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The commercial storage of cut flowers is, as yet, little practised in Australia, but interest in it is growing. The following information, based largely on American research and experience and partly on exploratory experiments in the C.S.I.R.O. Homebush laboratory, is intended as a guide to the flower trade in developing successful storage methods.

THE STORAGE

ALMOST ALL TYPES OF FLOWERS ARE HIGHLY perishable; even when freshly cut they will keep for only a few days in a vase at normal room temperatures. The temperature at which they are held is the most important factor in their preservation, and cool storage offers a means of considerably extending the life of most kinds. A few flowers, notably orchids, cannot be cooled very much without damage but many of the common sorts can be stored at temperatures as low as 31 °F, which is very little above their freezing point.

The cool storage of flowers has been practised on a commercial scale for a number of years in the United States of America. While the buyer will generally prefer freshly cut flowers, suitable storage conditions have been developed that enable the material after storage to keep as long and almost as well as fresh flowers.

Until very recently the practice was to place the stems in water and hold at some temperature in the range 45-50 °F. As a result, however, of investigations by a group of research workers at Cornell University in New York a new storage technique has been developed which enables the cool-storage life of many types of flowers to be greatly extended. The technique consists essentially of "dry" storage in a tightly sealed container at the much lower temperature of 31 °F. It is being increasingly adopted where the longest possible storage life is sought.

STORAGE IN WATER

While most commercially stored flowers are still held freely exposed to the air with their stems in water the storage temperatures are nowadays somewhat lower than they were some years ago, being down to 33-35 °F for some types of flowers and 40 °F for others. Certain flowers, notably orchids and dahlias, are more sensitive and, because of characteristic injury at lower temperatures, cannot be stored successfully below about 50 °F. This simple method of open storage in water is quite satisfactory for storage for a few days, which is often all that is required by the trade. The storage lives of a wide range of flowers under such conditions have recently been listed by Wright, Rose, and Whiteman (1954). Data, including recommended temperatures, for the more common types are given in the table opposite.

DRY STORAGE

In early work with carnations Neff (1939) found that many factors affected their keeping quality. The most important of these was the temperature at which they were stored. However, the humidity of the air and its carbon dioxide and oxygen contents and the maturity of the flowers also influenced the storage period considerably.

A temperature of 32 °F was found to be better than 40 °F, and dry packing in a sealed container or moisture-proof film

By E. G. Hall

Division of Food Preservation and Transport, C.S.I.R.O., Homebush, N.S.W.

OF CUT FLOWERS

Temperature and Approximate Duration of Storage of Cut Flowers exposed with Stems in Water (after Wright, Rose, and Whiteman 1954)

Flower	Temperature (°F)	Approx. Storage Period (days)
Anemone	45	1-2
China aster	40	7
Calendula	40	3
Camellia	45	3-6
Carnation	35	7
	40	4
Chrysanthemum	35	14
Daffodil	33	14
	36	7
Dahlia	50	2
Delphinium	40	1-2
Gardenia	45	3-6
Gladiolus	35	7
Hyacinth	33	14
	36	7
Lilies (various)	35	14
Orchids (various)	55	2-3
Rose		
Tight buds	40	4-5
Loose buds	40	2-3
Snapdragon	40	3
Stock	40	3
Sweet pea	50	1-2
Tulip	33	7
Violet	40	3

wrapping was much better than storing the flowers freely exposed with their stems in water. Neff found that dry-packed carnations sealed in M.S.T. "Cellophane", in which the carbon dioxide concentration built up to 6·5 per cent., kept well for 32 days at a temperature of 32 °F. When placed in a vase at room temperature, their condition was as good as that of fresh carnations. This was shown to be due to the much better retention of food reserves, especially sugars, in "dry-pack" storage. Neff showed that only young flowers with half-open buds should be stored and that the humidity of the atmosphere in the container should be near saturation.

Haugė, Bryant, and Laurie (1947) carried out trials of pre-packaging in M.S.T. 300 "Cellophane" at a temperature of 40 °F. They found that roses, carnations, and chrysanthemums kept much better when stored in the moisture-proof package and attributed this to minimum water loss and a build-up of carbon dioxide.

Tests carried out with several kinds of flowers with a view to exporting them from Holland to warmer climates were reported by van Stuivenberg (1949). The blooms were stored at different temperatures with varying levels of carbon dioxide. Tulips kept satisfactorily for 14 days at a temperature of 34 °F in 4-5 per cent. carbon dioxide. A life of up to 21 days, depending on variety, was obtained with roses in 8-15 per cent. carbon dioxide at a temperature of 37 °F.

At this temperature there was less browning of the petals than at 33 °F. Carnations kept well for 22 days at a temperature of 33 °F in 10 per cent. carbon dioxide.

Most work on the "dry-pack" method of storage has been carried out at Cornell University by Post and Fischer (1952). In the table below are given the maximum storage periods found by these authors for various flowers when dry packed and cool stored at a temperature of 31 °F. This temperature was chosen to obtain the maximum benefit from refrigeration without risk of freezing the blooms.

Storage Life of Cut Flowers Dry Packed at 31 °F (after Post and Fischer 1952)

Flower	Maximum Storage Period (days)
Carnation	28
Pompon chrysanthemum	35
Rose (var. Better Times)	18
Lily	28
Lily of the valley	21
Gardenia	21
Tulip	50
Daffodil	14
Sweet pea	14
Iris	14

This new low-temperature technique was unsuitable for orchids and gladioli. Orchids were found to require a temperature of not less than 45 °F to avoid low-temperature damage manifest as browning of the pollinia, the lip, and middle portions of the sepals and petals, while gladioli in the tight-bud stage failed to open after 21 days "dry-pack" storage at temperatures up to 36 °F. However, Sheehan (1954) found that cymbidium orchids kept well at 31 °F for 2-3 weeks when packed dry in sealed moisture-proof "Cellophane", whereas cattleyas and other types required a temperature of 45 °F to avoid injury.

In experiments in the C.S.I.R.O. laboratories roses and carnations dry packed in polyethylene film kept much better at 32 °F than when stored exposed with their stems in water; results were not as good at a temperature of 41 °F. There was no apparent advantage in pre-cooling the flowers before packing to reduce condensation of water on the inside of the polyethylene bags. Storage life was only 8-10 days but the flowers were not freshly picked and had to be kept in a fruit store where the presence of small amounts of ethylene gas may have accelerated deterioration. Tests of carbon dioxide concentrations indicated that polyethylene would be a very suitable film in which to dry pack flowers for long storage. It is clear that a film resistant to the passage of carbon dioxide is required so that a concentration of several per cent. can build up inside the package.

