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The Fishing Industries of Denmark and Greenland

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This article is based on observations by the author who recently spent 15 months in Denmark and Greenland. He assisted with an FAO/DANIDA training course on quality aspects of the handling and storage of fish and was subsequently awarded a NATO Fellowship.

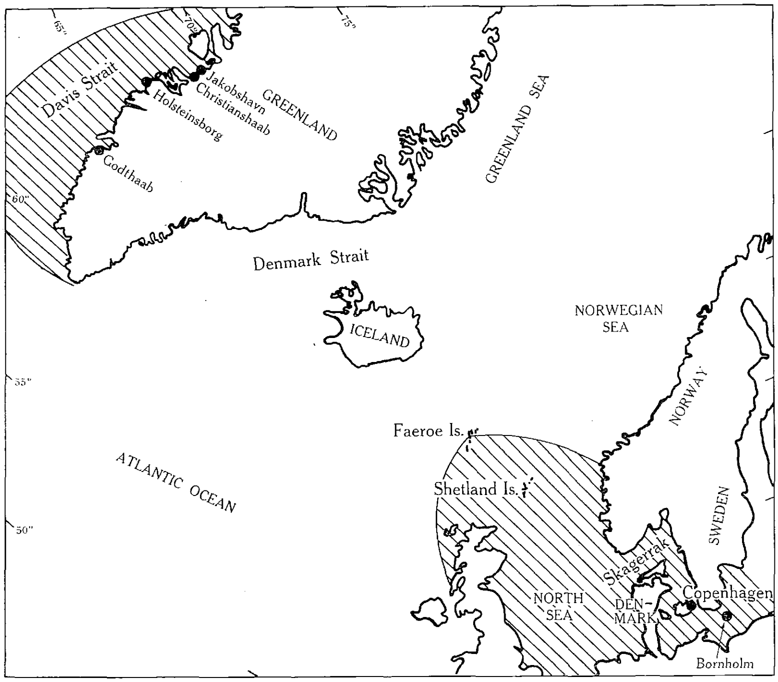
The annual fish catch in Denmark is about 1·4 million tonnes and supports an export industry valued at more than 100 million dollars. In Greenland, which is administered from Denmark, the recorded catch, although only about 50,000 tonnes, is the basis of the island's biggest industry and is almost the sole source of export income. Because of the geographical, social, and economic differences between Denmark and Greenland they are treated separately in this article.

Denmark

The Catch

Although only a small country, Denmark has an extremely long coastline and is surrounded by productive waters. About 12,000 people are dependent solely on fishing for their livelihood, and further large numbers are employed by the efficient processing industry in producing high-quality fish. Plaice, cod, and herring, in that order of value, are the most important part of the catch used for human consumption, but of the total catch of 1·4 million tonnes about 1 million tonnes goes to production of fish meal. This and imported meal are used for the intensive feeding of pigs and poultry. The fish-meal industry has developed since 1945 and the plants are large and highly mechanized. The Danes and Norwegians have led the world in the technology of fish-meal manufacture, and

Typical wooden fishing cutters in a Danish harbour.



Shaded areas show fishing grounds mentioned in the text.

now build and export a large proportion of the machinery used elsewhere. More than half of the remaining 400,000 tonnes of their total catch is exported, either fresh or frozen. This trade has developed since 1930 when improvements in transport and technology opened up good markets in the rest of Europe. Today fresh fish held in ice is carried by road and rail throughout Europe to markets as distant as Milan.

The Danish fleet fishes in three main areas: the North Sea, the Baltic, and the Skagerrak (see map); there is no distant-water fishery. The industry is concentrated mainly in Jutland, the north-western part of Denmark. There are about 10,000 registered fishing boats, although many are small open boats that work permanent stake nets and lobster pots close to the coast; the rest of the fleet are trawlers and danish seiners. The traditional wooden fishing cutters of 15–50 tonnes, which work in coastal waters, may be rigged as either trawlers or danish seiners; the large steel trawlers fish in the North Sea. There is very little mid-water trawling, and most of the catch is taken on the bottom by single boat side trawls with otter boards, but some of the smaller trawlers are adapted for pair trawling. There are no Danish purse seiners but many Swedish, Norwegian, Icelandic, and Faeroese purse seiners land their catches in Danish ports.

Although most of the steel trawlers were built recently they do not reflect the advances in technology and design that are a characteristic of the many fine fishing vessels built in Danish shipyards for Russia, Iceland, and other countries. The rate of replacement of boats is not keeping pace with deterioration and so the fleet is aging. The fact that the fishery is restricted to waters close to home may be responsible for the slow incorporation of new technological advances which have been restricted to the bigger and more efficient freezer stern trawlers. However, developments leading to increased mechanization and reduction of crew have been eagerly taken up. With Denmark's entry to the EEC there is concern that the Danish fleet will not be able to compete with the more efficient boats from other countries when territorial limits are removed.

Handling

Handling methods vary from one area to another and also depend on the size of the boat. The small boats engaged in day fishing do not carry ice and they land their fish directly onto the auction floor. The larger boats use ice to preserve their catch during extended trips, and the fish are iced either in boxes or on shelves in the fish-room. Both types of boat unload at the same auction markets. Some vessels are equipped with tanks to store catches of fatty fish, such as herring and mackerel, in chilled sea water. This method is widely used in the other Scandinavian countries both for fish intended for human consumption (consumer fish) and for the raw material for fish meal, which is known as industrial fish. Most lean consumer fish are gutted and washed on board before icing. Wooden fish boxes are still used in a few ports but the trend is to use plastic. The boxes can be taken to sea with the boat, but where shelving is the normal practice the fish are usually unloaded first and then put into plastic boxes for auctioning. Most consumer fish passes through the fish halls at the auction markets; these are efficiently run and standards of hygiene are generally very high.

Industrial fish are unloaded from the boat by mechanical conveyor and taken straight to the fish-meal plant by truck. The composition and quality of fish-meal catches are extremely variable and have been the subject of much research and discussion in Denmark. It is rare for ice or cooling to be applied to this type of fish, unless it has been tank stored, and it may be up to eight days old when the boat reaches port. It consists of both oily and non-oily species such as herring, mackerel, sand eel, Norway pout, and small haddock and cod; nothing is thrown back by the fish-meal trawlers. Salable consumer fish are sorted out, gutted, and boxed in ice. A large proportion of the catches could be used for human consumption but chilling and handling facilities are limited. There is a good prospect that gutting machines, recently developed for small fish, will enable a better return to be made on this fish. It has also been shown that increases of up to 15% in yield can be obtained by chilling industrial fish for fish meal with ice or cold sea water, because crushing and autolysis in the hold are reduced. This damage produces great volumes of blood water which is pumped over the side into the sea. Moreover, hydrogen sulphide from rotting fish has been responsible for several deaths among people unloading industrial fish. The fish-meal industry is under growing pressure to stop polluting the air and water and to use the total fish resource more effectively.

The auction shed at Esbjerg with some of the night's catch.

Photo: Arne U Franken, Copenhagen.

Processing

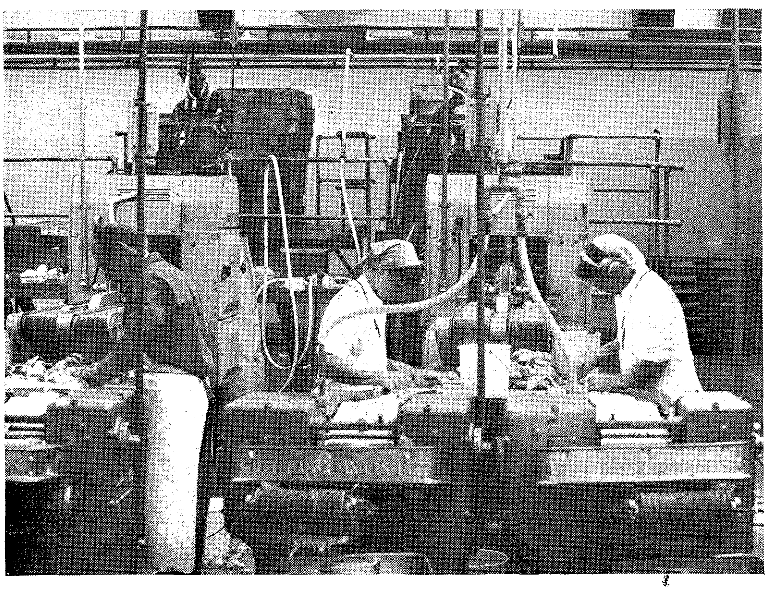
The largest processing plants engaged in filleting and packing are close to where the fish are landed and can handle up to 100 tonnes per day. They mainly export cod, plaice, and herring, either iced or frozen. The use of non-returnable expanded polystyrene or waxed cardboard cartons for iced fish is growing. Quality control standards are high and these plants are clean and well run. Heading, filleting, and skinning, particularly of cod, are carried out by high-capacity machines most of which are made in Germany or Sweden. In some factories plaice, which is a costly fish, is still filleted by hand. Fillets or whole plaice are sometimes battered and breaded before freezing, and skinless and boneless cod fillets are formed into frozen blocks for making fish fingers. Herring fillets are mostly exported in ice to Holland, Belgium, and Germany for preparation as marinades.

