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Japanese Fish Technology

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This article is based on the experiences of the author during a 10-month stay in Japan as the recipient of a Japanese Government Fellowship for foreign research workers.

THE Japanese fishing industry, with an annual catch of 7·2 million tons, is not the world's largest in terms of weight, but it is by far the most valuable. Fish has always been a traditional part of the Japanese diet. Today it is still the most important source of flesh protein.

The Bering, Okhotsk, Japan, China, and Yellow Seas, as well as the Pacific Ocean, all touch the shores of Japan. As a result of warm and cold currents from these waters the seas round Japan abound with many species of fish. Starting from the coastal and near-water fisheries in these areas the Japanese fishing fleets now range all over the world to maintain the volume and quality of their catch. Today Japanese fishing boats can be found as far afield as the North Atlantic and the Southern Ocean. The growth of the Japanese fishing industry to the pre-war level of 4 million tons a year, and thence to its present size, is due to sound technology. The Japanese have been quick to apply modern food processing innovations to fish preservation, particularly canning and subsequently freezing.

The variety of marine products eaten in Japan and the processed forms in which they are presented is extremely wide, as over 200 species are found in the Japanese fish markets. It appears that the Japanese can utilize almost any fish that can be caught in quantity.

Catching or Harvesting

For convenience, the total fish catch can be divided into three main areas. The bulk of the catch comes from the high-seas fishery, which includes the tuna resources of the Pacific and the Antarctic whale fishery. The coastal fishery is second in volume and provides both high-quality fish for the table and school fish for processing. The third source is the rapidly growing practice of culturing and intensively rearing marine fish in enclosed areas.

The development of the high-seas fishery has taken place since 1952. This is carried on by large sophisticated vessels using modern well-designed gear. The Japanese are world leaders in the design and manufacture of fishing vessels and equipment. Due to the long distances from the home ports the Japanese have developed an efficient system of mother ships and processing ships which are effectively large floating factories. The greater part of the catch of the high-seas fleets is frozen at sea and either transhipped at sea or in foreign ports, or taken back to Japan by the catching boats. The standard of crew training of the vessels engaged in the high-seas fishery is generally very high. All the skippers and fishing masters of these vessels have undertaken a formal course of study at a fisheries college or fisheries university.

The coastal and near-water fishery is based on traditional fishing areas around Japan. The fishing-boats are generally smaller than those fishing on the high seas, and not as well equipped. Often they are of wooden construction and traditional design. Those fishing close to the shores of Japan do not have freezing facilities and land their catches in ice.

The recent growth of fish culturing or farming has come about as a result of economic pressure on the fishing industry and decreasing catches in the coastal fishery. The Japanese are faced with increasing difficulty in maintaining the high volume of their annual catch. As the exploitation of the world's available fish resources increases and more countries extend their territorial limits to cover prolific fishing grounds, the Japanese must either fish more efficiently in the remaining areas or provide additional stocks of fish by artificial means.

The economic boom which has taken place in Japan since 1952 has greatly increased the average Japanese income, resulting in an increased demand for high-quality protein. Since the Japanese have always been a fish-eating nation, they have demanded, and have been able to afford, to increase their per capita consumption of fish. The possibilities of well-paid employment in land-based industry have depleted the labour resources available to the fishing industry. There has been a noticeable fall in the high standards of fishing vessel crews in recent years. For these reasons a massive research effort has been devoted to fish farming. Today there are many successful enterprises round the Japanese coast which raise considerable quantities of fish, shellfish, and other marine products such as seaweed. The increased demand for seafood has led to more research into increased utilization of the catch. Today there is very little waste in the Japanese fishing industry. All fish caught are used for human consumption, converted to fish meal for animal feeding, or fed to fish being reared in enclosed areas. Research into fish handling and processing technology and the development of new products have contributed to the growth of the fishing industry.

Utilization of Most Important Species

The quantities of the individual species of fish and seafood harvested by the Japanese fishing industry in 1966 are given in Table 1.

Table 1
The Fishing Industry of Japan—Catch by Species, 1964

Species	Catch ('000 tons)	Catch (%)
Cod	779	12·3
Horse mackerel	519	8·2
Tuna	513	8·1
Mackerel	495	7·8
Sardine	383	6·0
Saury	210	3·3
Herring	57	0·9
Squid	329	5·2
Others	2712	42·7
Shellfish	147	2·3
Seaweed	206	3·2
Total catch	6350	100