GENERAL PRECAUTIONS

Flowers for storage should be as fresh and undamaged as possible and should be in the bud stage for types which readily open after picking. They should be packed dry, with no moisture on them. If more than very slightly wilted, they should be freshened in water for 2-3 hours, preferably in a cool place. The free air space in the package should be as small as practicable to minimize moisture loss from the flowers and to allow for more rapid build-up of carbon dioxide.

Proper dry packing requires a moisture-proof and vapour-proof package which can be *sealed*, but the flowers should not be wrapped in newspaper or other water-absorbing material. Metal or waxed fibreboard cans with tight-fitting lids are very satisfactory. Bags of polyethylene, moisture-proof "Cellophane", or similar film can be used or paraffined boxes can be over-wrapped with these materials. The storage temperature should be kept constant and variations should not exceed 1 °F.

After storage, particularly if stored for a long period, the packages should be opened and the flowers "hardened" by cutting the stems, placing them in water or suitable solution at a temperature of 80-100 °F, and holding in a *cool* place for 6-8 hours. The use of certain commercial cut-flower foods dissolved in the water is of distinct benefit; one satisfactory mixture contains 1 per cent. of sugar plus aluminium sulphate and a small amount of hexamethylene tetramine (hexamine).

Factors affecting the keeping of cut flowers in water were investigated by Dickey

(1950). He found that the presence of metallic copper in the water was beneficial to many kinds of flowers. Cutting the stems under water benefits flowers such as asters, sweet peas, snapdragons, and carnations, which have small vessels. Killing the tissue of the cut end of the stem by boiling or burning improves poppies and dahlias.

The addition of chemicals to the water was often an advantage. For example, a solution made by adding two teaspoons of hydrazine sulphate solution (made by dissolving 1 oz in 1 qt of water), 2 grams of manganese sulphate, and 1 tablespoon of sugar to 1 qt of water was beneficial to roses and carnations.

SUMMARY

Refrigerated storage will increase the life of cut flowers. Most flowers can be kept satisfactorily for a few days if stored exposed in water in a room held at temperatures between 33 and 40 °F. Long storage for 2-4 weeks can be achieved with a number of kinds by packing dry in a moisture-proof package and holding at 31 °F.

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Antibiotics in Food Preservation

By W. J. Scott

Division of Food Preservation and Transport, C.S.I.R.O., Homebush, N.S.W.

FOLLOWING THE INTRODUCTION AND WIDESPREAD use of various antibiotic drugs in human and veterinary medicine there has naturally been a certain interest in the use of these substances for combating the growth of bacteria in foods. There have now been published a number of papers describing experiments with most of the available antibiotics. It is not the purpose of this note to review all the published work, but rather to indicate what has been achieved so far and to mention some of the difficulties inherent in any proposals for the widespread use of antibiotics in foods.

The first and most famous of the antibiotics, penicillin, was the first to be tested as a possible food preservative. Experiments showed that it was of little use. This was not unexpected, as it was already well known that a great many bacteria were highly resistant to penicillin.

CANNED FOODS

Later, some antibiotics were tested in canned foods, and it was reported that subtilin substantially increased the rate at which certain types of bacterial spores were destroyed by heat. As a result of these experiments it was suggested that some canned foods might be processed successfully without recourse to processing under steam pressure, which hitherto had been regarded as essential. Further work showed that subtilin was not sufficiently dependable to ensure the destruction of *Clostridium botulinum* spores, and that conventional heat processing schedules were still required to safeguard consumers against botulism. The relatively greater susceptibility to subtilin of the very heat-resistant spores of some thermophilic bacteria was, however, confirmed.

FISH AND MEAT

Other workers in Canada and in the United States of America have studied the use of antibiotics for preserving fish and meat in the fresh or chilled condition. In these foods the problem has a somewhat different emphasis from the experiments with canned foods. With fish and meat there is no heat process to destroy all heat-labile organisms other than spores, and as these foods always become contaminated with a great variety of bacterial species, the antibiotic, to be successful, must retard the growth of most types present. As a result only a few of the antibiotics tested proved successful, these being the ones which clinical experience had already shown to be useful against a variety of infections.

The three drugs of greatest promise were aureomycin (chlorotetracycline), terramycin (oxytetracycline), and chloromycin (chloramphenicol), the first named being the most effective under the conditions of the tests. Concentrations of aureomycin of two parts per million greatly delayed spoilage of fish fillets and of beef.

With fish the antibiotic could be incorporated in a dip or in the ice used for cooling. With beef it was possible to introduce the drug by pumping weak solutions into butts or by the infusion of whole carcasses at the time of slaughter by injection into the carotid artery. The volume of infusion added was, however, rather large and amounted to some 10 per cent. of the carcass weight. It has not so far been demonstrated that uniform distribution can be achieved by injecting fluid equivalent to only 1 or 2 per cent. of the carcass weight. Most of the aureomycin disappeared from the beef during 3 days at 25 °C, and about half of it during 3 days at 3 °C. The nature of the end products formed when the antibiotic disappeared has not been revealed.

There has also been some study of the antibiotic nisin, which is produced by bacteria used in the manufacture of cheese. It is likely that this substance may prove useful in combating spoilage by some undesirable organisms in cheese and perhaps other products as well.

DIFFICULTIES

It is a matter of great importance that the results so far available relate only to experiments carried out over a short period of time. As drug-resistant types of bacteria occur naturally and appear spontaneously from time to time, such resistant types will be selected in foods containing the antibiotic. The relative frequency of drug-resistant types is, therefore, very likely to increase in food-processing establishments constantly employing antibiotics as preservatives. In such circumstances it is likely that any benefits obtained initially would decline progressively as the use of the antibiotic was continued.

There are also some risks that public health would be endangered by the widespread use of antibiotics in foods. One of these risks arises from the likelihood that drug-resistant organisms would become more widespread in the community, and so lessen the efficiency of the drugs in controlling human infections. There is also no certainty that the ingestion of small amounts of the drugs, or their decomposition products, would be harmless to man when such consumption was continued over a period.