In addition to the large filleting factories there are many smaller processing establishments run as family concerns or as cooperatives. They use Danish and imported fish to produce a very wide range of products. The stress placed on quality and efficiency by these operators is indicated by the fact that they can run a profitable business, while often using imported frozen raw material which is processed and much of it re-exported. The Danes have a well-earned reputation for high quality, and this is a most important asset for marketing. The products of the small plants are mostly Danish and Northern European delicacies, and processing methods are based on the wealth of experience accumulated over many years. Today there is a tendency for traditional methods to be replaced by new technology; some products have been modified to suit modern tastes and other new products have been developed.

Marinades

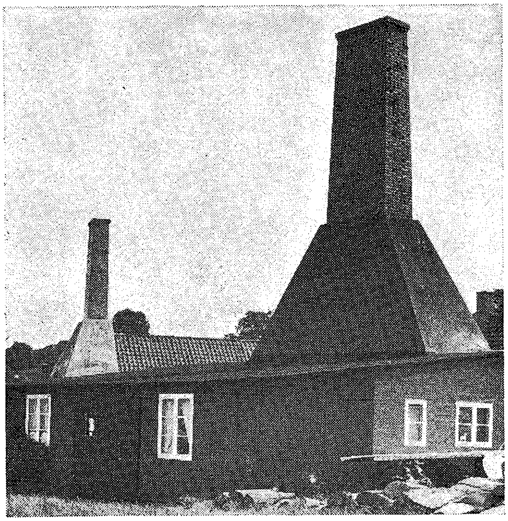
The most popular species for preparing as a marinade is herring, particularly the fat fish taken in late summer. Local supplies come from the North Sea, the Skagerrak, and the Baltic but large quantities are imported fresh from the west coast of Scotland, and either salted or frozen from the east coast of Canada. The condition and quality of the fish from different areas vary considerably, so assessment of initial quality is important in order to produce consistent products. There is a great deal of mystique attached to the marinading of herring, particularly regarding the added spices and flavourings that give the characteristic taste of a particular company's product.

Gibbed herring, i.e. with head and guts removed, are salted in barrels or concrete tanks with 16% dry salt, 5% sugar, and 1%



A high-speed cod-filleting machine.

mixed spice for at least one month. This prolonged salting is to ensure that the parasite *Anisakis* is killed. The fish are then filleted, and sometimes skinned, by hand or machine before being packed in glass jars with a cover brine containing 1·75% acetic acid and 25–50% sugar. Sodium benzoate may be used as a preservative and a variety of exotic flavours are often imparted by sherry, port, dill, or other additives. The pack is not heat processed and relies for preservation on reduction of water activity, as a result of its high salt and sugar contents and low pH. This type of product is known as a semi-preserve and is normally retailed under refrigeration, but the keeping qualities are quite good. Because the demand for herring exceeds the supply of raw material, these processes are being applied to other fish such as mackerel. However, the Danes, who consider that herring and *snaps* are an essential part of life, are resistant to change.



Small smokehouse on the Baltic island of Bornholm.

Smoking

Smoked fish is mainly produced from herring, mackerel, eel, salmon, and halibut. Smokehouses vary from the traditional open hearth and chimney to the most modern Torry kilns with automatic smoke producers. Either hot or cold smoking may be used depending on the species and the cure required. Herring, eel, and mackerel are usually hot smoked while salmon and halibut are cold smoked.

Traditionally herring and mackerel are smoked as whole fish, with only the guts and gills removed, leaving the milt or roe in the belly cavity. After brining, the fish are hung on rods in the smoking racks where they are dried for a short period before being smoked for several hours at 70–80°C. When they have been smoked and cooled the fish are packed either in cartons lined with parchment paper or in wooden boxes. When longer keeping times are required the fish are vacuum packed, one or two to a polyethylene bag, before freezing.

Denmark is the most important centre for the production of smoked salmon, much of which is exported. Pollution has reduced the Baltic catches and restrictions have been placed on Danish fishermen in the North Atlantic, but large quantities are still produced from Greenland salmon and imported Canadian fish. Curing methods vary but nitrite is generally used in the brine to give a good colour. Smoked salmon, sliced and vacuum packed in polyethylene pouches, is an important part of the production; other products are whole smoked salmon, split fish with or without the backbone, and smoked fillets.

Various products from fish roe are also made by the smoking factories. Smoked cod roe is a popular delicacy in Scandinavia and salted lumpfisch roe is exported as a substitute for caviar. The lumpfisch is caught in Greenland where the roe is removed and salted in polyethylene barrels for shipment to Denmark. It is separated, washed, and coloured red or black before packing and is sometimes pasteurized. A considerable quantity is exported, particularly in 20-g plastic containers for airlines.

Gravad Fish

Producing the delicacy called gravad fish has always been a German and Scandinavian home industry, but the process has recently been commercialized. The cut surfaces of fillets of salmon, plaice, turbot, halibut, and other species are lightly salted and a mixture of dill and spices is added. The surfaces are then pressed together and the fish is held in ice or under refrigeration for about 24 hours. It can then be sliced and eaten, or frozen.

Industrially, the frozen product is vacuum packed in polyethylene. Home-produced gravad fish has been responsible for outbreaks of botulism, since the holding period, with anaerobic conditions between the fillets, can permit production of toxin.

Trout

An annual production of 12,000 tonnes makes Denmark the largest producer of farmed trout. The industry is centred on the agricultural area in the middle of Jutland where many farmers have trout ponds, and either have their own hatcheries or buy fry from central hatcheries. The normal feed for the trout is made from trash fish and offal, but at week-ends they are fed with dry pellets through an automatic system. Much of the production is handled by cooperatives and the industry is efficient and very competitive. Production is carefully regulated and factory utilization maximized, because the fish are kept alive up to the time of processing. They are taken to the processing factory in tank trucks and held alive there for several days without feed, to remove the stomach contents. The fish are killed by electrocution and after grading they are gilled and gutted by machine. An ascorbic acid wash is used to remove blood and improve the colour. Trout are vacuum packed, two to a bag, and frozen or shipped in ice. A very high proportion is exported to the rest of Europe and many other parts of the world.

The main market requirement for trout is for firm pink flesh. Trout reared in brackish water show this quality, but at present, because of technical difficulties, only a small quantity is grown in this way. Another more successful approach has been to add to the feed vacuum-dried meal produced from shrimp waste. It appears that if the meal is dried at less than 76°C the pigments are not destroyed and will produce pink coloration in the trout.

A major cloud on the horizon of the trout producers is the finding by British importers that much Danish trout is contaminated with *Clostridium botulinum* type E, which commonly occurs in the mud of the trout ponds. The coastal waters of Denmark and the North Sea are heavily contaminated and people in the fishing industry are generally conscious of the need for care. The industry relies primarily on temperature control to prevent the formation of toxin, and with the development of processed foods there is always the possibility that failure to control the temperature satisfactorily will cause poisoning. The trout industry is threatened by the possible introduction of microbiological standards that it might not be able to meet. Previously a considerable amount of smoked trout was produced, but this product is now viewed with suspicion because smoking kills all organisms on the surface except spores of *Clostridium botulinum*, which can then germinate and grow without competition. An investigation on the incidence of *Clostridium botulinum* in trout and the possibility of controlling it is in progress.

Shrimp

Although the Danish shrimp (*Pandalus borealis*) catch is only 4500 tonnes, the processing industry also handles a large quantity of shrimp and prawns imported from many parts of the world. Processed shrimp is also exported in considerable quantities. Danish shrimp is caught by otter trawl in the Skagerrak and North Sea. It is held in ice for up to eight days before landing and processing. The regulations stipulate that boxes of new wood or of plastic must be used for shrimp storage, and plastic boxes are now used almost exclusively. After eight days' storage in ice, shrimp is approaching the limit of acceptability, but the economics of fishing in the North Sea make it necessary to stay at sea for this length of time. Peeling machines developed in the United States and Denmark have greatly increased the throughput of shrimp processing plants and reduced contamination caused by hand-peeling. At present the industry prefers the American machines which are more suitable for the North Sea *Pandalus*. These machines first cook the shrimp and then peel them using a system of rollers and water sprays. Fluidized-bed freezers have recently been introduced for production of individually frozen shrimp. Alternatively, pasteurized, vacuum-packed bags of shrimp are plate-frozen. Before freezing, the shrimp are dipped in a mixture of salt and citric acid and for some markets colour is added. Canned and glass-packed shrimp are also produced.

Fish Canning

Imported frozen tuna and some local

mackerel and herring are canned, but production is limited; mussels are probably the greatest single item. Some speciality products are made, mainly for the Scandinavian market—for instance, fish balls prepared from cod and canned cod-roe and liver.

Mussels

Denmark is the leading producer of canned mussels, and cans most of its catch of about 13,000 tonnes per year; the mussels are taken by dredging, mainly from the Lim Fiord area. Some frozen blocks of mussels are also produced.

