentration (e.g. in clam chowder). They also fill the can, reducing the amount of headspace and thereby the possibility of corrosion in the can.

Water

Water is added chiefly to the pre-cooked flesh of fish, shellfish, oysters, and crustaceans. Often it is added with other ingredients such as salt. The water should be as pure as possible, and free from microbiological contamination and chemical impurities.

Salt

Salt is often added to improve the texture of soft-fleshed fish and to flavour the product. It is important to use good-quality salt with less than 1% of chemical impurities such as salts of calcium and magnesium.

Salt may be added in the dry state, in the form of powder or tablets, or it may be added in the form of brine to the flesh before or after filling. Tablet salting would ensure that each can received the right amount of salt, but a practicable method of introducing the tablets under commercial conditions has yet to be devised. The optimum concentration of salt is between 1 and 1·5% of the can contents. The made-up brine solutions should be tested for strength with either the Baumé hydrometer or the "salinometer". The reading on the Baumé hydrometer multiplied by four is approximately equal to the salinometer reading. A brine registering 100° salinometer will contain approximately 25% salt by weight.

Oils

Many different types of oils are used in fish canning, such as cottonseed oil, olive oil, peanut oil, soy bean oil, and fish oils such as pilchard oil (recovered from liquid drained from cans after pre-cooking), sild oil (recovered from sild sardines in Norway after pre-cooking, centrifuging, and partial polymerization), and salmon oil (extracted from fresh salmon trimmings).

The two most commonly used vegetable oils are cottonseed oil and olive oil; olive oil is used principally in Europe and cottonseed oil in the United States. It is necessary to use high-grade oils in fish canning to ensure a product of pleasing palatability. The addition of an ordinary grade of cottonseed oil to fishery products gives the goods a reputation of being inferior in quality. Norway has specifications for purity of olive oil, but the oil is not used as frequently now as in former times.

Vinegar and Spices

Some fish, such as mackerel fillets and sardines, are packed in special vinegar sauce High-quality ingredients should be used to ensure a product of good quality; the vinegar should be white, distilled, pickling vinegar, with an acetic acid content of 6%. It will be necessary to dilute this vinegar, but it is better to dilute a strong vinegar accordding to formula than to use a vinegar of lower acid content.

The use of ready-mixed spices is not recommended, because of variation in proportions of the spices in the mixture, and because often the quality is poor. It is preferable to purchase fresh, whole spices for grinding and mixing in the canning factory as required.

Mustard Sauce

Mustard sauce should be made from clean mustard seed, and the other ingredients such as salt, vinegar, and spices should be fresh and unadulterated. The amount of mustard seed should not be less than 5% of the total weight of the sauce. The main spices used are cayenne, or red pepper, and turmeric, other spices varying with individual requirements. The acid content of the vinegar, calculated as acetic acid, should not exceed 1·5%; figures higher than this may cause the formation of "hydrogen swells" in cans.

Tomato

Tomato is added to fish products in the form of purée, paste, or sauce The Fishing Industry Research Institute, South Africa, has investigated problems concerned with the addition of tomato products in fish canning and has set out recommendations for purity, colour, total soluble solids, etc. (Dreosti and Bloch 1948). The sauce is made up of screened tomato pulp, vinegar, spices, onions, and salt. A variety of spices can be used, but bay leaves and cloves form the most popular combination.

The acid content of the vinegar in the sauce must be carefully controlled to avoid the formation of "hydrogen swells". The specific gravity of the sauce should be 1·07 or better; a thin sauce adds neither to the appearance nor to the flavour.

Monosodium Glutamate

This is sometimes added in low concentration to canned tuna and other fish to enhance the natural flavours.

Colouring Matter

The addition of certain colouring substances is permitted in some countries for products such as fish paste. They are chiefly of vegetable origin because many countries prohibit the use of a number of the coal-tar dyes for colouring foodstuffs. Certain dyes which are permitted will not withstand processing without some destruction of the colour.

PRESERVING METHODS

As with many other types of canned foods it is usually advantageous, once the container has been filled and sealed, to apply some form of heat sterilization to the product, in order to ensure reasonable shelf life. In some cases, however, preservation may be achieved by the use of appropriate additives before the container is sealed. The principles underlying the various techniques are dealt with below.

Unprocessed Packs

Some products such as oysters, crab, and shrimp are heat processed, but there is a market for these foods in unprocessed form. Other examples of this type of raw product are anchovies, codfish, smoked herring, smoked salmon, and spiced herring. The storage life of the products depends on partial microbial control by addition of salt, acetic acid or other acid, spices, and in some cases in Europe, the addition of permitted preservatives. (Many European countries have recently prohibited the use of preservatives.) In some foods with a high salt content fermentation by a non-harmful microorganism is allowed to develop. Storage at low temperatures is generally an essential requirement for satisfactory shelf life.

Commercially Sterile Packs

In an earlier article in this series, Empey (1960) defined the term "commercial sterility". In canning by heat sterilization, heat is applied to the product in hermetically sealed containers in order to destroy moulds, yeasts, and microbial and tissue enzymes, and to destroy or inactivate bacteria likely to cause spoilage. Some bacteria form heat-resistant spores which are impossible to destroy completely without adversely affecting the appearance, texture, or flavour of the product. The canner is compelled to limit his objective to commercially sterile products in which microorganisms likely to cause spoilage during commercial storage have been destroyed. Details of the type of equipment and its use, and particulars of processes for individual products, may be found in a code of practice of the South African Bureau of Standards (1957) and in a bulletin of the National Canners Association (1955). Some of the principles involved in obtaining commercial sterility are outlined below.