For these reasons the addition of antibiotics to human foods is not at present permitted by the Food and Drug Administration in the United States of America. In certain other countries, including Australia, the decision of the public health authorities has not yet been announced.

Insoluble Solids Content

By J. F. Kefford

Division of Food Preservation and Transport, C.S.I.R.O., Homebush, N.S.W.

Earlier articles in this series appeared in *C.S.I.R.O. Food Preservation Quarterly*, Vol. 13 (1953), pp. 3-8, 21-31; Vol. 14 (1954), pp. 8-18, 26-31, 46-52, 74-6; and Vol. 15 (1955), pp. 28-32, 52-7, 72-7. Critical comments on the procedures described, and suggestions for modified or alternative methods found to be useful in practice, will be welcomed.

Total solids content and soluble solids content in canned foods have already been discussed in this series. The insoluble solids content, the subject of this article, may be found by calculating the difference between them. A direct measure is, however, preferable and a number of methods have been devised for the determination of water-insoluble or alcohol-insoluble solids in canned foods (Joslyn 1950). The methods involve simple, though sometimes tedious, washing procedures to remove soluble constituents, followed by a determination of the dry weight of the insoluble residue. Alternatively, with some foods, the wet volume of residue under standard conditions may provide a measure of the content of insoluble solids.

Insoluble solids content in fruit products, jams, and tomato products has been used to provide evidence of the amount of fruit or tomato used in manufacture. Moreover, the insoluble solids in these foods, being mainly lyophilic colloids, contribute usefully to the consistency or "body", and provide the vehicle for natural pigments (as in citrus and tomato products) and for flavouring constituents. Chemically, the constituents of fruits and vegetables insoluble in water or alcohol (concentration usually 80 per cent.) may comprise pectic substances, celluloses, lignins, hemicelluloses, pentosans, starches, and proteins. Williams and Bevenue (1954) examined the alcohol-insoluble solids of tomatoes and found pectin, α-cellulose, protein, a xylan fraction, and an arabangalactan mixture to be present in comparable amounts.

WATER-INSOLUBLE SOLIDS CONTENT

Fruit Products and Jams

The Association of Official Agricultural Chemists (1950*a*) sets out two alternative methods for the determination of water-insoluble solids in fruit products.

In the first procedure the sample is boiled in water for 15-20 minutes to dissolve soluble solids, then filtered through a weighed filtering medium (fast filter paper or cotton wool) held in a Buchner funnel or 60° funnel. After repeated washing with hot water, the filtering medium bearing the insoluble solids is dried and weighed. Ruck and Kitson (1953) made a statistical study of the reproducibility of this method as applied to strawberry jam and found that the standard deviation for duplicate determination was 0·091 per cent. and was not significantly different for triplicate determinations. To allow for this variation of the method they concluded that a content of 0·9 per cent. insoluble solids should be regarded as the minimum for strawberry jam to comply with the minimum standard of 1·1 per cent. laid down in Canadian regulations. The corresponding minimum standard for raspberry jam is 2·1 per cent. insoluble solids.

The alternative rapid procedure (A.O.A.C. 1950*a*) was devised by Osborn (1949, 1950). Comminution of the sample in a Waring Blendor permits a reduction in boiling time and the filtered solids are dried in approximately 15 minutes in a forced-draft drier.

When comminuting jam in a blender, troublesome foaming may occur; this is best eliminated by pulling a vacuum on the blend and then suddenly releasing it (Teeny 1955).

Vegetables and Tomato Products

For estimating the insoluble solids content in canned vegetables, including tomato products, the A.O.A.C. (1950*c*) recommends a procedure differing slightly from the procedure for fruit products. The sample is washed 4 or 5 times with hot water and centrifuged after each washing to separate the insoluble solids. The washings are poured through a filter and finally the insoluble solids are transferred to the filter, dried, and weighed.

In the C.S.I.R.O. laboratory at Homebush, however, the Osborn method mentioned above has been used for large numbers of determinations of insoluble solids content in tomatoes and tomato products and has provided worth-while advantages in convenience and speed.

Kimball and Kertesz (1952) examined the particle size distribution in the insoluble solids of macerated tomato products and measured the amounts of several size fractions in terms of the volume occupied in water after settling under gravity.

SEED CONTENT

In berry jams, berry fruit pulps, and canned berry fruits, the insoluble solids include the seeds, and the seed content has been used as an index of the amount of true fruit ingredient in such products.

To determine the seed content (A.O.A.C. 1950*b*; Osborn 1949, 1950), the sample is comminuted with hot water in a Waring Blendor and passed not through a filter, but through a 20-mesh screen. The seeds are retained on the screen and are washed free from other solids, dried, and weighed. The average weight of one seed is assessed by counting and weighing several separate lots of 100 seeds. It is then possible to report the percentage of seeds by weight in the sample, the number of seeds per 100 grams, and the average weight of one seed. The percentage of the total insoluble solids made up of seeds and the percentage of non-seed solids may also be calculated.

Information on the insoluble solids content and seed content of some berry fruits is tabulated by Hinton and Macara (1940) and Osborn (1949).

ALCOHOL-INSOLUBLE SOLIDS CONTENT

A widely used index of maturity in vegetables is the alcohol-insoluble solids (A.I.S.) content. During maturation, vegetables such as peas, beans, and sweet corn accumulate substances insoluble in 80 per cent. alcohol, comprising mainly cell-wall constituents and starch. Maturity standards based on A.I.S. are incorporated in United States standards of quality for canned green peas, whole kernel corn, and cream-style corn (U.S. Food and Drug Administration 1951).

The N.S.W. Pure Food Act (1908-1944, as amended 1953) lays down a maximum limit of 20 per cent. for the A.I.S. of canned green peas. The method prescribed for the estimation of A.I.S. is the A.O.A.C. (1950*d*) official method. The canned product is drained, washed, and minced, and a sample is boiled with 80 per cent. alcohol for 30 minutes. After filtering and washing on a Buchner funnel, the remaining solids are dried and weighed. The National Canners' Association Research Laboratories (Townsend *et al.* 1954) prepare the sample by blending with an equal weight of water in a Waring Blendor.