Processing lines are well planned and efficient. Mussels are delivered in tip trucks, washed in a rod washer to remove stones and mud, and cooked in steam to open the shell. Meat and shell are separated on a vibrating screen and then further separation of meat and pieces of shell is achieved by brine flotation. After washing, the meat is packed into cans, which are then filled with water or weak brine, closed, and sterilized. Some packs in oil or brine with added herbs and spices are also produced.

An interesting sideline of the mussel industry is the production of meal from starfish, which is unique to Denmark. The starfish sometimes reach plague proportions on the mussel beds and those dredged up with the mussels are used to make a low-grade meal rather than being thrown back.

Silage

Some fish are ensiled for stock feeding, and one factory has a capacity of 17,000 tonnes a year, mainly using herring of reasonable quality. Fish silage, like fish meal, seems to contain an elusive unknown growth factor, giving it a market advantage over other fodders. The raw fish is chopped and mixed with sulphuric and formic acids to reduce the pH to 4. The liquid silage is fermented for some weeks and then retailed in 50- or 100-kg plastic barrels. It is usually neutralized before feeding and may also be compounded with dried grass meal or soya-bean meal. This factory also produces vacuum-dried shrimp meal for trout feeding and some fish meal. The *stickwater* from the meal plant is used to fertilize grass in fields around the factory, and the grass is then cut to make grass meal.

Inspection

No review of the Danish fishing industry would be complete without reference to the comprehensive fish inspection service run by the Ministry of Fisheries. This service with its headquarters and laboratory in Copenhagen has inspectors stationed at all the major fishing ports. Fishing boats are inspected, and inspectors may demand that dirty fish rooms be steam-cleaned. From the time of landing until final sale or export, the fish are under continual inspection. At the inspection before auction substandard fish are withdrawn from sale and covered with red dye. Inspectors follow the progress of the fish through processing plants by regular visits, although inspectors are not specifically assigned to individual factories. All exported fish are inspected again at the border before a certificate of condition is issued.

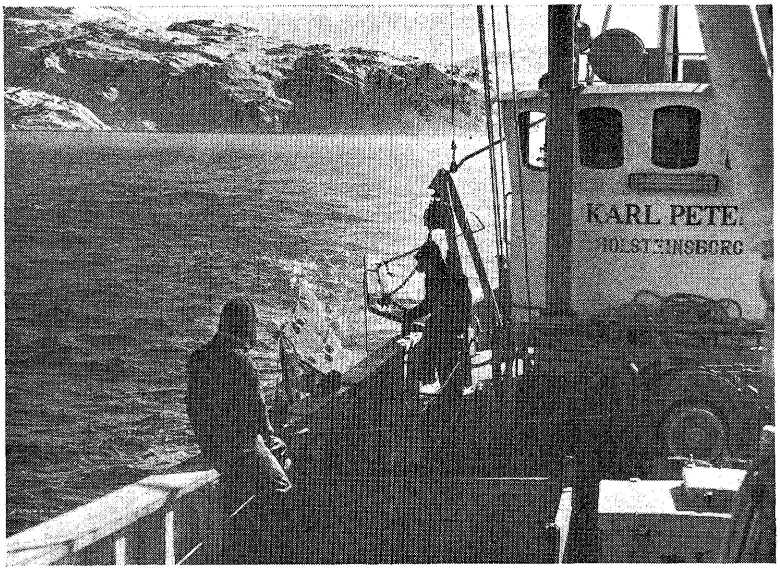
Research

The Ministry of Fisheries operates two laboratories, one for biological research and the other as a technological laboratory for research into the handling and storage of fish. Projects in biological research include stock assessment in coastal waters and the North Sea and biological work in the waters around Greenland.

The technological laboratory was established in 1931, when the Government made the decision to start a fish processing industry, and it now employs about 25 people. They work in close contact with industry and advise on technological problems as well as on the construction and design of factories and fishing vessels. Research work at present is concentrated on bacteriological changes in chilled fish and attempts to upgrade the quality of the raw materials used for fish meal.

The Future

The strength of the Danish fishing industry lies in its diversity and the emphasis on high quality. The large range of species and products makes the industry flexible enough to absorb periods of low catch of a particular species and to keep production in line with changing tastes. Technology is well accepted by the industry and its use is expected to increase. However, there are problems that will effectively limit growth. To develop a high seas fishery would be enormously expensive and would lead to competition with the



Trawling for shrimp in a fiord on the west coast of Greenland.

world's fishing giants, but coastal waters are becoming increasingly polluted and over-fished. The International Commission on North Sea Fisheries has pointed out that the catch per unit effort is decreasing and stocks are probably declining. The competition from other nations fishing in the North Sea is intense, and when territorial limits between the EEC countries are removed, the coastal fishery will be affected. However, the processing industry may benefit from tariff-free landings of fish from vessels of the other EEC countries.

Although attempts are being made to control pollution, it will be difficult to reach an international agreement. The Baltic is so seriously affected that the number of species living there has fallen to 10% of the former total. On the island community of Bornholm, where fishing is the principal means of livelihood, the effect has been disastrous. The fish have either disappeared or else cannot be processed because of high contents of metals or insecticide residues. The production of canned cod liver, for example, has ceased because the DDT content is above safe limits.

The trout industry will grow if the problems connected with botulism can be solved. A large proportion of the industrial fish catch can be used for human feeding if handling methods are improved and machinery is developed for automatically processing small fish. However, even without substantial growth the Danish industry is versatile enough to withstand temporary set-backs and should remain profitable and efficient.

Greenland

The development of a modern fishing industry in Greenland started in the 1950s, after biological surveys showed that there were large stocks of cod and shrimp available in the fiords and coastal waters. The Danish Government, through a branch of the Ministry of Greenland, the Royal Greenland Trade Company, built small fishing cutters and trained the Greenlanders in modern methods of trawling and long-lining; modern factories for fish processing were set up around the coast. This effectively established a cash economy in Greenland and today the industry is growing rapidly, with many Danes still employed in managerial positions. Because the coastal waters are now well exploited there is a move to fish the off-shore grounds in the Davis Strait, particularly for cod and shrimp; resource surveys have shown good stocks, and a series of modern stern trawlers has been designed. However, results so far have been disappointing because the Greenlanders prefer to make day trips rather than spend longer periods at sea.

In the south there are areas that are free of ice all year round and fishing is continuous, but in the north it is not possible to fish by boat in the winter. Here the Greenlanders revert to the traditional practice of fishing by long line through holes in the ice; they carry their catches to the factory by dog sledge, and the fish are usually frozen by the time they are delivered. In winter, storage on board the boats is no problem since ambient temperatures are very low, and ice is not normally used. On long trips in the summer, however, it is necessary to cool the catch. The author spent a period in Greenland comparing the quality of shrimp stored in ice and in chilled sea water, in order to help determine whether new vessels should be designed with tanks for storage in cold sea water or whether boxing in ice, which is the practice in Denmark, should be introduced. The keeping qualities were not much different, and although storage in sea water gave better colour and texture it also resulted in reduced yields and high salt penetration.

The Catch

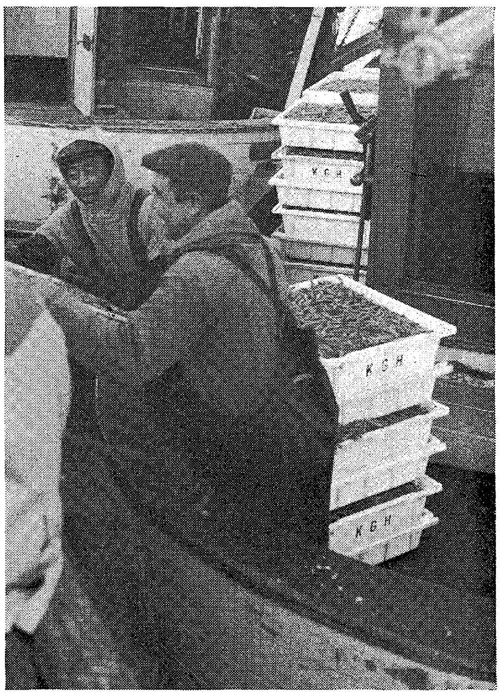
In Greenland as in Denmark, cod makes up the major part of the catch. Economically shrimp is the most important species, and salmon, Greenland turbot, and lumpfisch are also caught in quantity. There is no industrial fishery as fish-meal production would not be economic.

The major part of the *cod* catch is probably not included in the statistics as it is caught by the Greenlanders for their own household use. Preservation is generally by means of air-drying without prior salting; the split fish are hung on racks or laid out on rocky parts of the coast where with the low relative humidity and low temperature they dry rapidly without spoilage. This product is known as stockfish; it keeps well, and is eaten by the Greenlanders and used as dog-food during winter sledging trips. Cod for export is almost all frozen, but before freezers were generally available there was a substantial export of salted and dried cod. Most of the export cod is made up into fillet blocks which are plate-frozen, but there are also some retail packets of fillets.