Efficiency of Sterilization

It is imperative that the material to be canned is fresh. Decomposing or stale material would have a greater number of microorganisms present, and a longer processing time at the same temperature would be required for commercial sterility. A longer process would produce sterility, but off-flavours and odours would persist.

Maturity in fish is accompanied by changes associated with approaching spawning. A softening of the flesh is often accompanied by an increase in the number of microorganisms present, and heavier processing is therefore required. In fish such as salmon, off-odours and flavours are present during spawning and the material needs to be well exhausted and processed to improve quality.

Variation in the amount of material in the can may affect the processing conditions. Overfilling retards heat penetration and reduces the vacuum in the can. Underfilling shortens the process, but increases the possibility of corrosion in the headspace of the can.

Starchy foods such as fish balls have a slow rate of heat penetration and a reduction in the size of pieces assists in shortening the processing time. The rate of heat penetration will vary with the thickness of the container walls, and is also affected by the composition of the container itself, e.g., iron is a much better conductor than glass. Water, an important component in fish products, is a poorer conductor than either of these two materials except when there is free convection.

The time for sterilization will vary with the ratio of surface area to volume of the container, and also with the distance from the surface to the centre. Also, the initial temperature of the product will determine time of processing, and a mechanically exhausted pack will have a lower temperature than a hot-filled pack and therefore requires a longer sterilization period. Overcooking can result if the "coming up" time is not standardized. Processing times will be longer in packs where heat penetration is mainly by conduction than when it is mainly by convection, as in wet packs, such as shrimp. Fish products of high-oil content generally require heavier processing than those of low-oil content.

In heat sterilizing, time and temperature are intimately associated. A short time at a high temperature has a number of advantages over a longer time at a lower temperature. However, short time/high temperature treatments cannot be applied to some products without resultant damage, e.g. minced razor clams.

The can should be cooled rapidly after processing in order to avoid overcooking. The processing time is often shortened by the addition of acids such as citric, but in the case of crustaceans, this acid is added to limit sulphur staining.

Pasteurized Packs

In pasteurization or partial sterilization the temperature level at the slowest heating point is raised to between 160 and 180°F, which is sufficient to destroy moulds, yeasts, and vegetative bacterial cells, but not spores. This process is generally applied where the texture and flavour would be adversely affected by the higher heat process, e.g. fish roe used for production of caviare. The safe storage life of these products depends on their having a salt concentration of 10% or greater, or being stored below 40°F.

As discussed earlier, prompt and rapid cooling is standard canning practice, particularly for products susceptible to overcooking, e.g. crustaceans. Water should be admitted slowly at first and the air pressure should be sufficient to maintain a pressure equal to the steam pressure.

CHANGES DURING PROCESSING AND STORAGE

Texture Changes

Many fish are subjected to some cooking or drying process before canning, in order to remove excess water. Pressure cooking of raw flesh causes a loss of muscle juice of 15–25% by weight, but the loss is much smaller if processing is preceded by precooking. Schoonens (1952) states that precooking is unnecessary if the fish are treated with a water binding agent, such as sodium carboxymethylcellulose.

Texture changes take place due to heat coagulation of the proteins during precooking and processing. Poor texture often occurs during processing because of oversalting before canning. Careless thawing of frozen fish may also cause inferior texture during processing.

Flavour Changes

Owing to the intensity of the heat processing, certain flavour changes take place which are more pronounced than in normal cooking. In general, strongly flavoured pelagic fish such as herring, pilchards, and salmon give more palatable canned products than the white-fleshed demersal species. In the latter the more delicate natural flavours are replaced by less desirable cooked flavours.

Very little is known of the chemistry of flavour changes during cooking and subsequent storage, but work in this field has begun in the United Kingdom, South Africa, and Japan. It has been known for some time that a part of the trimethylamine oxide in sea-water fish is reduced to trimethylamine during processing and subsequent storage. Also, some of the urea in the flesh of sharks and rays is converted into ammonia. Some methods of cooking shark involve the addition of organic acids to reduce the pH of the flesh prior to pressure-cooking, thereby preventing the development of ammoniacal odours and flavours in the canned product. However, in this laboratory (Anderson, unpublished data) it was shown that with school shark (*Galeorhinus rhinophares*) there was an accelerated heat breakdown of urea when the pH of the flesh was reduced.

Discolorations

Certain types of colour change have been discussed in a previous article in this series (Empey 1960). Changes in colour frequently occur during canning, and are particularly difficult to avoid when the contents of the container are heat sterilized.

Sulphur compounds in the flesh of certain species break down on processing and react with the iron base of the tinplate to form iron sulphide. Blackening of the contents or inside of the can due to this cause is often found in crab, clam, shrimp, and lobster packs, but may also be found in other packs, such as tuna (Pigott and Stansby 1957). Suitable sulphur-resisting lacquers overcome this problem. However, as sulphur staining occurs most readily when the product has an alkaline reaction, and because even on lacquered cans some blackening may occur at the side seam where the enamel lining may become damaged during can making, it may still be necessary to use organic acid additives or to employ parchment paper linings.

A melanin type of discoloration, often found in crustaceans, may be avoided by close attention to removal of as much blood as possible and to prompt handling prior to canning.

Carter (1938) has shown that the proteinaceous curd which frequently forms on the surface of canned fish products can be effectively controlled by dipping the product in tartaric acid. This has been confirmed by American investigators (Dassow and Craven 1955), who have shown that dipping thawed red salmon for 1 min in a solution of 5% tartaric acid before canning effectively reduces curd formation and is superior in this respect to brining. Treatment with tartaric acid tends to prevent fading of colour, but slightly alters the shade to orange-red.