Salmon

The Japanese fish for six species of salmon (*Onchorhynchus*) in the Northern Pacific and Aleutian waters, from Kamchatka to the North American coast. They are mostly caught by gill netting, using gill nets made from fine synthetic fibres. The species are red salmon (*O. nerka*), pink salmon (*O. gorbuscha*), silver salmon (*O. kisutch*), chum salmon (*O. keta*), king salmon (*O. tschawytscha*), and *masu* (*O. masou*). Salmon are generally frozen at sea for transport back to Japan, though some are processed in floating canneries. Red salmon is the most valuable catch and is used for the high-quality canned pack and for smoked salmon. Silver salmon is next in quality and is used for canning. The greater part of the pack of red and silver salmon is exported. Chum, pink, king, and *masu* salmon are also canned, but the quality of the canned product is not as good as the red and silver. A proportion of this pack is exported and the rest is consumed in Japan. Some traditional products, such as *shiobiki*, a heavily salted salmon, are made from the chum and pink salmon. This is eaten grilled or broiled. *Masu* is often consumed as fresh fish. The roe from all salmon species is extremely popular with the Japanese.

Tuna

Most of the Japanese tuna and similar large fish come from the overseas fishery. The favourite way of eating tuna in Japan is raw. It is eaten with soya sauce as *sushi* or *sashimi*. The highest-quality portion of the catch is selected for this trade by extremely experienced inspectors. The remainder is canned and most of it is exported. Because of the demand for high-quality fish great care is taken with the handling of tuna. Most of the catch is taken with long lines, though experimental fishing with purse seines is now in progress. The fish is gilled, gutted, frozen, and glazed for transport back to Japan in the round. The temperature of storage is −35°C. The species most prized for *sushi* is the southern bluefin tuna (*Thunnus thynnus maccoyii*). Some yellowfin tuna (*Germo macropterus*) is also eaten raw. Other species of tuna and similar fish which are landed in commercially important quantities are the albacore (*Germo germo*), the Japanese tuna (*Thunnus orientalis*), the striped tunas (*Gymnosardae epelamis*), the bonito (*Sarda chilensis*), the yellowtail (*Seriola dorsalis*), and the barred marlin (*Xithias gladius*).

All the albacore, which is a very light meat, is canned, and most of it is exported. The bonito is used for the preparation of a traditional product, *katsuobushi*, which is a unique smoked, boiled, and dried product, used for the preparation of soups. Yellowtail is consumed as fresh fish either raw, grilled, or boiled. However, the greater part of the catch of these species is canned. The barred-marlin catch has recently been utilized on a large scale for the manufacture of fish sausage.

Mackerel

There are two species of horse mackerel caught close to Japan. These are *Scomber japonicus* and *Scomber tapeincephalus*. The former is considered to be of higher quality. A canned pack in brine is exported to South-east Asia and a seasoned canned pack is eaten in Japan. The saury (*Cololabis saira*) and jack mackerel (*Trachurus japonicus*) are also caught in large quantities around Japan. All these species are canned, and eaten fresh or frozen. Many are made into traditional products such as the salted and lightly dried mackerel which is often prepared domestically. The fish is split down the backbone, opened out, salted, and partially air-dried by hanging on racks. A proportion of the mackerel catch is made into fish meal.

Sardine and Anchovy

Large catches of Clupeidae and Engraulidae are taken round the Japanese coast. A proportion of the catch is canned as sardine or anchovy and about half is exported. The remainder of the catch is eaten fresh or dried or made into fish meal.

Cod and Alaska Pollack

The catch of cod (*Gadus macrocephalus*) is eaten fresh, salted, dried, or smoked. The Alaska pollack (*Theragra chalcogramma*), which is a similar species to cod, has been caught in increased quantity recently. Technological research has proved its suitability for the preparation of frozen *surimi*, which is a minced and washed fish meat, frozen into blocks. It is used for the manufacture of *kamaboko* and fish sausage which is described in more detail later. The roe of cod and Alaska pollack is salted and sometimes smoked.

Whale

The Japanese have now moved into first place in terms of world whale catch. Whaling operations, on a massive scale, are carried out each year in the Antarctic and Northern Pacific Oceans. The whale catchers and factory ships cut up and freeze the whale meat as well as processing the oil. The meat is then taken back to Japan and held in large cold stores. The discovery that washing whale meat in fresh water removes the blood and water-soluble off-flavours has improved the quality of meat available in Japan. Whale meat is eaten fresh, canned, and made into sausages. Before eating or processing it is soaked in fresh water for from 12 to 24 hours. Canned whale meat, which takes the place of canned beef, is very popular in Japan. It is often made up in seasoned sauces.

The above species are the most important in the Japanese fishery. There are many other important species, some of which will be described later. However, the catch or economic yield is not as high as for those mentioned above.