In the Homebush laboratory, a modified procedure (Lynch and Mitchell 1950) which eliminates the period of boiling with alcohol has been found to agree well with the official method when applied to green peas. A can of peas under examination is drained as for the determination of drained weight (Kefford 1954), and any foreign material is removed. The peas are washed in a volume of water equal to twice the volume of the sample can, and again drained. Then the peas are minced in a domestic mincer with a plate having approximately ⅛-in. holes. The minced material is mixed thoroughly but this must be done quickly in order to avoid loss of moisture. A 20-g sample is weighed and blended with 300 ml of cold 80 per cent. alcohol for 3 min in a Waring Blendor. The blend is then filtered with suction through a dried, weighed filter paper (Whatman No. 1, 12·5 cm) placed in a Buchner funnel about 12 cm in diameter so that the edges of the paper are turned up. The material on the filter is washed three or four times with cold 80 per cent. alcohol until the residues and washings are free from green colour. Then the filter paper and residues are transferred to the aluminium dish used to weigh the filter paper and dried, uncovered, in an air oven at 100 °C for two hours. The dish is covered, cooled in a desiccator, and weighed. The percentage of alcohol-insoluble solids is then the weight of the dried residues multiplied by five.

PULP IN FRUIT JUICES

In canned fruit juices, the presence of excessive amounts of pulp, i.e. juice cell and membrane fragments, is detrimental to palatability. A measure of the relative amounts of pulp present in juices is obtained by determining the volume of sediment after centrifuging under standard conditions (Royal Australian Chemical Institute 1952).

A 50-ml sample of juice is pipetted into a graduated tapered centrifuge tube and centrifuged for 10 minutes at the speeds below. "Diameter" is the distance between the bottom ends of opposing centrifuge tubes in the operating position.

Diameter (in.)	Approx. Speed (r.p.m.)
10	1609
12	1468
14	1359
16	1271
18	1199
20	1137

The volume of the sediment in the tube is read and multiplied by two to give the percentage of "free and suspended pulp".

Commonwealth Food Specifications (1952) prescribe maximum limits for free and suspended pulp in canned citrus juices (15 per cent.) and pineapple juice (5 per cent.).

Pulp content is also an important characteristic of concentrated citrus juices, since concentrates with high pulp contents are particularly subject to the quality defects known as clarification and gelation (Wenzel *et al.* 1951). Evaporation of citrus juices at low temperatures, according to modern practice, permits the survival of pectolysing enzymes which degrade the pectin present so that it no longer suspends the "cloud" of chromatophores and the juice clarifies to a clear serum above a yellow sludge. Moreover, during storage the low-methoxyl pectins formed may react with calcium ions to form gels, which are difficult to reconstitute.

The application of the centrifuging method to the estimation of the pulp content of concentrated citrus juices was examined by Olsen and Asbell (1951). To obtain consistent results it was necessary to reduce the heterogeneous pulp particles in the concentrate to uniform size by treatment in a Waring Blendor or a colloid mill before reconstitution and centrifuging. The same authors estimated the *coarse pulp content* of concentrates by washing on a sieve with 0·0098-in. openings and re-suspending the pulp in a 4 per cent. sodium chloride solution in a graduated cylinder. The volume of floating pulp was then read. A similar procedure is described by Olsen, Huggart, and Asbell (1951).

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Low-methoxyl pectins are proving of increasing value to the food industry. This article deals with an important field in which they could be more widely used.

The Use of Low-methoxyl Pectins in Fruit Canning

By R. A. Gallop

Division of Food Preservation and Transport, C.S.I.R.O., Tasmanian Regional Laboratory, Hobart, Tas.

PECTINS ARE MIXTURES OF PARTIAL METHYL esters of polygalacturonic acids, often referred to as "pectinic acids". The properties of pectins depend largely on the number and distribution of methoxyl groups in the molecules comprising the mixtures, the size of the molecules, and their state of aggregation. Pectins with methoxyl contents between 7 and 12 per cent. are usually called "high-methoxyl pectins" and those with 0·5 to 7 per cent. methoxyl are called "low-methoxyl pectins". The former are noteworthy for their property of forming strong jellies when added in low concentrations (e.g. 0·3 per cent.) to solutions containing above 50 per cent. sugars and having a pH of 2·5-3·5. The high-methoxyl pectins may be de-esterified by means of enzymes, acids, alkalies, or heat to yield low-methoxyl pectins which will form gels in the presence of acids or metal salts, even in the absence of sugars (Baker 1948; Kertesz 1951).

The two principal sources of commercial pectins are citrus and apple processing wastes, each of which yields a distinctive type of high-methoxyl pectin. These citrus and apple pectins can then be degraded to provide a range of low-methoxyl pectins with very interesting and useful properties.

High-methoxyl pectins are widely used in jam manufacture, but standardized low-methoxyl pectins have become available in quantity only during the past decade, and their applications in the food industry are still being explored.

A considerable amount of experimental work has been done on the use of low-methoxyl pectins, both overseas and at the C.S.I.R.O. Tasmanian Regional Laboratory. The factors involved are now well understood and a good range of low-methoxyl pectins is available from Europe and the United States of America, so that one may look forward to the wider use of these materials in the Australian food industry. In particular, the addition of low-methoxyl pectin to the syrup in canned berry fruits brings about a notable improvement in quality.

QUALITY DETERIORATION IN CANNED BERRIES

Quality deterioration in canned berry fruits has seriously embarrassed packers of these products for many years. The deterioration affects the colour, flavour, and general appearance of the packs.

• *Colour.*—The natural pale red colour of canned berries such as raspberries and strawberries is not very attractive even in the freshly canned product. Other berries such as loganberries, boysenberries, and blackberries have sufficient natural pigment to ensure satisfactory colour after canning. The colours of all canned berry fruits are changed to bluish shades by dissolved metals following corrosion of the can, but fortunately this has been reduced considerably in recent years by the use of improved can lacquers. Apart from the effects of corrosion, the pigments of berries slowly deteriorate in storage, especially in glass packs exposed to light.

• *Flavour.*—The characteristic "ester" flavours of berries disappear fairly rapidly during storage. Products which are otherwise good become unattractive in flavour within nine months of canning.