The *shrimp* catch is about 10,000 tonnes; it is processed in factories on the west coast of Greenland. Until recently the whole catch was peeled by hand by women workers, but now American peeling machines are widely used. Canned, glass-packed, and frozen shrimps are produced and a large fluidized-bed freezer has recently been installed. The equipment is modern, and throughput is expected to increase greatly when fishing of the off-shore waters becomes more widely practised.

The *salmon* season is short and has recently been further curtailed as a result of pressure from conservationists in Canada and the United States. Danish boats, which used to take most of the catch, are now being withdrawn; the Greenlanders will be allowed to go on catching, but in reduced quantities. The normal practice is to freeze the salmon catch and send it to Denmark for further processing.

Greenland *turbot* is taken at present as part of the catch of the shrimp trawlers, but it is not yet being fully exploited; it is frozen as fillets or made into gravad turbot, production of which has recently begun. Lumpfisch is exploited mainly for the roe.



Unloading shrimp at Christianshaab.

A shrimp packing plant at Christianshaab.

Photo: Elfelt, Copenhagen.

Recently some of the fish processing factories have diversified into packing *reindeer meat*. The demand for frozen reindeer is growing and in the future farming of reindeer may be feasible; at present they are hunted from dog sledges and prepared and frozen in the factories.

The main problem faced by the Greenland fishing industry is that of transport for exporting its products. Everything must be consigned through Denmark and although the Danish Government subsidizes freight costs very heavily they are still high. The whole social structure of Greenland has been changed by the introduction of a modern way of life. Exploitation of the large fish stocks and the small mining industry are the only avenues by which foreign exchange can be obtained to support the new life style. In these circumstances, it is most unlikely that the fishing industry will lose its importance as the major export earner.

Some Aspects of the Microbiology of Packaged Foods

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This article is based on a talk given to the New South Wales Branch of the Australian Institute of Packaging. It discusses the conditions within a foodstuff that determine microbial growth and shows how far they may be modified by the packaging system chosen.

Prevention of microbial spoilage is the major concern in a food plant and the application of correct practice at all stages of food handling is essential. This applies no less to the packaging of the final product than to any other step in the production or distribution chain. Before an informed decision can be made about the most suitable packaging material for a non-sterile product, it is necessary to understand something of the interaction between a microbial population and its environment. It should also be remembered that if a food has the opportunity to spoil it may also become toxic as a result of microbial action or it may act as a vehicle for microbial infection.

Heat-processed foods packaged in metal, glass, or flexible containers are intended to be commercially sterile, i.e. microbial activity will not take place during normal storage and distribution; they are quite distinct from other forms of packaged foods since the microbial population they contained before processing has been effectively destroyed. All other packaged foods are non-sterile and represent a more complex biological system, and here the packaging materials and methods used can markedly influence the activities of microorganisms present, and correspondingly affect the shelf life of the food.

In order to grow and reproduce in a food, and so cause spoilage, microorganisms require favourable conditions in their immediate environment; the factors that determine whether microorganisms can grow and what type will grow include:

- availability of nutrients
- concentration of inhibitors (natural or added)
- temperature
- pH
- water activity
- oxygen concentration

The system of packaging chosen will affect each of these factors to a greater or lesser degree.

Availability of Nutrients

Most foodstuffs contain all the nutrients essential for microbial growth and in general this factor is not significantly influenced by the packaging system.

Concentration of Inhibitors

A large number of chemical compounds exert a specific inhibitory influence on microorganisms. They may be substances that are naturally present in the food, certain organic acids, spices, alcohol, and carbon dioxide, or they may be intentionally added in accordance with the appropriate food regulations. Compounds in this group include sulphur dioxide, benzoic acid, sorbic acid, propionic acid, and sodium nitrate. Chemical inhibition of microorganisms is mainly a function of the foodstuff rather than the packaging material, but the activity of many of the inhibitors can be influenced by variation in oxygen or water availability, variables which may themselves be radically influenced by packaging materials. In the case of sulphur dioxide, the concentration of the inhibitor itself can be affected by the choice of packaging material. For instance, a microbiological problem is encountered if sulphur dioxide is used to preserve fruit drinks and fruit-flavoured drinks packed in moulded polyethylene containers. The rapid loss of the sulphur dioxide by

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oxidation and permeation leads to a rapid growth of contaminating yeasts in the drink with accompanying fermentation and 'blowing' of the container. These attractive containers can be used, however, if benzoic or sorbic acid is chosen as the preservative, since neither of these permeates the container and neither is subject to oxidation.

A further example of loss of sulphur dioxide, partly as a result of packing variables, occurs when it is used as a preservative for dried fruit; here, of course, the resulting spoilage is not microbial but is in a loss of acceptability through discoloration. Rooney (1970) examined the effects of packaging variables on the shelf life of dried apricots preserved with sulphur dioxide and he found that, during storage, sulphur dioxide was lost by four mechanisms:

- chemical reaction with fruit constituents
- oxidation by atmospheric oxygen initially present in the package head space
- oxidation by atmospheric oxygen permeating into the head space
- permeation through the package material

Over a 50-week period the three packaging variables, i.e. oxygen in the head space, permeated oxygen, and permeation by sulphur dioxide, accounted for 12%, 32%, and 18% respectively of the sulphur dioxide lost from polyethylene pouches. The lowest rate of loss occurred in apricots packed and stored in nitrogen in pouches of impermeable aluminium foil laminate; good results could also be obtained by packing in PVC or in a wide range of substrates coated with PVC.

Temperature

Temperature is another factor which packaging material influences little or not at all, but it is so important in determining the growth rate of microorganisms that some comment is necessary.

Microbes can be roughly divided into three classes on the basis of their temperature growth range. Psychrotrophes grow well at the lower end of the temperature scale, $-5°C$ to $+15°C$, so these organisms are of prime concern in refrigerated foods, particularly meat products. The packaging material for meat products, by determining the rate of exchange of gases to and from the surface of the meat, may significantly affect the psychrophilic flora that develops.

Thermophiles grow in the upper temperature range of 45°C to 70°C and are of concern mainly in heat-processed foods. Between these groups lie the mesophiles with a growth range from about 15°C to 45°C. The growth temperature ranges quoted are obviously somewhat arbitrary and the ranges of certain organisms overlap the limits given.

Most food-poisoning organisms fall into the mesophile group and their growth can be arrested by storage below 5°C. *Clostridium botulinum* type E is an important exception, and storage below 3·3°C is necessary to arrest completely its growth and production of toxin.

Freezing and subsequent frozen storage will kill some of the microorganisms present in food but this is a slow and variable process dependent on a number of factors, including the nature of the food. Freezing cannot be relied upon to reduce bacterial contamination and the hygienic state of the product before freezing is consequently of major importance. Bacterial growth does not occur below $-10°C$, and there is no record of yeasts growing below $-12°C$ or of fungi below $-18°C$. Microbial growth of any kind is extremely slow at these temperatures and for practical purposes can be disregarded below $-10°C$ (International Institute of Refrigeration 1972).

pH

The acidity of a food is commonly expressed in terms of pH. The pH scale ranges from 0 (acid) to 14 (alkaline). Pure water, which is neutral, has a pH of 7. The pH of most foodstuffs lies on the acid side of neutrality: meat, fish, most dairy products, and many vegetables have pH values in the range 4·5 to 6·5 while the pH range for most fruits is 3·5 to 4·5. Some tropical fruits, e.g. banana, mango, commonly have a pH in the range 4·5 to 5·5 and must be acidified to below pH 4·5 before being processed at boiling water temperatures. Products with pH greater than 4·5 are usually processed at temperatures above 116°C. *Clostridium botulinum*, the most toxic and most heat-resistant of the food-poisoning organisms, cannot grow at pH below 4·5 so this pH is of extreme importance in the canning industry.

Of more importance in the field of non-sterile packaged foods are the properties of water activity and oxygen partial pressure.

Water Activity

It is well established that a variety of foods depend for their microbiological stability on the presence of a high concentration of dissolved solids, or on a low moisture content which amounts to the same thing. Over the entire range of solute concentration that permits microbial growth, microorganisms must compete with dissolved solute molecules, naturally present or added, for the water they require for growth. The availability of water in any foodstuff is best defined in terms of water activity (a_w) which in practice is measured as the equilibrium relative humidity (E.R.H.). The a_w represents the ratio of the water vapour pressure of the food to the water vapour pressure of pure water under the same conditions and it is expressed as a fraction. If we multiply this ratio by 100, we obtain the E.R.H. that the foodstuff would produce if enclosed with air in a sealed container at constant temperature. Thus a food with an a_w of 0·7 would produce an E.R.H. of 70%.