Table 2
The Fishing Industry of Japan—Production and Utilization

	'000 Tons 1960	'000 Tons 1965	%
Fresh	1319	655	9·0
Processed	4874	6254	91·0
Frozen	873	1799	26·2
Canned	490	449	6·6
Kamaboko and sausage	1056	1633	23·7
Salted, dried, and smoked	1602	1665	24·2
Oil, fat, bait, or feed	769	644	9·4
Inedible weed dried	84	64	0·9
Total production	6193	6909	

The long history of fish as food in Japan has given rise to many traditional products. The preparation and consumption of these are often restricted to a small area of the country. The Japanese have taken advantage of modern processing technology to increase the quantities and control the quality of many of these products. Space will not allow a detailed coverage of the manufacture of all these products. Some examples drawn from the different forms of processing are given in the next section.

Fish Processing

The production figures for fresh and processed fish in Japan in 1960 and 1965 are given in Table 2.

The high quality of fresh and processed fish available on the Japanese market results from careful handling and close attention to detail during processing. From catching to the retailing stage, whether fresh or processed, the marine products of Japan are handled by an efficient system based on many years of experience. Marketing is organized on a regional basis with the country divided into twenty regions. The largest market, in Tokyo, handles 2000 tons of fish each day. This quantity comprises fish from the overseas fishery which is landed in Tokyo, fish landed in other areas which is trucked or railed to Tokyo, and fish from the coastal fishery which also reaches the market by truck or rail. Fish from the overseas fishery reaches the market frozen and is thawed out before being offered for sale. That from the coastal fishery is usually fresh and held in ice. Most fish is sold at auction, either to larger processing companies or to 'middle-men' for re-sale to the retail trade and restaurants. The processing companies also buy frozen fish, which is held in cold store for subsequent processing.

There is a great demand for high-quality fresh fish in Japan. Traditionally, the favourite way of eating fish is raw as *sushi* or *sashimi*. The highly stylized presentation of *sushi* and *sashimi* is exclusive to Japan. The fish is sliced thinly and eaten with soy sauce and a type of horse-radish. The difficulties of providing sufficient high-quality fresh fish for this market have led to a development of the high-quality frozen fish market. Recently, frozen fish has been accepted as a substitute for fresh by the *sushi* trade. With the increasing westernization of the Japanese way of life there has been a growing demand for frozen fish fillets. These are an important export item and consumption in Japan is increasing, either as *tempura*, which is small pieces of fish covered with batter and fried in oil, or in the more usual western way as whole fillets either fried or grilled. In some cases fish is filleted, packed, and frozen at sea by factory ships. Alternatively fish is gilled, gutted, and frozen at sea for filleting at factories on shore. However, the conditions of freezing and storage are always good. Modern cold-storage facilities have sprung up in the large cities and fish-landing ports in recent years. Many cold stores have capacities of 10,000–15,000 tons. They are all classified according to storage temperature and size. Ratings are SA (Super A), A, B, and C. For an SA rating, which applies to most recent constructions, the storage temperature must be below −30°C. Storage temperatures on fishing boats are also in the range −25°C to −40°C.

Canning

The figures for the Japanese production of canned fish in 1960 and 1964 are given in Table 3.

Table 3
The Fishing Industry of Japan—Production of Canned Fish

	'000 Cases 1960	'000 Cases 1964
Crab	313	324
Salmon	2392	1292
Tuna	2626	2769
Mackerel	1220	2450
Sardine	929	213
Saury	830	1332
Horse mackerel	737	926
Whale	1244	940
Shellfish	757	592
Others	949	775
Total	11,997	11,613

The canning section of the Japanese fishing industry makes an important contribution to fish exports. Economically, the most important species is salmon, which is exported to many western countries, and the different species and various qualities have already been mentioned. Production of canned salmon is centred in the north of Japan and a proportion is canned on floating factories which are supplied by small catcher boats. The remainder is produced on shore either from fresh or from frozen material. Other important species for canning are crab, tuna, jack mackerel, and saury. A substantial part of the annual production of these also is exported.

The two most important species of crab used for canning are the Alaska king crab (*Paralithodes camtschatica*) and the horse-hair crab (*Erimacrus isenbeckii*). The king crab is caught with long tangle nets in the Okhotsk Sea and the horse-hair crab is caught with baited pots off the north coast of Hokkaido. The king crab is the largest crab species canned and the average weight is 12 lb. It is mostly processed on floating canneries while the horse-hair crab is mostly processed on shore. Methods of processing vary slightly from one area to another. Generally, the carapace is removed and the carcass is cooked for about 20 min in boiling sea water. If the carapace is not removed the hepatopancreas breaks down and digests the shoulder meat. The cooked carcasses are cooled for 10 min in running sea water, which firms the meat. The meat is then separated from the shell by hand labour using scissors. The picked meat is then washed and packed in parchment-lined $\frac{1}{2}$-lb cans. Sometimes 2 g of salt per $\frac{1}{2}$-lb can is added. After sealing, cans are processed for 80 min at 108°C. The main problem with canning of crab is a blue discoloration that comes from the copper in the haemocyanin blood pigment. To overcome this problem some canneries use a double cooking treatment at different temperatures. The muscle protein is denatured by cooking to 60°C for about 20 min. This does not coagulate the blood, which is washed away after the meat and shell have been separated. The separated meat is then boiled for a brief period. Another problem is blackening caused by hydrogen sulphide produced during retorting, which forms ferrous sulphide with ferrous ions at imperfections in the tin plate. This is overcome by the use of parchment paper or by adding citric or tartaric acid to the can.