Crystals of struvite, which is a magnesium ammonium phosphate resembling glass, frequently develop in fish products during storage. Development of this "glass" in canned rock lobster can be controlled by the addition of "Calgon" (a hexametaphosphate) at the rate of 1 grain per 8-oz can (van der Merwe 1950).

QUALITY CONTROL AND THE MARKET

Canning is a method of food preservation developed only in modern times, and sea foods were among the first products canned. In the developmental stages of the industry trial-and-error methods were used, but today the industry depends on the application of scientific principles to ensure a top-quality product for the consumer. Laboratory examination of the canned product is essential for compliance with the food and drug regulations, and also aids the manufacturers in quality control. Fish products are more delicate than most other flesh foods, and care is required to ensure that the raw material is fresh prior to canning and that it is not damaged during processing.

The nutritive value of canned fish products is generally high, but demand is influenced by other factors as well. Jarvis (1943) listed factors in the following order: nutritive value, appetite appeal, amount of waste, cost, variety of choice, ease of purchase, ability to purchase in convenient amounts, and packages. Each of these factors is important, and serious consideration must be given to them by the manufacturer in order to ensure the continued popularity of canned fish products in a market of ever increasing variety.

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BOOK REVIEW

Food Technology Review

"ANNUAL REVIEW OF FOOD TECHNOLOGY." Vol. 1, 1959, (Issued by the Association of Food Technologists, Central Food Technological Research Institute: Mysore, India, 1960.) Price 10*s*. sterling, or Rs. 5.00.

This Review presents five articles contributed by senior research workers in India, which provide a useful survey of both past and recent work in various parts of the world on topics of interest to food technologists.

The contributions of J. V. Bhat (on micro-organism control in foods) and of S. K. Majunder (on health hazards of pesticides) are extremely wide in scope, and consequently may be rather too condensed for the specialist. Nevertheless, both articles are excellent general surveys and are supported by extensive lists of references.

The articles dealing respectively with processed protein foods of vegetable origin (by M. N. Rao and M. Swaminathan), recent advances in the chemistry and technology of coffee and tea (by C. P. Natarajan), and fruit-juice concentrates (by G. S. Siddappa) are particularly valuable because of their authoritative accounts of recent Indian work.

The Bread Research Institute Of Australia

By E. E. Bond
Bread Research Institute, North Ryde, N.S.W.

Originally established in 1947 as a research and advisory institute by the Bread Manufacturers of New South Wales, the Bread Research Institute has rapidly grown into an Australia-wide organization with an expanding programme of basic and applied research. The present article by the Director, Mr. E. E. Bond, outlines the history of the Institute and its research activities.

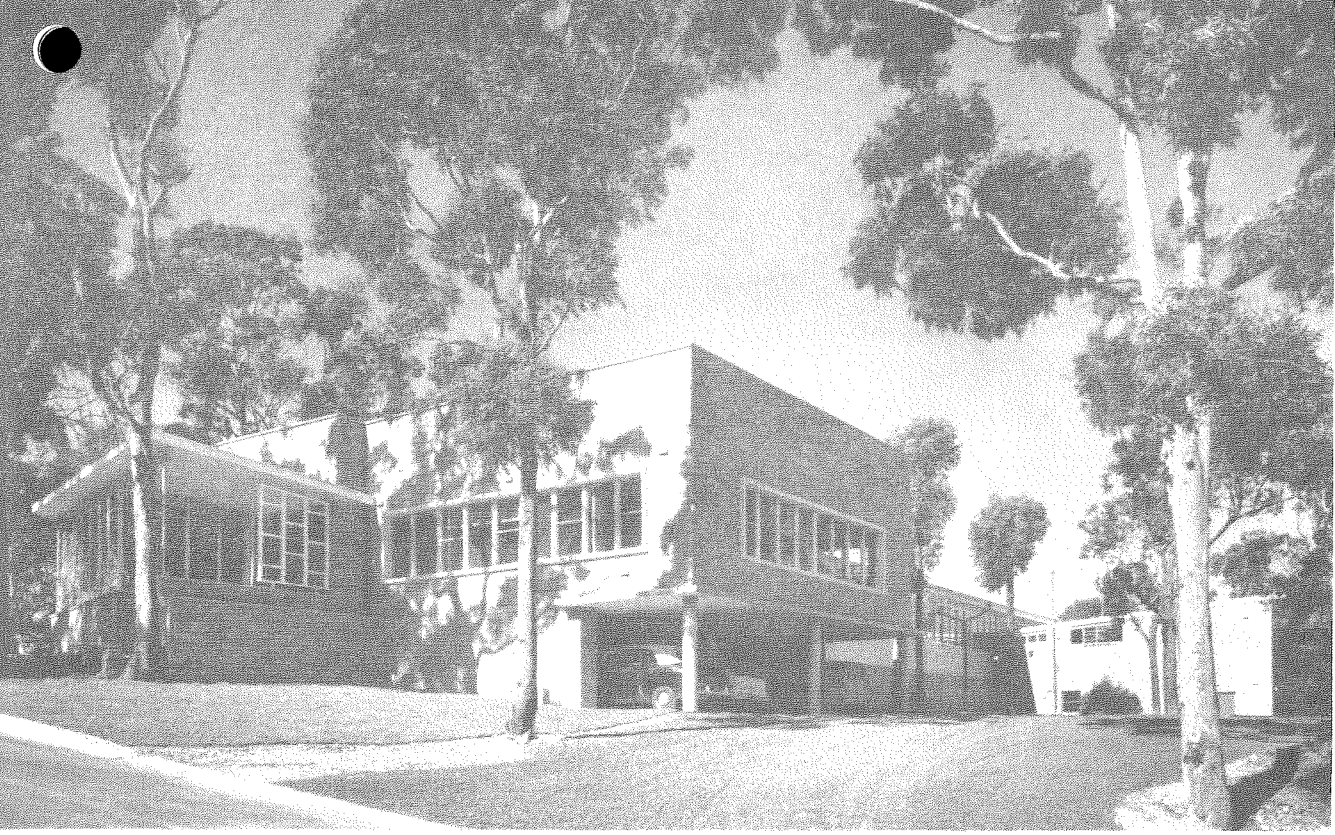
For many years prior to 1947 there had been agitation within the baking industry for the establishment of a baking trades scientific centre, and the beliefs of progressive members of the trade found support in the independent judgment of two judicial committees, namely, the Royal Commission on the Wheat, Flour, and Bread Industries, and the N.S.W. State Government Enquiry, both of which recommended the establishment of a Wheat and Flour Research Institute. By 1944 the Bread Manufacturers of New South Wales were levying themselves 2*s.* 6*d.* per ton of flour used, to form an establishment fund for a scientific centre. In 1947 they brought to Australia an eminent English cereal chemist, Dr. D. W. Kent-Jones, to advise on the establishment and conduct of a research institute, and in the same year the Institute was founded, with an establishment fund of £12,000 and an income of £4500 per year.