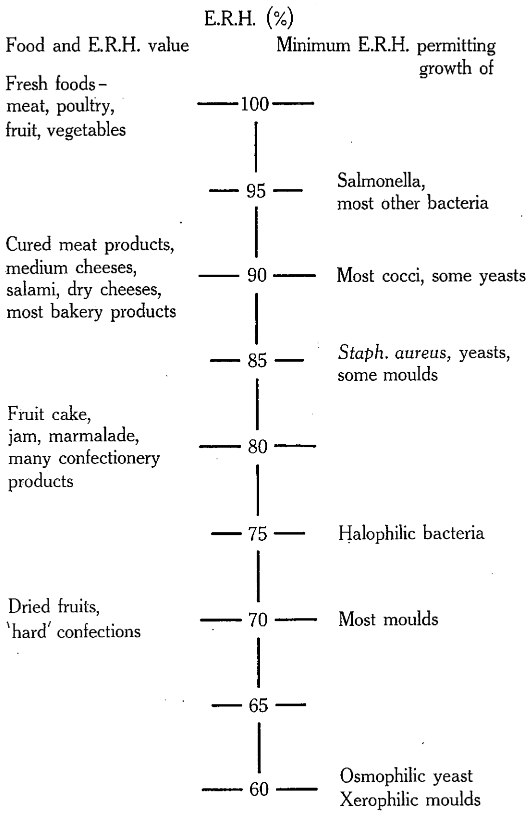
The diagram, prepared from data given by Perigo (1966) and Mossel (1971), lists some common foodstuffs and their usual E.R.H. On the right-hand side of the scale different microbial groups are listed at approximately the lowest E.R.H. value at which they can grow. *Clostridium botulinum* is unable to grow at an a_w of 0·94 and below; the lower limit of a_w for salmonellae is 0·93. Staphylococci are able to grow at an a_w of 0·86 under aerobic conditions, but this lower limit rises to 0·90 under anaerobic conditions (Perigo 1966). The risk of food poisoning must therefore be considered in foodstuffs down to an E.R.H. of 86%.

The choice of a suitable material in which to package a non-sterile foodstuff is highly dependent on the E.R.H. of the foodstuff. Products which have a low E.R.H. and consequently are very stable, e.g. freeze-dried foods, must be packed in materials highly impermeable to water such as aluminium foil laminates. Packaging in these materials prevents the food from taking up water from the atmosphere and becoming unstable. Similarly, if a food is microbiologically unstable by virtue of its high E.R.H., the packaging material used will not confer any additional protection except in a few special cases, e.g. the use of wrappers impregnated with sorbates for the packaging of cheese. In these circumstances the product must be stored under temperature conditions unsuitable for microbial growth.

In other instances a different situation obtains: spoilage organisms are commonly most active on the surface of foodstuffs and in some products that have a high E.R.H., an acceptable stability is only achieved by encouraging a continuous loss of moisture from the surface. In this way, the water activity at the surface of the product may be significantly lower than in its interior.

Meat

Packaged fresh meat is a product in which some surface drying is desirable. With such a product it may be disastrous to use a packaging material with very good water barrier properties. In practice a compromise must be reached where the rate of drying at the surface is fast enough to inhibit microbial spoilage



Some common foodstuffs and their usual E.R.H.

but not so great as to result in an unacceptable shelf life due to desiccation. It is usual to select a film sufficiently permeable to moisture vapour to prevent unsightly condensation within the package but not so permeable as to lead to excessive weight losses (Anon. 1970*a*). With fresh and cured meats the permeability of the packaging film with respect to oxygen and carbon dioxide is more critical than is its permeability to water vapour.

Garden Produce

In films used to prepackage fruits and vegetables, permeability to water vapour is also important, a fact not always recognized by produce merchants and purveyors of flexible film. It is important to minimize the loss of water from the produce to lessen shrinkage and maintain crispness. However, excessive accumulation of water vapour encourages attack by mould, and refrigeration is essential for prepackaged perishable material that is being held longer than 48 hours (Hall 1962). Perforations sometimes made in packaging material to permit freer exchange of respiratory gases also allow a small and desirable loss of water vapour, and so the use of perforated bags is strongly recommended. For a concise account of the complex biological situation involved in the prepackaging of fresh produce the reader is referred to an article by Hall (1957). This is an area where too often in the past packaging for ease of marketing has received precedence over packaging for maintenance of the highest quality of the foodstuff.

Oxygen Concentration

The oxygen tension or partial pressure of oxygen about a food may exert a powerful influence on the type of organism that will grow on the food and the type of waste products a given microbial population will produce. Obviously, then, the extent to which packaging materials constitute an oxygen barrier may exert a very marked influence on the activities of microbes on the surface of food products. This is particularly so with packaged meat products; the effects of packaging on spoilage of packaged meats has been described in detail by Ingram (1962), Ingram and Dainty (1971), and Dallyn and Everton (1972).

The storage life of a non-sterile packaged food is related directly to the bacterial load at the time of packaging and the temperature conditions under which the product is held. This applies for all packaged foods and must always be borne in mind by the food processor. The problems in packaging fresh meats relate to colour stability and bacterial spoilage and the requirements for the control of each are sometimes incompatible (Anon. 1970*a*).

Fresh Meats

Films with high permeability to oxygen and carbon dioxide are commonly used for short-term storage of fresh meats where the most important consideration is the appearance of the product, e.g. in supermarket butcher stores. Satisfactory development of a bright red colour due to the formation of oxymyoglobin occurs at oxygen concentrations comparable to that in air. Storage temperatures as close as possible to $-1°C$ are desirable to give maximum shelf life. This maximum shelf life will be 3–4 days, depending on the initial condition of the meat and the storage temperature.

If oxygen is freely available to the surface of meat and if the meat remains moist, spoilage will be caused quickly by a superficial slime of Gram-negative bacteria of the *Pseudomonas* group. The accompanying odour is usually described as putrid.

If the package is insufficiently permeable, the oxygen will be largely replaced by carbon dioxide, or if the meat is packaged in an atmosphere of carbon dioxide, the rate of bacterial spoilage is decreased appreciably (Selby 1961; Anon. 1970*a*). In these circumstances the putrid odours of spoilage do not appear and the bacterial numbers may rise to very high levels, e.g. 10^9/g, before there is any obvious change in the appearance of the meat (Ingram and Dainty 1971). Concentrations of over 30% carbon dioxide may cause grey discoloration of the meat and should be avoided.

Cured Meats

As with fresh meat, the preservation of colour in cured meat is of great importance if the product is to retain market acceptability. Since cured meats retain their colour best in the absence of oxygen, films with low permeability to oxygen are commonly used for packaging these products. To get maximum colour retention in a vacuum package, free spaces in or around the product must be avoided (Anon. 1970*b*). With cured meats, the presence of salt and nitrite modifies the bacterial flora and inhibits the growth of bacteria that normally cause spoilage of fresh meats. However, under the conditions of vacuum or gas packaging, dominant types of microorganisms change in succession.

With uncooked cured meats, removal of air by vacuum packaging permits carbon dioxide to build up in the pack to a level of about 30% and this helps retain the desired colour. Alternatively, gas flushing with 25–40% carbon dioxide has a similar effect. As cooked cured meats contain little dissolved carbon dioxide and normally have low microbial populations, vacuum packaging does not lead to an appreciable accumulation of this gas within the package. Gas packaging of cooked meats is therefore often preferred (Anon. 1970*b*).

As the composition of the environment within a package of cured meat changes, so does the accompanying bacterial flora. At the low salt concentrations of around 5% commonly used by many Australian processors, micrococci at first predominate but are eventually succeeded by lactobacilli which are able to multiply at the low temperature of storage, the relatively low salt concentration, and the low oxygen tension. At higher salt concentrations of 8% or more the micrococci may continue to dominate (Ingram and Dainty 1971).

It is important to emphasize that as with fresh meats, the storage life of cured packaged meats is related directly to the initial bacterial contamination and the temperature at which the product is held. For this reason, strict hygienic practice must be followed during preparation and packaging of the meat and the product must be refrigerated as close as practicable to −1°C during distribution and storage before and after sale.

Conclusion

The purpose of this article has been to show that packaging of foods in flexible films does not change the inherent stability, or lack of stability, of a given food. The choice of packaging material may, however, have a marked effect on the type of microbial population that develops. This in turn can determine how long a food will remain acceptable under proper conditions of storage. For this reason it should be the concern of the packaging technologist as much as the food technologist to understand and familiarize himself with the complex systems with which he works.

Information on packaging of general foodstuffs, including fresh fruit and vegetables, is obtainable from the Division's Food Research Laboratory at North Ryde, N.S.W. Enquiries on packaging of meat should be directed to the Meat Research Laboratory, Cannon Hill, Qld., and on dairy products to the Dairy Research Laboratory, Highett, Vic.

References

Anon. (1970*a*).—The use of packaging films for chilled fresh meats. CSIRO Meat Research News Letter No. 70/6.

Anon. (1970*b*).—The use of packaging films for chilled processed meats. CSIRO Meat Research News Letter No. 70/7.

Dallyn, H., and Everton, J. R. (1972).—The influence of packaging materials on microbial growth. *I.F.S.T. Proc.* **5**, 95–105.

Hall, E. G. (1957).—Pre-packaging fresh fruits and vegetables. *CSIRO Fd Preserv. Q.* **17**, 58–63.

Hall, E. G. (1962).—Refrigeration in the retailing of fruit and vegetables. *CSIRO Fd Preserv. Q.* **22**, 11–14.

Ingram, M. (1962).—Microbiological principles in prepacking meats. *J. appl. Bact.* **25**, 259–81.

Ingram, M., and Dainty, R. H. (1971).—Changes caused by microbes in spoilage of meats. *J. appl. Bact.* **34**, 21–39.