The tuna canning industry is centred around Shizuoka, south of Tokyo. Features of Japanese tuna canneries are their size and the high degree of mechanization. Technically they are very similar to tuna canneries in Australia and elsewhere. They operate on a recovery of about 40% for large fish after precooking and removal of inedible parts. However, the Japanese can large quantities of skipjack and bonito, which are relatively smaller and give lower recovery rates. The main packs are tuna in brine, tuna in oil, and seasoned flaked tuna.

Jack mackerel, saury, and other similar species are canned as cheap fish. Most of the production is exported to the Pacific Islands and South-east Asia where low cost is more important than high quality and where canned food is popular due to lack of refrigeration facilities.

Smoked, Dried, Salted, and Fermented Products

Some of the favourite traditional marine products are prepared by smoking, drying, salting, or fermentation. *Katsuobushi*, which is made from bonito, is widely used as a flavouring for soups. In the preparation of *katsuobushi* the bonito is filleted and boiled in water. After cooling, the fillets are smoked for several days, being removed from the smoke chamber overnight. Any cracks that appear in the fillet are pasted up with a mash of flaked bonito meat. The product is then sun-dried for lengthy periods and shaped with sharp knives to give smooth, rounded, brown pieces. These are then inoculated with *Penicillium* and *Aspergillus* moulds which grow on the surface and are said to improve the colour and flavour of the product. The consumption of dried and salted fish has decreased as a result of the increased production of canned and frozen fish and fish sausage. However, the production of speciality products such as salted jelly-fish, fish stomachs, and salmon is still considerable. Some of the interesting fermented fish foods have been the subject of recent research work, e.g. fermented squid, *ika no shiokara.* This is prepared by mixing the visceral mass and muscle of squid with the addition of 15–20% of salt to prevent spoilage. This mixture digests at room temperature for about one month. It has a strong smell but the taste is not unpleasant. The amino acids and other products of digestion have recently been separated and characterized to assist in controlling fermentation procedures. If allowed to ferment for about one year a liquid fish sauce, *gyo-shoyu*, is produced. Cured and fermented foods are also produced by fermenting fish muscle or roe with boiled rice or the lees remaining after *sake* brewing. Modern packaging and processing developments have had a great effect on many of these traditional products. Several large factories have been set up to produce smoked and dried squid, which is vacuum-packed and finds a ready market in Japanese bars.

Fish Sausage and Fish Ham

The most spectacular recent development in the Japanese fish processing industry has been the rapid growth of fish sausage and fish ham production. Fish sausage was developed from the old-style fish cake or fish jelly, *kamaboko*. The manufacture of *kamaboko* is a long and highly skilled process. Almost half a million tons per year are produced by small manufacturers who guard their secret recipes very carefully. The main species used for *kamaboko* are croaker (*Nibea mitsukuri*), lizard fish (*Saurida argyrophanes*), jack mackerel (*Trachurus japonicus*), and Alaska pollack (*Theragra chalcogramma*). Some species of shark are also used. An important feature of these fish is that the muscle develops a jelly-like texture when minced with salt and cooked. This effect, which is known by the Japanese as *ashi*, is the most important factor in the making of *kamaboko*. To make *kamaboko* the fish is headed and gutted and the belly flaps are cut off. The meat is then separated from the skin and bone by a machine consisting of a perforated drum and rubber belt called *gyoniku-saishuki*. The meat comes through the perforations in the drum as minced meat. This is then washed with water in a tank with a revolving paddle at the bottom. The blood and oil separate and float off at the top of the tank. When the water and meat are separated by hydraulic press, the meat appears to be white. The meat is then ground in a stone mortar with the addition of salt, sugar, monosodium glutamate, and other flavouring substances depending on the recipe. After 30 min grinding the mass has a jelly-like texture. The temperature is kept down by the addition of ice or frozen ground meat. The mass is formed as cakes on wooden blocks and steam-cooked to a centre temperature of 90°C. *Kamaboko* does not keep well, even under refrigeration, as no preservative is used in the preparation.