• *Appearance.*—Canned berries in heavy syrup (55° Brix) usually exhibit general shrinkage and considerable collapse of the drupelet walls, leading to a dull appearance and low drained weight. The shrinkage also causes the berries to appear unduly fibrous and seedy to the taster. However, the chief defect in appearance of canned raspberries is disintegration of the whole berries during transport. The out-turn quality in the United Kingdom of canned raspberries from Tasmania has often been disappointing. At the worst the can contains a slurry of berry drupelets floating in syrup. Trial shipments to the United Kingdom have shown that packs sent by sea generally arrive with the fruit noticeably disintegrated, whereas replicates sent by air are virtually unchanged. Vibration in the ship's holds seems to be responsible. Prolonged road transport is also detrimental.

Consideration of the problem of mechanical breakdown in canned berries suggested that gelling of the syrup might provide a solution by minimizing movement of the can contents during transport.

GELLED PACKS

Low-methoxyl pectins have been applied commercially overseas to form calcium pectinate gels in products with low soluble solids contents (Anon. 1953; Kaufman, Fehlberg, and Olsen 1944) such as tomato and other juices, fruit salads, pie-fillings, and diabetic jams (Beck 1954). However, when this technique was applied to canned berries at the Tasmanian Regional Laboratory the results were rather disappointing.

Even when sparingly soluble calcium salts are used, the increase in viscosity of the pack after filling is so rapid that exhausting is difficult and residual oxygen may cause discoloration. In addition, heat penetration during processing is seriously retarded and a gelled layer is likely to form on the can walls when a rotary cooler is used.

Diffusion during storage is also retarded, so that internal equilibrium is not reached within a desirable time. For instance, in canned berries the fruit and gel phases, even six months after canning, may show differences of 0·3 pH unit and 5° Brix. Further, low-methoxyl pectins with calcium tend to produce a flat flavour. Sidwell and Cain (1955) reported a bitter flavour in canned raspberries to which calcium salts had been added. Finally, the appearance is unattractive, unless the fruit can be uniformly distributed and set in position during processing.

The commercial prospects for berry packs gelled with low-methoxyl pectins are, therefore, not favourable. It appeared likely, however, that the object of mechanical protection of the berries might be achieved by using low-methoxyl pectin to increase the viscosity of the syrup without causing gelation.

THICK-SYRUP PACKS

In the first instance low-methoxyl pectins alone were added to the syrup, in the hope that they would react during cooking with the metals naturally present in the fruit to form a weak gel on cooling. Gels of various strengths were obtained by this method, particularly with pectins very sensitive to metals, but the results were variable, depending on the type of pectin used.

The optimum pH range for metal pectinate gels is generally 3·2-4·5. It is therefore probable that at pH 2·95-3·25, the normal range for raspberries and loganberries, the pectin is mostly in the form of pectinic acids. It was then found that satisfactory results were achieved by slight acidification of the canned berries to ensure precipitation of low-methoxyl pectins in the acid form. The viscosity of the acid gels decreased on heating to a greater extent than that of salt gels. Thus the syrup viscosity was low during processing but increased to a desirable extent subsequently. Equilibrium between the sugar and acid contents of the solid and liquid phases was also achieved rapidly.

Therefore, in the process now recommended low-methoxyl pectin is dissolved in the syrup, and citric acid is added to the cans before syruping. The quantities of each used depend on the particular pectin and the processing schedule. Allowance must be made for partial hydrolysis of the added pectin. Only a few pectins are suitable for the purpose and commercial pectins should be tested experimentally before being used in production. Information on the recommended procedure and on commercial low-methoxyl pectins known to be suitable for addition to canned berries is available on application to the author.

No major alterations to normal berry canning lines are required. A citric acid solution is dispensed into the cans of fruit prior to syruping by means of a simple metering device. The syrup containing the low-methoxyl pectin is more viscous than normal syrup, and is best filled in a vacuum syruper. The cans are then closed with steam-flow and promptly processed in a rotary cooker. Processing times may have to be extended slightly. The method has been applied successfully to the canning of raspberries and loganberries on a medium-speed commercial line.

QUALITY CHARACTERISTICS

The appearance of berry packs processed according to the recommended procedure is most attractive. The viscous syrup adheres to the berries for at least two hours after emptying out, conferring a glossy appearance and enhancing the colour. The berries show less shrinkage and the drained weight is increased. The consumer has less grounds for complaint that there is excessive syrup in the pack, and the berries are smoother to the taste. Sidwell and Cain (1955) found increased drained weights and improved appearance in canned raspberries containing low-methoxyl pectins. Some consumers may not like the glossy appearance of the berries at first, and canners might do well to prepare batches to obtain the reaction of consumers on this point.

Raspberries in viscous syrups shipped from Hobart to the United Kingdom and back have retained their wholeness very well. The colour retention during processing and storage is also improved in the thick-syrup packs. The new process has removed the need for the addition of dyes to Tasmanian fruits other than strawberries. Conventional packs of berries darken after opening but this does not happen with berries in viscous syrups. The characteristic colour deterioration due to uptake of tin is also reduced, probably because the viscosity of the syrup retards corrosion of the can. This point is being investigated further.

Moreover, the new process improves the flavour of canned berries, both initially and after storage.

The process described is cheap, and as the substances added are both of fruit origin they should not cause any concern on grounds of public health. The process recommended here for berries should be applicable to other fruit products, and work is proceeding in this direction.

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Absorption of Salt by Whole Crayfish during Cooking

By K. W. Anderson

The Nicholas Institute, Sherbrooke, Vic., formerly of the Division of Food Preservation and Transport, C.S.I.R.O., Hobart, Tas.

IT HAS BEEN THE PRACTICE IN TASMANIA TO prepare sea-water crayfish (*Jasus lalandi*) for the home market by drowning them in fresh water and cooking them whole in boiling salt water. It was believed that salt was taken up by the edible flesh, thereby improving its palatability.

A survey of Tasmanian processing establishments by an officer of the Division of Food Preservation and Transport led to the following observations:

- Salt concentrations in cooking waters in various factories ranged from 3·5 per cent. (sea water) to 23 per cent. by weight.
- Many processors assessed the degree of saltiness of the cooked edible flesh merely by tasting the leg meat.
- No accurate data were available on the extent of salt absorption by the edible flesh in different parts of the crayfish.
- There was no evidence of excessive saltiness in the taste of tail meat from crayfish which had been cooked in water having a high salt content.
- Recently some processors, in an attempt to introduce salt into the flesh, have drowned the crayfish in warm concentrated brine and cooked them in steam. Here again there was no information on the effectiveness of the procedure.