EARLY DEVELOPMENT

By 1949, when the first stage of the Institute's laboratories at North Sydney was opened, the Bread Manufacturers of Perth and Tasmania had affiliated with the Institute. Towards the end of 1950 the other States affiliated, and it was at this time that the Institute changed its name to the Bread Research Institute of Australia.

The close association between C.S.I.R.O. and the Institute which exists today was conceived in 1951, when an initial grant of £5000 annually for a three-year period was made in aid of research. Two C.S.I.R.O. representatives, Dr. O. H. Frankel and Mr. G. B. Gresford, were appointed to the Institute's Council in 1952, and in 1958 it was decided to establish a C.S.I.R.O. Wheat Research Unit and place it under the administrative control of the Institute's Director, who acts as Officer-in-charge.

The Institute is governed by a Council of nine representatives of the baking industry and two C.S.I.R.O. representatives. The Baking Industry in Australia is represented proportionally as follows: New South Wales—three representatives; Melbourne—two; Victorian Country—one;



The Bread Research Institute of Australia, North Ryde.

Queensland—one; South Australia— one; and Perth and Tasmania—one, alternately.

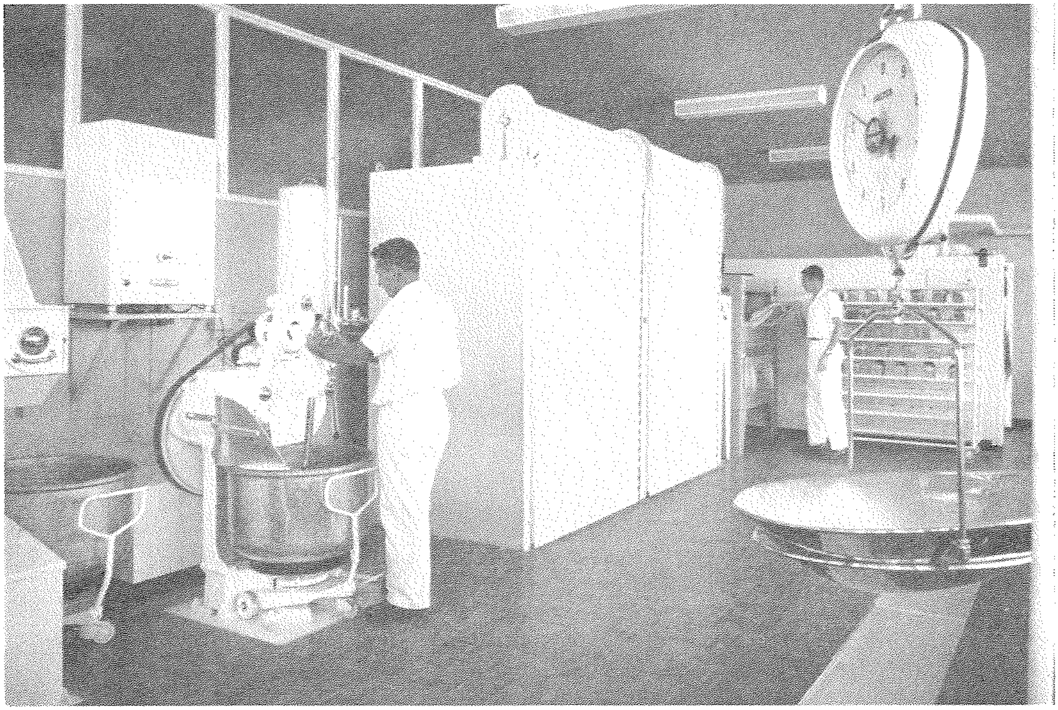
The greater part of the Institute's income is subscribed by members of the baking industry, who levy themselves 1*s*. 3*d*. per ton of flour used in the baking of bread. C.S.I.R.O. supports the Institute by research grants related to the income subscribed by industry. Valuable grants have also been received from the Wheat Industry Research Council, and the Rural Credits Development Fund of the Commonwealth Trading Bank, for specific research projects. During the 14 years of the Institute's existence, its income has risen from £5000 annually, to £58,000. The total expenditure during this time has been £350,000, of which £250,000 has been contributed by the baking industry.