The development of fish sausage and fish ham resulted from changing food habits and the need to utilize species of fish unsuitable for *kamaboko* or other products. The key to the success of fish sausage was the availability of butyl rubber hydrochloride sausage casings and preservatives such as sorbic acid, nitrofurazone, and nitrofurylacrylamide. The manufacture of fish sausage is similar to that of *kamaboko* except that the factories are gigantic and highly mechanized. All the major fishing companies have fish sausage factories and some produce as many as half a million sausages per day. Fish sausage is invariably made from frozen fish. The big advantage of presentation as sausage is that almost any species can be utilized. The major raw materials are whale, tuna, Alaska pollack, shark, and jack mackerel. The meat is separated from the skin and bone and washed as in the manufacture of *kamaboko*. Then it is passed through a food chopper and subsequently ground with the addition of salt, vegetable oil, monosodium glutamate, sodium 5′ ribonucleotide, and preservatives. Some starch is added during grinding to produce a firm texture. After grinding, diced pork lard is added to the mixture. There are some differences in formulation and production between fish sausage and fish ham.

Table 4
Contents of Fish Sausage and Fish Ham

	Sausage	Ham
Whale (%)	35	40
Tuna (%)	7	17
Frozen *surimi* (%)	10	33
Small fish (%)	42	—
Lard (%)	6	10
Total	100	100

Table 4 gives an indication of the proportions of different species used. After grinding, the sausage mixture is stuffed into synthetic casings of butyl rubber hydrochloride or P.V.C. which are sealed with aluminium wire closures. The sealed sausages are processed for 60 min at 86°C in continuous water cookers and are then cooled. The aluminium closure prevents re-infection and the shelf life of fish sausage or ham is about one month, without refrigeration. The remarkable growth of the fish sausage industry has taken place since 1953 when the annual production was 2000 tons. In 1966 it was 200,000 tons and it is still growing rapidly. This growth was made possible by the application of technology. Frozen *surimi* has also been developed since 1960 as a raw material for *kamaboko* and fish sausage. Fish frozen in the round tends to lose the ability to form *ashi*, which is important for *kamaboko* and sausage. However, when processed as a washed mince with the addition of salt and sugar the *ashi*-forming ability is retained. Frozen *surimi* made mainly from Alaska pollack, squid, and horse mackerel is packed in 25-kg frozen blocks.

Conclusion

The Japanese fishing industry is dominated by five large companies, all of which are engaged in fish catching, processing, and marketing. The position in the overall economy is indicated by the fact that the largest of these companies is the sixth largest industrial group in Japan. Fish is also important in the export economy and the ratio between exports and imports is 3:1 in terms of value. However, this situation is changing and Japan is expected to become an importing country in the near future. A recently drafted economic programme estimates that the demand for fish products will grow to 9 million tons in 1971 and 10 million tons in 1976. The demand is expected to fall after 1976 as higher per capita incomes bring a demand for the higher-quality protein of meat. Without a major technological break-through, the Japanese fishing industry cannot supply much more than 8 million tons a year and the remainder will have to be imported.

Citrus Quality Standards and their Measurement

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This paper was presented by the author to the Second Annual Convention of the Australian Institute of Food Science and Technology, Sydney, June 1968.

In reviews of the Australian citrus industry prepared early this decade by the Commonwealth Bureau of Agricultural Economics, it was estimated that by 1970 the industry would be required to produce about 7½ million bushels of oranges per annum (Dall 1961, 1962). An approximate ratio of 5 Valencias to 4 Navels was recommended, unless there was a rapid increase in the demand for oranges for processing, when a higher ratio would be necessary. In actual fact, in 1966/67 the Australian industry produced over 10½ million bushels of oranges in the approximate ratio of 5 Valencias to 3 Navels. In other words, a few years before 1970, the orange crop had been almost 50% more than anticipated requirements for that year, and most of this increase occurred in the production of Valencias.

The increase in the demand for oranges for processing is further indicated by the 50% increase in the production of single-strength fruit juices and the 100% increase in the production of concentrated fruit juices over the four-year period from 1962/63 to 1965/66. Australians now consume annually 7 to 20 pounds of citrus per head in the form of processed products, representing about 20% of the total orange crop. But our industry still has a long way to go to match the operations in Florida, where more than 75% of the orange crop is processed into frozen concentrate and other juice products. In the next decade, there will be pressure on our processors to increase their utilization of citrus beyond the present 20%, since current citrus plantings will only become fully bearing in the next five years, resulting in an even greater expansion in the crop than that recorded in the past decade.