Experiments, the results of which are given in this paper, have since been carried out at the C.S.I.R.O. Tasmanian Regional Laboratory at Hobart to obtain quantitative data on the absorption of salt by the flesh of crayfish cooked in salt brines.

EXPERIMENTS

Fifteen live crayfish (1½-2 lb in weight) were drowned in fresh water and divided into five groups of three fish each. The first group was held raw and the other four groups were cooked by boiling for 15 minutes in fresh water and in 5, 10, and 20 per cent. salt solutions respectively. The crayfish cooked in brine were given a brief rinse in fresh water to remove excess salt solution. The edible meat was then picked from the legs and the tail of each fish and divided into four portions as follows:

- Tail meat (surface)—the outer layer of tail flesh stripped off to a depth of about ⅜ in.
- Tail meat (second layer)—a further peeled layer of about ⅜ in. thickness.
- Tail meat (inner)—the remainder of the tail flesh, being roughly cylindrical and of ¾-in. diameter.
- Leg meat—the combined meat from the 10 walking legs.

The 60 portions were separately homogenized in a Waring Blendor and samples were extracted and analysed for chloride by the potentiometric method of Samson (1953).

RESULTS

The concentrations of salt found in the four selected portions of meat, raw and after various cooking treatments, are shown in the table on the opposite page, each figure being the average value for the three fish in each group. Deviations of individual values from

Percentage Concentration of Salt in Crayfish Meat

	Raw	Cooked in			
		Fresh Water	5% Salt	10% Salt	20% Salt
Tail meat (inner)	0·5	0·5	0·5	0·5	0·7
Tail meat (2nd layer)	0·7	0·7	0·7	0·7	1·0
Tail meat (surface)	1·0	0·9	1·0	1·2	1·3
Leg meat	1·3	1·2	1·5	1·8	2·8

the mean were very small. The tail flesh absorbed very little salt even in the concentrated solutions; flesh more than ⅜ in. below the surface did not absorb salt until the brine strength was increased beyond 10 per cent. There was a slight loss of natural salt by leaching on cooking in fresh water, but only from the surface layer. Leg meat absorbed small amounts of salt in brines of low strength and about 1·5 per cent. in the most concentrated solution.

DISCUSSION

Although marine crayfish contain appreciable concentrations of sodium chloride in the edible flesh it is generally considered in the trade that the palatability of the cooked flesh is improved by the addition of salt to bring its concentration up to about 1·5 per cent. To reach such a level in the tail meat of fish similar to those used in these experiments would require an additional 0·8 per cent.

The assumption by the trade that cooking whole crayfish in boiling salt brines brings about such an increase is not supported by the experimental evidence. Even when they were cooked in very strong salt brines, the increase was only about 0·3 per cent. In weaker brines similar to those used by most of the Tasmanian processors, there was very little change in salt content of the tail flesh during cooking. Cooking in fresh water reduced the salt content only slightly.

It is also clear that the saltiness of leg meat cannot be used as a satisfactory index for assessing the concentration of salt in tail meat. The leg meat in the raw material used had an initial salt content almost twice that of the tail meat and in addition it showed an appreciable increase in salt concentration even in weak brines.

It has been assumed that the practice of drowning the crayfish in strong salt brines prior to cooking in steam appreciably increases the salt content of the tail meat. The above results suggest that this would be most unlikely during the short periods of immersion used for drowning.

When the whole crayfish is immersed in strong salt brine before or during cooking, small quantities of brine may be entrapped within the shell. It has been argued that there may be an additional uptake of salt from these areas during frozen storage. Schmidt-Nielsen (1920) showed that salt penetrates only to a depth of 2 mm (0·08 in.) in fish held in mixtures of ice and salt water at —5 to —15 °C; in frozen fish the rate of penetration even over this small distance would be extremely slow. The diffusion of salt into the edible flesh during frozen storage is, therefore, not likely to be of great importance.

In the raw flesh of the three fish used in the experiment there was a well-defined gradient in salt concentration from the centre to the surface of the tail and a larger concentration in the leg muscles. The existence of this gradient has since been confirmed in other cases. It is unlikely, therefore, that it was introduced during handling, for example by contamination with sea water.

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Dehydrofreezing

A New Method of Preservation

By D. McBean

Division of Food Preservation and Transport, C.S.I.R.O., Homebush, N.S.W.

A NEW METHOD OF PRESERVATION WHICH combines the two common processing procedures of dehydration and quick freezing has been developed in the United States of America by the Western Utilization Research Branch of the Department of Agriculture working at Albany, California (Anon. 1954). This combination procedure has already been tested on a variety of fruit and vegetables such as peas, carrots, green peppers, lima beans, apricots, apples, and cherries. Satisfactory results have also been obtained in the U.S.A. in commercial trials on peas, peppers, and apples. In Australia, the method has been tested on peas and sweet corn in the laboratory of the Division of Food Preservation and Transport at Homebush. A commercial processor has also applied the technique in the production of approximately 27 tons of dehydrofrozen peas.

The process consists of the removal of about 50 per cent. of the initial weight of the product by dehydration followed immediately by freezing. The loss of water during the drying stage is critical; the removal of much more than 50 per cent. may result in adverse changes in the quality of the product, particularly in its texture on reconstitution. Except for blanching, which appears to be most necessary, no additional treatments are needed prior to dehydration. This means that the troublesome sulphiting process can be omitted.

Temperatures of dehydration up to 200 °F may be used because loss of water in the early stages is so rapid that evaporative cooling ensures that the temperature of the product does not exceed 120 °F. Drying takes about 45 minutes. In tests at Homebush, peas were dried in a cross-draught cabinet dehydrator on trays. During the drying the peas were moved two or three times to prevent uneven drying. Rockwell *et al.* (1954) used a small rotary dehydrator to overcome the problem of uneven drying. Subsequently Lowe *et al.* (1955) described an improved belt-trough dehydrator which is a through-draught drier in which the belt is inclined laterally and longitudinally. The inclination can be altered to suit characteristics of the material being dried.

The partially dried material is then frozen, and stored at a temperature close to 0 °F, as with other frozen fruit and vegetables. Dehydrofrozen peas stored for eight months at 0 °F have been found to be indistinguishable from the freshly prepared product and there seems no reason why this storage period should not be considerably extended.