International Institute of Refrigeration (1972).—'Recommendations for the Processing and Handling of Frozen Foods.' 2nd Ed. p. 54. (Int. Inst. Refrigeration: Paris.)

Mossel, D. A. A. (1971).—Physiological and metabolic attributes of microbial groups associated with foods. *J. appl. Bact.* **34**, 95–118.

Perigo, J. A. (1966).—The protection of foodstuffs from microbial attack. *J. Inst. Packag.* **12**(89), 10–18, 34.

Rooney, M. L. (1970).—The influence of packaging variables on the loss of sulphur dioxide from dried fruits. *Fd Technol. Aust.* **22**, 288.

Selby, J. W. (1961).—Modern food packaging film technology. Scient. tech. Surv. Br. Fd Mfg Inds Res. Ass. No. 39.

Production of Pear Purée and Concentrated Pear Purée

By D. J. Casimir
Division of Food Research, CSIRO, North Ryde, N.S.W.

In recent years the Division has investigated some new methods of processing pears that might help to ease the problem of over-production. An article on pear-drying appeared in this *Quarterly* in 1969, and the following article describes a method for producing high-quality purées without the gritty texture often associated with processed pears.

Processed pear products other than canned pears in syrup include:

- Pear juice, either pure or blended with other juices,
- Concentrated pear juice for use in aerated soft drinks,
- Fermented pear juice (perry),
- Crystallized or glacé pears,
- Halved or diced air-dried pears, or roller-dried flakes.

A further use for processed pears, as single-strength or concentrated purée, is presented here; however, the market for this or any of the products listed should be investigated fully before commercial production is started.

Making the Purée

Raw Material

Only William Bon Chrétien pears were used as test material, since these are in greatest over-supply. The pears were within the usual canning range of maturity; Magnus Taylor pressure readings with a 0·375-in. (9·525-mm) plunger ranged from 5 to 15 lb (2·3 to 6·8 kg) with a mean of 8·4 lb (3·8 kg). Fruit was washed by hand before processing.

Slicing

Unpeeled and uncored pears were sliced 0·4 in. (10 mm) thick in a Hällde cutter using a fluted sickle blade.

Blanching

Slices were blanched in a jacketed vacuum steam blancher of approx. 4 ft^3 (0·11 m^3) total capacity (Pfaudler Model No. 24-45CD-SB), with an interior lining of stainless steel. The blancher was connected to a two-stage steam ejector vacuum system. The following schedule was used for blanching:

Time to pull vacuum of 28 in. ($6\cdot8\times10^3$N/m^2)	90 s
Steam pressure in jacket held at	5 p.s.i.g. ($1\cdot4\times10^5$N/m^2)
Time to break vacuum of 28 in. with steam and reach 2 p.s.i.g. ($1\cdot2\times10^5$N/m^2)	120 s
Holding time at 2 p.s.i.g.	300 s
Temperature at end of holding time	98·8°C
Tumble blancher rotated at	10 r.p.m.

Pressing

Hot blanched slices were discharged into a Brown International Screw Press (Model No. 3600, Covina, California), fitted with a screen having 35% open area, i.e. 126 holes/in^2 (20 holes/cm^2), each 0·06 in. (1·5 mm) in diameter. The screw press was preheated with steam so that the press liquid (purée) could be filled directly into cans at 85°C; the cans were then closed and inverted. A flow diagram showing yields at different stages of the process is given in Figure 1.

Texture of the Purée

Stone Cells

Most pears contain gritty conglomerates composed of stone cells which have a 'sand-like' feel on the palate or when ground between the teeth. Reeve (1970)* showed that grit clusters in pear fruits are composed of irregular globose or polyhedral scleroids. The

*Reeve, R. M. (1970).—*J. Texture Stud.* **1**, 247–84.

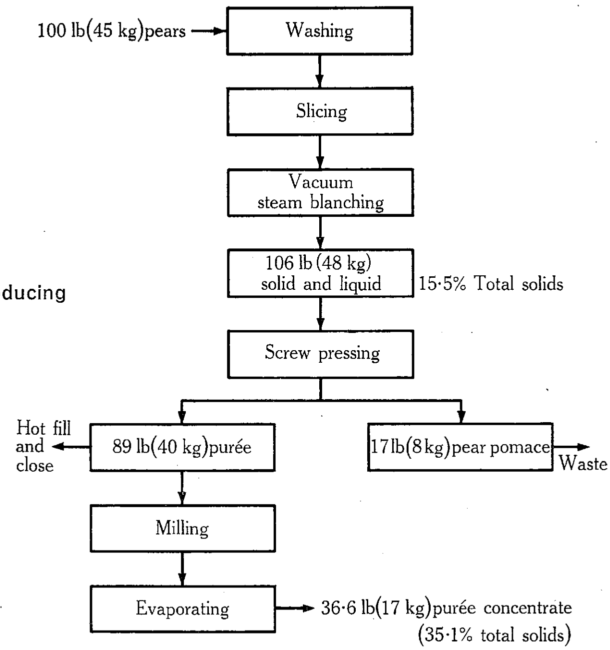


Fig. 1.—Flow diagram showing the steps for producing pear purée and concentrated purée.

secondary walls of these cells are exceptionally thick, and have many fine pit-canals through which plasmodesmata interconnect between cells. The walls are highly lignified and have a high hemicellulose content.

Grittiness

Purée prepared by the method described earlier in this paper had a gritty texture as a result of the carry-through of stone cells. The average size of particles was in the range 160–260 μm and a typical aggregate is shown in Figure 2.

After milling in a Fryma colloid mill, the maximum dimension of the stone cell aggregates was reduced to about 50 μm, resulting in a smooth-textured product. Inclusions in the range of 25–50 μm were just detectable, but only when purée was ground between the

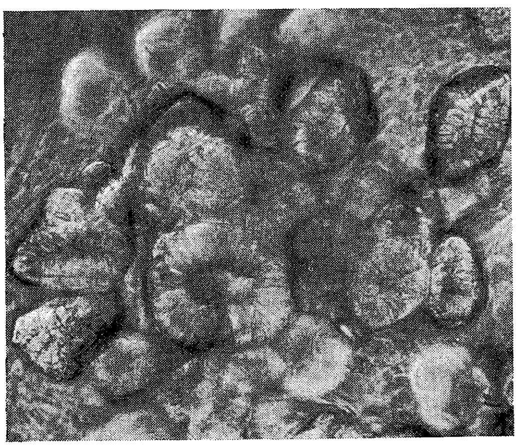


Fig. 2.—A typical aggregate of stone cells as they occur in pear purée. ×24.

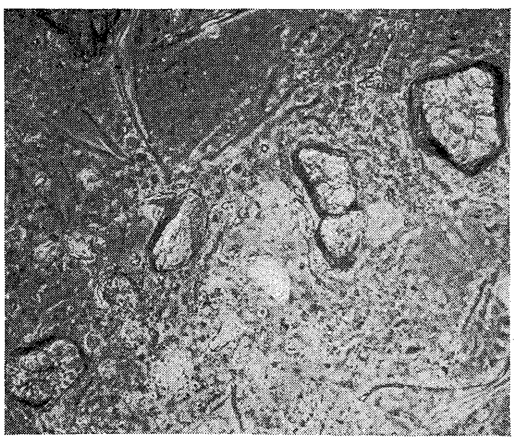


Fig. 3.—Single stone cells typical of those occurring in milled pear purée. ×24.

Fig. 4.—Passing the purée through a colloid mill to get rid of grittiness.

teeth. Single stone cells typical of those in the milled purée are shown in Figure 3.

When pressed between a white tile and a glass cover plate, unmilled purée showed numerous particles that were clearly visible to the naked eye, but milled purée showed very few visible particles.

Milling

The tests on milled purée defined the process that should be applied to the press-liquid from the screw press to eliminate grittiness. Consequently, the purée was passed through a carborundum stone colloid mill (Fryma MK-95R) of 3 hp (2·2 kW), with the stones set at 50 μm clearance (Fig. 4). Rotating and stationary stones were 60 grit. A throughput of 1·33 lb/min/hp (0·27 kg/min/kW) was attained using a head of 10 in. (25·4 cm) in the feed hopper; this could probably be doubled by using a pressure feed to the colloid mill. Temperature of the product increased from 52·8 to 56·1°C during passage through the mill.

Concentrating the Purée

Pear purée from the Fryma mill was concentrated using a centrifugal film evaporator (Centritherm CT-1B), as set out in the table.

Conditions of Evaporation

	Rate (lb/hr) (kg/hr)	Soluble solids (°Brix)	Total solids (%)	Temperature (°C)
Feed purée	126 (57)	12·3	15·5	48·9
Concentrated purée	55·7 (25)	29·6	35·1	60·0
Distillate	70·3 (32)			31·7
Vapour				61·7
Steam				102·2

The heat transfer coefficient was calculated as 1002 Btu/h ft² degF (5690 W/m² degC); from this calculation, and under the same evaporating conditions, the Centritherm CT-6 would have the following capacity:

feed = 2772 lb/hr (1260 kg/hr)

concentrate = 1225 lb/hr (556 kg/hr)

and the Centritherm CT-9:

feed = 8316 lb/hr (3775 kg/hr)

concentrate = 3676 lb/hr (1669 kg/hr)

Heating and Hot-filling

After reheating at atmospheric pressure in the Centritherm CT-1B evaporator, the concentrated purée was filled at 93°C into 301×407 plain cans. They were closed without head space, inverted, and then water-cooled.