Improvement in the quality of the processed products is one of the best ways to increase the utilization of the citrus crop. Wenzel and Moore (1964) have recently argued this case for the Florida industry: 'In the future it may be absolutely necessary to pack orange products of the best possible quality to sell the large quantity of processed products resulting from the use of the continually increasing supply of oranges'. The production of frozen orange juice concentrate, still in its infancy in Australia, is expected to absorb a considerable amount of the expanded citrus crop in the next decade (Dall 1962), but this product cannot be regarded as an outlet for cull fruit, nor the industry as a salvage operation. Firstly, poor-quality, weakly flavoured oranges yield a juice much more susceptible to flavour deterioration in processing and storage than do fruit of good quality; secondly, the cost of producing orange juice concentrate increases as the quality of the raw material decreases. Only oranges of good or very good quality should be used in the production of frozen concentrated orange juice (Wenzel and Moore 1964), since this is a high-cost product which relies on quality to compete with lower-cost beverages and cordials, for which the quality of the original fruit is not such an important consideration.

To maintain a high-grade product that will be marketed more readily and in greater quantities, the Australian concentrate processors are entitled to insist, as is done in Florida, on standards for the fruit they will accept from growers. This paper discusses briefly the basis for the various quality standards applied to citrus, and their measurement and application.

Factors Involved in Quality Standards

Food quality is a very complex conception—a sum of all the factors that make a foodstuff acceptable, desirable, and nutritionally valuable. For food standards to be workable they must be free from personal taste and prejudice and based firmly on measurements that will give reasonably reproducible results for all operators. In the search for satisfactory quality standards, therefore, particular attention has been paid to chemical and physical measurements, which offer the best prospect for avoiding the errors of personal judgment that may occur, for example, in the taste assessment of juice flavour.

During ripening, changes occur in the acceptability of fruit for processing which correspond to changes in the chemical composition or physical make-up of the fruit. It should therefore be possible, in theory, to measure such quality factors as flavour, sweetness, sugar–acid balance, colour, and juice yield by objective measurements based on standard chemical and physical techniques, and to say that a fruit should be considered mature and acceptable when the values for these measurements fall within certain limits. Thus the establishment of many quality standards depends upon the objective measurement of one or more of these factors and upon setting the limits for the classification of the fruit into the various grades of quality.

Skin Colour

Although fresh fruit are purchased mainly on the basis of external quality, viz. colour, feel, shape, and size, only one of these factors bears any reliable relation to internal fruit quality, i.e. skin colour—a dark green colour is associated with immaturity. Thus, the Florida Citrus Code contains a specification designed to ensure that the dark green colour of the immature orange has been replaced by a predominantly yellow or orange colour (Soule and Lawrence 1959). A representative sample of at least 50 oranges is taken before any artificial de-greening process and the colour of each fruit is compared with a standard colour disk, an operation which could be carried out instrumentally. At least 75% of the fruits in the sample must meet the required colour specifications relating to the percentage of the surface area of the fruit in which yellow or orange predominates. This required surface area is highest early in the season, so that fruits are rejected when the external ripening has preceded the internal maturation processes, and is lowest late in the season to allow for the natural process of re-greening.

Acid Content

Internal fruit quality can only be estimated, not measured, by considerations of external fruit characteristics. However, there are several measurable factors involved in internal fruit quality which can be used as criteria for setting quality standards. The sugar content of citrus fruit, for instance, tends to increase and the acid content tends to decrease in the ripening process. Of the two criteria, the sugar content is more susceptible to chance variation in the ripening fruit, while the acid content generally shows a steady decline, thus providing the better means for assessing fruit quality.

The acid content of citrus juice can be measured conveniently by determining the volume of a standard solution of caustic soda needed to neutralize the acid in a certain volume of juice (Kefford 1957*a*). Since a high acid content renders the juice too tart for the consumer, quality standards set an upper

Table 1
Canned Citrus Juice—CFS 4-2-3

Type	Soluble Solids (°Brix)	Acidity Range (g/100 ml)	Minimum Ascorbic Acid (mg/100 ml)	Maximum Free and Suspended Pulp (% vol.)	Maximum Recoverable Oil (% vol.)
Orange	10 (min.)	0·70–1·60	40	15	0·040
Grapefruit	18–22	0·80–2·00	30	15	0·030
75% Orange, 25% grapefruit	12–15	0·75–1·70	40	15	0·035
Lemon	7 (min.)	4·75 (min.)	35	15	0·015

limit to acid content, usually expressed as the amount of caustic soda solution needed for this neutralization. The Commonwealth Food Specifications Committee (1952*a*) has laid down for canned orange juice for export an upper limit of 1·60% for the acid content (Table 1), although by the standards operating in other countries such fruit would be regarded as immature. In addition, a lower limit for acidity is specified at about 0·70% to ensure that the orange is not so bland as to have lost its character as a citrus fruit. Attempts have been made to use the pH of the juice, another way of measuring the acidity, in setting quality standards, but because the pH changes only slightly over most of the maturation period this factor does not provide a satisfactory measure of quality.