GROWTH

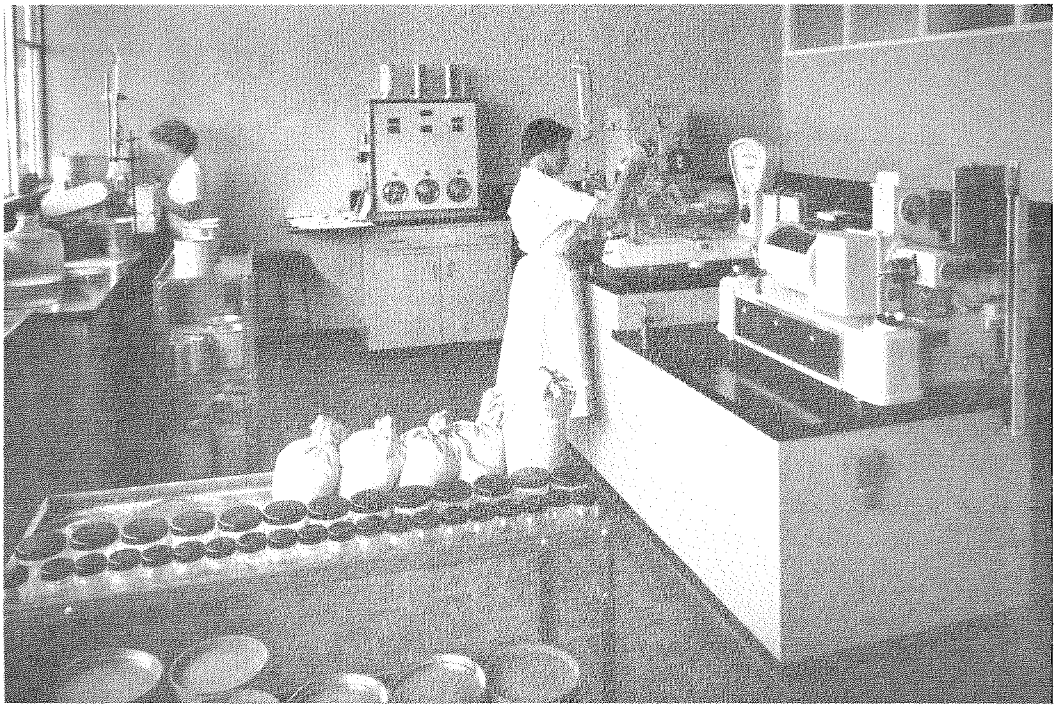
Despite the addition of a second floor to the laboratories at North Sydney in 1953, the Institute's activities expanded so rapidly that in 1958 it was announced that new laboratories would be built on a Commonwealth site at North Ryde. The 3-acre site, adjacent to the new laboratories of the C.S.I.R.O. Division of Food Preservation, has been made available on a 99-year lease. Tenders were called during 1959, and in May 1960 the laboratories were opened by the Minister for Health and Minister-in-Charge of C.S.I.R.O., Dr. D. A. Cameron.

The new building provides the Institute with:

- Physical and chemical testing laboratories, and a test bakery, for routine analyses and quality evaluations of ingredients.
- Laboratories, and a pilot-scale commercial bakery which is almost completely mechanized, for technological research and examination of production problems.
- Laboratories and ancillary service rooms for research workers engaged in fundamental biochemical and physico-chemical studies of bread, flour, and wheat quality.
- Workshop, library, conference room, and offices.



Pilot-scale commercial bakery (above) *and physical testing laboratory* (below).



The site allows for expansion, and the Institute has been designed to a 3-foot module, so that redistribution of research areas is possible.

FUNCTIONS

The services of the Institute's laboratories and staff are available to all members of the Institute and its affiliated organizations. The Institute's activities can be divided into four main groups: technical advisory services, applied research in the field of baking technology, fundamental research, and extension services. Of most immediate value to the baking industry are the monthly surveys of ingredient qualities, reports on loaves and ingredients sent to the Institute, and the services of the Institute's bakery instructors, who travel widely, demonstrating and giving on-the-spot advice. As well as sending advice and reports of technological advances in Newsletters, the Institute attempts to maintain personal contact with members by means of bakery visits, meetings, and symposia.

When the Institute was first formed, conditions in the baking industry were such that the Institute's main function was to look after the interests of the Bread Manufacturers of New South Wales, by means of advisory services and research into day-to-day problems. It is generally considered that the strength of the Institute, as a cooperative research organization, has lain in the fact that its establishment was initiated and carried out by the bread manufacturers themselves and that the bread manufacturers still provide the greater part of the finance. This early advisory work certainly strengthened the position of the Institute, convincing many sceptics of the value of scientific application within the industry.

Subsequently, however, the Institute developed a broad basic research programme. Building restrictions in the post-war years hindered expansion, and because of lack of space and staff during that period, it was decided that research was best done in conjunction with other organizations. Early research included work on the utilization of skim milk powder, undertaken in conjunction with C.S.I.R.O.; wheat quality evaluations carried out with the Faculty of Agriculture at the University of Sydney; and physico-chemical studies of wheat protein and dough undertaken at the University of New South Wales.