Conclusion

In this procedure for making smooth-textured purée and concentrated purée from pears, the most important points in the operation are:

- Rapid inactivation of enzymes responsible for browning by heating pear tissue in the absence of oxygen in a vacuum steam blancher.
- Removal of fibrous material, seeds, skin fragments, etc., from pulp using a screw press.
- Milling of the extracted purée by means of a carborundum stone mill to reduce the size of gritty aggregates from about 250 to 50 μm so that the purée feels smooth on the palate.
- Concentration of the milled purée on a centrifugal film evaporator from 15·5 to 35% total solids.

A Simple Conductivity Meter for the Food Industry

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

A simple conductivity meter was developed in the Division of Food Research following enquiries from the food industry about equipment for measuring the concentration of sulphite in dipping solutions. This article gives details of the construction and use of the meter.

There are a number of food processing operations where it is important to maintain a known concentration of an electrolyte in solution; the sulphite dipping of vegetables before dehydration is a good example. As the sulphite solution becomes depleted during a production run the effectiveness of the operation is reduced. On the other hand, random additions of extra sulphite may give high temporary levels of SO_2 which will decrease according to the processing rate and other variables, and so these changing factors will result in a product of variable quality. Where laboratory facilities are not available it is impossible to estimate the sulphite concentration of the solution at any time after processing has begun.

The instrument described in this paper (Fig. 1) gives a good indication of the solute level in situations in which the major variable is an electrolyte at a relatively low concentration.

Principle of Operation

Figure 2 is a block diagram of the instrument showing the arrangement of the circuit units; details of the circuits are shown in Figure 3. Changes in concentration of the ionic species

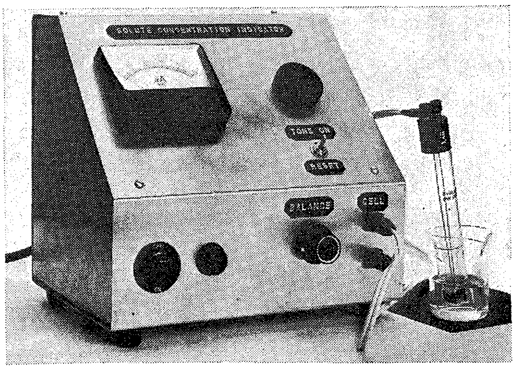


Fig. 1.—Simple conductivity meter.

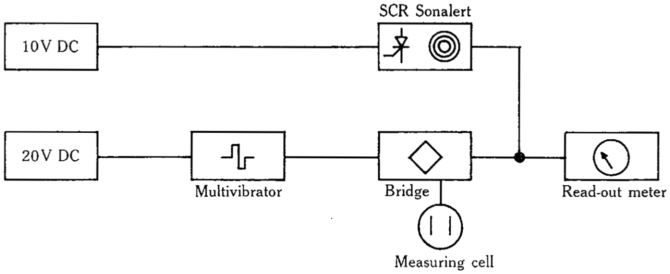


Fig. 2.—Block diagram of circuit units.

produce a change of electrical conductivity in the measuring cell and alter the balance of the Wheatstone bridge. The bridge is supplied from a 1000-Hz multivibrator and is operated in the off-balance position. The out-of-balance signal is rectified by a diode bridge and applied to a 100-μA moving-coil meter. An optional audible warning system is switched by means of a silicon controlled rectifier (SCR). When the meter reads a certain value (which can be pre-set by stacking diodes in series with the meter) the steady d.c. voltage applied to the gate of the SCR will be sufficient to trigger the device into conduction, thus switching on a Mallory Sonalert or alternatively a small electric bell. The SCR acts as a latching relay and the reset switch must be opened to remove power from the Sonalert even after the solution concentration has been corrected. Power is supplied from the mains through a dual 6·3V 1A transformer. The multivibrator is supplied with about 20V d.c. from a voltage-doubling rectifier on one LT winding and the Sonalert/SCR with 10V d.c. from a bridge rectifier on the other LT winding.

Mode of Operation

To use the instrument, the measuring cell is placed in a solution of known concentration

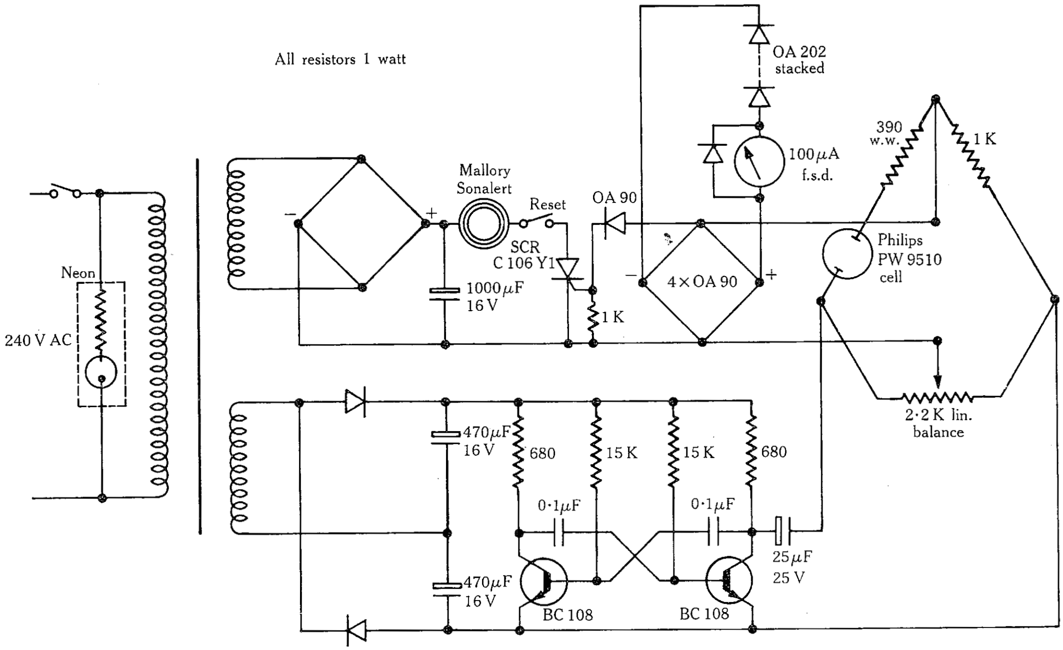


Fig. 3.—Details of electrical circuitry.

and the instrument is switched on (Fig. 1). After a short warm-up period the 100-μA meter will indicate a steady reading which may be adjusted by use of the balance knob. The measuring cell is then placed in the processing solution in the dipping tank and the concentration of this solution is adjusted to give the same meter reading as the standard previously chosen. During a processing run the meter needle can be kept close to standard by additions of fresh solute either by batch lots or drip feed.

It should be noted that the meter may be used in two ways: where *either* increasing *or* decreasing solute concentrations will produce increasing meter readings by suitable adjustment of the balance knob. The instrument can therefore be set to warn of low concentrations where batch additions are being used or, if a drip feed is used, the instrument may be set to indicate if the concentration is becoming too high. The SCR-triggered audible warning device may be separated and placed where convenient, thus doing away with the need for constant monitoring of the meter by an operative.

Discussion

The measuring cell is a commercial dip type with platinum black electrodes; the Philips PW 9510 and Mullard E7591/B have been found to be satisfactory. Other types of similar construction may also be suitable since all settings are arbitrary and will depend upon the system in which the instrument is being used. Use of the 1000-Hz square-wave supply from the transistor multivibrator reduces polarization effects to negligible proportions. Interference is not noticeable with starch and sugars but foreign electrolytes must be avoided. The range of concentration in which the instrument will operate depends on the particular ions being monitored; with $Na_2S_2O_5$ solutions the performance was good in the range 0·05% to 0·5% and NaCl solutions gave similar results. The surest way of evaluating the meter is a practical test in a particular system. Difficulty may be encountered in acid systems because of the high mobility of the hydrogen ion. Conductivity varies with temperature, so standardization of the instrument and measurements should be carried out at the same temperature.

A unit based on the principles outlined above has been in operation in a food processing plant for over two years and has proved a useful and reliable aid in maintaining product quality.

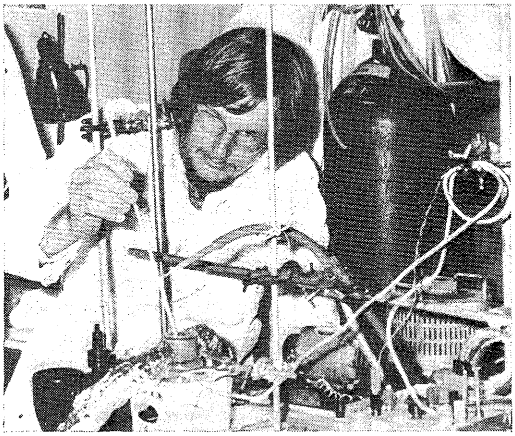
Polyunsaturated Meat and Dairy Products

In recent issues of this *Quarterly* we have mentioned inter-divisional research into polyunsaturated ruminant products, and we feel that our readers will be interested in this fuller account of the work. The report published here gives some details of the way in which the products are obtained, and outlines their potential value for several different markets.