Sugar/Acid Ratio

The problem of a standard based on acid content alone is that sugar content can mask the acid taste of a juice to a remarkable extent, so that at the same acid content a juice with a low sugar content will taste much tarter than a juice with a high sugar content, and would be less suitable for processing. Thus, the Florida Citrus Code specifications would only accept our upper limit of 1·60% acid if it were accompanied by a sugar content of 12·8% or more (Soule and Lawrence 1958), and our specifications pass juice that would be unacceptable in Florida.

As mentioned earlier, an immature fruit is characterized by high acid and low sugar, and a mature fruit by low acid and high sugar, so that the changes accompanying maturation lead to a fruit with acceptable sugar/acid balance. However, these changes in sugar and acid do not always keep pace with each other, and for this reason maturity standards in Florida and elsewhere operate so that the maximum amount of acid permitted is governed by the amount of sugar present in the sample. The standards are expressed as a minimum ratio of sugar to acid contents, which provides a measure of the sugar/acid balance. Since sugar increases and acid decreases as fruit matures, the sugar/acid ratio can show the greatest changes with maturity of all the compositional factors, markedly increasing as the fruit ripens.

Sugar Content

Measurement of sugar content is the easiest and the most frequent determination made on orange juice. Actually, most measurements relate to total soluble solids, which include sugar, acid, soluble pectins, and other compounds. In practice, because about 90% of the total soluble solids is sugar, the term 'total soluble solids content' has become virtually synonymous with 'sugar content'. Corrections can be made to take into account the other constituents present (Stevens and Baier 1940); such corrections must be made with concentrates (Pilnik 1959; Basker 1966) but are rarely applied to straight orange juice. Instead, one of two simple measurements is made, depending on the fact that the sugar content of a solution determines its specific gravity and its refractive index. The sugar content is determined by a hygrometer which measures the specific gravity or by a refractometer which measures the refractive index (Kefford 1955), and the degrees Brix or sugar content of the juice can be read directly from such instruments. In either case, corrections have to be applied to make allowances for the effect of temperature on these two physical properties.

Maturity standards in some countries take the sugar content directly into consideration. For instance, the Florida regulations set a lower limit for total soluble solids which varies as the season advances, 9·0% early and 8·5% late in the season (Soule and Lawrence 1958). Soluble solids contents also can be used in conjunction with acid contents to derive the sugar/acid ratio, as mentioned earlier. In Florida the specifications for this ratio operate on a sliding scale (Table 2), so that fruit with higher solids are permitted to have disproportionately higher acid, i.e. to have a lower ratio than juice with lower solids.

Juice Content

The next quality factor to be considered is the important one of juice content, which takes into account both the juiciness of the flesh and the ratio of the flesh to the peel. In Australia, juice yield is determined by weighing the amount of juice expressed from a known weight of oranges with a simple hand reamer. Thus, in Commonwealth Regulations for fresh oranges for export (Commonwealth Food Specifications Committee 1952*b*) the juice is extracted from oranges by rotating the halves on a conical glass lemon squeezer under hand pressure only, and the resultant juice is strained through a sieve of not less than 30 meshes to the lineal inch. The yield of juice so obtained must not be less than 35% of the weight of the oranges for the fruit to pass as export quality.

This hand-reaming procedure for the determination of juice content involves a number of variables: pressure exerted, duration of operation, type of reamer, and the sieve used, which the regulations do not adequately specify. And yet, surprisingly consistent results are obtained. In a recent trial at North Ryde involving nine samples of Valencia fruit, three operators, and three hand reamers there was no significant difference in the juice yields obtained for any one of the fruit samples as determined by the three operators on each of the three reamers. However, at the same time the results of the hand-reaming method were compared with the juice yields determined by means of a mechanical juice extractor, an FMC In-Line juice tester (Fig. 1) such as is used in U.S. processing plants for determination of juice yields. This comparison showed that the hand-reaming method, although consistent from operator to operator, did not give a true indication of the yield obtained by mechanical extraction, and could differ by as much as 8% either way, i.e. from 37% to 53% by hand compared with 45% by the mechanical extractor. The reason for this probably lies in the different efficiencies of the two methods of extraction when applied to dry or to juicy fruits.