RESEARCH PROGRAMMES

The new laboratories provide full facilities for the present programme of biochemical and physico-chemical research into the nature of wheat, flour, and dough quality. This programme has been coordinated with the research programmes of the C.S.I.R.O. Wheat Research Unit and the Waite Agricultural Research Institute, to avoid duplication. The Institute's basic studies are concentrated on the physico-chemical properties of doughs, while the Wheat Research Unit is studying biochemical aspects of wheat and flour quality. Recent work includes: studies of the viscosity and rigidity of gluten films; comparative studies of wheat, rye, and barley protein films; and the separation of wheat gluten into protein fractions by means of continuous paper electrophoresis. In the immediate future the programme of research on dough rheology will be expanded.

The Institute's baking technology research has in the past covered such fields as the machining of doughs, dough temperature measurement, air classification of flours, application of a dry solids method for determining bread weights, the dispersion of shortening and gluten in dough, methods of ingredient determination, quality assessment and bread scoring, and studies of improvers and additives. At present the Institute's main research topic is mechanical dough development, and the rapid advance in the application of this new technique has created great interest in the baking trade. Already the studies have opened up a wide field of research, and the Institute has become interested in the concept of mechanical dough development as a means of improving general bread quality.

After fourteen years the Institute is in a stronger position than at any time in the past. The Institute has been fortunate in being associated with an industry in which there is an appreciation of scientific application, and which is at present undergoing quite a revolution.

Measurement by Sensory Tests

By C. P. Kenna

School of Applied Psychology, University of New South Wales, Kensington, N.S.W.

AS THE TIME for a birth is approached, the clock is watched; and for days after, the weight and length of the baby are facts of considerable importance to many. Human life is directed, from birth to death, by measurement: by the thermometer, the scales, the clock, the calendar, the speedometer, and other measuring devices.

One might ask why measurement occupies such a central position in the scheme of things. It appears to this writer that this stems from Man's long history of experiencing difficulties in adjusting himself to his environment. The form of the problem may well have varied somewhat from time to time, and still more the method of meeting it, but throughout time the ingenuity of Man has been directed towards gaining practical control over the world about him.

From early trial-and-error attempts a Forking principle was evolved and applied some centuries ago by Galileo and others—a principle which provides the basis for modern scientific method. This is the sequential method of Observation—Deduction—Experimentation, in order to establish facts and draw valid conclusions; and an essential part of Observation and Experimentation is Measurement. It is by measurement that we determine what alleged facts really are facts, and it is by measurement that we are provided with an exact description of objects and phenomena.

SOME BASIC ERRORS AND THEIR CONTROL

Admitting that measurement is necessary for a control and understanding of the world about us, it is necessary to attend to some of the difficulties and problems of measurement. It must not be assumed that the tools and techniques of measurement have been developed to a state of perfection. This is far from true, even in physics and chemistry, where most progress has been made. In fact, we may look upon the existence of error in all measurements as inevitable for, as Bertrand Russell commented, "Science is a succession of approximations". In general, it may be said that the sources of error in measurement are due to imperfections either in the measuring instruments themselves or in the method with which they are used. While both of these sources of error are subject to a considerable measure of control, neither can be eliminated altogether.

Three methods of controlling errors may be suggested:

- The improvement of measuring instruments.
- The devising of adequate methods of estimating or allowing for errors.
- The development of skill in applying the instruments of measurement so as to reduce errors to a minimum.

THE SENSITIVITY OF SENSORY MEASUREMENTS

The need for improvement of measuring instruments can be illustrated by an examination of the techniques available for temperature measurement. In the absence of a thermometer, if we were to measure the effects of heat, one can readily see how crude our measurements would be. In the first place, the effects would have to be sensed by a person. We can tell the difference between near-boiling and actually boiling water by looking at it. But we are certainly unable to be accurate in detecting the near-boiling phase from visual observation alone. Where visual cues are not available, or do not provide useful criteria of the state of temperature of the water, we might still use our skin, with its temperature receptors. We would then be relying upon sensations. It is obvious that such a measuring basis is much less scientific than that in current use, namely, the thermometer, because the nervous system is not as reliable nor as valid a measuring instrument as one would want. It is first of all limited in its qualitative coverage of the effects of physical energies abounding in the environment, and it is also limited in its coverage of the intensity factor.

Thresholds

All sensory systems have absolute thresholds. A manifestation of physical energy, although adequate in form, must have a certain minimal magnitude to be detected by the organism concerned. An illustration of this is the inaudibility of a ticking watch held at arm's length until the watch is brought to a certain distance from the ear, where the intensity of sound is such that it passes the lower sensory threshold.

A further characteristic of sensory systems is that they have *difference* thresholds. If any change in the environment is to be sensed, the change in physical energy applied to the nervous receptor must be greater than a certain minimal amount. For example, it can be demonstrated that two lines originally equal in length may continue to *appear* to be the same in length, even when the length of one is being altered. Ultimately a stage is reached where they differ from one another by a certain amount, which corresponds to the minimum increment detectable by the eye.

A further limitation on intensive sensitivity is the phenomenon of adaptation. This relates to the phenomenon where, although energy of a constant magnitude may be applied to a receptor, its sensory effect nevertheless varies. For example, a tight-fitting skull cap is sensed when first put on, but after a time its presence on the head is not felt. An additional factor affecting the reliability and validity of one's judgements about sensory intensity is, of course, fatigue. This should be distinguished from adaptation, as it is not quite the same thing.