Tasting tests both in America and in Australia have shown no significant differences between quick-frozen and dehydrofrozen peas. In the Homebush laboratory it has been found that sweet corn yields a very satisfactory dehydrofrozen product.

Soaking prior to cooking is not needed since dehydrofrozen material reconstitutes quickly during normal cooking. The texture of some dehydrofrozen products has been claimed to be superior to their frozen counterparts. This was particularly true for products such as apples and apricots which tend to be mushy when thawed from the frozen state.

The production of dehydrofrozen materials appears to be an economical proposition. Compared with quick-freezing, the following advantages are evident:

- The cost of freezing is reduced since only half the bulk is frozen.
- Packaging costs are almost halved.
- Only half the amount of storage space is required.
- Transport and distribution costs are reduced.

These savings probably offset the expenditure on a dehydrator and the cost of dehydration, particularly if it is carried out in the highly efficient dehydrators of recent design.

Technically, dehydrofreezing has certain advantages over straightforward dehydration: the sulphiting step, which is not easy to control in a continuous line, is eliminated; difficulties with reconstitution are almost entirely removed; and, since the material is stored at sufficiently low temperatures, no difficulties arise with deteriorative changes such as the "browning" reaction.

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ANSWERS TO INQUIRIES

FROZEN FISH STICKS

How are frozen fish sticks prepared?

In the United States of America, where sales in 1954 reached an average of more than 3 million lb per month, fish fillets are moulded by freezing in stainless steel trays, 36 in. by 10 in. by ⅝ in. The frozen slabs are taken from the trays and several together are cut on a band saw into strips 3 in. by ⅞ in. by ⅝ in. In some plants the fish is frozen into square blocks which are cut into strips later.

For frying, the strips are dipped in batter in lots of about 5 lb. The batter is a mixture of dried egg, dried skim milk, flour (plain or self-raising), salt, and pepper, made up with water in stainless steel basins which hold about 10 lb of batter. The fish sticks are lifted on to wire mesh trays to drain, then tipped into the crumb mixture. The crumbs are made from cracker biscuit if a pale golden product is required; from bread to obtain a reddish brown colour; or from toasted wheat meal for a golden brown colour. Different proportions of these crumbs may be used to vary the colour. They are mixed, in the proportion desired, with wheat flour or a combination of corn flour and wheat flour, and salt and pepper are added. The dry ingredients for the batter and the breading mixture are bought ready prepared by most American fish friers. The sticks, well coated with bread crumbs, are placed on wire mesh trays holding about 75 pieces of fish, and immersed in the frying oil. The cooking time depends on the oil temperature and the colour desired; 2½ minutes in fresh oil at 360 °F gives a medium colour, but the colour is deeper if the oil has been in use for some time. The oil must be clarified in a pressure filter twice a day, and the vat emptied and cleaned at the end of each day.

Excess fat is drained from the fried sticks by laying them on inclined stainless steel tables for several minutes. Cooling may be hastened by placing them for a few minutes on trays in a cooling cabinet equipped with fans. The cool drained sticks are packed into cartons lined with heavily waxed grease-proof paper, usually ten 10-oz sticks to the carton. After the weight of each carton has been checked, the cartons are loaded on to trays in a freezer, from which they go to a wrapping machine. Finally the cartons are packed in cases for delivery.

In some large companies the operations of breading, cooking, and packing are done on an automatic continuous-flow line.

WRAPPING OF BREAD

Does the wrapping of bread make it more susceptible to the growth of mould?

Wrapping bread in papers which restrict evaporation will accelerate the development of mould, especially if the bread is wrapped warm. The crumb of bread has an equilibrium humidity of about 95 per cent. and is accordingly susceptible to mould attack. The dry crust has a much lower equilibrium humidity and in dry climates will not become mouldy. When wrapping restricts evaporation the water content of the crust will tend to come into equilibrium with the crumb.

When hot bread is removed from the oven, water begins to evaporate from it at a high rate. If the bread is wrapped hot the evaporating water trapped inside the wrap will make the crust moist and susceptible to mould attack. It is, therefore, essential to cool bread before wrapping, and cooling the centre of the loaf to 80-90 °F is regarded as good practice.

Bread, being a poor conductor of heat, cools rather slowly. It has been calculated that in air at 70 °F it will take 1½-2 hr to reduce the centre temperature of a 2-lb loaf from 150° to 90 °F, the greater rate of cooling being obtained with rapid air movement.

NEWS from the Division of Food Preservation and Transport

FREEZING OF FRUITS AND VEGETABLES

Studies on the freezing of fruits and vegetables were commenced in the Homebush laboratories in 1948, being prompted by the very rapid growth of this method of food preservation in other countries, notably the United States of America. The cost of the work is shared by C.S.I.R.O. and the N.S.W. Department of Agriculture.

Before investigations commenced, an officer of the N.S.W. Department of Agriculture spent seven months in the U.S.A. studying the industry, and his findings were used in planning the programme of investigations at Homebush. The team of investigators is made up of one Senior Fruit Research Officer of the N.S.W. Department of Agriculture, one Research Officer of C.S.I.R.O., and two Technical Assistants.

The broad object of the research programme is the development of new methods of freezing fruits and vegetables and the improvement of existing methods. Aspects being investigated include the suitability of different types and varieties for freezing, the most suitable stage of maturity at which to harvest, the handling of raw material and its preparation for freezing, the freezing process, packaging, storage, transport, and finally the thawing and cooking of the product.

In the early stages of the investigations a limited amount of information was gathered on the suitability for freezing of a fairly wide range of fruits and vegetables, processing and laboratory techniques were investigated, and equipment was tested. More recently, as the industry has developed, the work has been directed to more specialized problems.

In view of their commercial importance, much attention has been given to frozen peas. Data have been collected on the suitability of different varieties grown in a number of districts, and methods devised for determining the most satisfactory stage of maturity for picking the peas. The effect of delay in handling peas before freezing has been studied and a fairly clear picture obtained of the factors responsible for loss in quality.

Varietal and maturity studies on beans, sweet corn, broccoli, Brussels sprouts, and cauliflower have either been completed or are still in progress.