The Special Feed Supplement

The Division of Animal Physiology and the Division of Food Research, in collaboration with the Ellinbank Dairy Research Station of the Victorian Department of Agriculture, have expanded their research into the production of polyunsaturated meat and dairy products. These products are obtained by feeding cattle and sheep a supplement containing oilseeds with highly unsaturated oils which have been protected against the saturating action of the bacteria in the rumen. The supplement consists of a powder composed of minute globules of sunflower seed oil, clad in a skin of protein hardened by formalin treatment. After passage through the rumen, the protected polyunsaturated oil is released in the small intestine and absorbed into the tissues of the animal.

CSIRO Fd Res. Q., 1973, **33**, 69–70



This scientist at FRL is using an oxygen electrode to test the efficiency of anti-oxidants in controlling the oxidative stability of polyunsaturated milk.

Thus, these ruminants have to some extent become like monogastric animals, such as the pig, chicken, or man, in that the fatty acid composition of the meat and milk reflects that of the diet of the animal.

Some Advantages of the New Products

It is now possible to produce a wide range of ruminant food products of more than 20% polyunsaturation, a development that has important implications in the field of human health. By replacing conventional food products from cattle and sheep, these foodstuffs will permit a significant increase in the levels of polyunsaturation in the diet of man. In this respect the milk may be useful in the preparation of infant feeding formulae, because the fats in it more closely resemble those of human milk. The preliminary results, indicating that diets containing polyunsaturated meat and dairy products in place of conventional products lowered the blood cholesterol level in man, have been confirmed in the Department of Clinical Science at the Australian National University, Canberra.

The changed chemical and physical properties of the new types of food will allow considerable diversification of food products derived from ruminant animals, particularly in the dairy industry, for example the production of a more spreadable butter, or of lamb that does not have the strong mutton flavour that some Australian and potential Asian consumers find objectionable. These desirable properties may be achieved at a level of polyunsaturation lower than that necessary for modifying the diet on medical grounds.

Controlling Oxidation

The high level of polyunsaturation in the milk produced by the protected lipid process makes it more liable to attack by oxygen, resulting in the production of oxidized flavours described as cardboardy, nutty, or oily. This oxidation can be controlled by the addition of antioxidants. Those used are the ones currently permitted as additives to a number of food products. A change in the relevant Acts will be required to permit the addition of antioxidants and their carriers to dairy products before such products can be put on the market. No such change is required for meat, as preliminary evidence shows that meat does not suffer the same problem of oxidation.

Further Development

One of CSIRO's desires is that its research findings be rapidly translated into commercial practice. Following a general invitation to industry to commercialize the process, a proposal from Dalgety Agri-Lines Pty Ltd of Sydney for the development and commercial production of polyunsaturated meat and dairy products was accepted by CSIRO.

Dalgety Agri-Lines Pty Ltd has established companies in Australia, New Zealand, Britain, and the United States under the name Alta Lipids and it is likely that the polyunsaturated ruminant food products will be known as Alta products. The companies are providing funds for research in four countries for the further development of the process and the products derived from it. The research programme now under way is unusual in that it has broken down many of the traditional barriers between workers in different types of organizations and between different countries. Researchers in industry, universities, and government all have a common interest in producing a range of new foods that have many technological and public health possibilities.

Retirement of E. G. Pont

Mr E. G. Pont retired in June, after 33 years' service with CSIRO. After graduating from the University of Sydney, Ted Pont spent his early years as a dairy bacteriologist with the New South Wales Department of Agriculture. In 1940 he joined the Dairy Research Section of CSIR and continued to work on bacterial problems of dairy products. Subsequently, he undertook research into chemical and physical aspects of butter storage and quality. He was the first to show that the washing of butter was an unnecessary step, and demonstrated that the quality of the product, if left unwashed, was at least as good as, if not superior to, that of the washed product. This was a major contribution to the understanding of the problems of manufacture and quality of butter. In 1949 he was awarded the Gold Medal of the Australian Society of Dairy Technology for his contribution to the science and technology of butter-making.

In recent years, Ted investigated the possibility of the preparation and use of concentrated starter cultures for cheese manufacture, and made advances in this field that could be of major practical significance to the cheese industry.

Ted Pont has published more than 50 papers in dairy science and he intends to occupy some of his time during retirement in editorial services for the Australian Society of Dairy Technology.

News from the Division

Awards

Dr J. R. Vickery, O.B.E., former Chief of the Division of Food Preservation, has been awarded the James Harrison Memorial Medal of the Australian Institute of Refrigeration. Dr Vickery is the first recipient of this medal which will be awarded annually for outstanding service in the science and engineering of refrigeration and air-conditioning.

At the Seventh Annual Convention of the Australian Institute of Food Science and Technology held in Melbourne in May, Dr K. J. Nicol, of FRL, was awarded the AIFST Council Research Award for the 'best contributed paper concerning original scientific research or development projects by an author under the age of thirty'. Dr Nicol's paper was entitled 'Biochemical studies related to orange juice bitterness'.

Mr P. W. Board, FRL, was elected Chairman of the New South Wales Branch of the Australian Institute of Food Science and Technology.

Mr E. G. Davis, FRL, has been made a Fellow of the Australian Institute of Packaging, and is currently Chairman of the New South Wales Division of the Institute.

R/V *Alpha-Helix* Expedition to the Great Barrier Reef

Three members of the Division's Plant Physiology Unit, Drs Smillie, Graham, and Bishop, were invited to take part in the Expedition, which was supported by the U.S. National Science Foundation and the Australian Department of Science. Its prime objective was to investigate the process of photorespiration (light-induced respiration) in marine plants. The R/V *Alpha-Helix* is a scientific research vessel of the Scripps Institute of Oceanography, La Jolla.

Work Overseas

Dr J. H. B. Christian, Associate Chief, who is at present overseas studying developments in international microbiological standards for foods, led the Australian delegation at a meeting of the Codex Alimentarius Committee on Quick Frozen Foods, Geneva, in April and May. In May also he attended a meeting of the Codex Alimentarius Committee on Food Hygiene, Washington, D.C., as a member of the Australian delegation, and took part in a working party on methods for detection of salmonellae in eggs and egg products. While in Washington, Dr Christain delivered a seminar paper at the Food and Drug Administration on food standards in Australia.

Dr Alex Buchanan, who has been in charge of the New Foods Group at DRL, has been seconded to the Department of Foreign Affairs for a two-year term to work in Thailand on a Colombo Plan project. He left Australia last month for Bangkok where he will assist the Institute for Food Research and Product Development, Kasetsart University, in their programme for producing a low-cost, high-protein weaning food for infants. The food is to be based as much as possible on local raw materials and will be designed to suit the present eating habits of Thai children.

Visitors

FRL was visited by a Hungarian agricultural delegation in April, as part of a tour of agricultural establishments organized by the Department of Overseas Trade. The delegation was led by the Deputy Minister for Agriculture and Food.

In May the well-known writer and lecturer on Food Science, Dr Magnus Pyke, visited Australia as guest of honour of the Seventh Convention of AIFST; during a stay in Sydney, Dr Pyke delivered lectures to FRL staff and to a joint meeting of RACI and AIFST.

Transfer

In July Mr Ian Eustace transferred from the Tasmanian Food Research Unit (TFRU), Hobart, to take up an appointment as Experimental Officer at DRL, Highett, where he will investigate some of the problems in using polyunsaturated milk for manufacturing a range of dairy products.

General

Mr R. Moeljanto, Colombo Plan fellow from Indonesia, is undertaking further training in Fish Processing Technology at TFRU, Hobart. Later in the year he will spend some time at FRL before returning to the important position he holds at the Indonesian Institute of Fishery Technology.

Mr R. Pichumani, UNIDO Fellow from India, spent several weeks at FRL in March, mostly in the Food Technology Section, studying processing, quality control, and preservation and production techniques for fruit and vegetables. Mr Pichumani is Assistant Director (Chemical) of Small Scale Industries in the Indian Ministry of Industrial Development.

During May, several scientific meetings of interest to the Division were held. Those at which papers were delivered by members of the Division included the Seventh Annual Convention of AIFST, the Annual Meetings of the Australian Society for Microbiology and the Australian Biochemical Society, the Annual Conference of the Australian Society of Plant Physiologists, a meeting of the Australian Society of Dairy Technology, the RACI Electrochemical Meeting, and the Third World Conference on Animal Production.

Specialist Courses for the Food Industry

The fourth in the Division's series of Specialist Courses is planned for 16–18 October 1973, on the topic 'Sensory Evaluation of Foods and Beverages'. The course will be held at FRL.

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