IMPROVING THE MEASURING INSTRUMENT

The foregoing comments make it apparent that the nervous system is not a perfectly valid and reliable measuring instrument. There are, however, individual differences in nervous systems between people, and to improve this admittedly imperfect instrument by reducing error, it is necessary to select the best person or persons, as it were, to make the judgments on sensory intensities. Such "best" persons have a more sensitive neurosensory apparatus—they have low and high lower and upper thresholds respectively, and small difference thresholds. Consequently, in the assessment of sensory intensity, where people's judgments have to be the basis of this measurement, selection of particular people possessed of better sensory acuity would be conducive to improvement of the measuring instrument.

ESTIMATING AND ALLOWING FOR ERRORS

Order Effects

Mention has been made of the desirability of devising adequate methods of estimating or allowing for errors, in order to control them.

Such errors are many and varied. One of the most important is due to the fact that changes in awareness do not parallel energy changes in physical stimuli in any one-to-one fashion, but are affected by the order of presentation of the stimuli.

This is a very important point. One order of sequence is not the same as another, and does not necessarily produce the same reactions or judgments from subjects. For example, if a subject lifts consecutively each of the following weights, in the order 88, 92, 96, 100, and 104 g, he will be fairly sure of the accuracy of his statement that the weight series is one in which the weights increase by equal increments. If, however, the series is reversed in its order of presentation, the relation between each successive item in the series to the previous one is by no means so evident to the subject.

A different type of example of the effect of ordering the stimuli is the presentation to a subject of a 9-point rating as, for example, a hedonic rating scale in which a product is to be placed at some point between "Like Extremely" and "Dislike Extremely". Each category in the scale may be used by the subject with varying frequency, depending as much on its relative position in the actual order of categories as on any varying assessment of the product, as such, by the subject.

Positional and Intensity Bias

Just as order of presentation can affect a subject's reactions to stimuli, so also can spatial placement of stimuli—e.g. to the right or to the left of the subject. Again, if a stimulus of a certain intensity is to be indicated from a range of possible stimulus values, the subject should have an equal number of trials: (*a*) with the original stimulus much more intense than the value to be indicated, and (*b*) with the original much less intense. Thus the subject goes through the two processes of judging by increments to, and by decrements from, the original.

Experimental Design

The nervous system is subject to unreliability and invalidity as a basis for measurement, even where the stimulus is remarkably free from distortion by external factors. And it must be remembered that this is so even in a set of conditions close to ideal, and that in the usual course of events further difficulties than these are invariably to be contended with.

The foregoing examples illustrate how a stimulus is sensed relative to the context in which it is experienced. This point must be always kept in mind, and in the setting up of any experimental design for the testing of reactions to a stimulus, control of such a factor must be ensured. Sequence in time should also be considered: if two stimuli, *A* and *B*, are to be compared, then the time interval between the experiences of *A* and *B* should be controlled or balanced, as this could well affect the judgment made.

The possible errors in measurement so far discussed have largely arisen from the external conditions under which the stimulus is experienced by the subject. Further difficulties occur through the nature of the individual being a real variable. An individual who is fatigued, or bored, or hungry will have different reactions to stimuli than when he is not in any of these states. A person's motivational state is a further factor to be controlled. In conducting taste tests with a panel of judges, it would be ideal to control their food and drink intake before carrying out the tests, control their smoking, and test them at the same time of day under the same conditions of room temperature, humidity, and environment.

TRAINING OF PERSONNEL

We may now turn to the question of how to reduce errors by increasing skill, and how most effectively to use the human person's sensory apparatus as the basis for measurement. This involves the technique adopted in the measurement itself. In all subjective assessments of stimuli, the instructions to the subject include a question which the subject is to answer. The instructions specify some dimension, e.g. length, bitterness, colour, or pleasantness, and within this dimension are specified certain degrees of intensity, or categories, in terms of which the subject is to report his experience.

Presentation

It may be that the subject has to rank stimuli in a certain order, or to rate them, and in this activity he may operate with a level of confidence or certainty. Admittedly his confidence will be affected by his own competence and experience, *but* it can also be affected by the way in which the question is asked. In all subjective assessments, we must do whatever we can to increase the certainty of the subject's judgments. There are, for instance, two alternative ways of obtaining from a subject his preferences from a group of six stimuli. The range of stimuli can in fact be ranked, or alternatively the subject can make his comparisons two at a time from the 15 pairs which can be drawn from the six stimuli. The latter procedure is certainly one which the subject carries out with a greater degree of certainty, and thereby greater reliability and validity of measurement is also achieved.

Recording

If a subject feels that he is expected to use a method of recording which does not correspond with the nature of his judgments, his confidence will be disturbed. This could happen when the subject is asked to use a 7-point rating scale, whereas in fact his judgment might only be classifiable into 3 categories. In other words we should always try to make the situation such that the subject can operate with high confidence in making his judgments and recording his comparisons.

The operation of recording judgments made by subjects is of such importance that considerable care must be taken in training the subjects to understand the operation in a thorough and uniform way. Suppose the situation is one in which a number of people are to record their reactions to the colour of frozen berries by using a 5-point rating scale of the type: 5—Bright attractive natural colour; 4—Good natural colour; 3—Fair natural colour, etc. It is to be expected that the subjective judgments of the group members would be at variance to some extent, and yet this could well be camouflaged if it happened that the subjects also varied in their interpretation of what the points 5, 4, 3, 2, 1 really referred to. In other words, subjects *A* and *B* might have quite different reactions to the frozen berries, but might record their impressions as befitting category 3 because they have different impressions of what category 3 actually is.

Consequently, subjects must be trained to uniformly interpret the rating scale so that their subjective judgments may be objectively recorded.