The freezing of freestone peaches has been investigated, especially the selection of varieties, the methods of preparation for freezing, and the problem of discoloration. Investigations on frozen berry fruits, which have been intensified recently, have been carried out in conjunction with the C.S.I.R.O. Tasmanian Regional Laboratory at Hobart. Frozen tropical fruits, particularly pineapples, have also been studied. Measurements have been made on an air-blast freezer of the freezing rates of different products under various conditions and some preliminary tests have been made on materials for packaging frozen foods.

In addition to its research activities, the group devotes time to giving technical advice to sections of the industry interested in the freezing of foods, and to a lesser extent to making laboratory tests on commercial products for the purpose of solving technical problems.

PERSONAL

Mr. K. W. ANDERSON, Senior Technical Officer of the Division of Food Preservation and Transport, who has been working on problems of fish preservation at the C.S.I.R.O. Tasmanian Regional Laboratory at Hobart, has resigned from the Division to take a research post in the Nicholas Institute, Burnham Beeches, Sherbrooke, Vic.

The Division is pleased to have as guest workers at Homebush Dr. M. N. Moorjani and Mr. J. S. Pruthi, from the Central Food Technological Research Institute, Mysore, India. Dr. Moorjani is studying the technology of the preservation of meat and fish, and Mr. Pruthi the technology of canning, and concentration of orange juice. Both Dr. Moorjani and Mr. Pruthi hold Colombo Plan Fellowships which will keep them in Australia until November 1956.

Dr. G. S. SIDDAPPA, a senior officer of the Central Food Technological Research Institute, has had two short sojourns at the Homebush laboratory in recent months during which he has studied a number of problems connected with food preservation.

PUBLICATIONS BY STAFF

STUDIES IN THE METABOLISM OF PLANT CELLS. X. RESPIRATORY ACTIVITY AND IONIC RELATIONS OF PLANT MITOCHONDRIA. *R. N. Robertson, Marjorie J. Wilkins, A. B. Hope, and Lydia Nesztel. Aust. J. Biol. Sci. **8**: 164-85 (1955).*

The respiratory activity and ionic balance of mitochondria isolated from carrot and beet tissues by differential centrifugation have been studied. The oxygen uptake of the mitochondria with different substrates was investigated. The mitochondria hold both cations and anions in concentrations greater than those in the supernatant. Experiments on the time of adjustment to a changed concentration of chloride in the supernatant solution have been used to calculate the diffusion constant of the salt in the particle. The concentrations of mobile cations (Na^+ and K^+) in the mitochondria are considerably greater than those in the supernatant. It is suggested that the internal concentrations are largely due to a Donnan equilibrium based on the immobile anions of the particle, and since no simple Donnan equilibrium will account for the simultaneous concentration of both mobile cations and mobile anions, it is suggested that the electron carrier of respiration could act as the anion carrier of accumulation. The results support the hypothesis that mitochondria are probably involved in electrolyte accumulation in plant cells and in secretion in animal cells such as those of the gastric mucosa.

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LES ECHANGES GAZEUX DANS LES POMMES GRANNY SMITH. *E. G. Hall, F. E. Huelin, Frances M. V. Hackney, and Joan Bain. Fruits d'outre Mer **10**: 149-55 (1955).*

The composition of the atmosphere in the intercellular spaces of the flesh of the apple varies considerably with the age of the fruit and is greatly affected by temperature and the composition of the external atmosphere. It can be extensively modified by the application of artificial skin coatings. Considerable differences in both oxygen and carbon dioxide tension between the internal and external atmospheres may appear during the life of the fruit, indicating the development of considerable resistance to the exchange of these gases. Although there may be small gradients in gas concentration across the flesh, this resistance is in the skin and probably mainly in the cuticle. As in mature Granny Smith apples the lenticels are non-functional and there is normally no passage from the core cavity to the calyx, gas exchange takes place by diffusion through the skin. The increase in resistance with age is due principally to the "waxing up" of the skin; in the Granny Smith variety the greatest increase is in the oil content of the cuticle. Gas exchange through the skin probably takes place by movement in gas phases, in aqueous solution, and in solution in the lipids of the cuticle. The rate of gas exchange is controlled by the resistance of the skin to the movement of oxygen and carbon dioxide (which is little affected by temperature) and by the rate of respiration (oxygen consumption and carbon dioxide production by the tissues). As is consistent with its lower solubility in lipids, the resistance to oxygen is greater than that of carbon dioxide.

This is a French translation of a paper read at the 8th International Congress of Botany in Paris in July 1954.

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COLUMN PARTITION CHROMATOGRAPHY OF THE FATTY HYDROXAMIC ACIDS. *J. B. Davenport. Chem. and Ind.* ***1955***: *705-6.*

No satisfactory technique is available for the chromatographic separation of unsaturated fatty acids. This paper describes the separation of their hydroxamic derivatives by partition chromatography on columns of cellulose powder. These derivatives are solids and are useful for characterizing the unsaturated fatty acids.

Copies of the papers mentioned above may be obtained from the Librarian, Division of Food Preservation and Transport, Private Bag, P.O., Homebush, N.S.W. (Telephone: UM 8431, UM 6782.)

FOOD SCIENCE ABSTRACTS

MODERN RAPID COOLING. *R. Jordan. Fleischwirtsch* *6*: *291-2* (*1954*). (In German, summary in English 292.)

The performance of a rapid cooling plant attached to the pig and calf slaughterhouse at Lemgo is described. The plant operates on the countercurrent principle at high atmospheric humidity, with rapid and efficient air circulation. There is little loss in weight of the chilled carcasses; the loss is only about half that which occurs with older methods of chilling. A pig carcass can be cooled down to an interior temperature of 4° to 6 °C in 16 to 18 hours. The loss of weight of pig carcasses during 24 hours is about 1·1 per cent.

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NEW DEVELOPMENTS IN RENDERING. *H. C. Dormitzer. Proc. 5th Res. Conf., Amer. Meat Inst., Chicago*: *1-5* (*1954*).

Accounts are given of the following processes for rendering fat: Pavia improved kettle process, Titan hot-water process, Viobin azeotropic process, Kingan continuous rendering system, and Chayen Sharples hammer-mill and centrifuge cold process. The trend of new processes is towards continuous operation. Attention must be devoted to producing not only a light-coloured fat with a minimum of free fatty acid, but also a high-quality residue, with no loss of vitamins or growth factors and no deterioration of the nutritive value of the protein. Choice of rendering system must depend partly on the use for which the fat is intended.