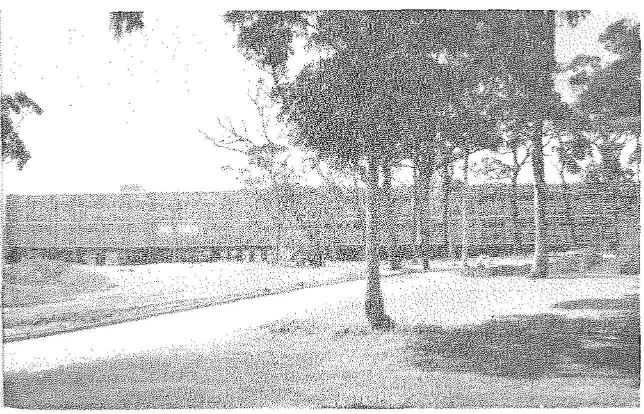
Refinement of Perception

One further provision necessary is that subjects have training in identifying differences between stimuli of a common class or quality but varying in intensity. There is a great deal of benefit to be gained from training subjects in such a way that they experience differences between stimuli. In the first instance such differences are made easily identifiable, because they are crude or gross; and then progressively they may be made less noticeable. Such training gives to a subject a confidence in his own capacities so that he is thereby not so threatened by, nor tentative in, the test situation proper.

VALUE OF ORGANOLEPTIC TESTS

One can now well ask, if there are so many difficulties involved in the whole process of sensing a stimulus and recording this sensory impression, why is it that organoleptic techniques are used at all? The answer is that they are necessary, because they alone can give us the answers sought, such as the acceptability or otherwise of a product in consumer reaction and preference testing. There is no other way we can predict this, except through empirical testing of subjects' reactions. When we do this, we must be always attentive to making our measuring techniques as far as possible free from constant and variable errors.

NEWS FROM THE DIVISION OF FOOD PRESERVATION



South face of main laboratory block, North Ryde.

NEW DIVISIONAL HEADQUARTERS

SINCE MAY 15, 1961, the Division of Food Preservation has been located at its new headquarters at North Ryde, a suburb of Sydney about 8 miles by road north-west of the city. The new postal address is: P.O. Box 43, Ryde, New South Wales; and the telephone number, 88-0233 (Sydney).

The extensive buildings stand on a 19-acre site extending from Delhi Road on the north to the Epping Highway on the south. Part of the site is occupied by the C.S.I.R.O. Division of Coal Research and by the Bread Research Institute of Australia.

For the past 23 years the headquarters and central laboratories of the Division of

Food Preservation have been located in the grounds of the Sydney Metropolitan Meat Industry Board's Abattoir at Homebush, but limitations of space made a move imperative.

The opportunity has been taken to bring to the more spacious laboratories at North Ryde several research groups of the Division which hitherto have operated in branch laboratories. However, the Physical Chemistry Unit and the Plant Physiology Unit are remaining at the University of Sydney, the former in the Biochemistry Department and the latter in the Botany School.

A full account of the new laboratories and of the facilities now available to the Division will be published in a future issue.

RETIREMENT OF MR. W. A. EMPEY

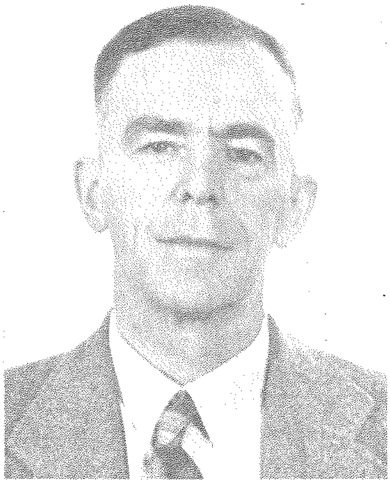
Mr. W. A. Empey, Principal Research Officer, retired on March 28, 1961, after 32 years in C.S.I.R.O.

Mr. Empey, a graduate in Veterinary Science of the University of Melbourne, commenced his scientific career in the Victorian Department of Agriculture. He began his association with food technology in 1926, when, with the late Professor Young of Melbourne University, he investigated the "drip" which exudes from frozen muscle on thawing.

In 1933 he published the results of his classic research on the conditions which determine the amount of drip from frozen mutton and beef. He demonstrated that the percentage of drip was least in muscles having a relatively low concentration of hydrogen ions, and in small-scale experiments reduced or eliminated drip by increasing the pH value of the muscle fibres prior to freezing. His research laid a firm basis for subsequent investigations into the problem of drip.

Mr. Empey was one of the foundation members of the Section of Food Preservation which was set up in 1932, at the Queensland Meat Industry Board's Abattoir at Cannon Hill. There he took an active part in the bacteriological investigations which made practicable the export of chilled beef from Australia to the United Kingdom.

During World War II Mr. Empey's knowledge of food technology was put to use in solving problems involved in the supply of food to the armed forces in the South-West Pacific. In the post-war years he led a small team investigating the preservation of fish, and under his guidance satisfactory canning processes were developed for some Australian species, notably the Australian salmon and the tuna. Other researches, which led to a reduction of losses of prawns during marketing, included the prevention of the disorder known as "Black Head" in commercial prawns.



Mr. W. A. Empey

Mr Empey was the first editor of the *C.S.I.R.O. Food Preservation Quarterly*. He was responsible for its initial development, frequently contributed articles, and was a member of its editorial staff until his retirement.

At a representative gathering at the Homebush laboratories on March 28, Mr Empey was farewelled by his C.S.I.R.O. colleagues and by friends from the meat and fish industries.