Table 2
Required Ratios of Total Soluble Solids to Total Acid*

Solids Not Less Than	Required Ratio	Solids Not Less Than	Required Ratio	Solids Not Less Than	Required Ratio	Solids Not Less Than	Required Ratio
%		%		%		%	
8·0	10·00:1	9·1	9·45:1	10·2	8·90:1	11·3	8·35:1
8·1	9·95:1	9·2	9·40:1	10·3	8·85:1	11·4	8·30:1
8·2	9·90:1	9·3	9·35:1	10·4	8·80:1	11·5	8·25:1
8·3	9·85:1	9·4	9·30:1	10·5	8·75:1	11·6	8·20:1
8·4	9·80:1	9·5	9·25:1	10·6	8·70:1	11·7	8·15:1
8·5	9·75:1	9·6	9·20:1	10·7	8·65:1	11·8	8·10:1
8·6	9·70:1	9·7	9·15:1	10·8	8·60:1	11·9	8:05:1
8·7	9·65:1	9·8	9·10:1	10·9	8·55:1	12·0	8·00:1
8·8	9·60:1	9·9	9·05:1	11·0	8·50:1	or	
8·9	9·55:1	10·0	9·00:1	11·1	8·45:1	above	
9·0	9·50:1	10·1	8·95:1	11·2	8·40:1		

* Florida Citrus Commission, State of Florida citrus law, Section 601.17, November 1957.

The Concept of Pounds Solids

The juice yield is of particular importance to the concentrate processor, and U.S. processors have introduced a new concept to the field of orange quality standards. A typical specification in Florida states that fruit for processing as concentrate should have a minimum soluble solids content of 10·5%, an acid content between 0·75% and 1·30%, and a minimum sugar/acid ratio of 10 (Soule and Lawrence 1958). Although juice yield is important for the processor, it is not mentioned in this specification because it is taken into account in the system used in Florida for calculating payment for fruit (Soule and Lawrence 1958). This system is based upon the marketing of orange juice concentrate at a fixed standard sugar content; the yield of such a concentrate and the cost of production will depend on the yield of juice and on its sugar content. Thus, for a constant juice yield, oranges with a lower sugar content will yield less concentrate with higher evaporating costs, while at a constant sugar content, oranges with a lower juice content will provide less concentrate, but less water has to be removed to produce it.

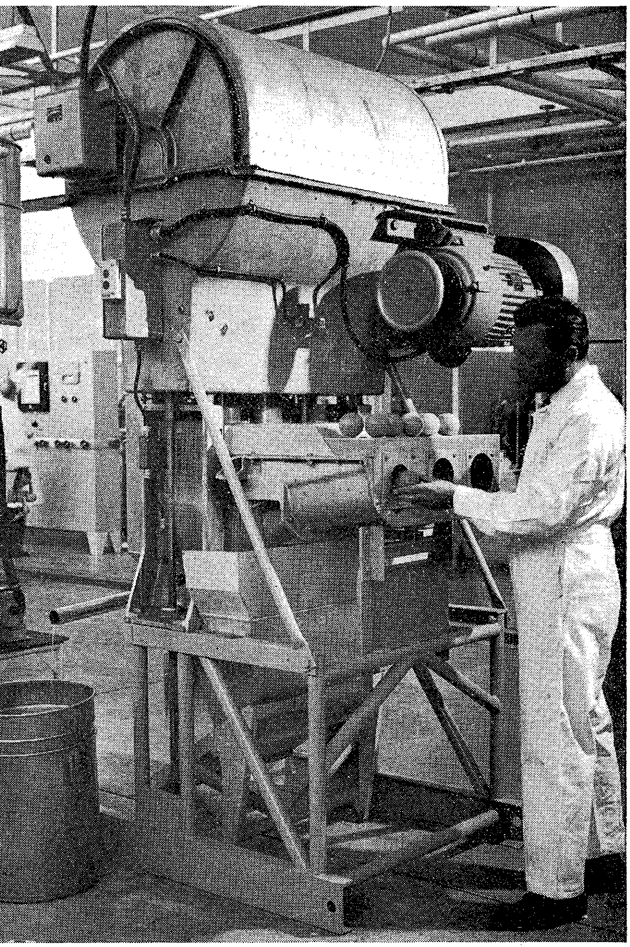

Fig. 1.—FMC In-Line juice extractor as used in U.S.A. for extraction of test samples of citrus juice.

Table 3

Juice Yield and Sugar Content in Concentration of Orange Juice to 42°Brix

Juice Yield from Fruit (% w/w)	Sugar Content of Juice (°Brix)	Concentrate per Ton Fruit (lb)	Water removed per Ton Fruit (lb)
40	10	213	683
40	9	192	704
35	10	187	597

From Table 3 it will be obvious why processors place such importance on the pounds solids per ton content of the fruit they receive for juice manufacture. By paying the grower for the weight of pounds solids delivered to the factory, rather than for the amount of fruit, the processor is merely applying the same considerations that operate when he sells the concentrate. A can of concentrate is bought not on the amount of oranges or volume of juice that went into it, but as a product containing a fixed amount of soluble solids which is broken down to yield an orange drink of constant sugar content.

Determination of Pounds Solids per Ton

The principle of purchasing oranges for processing on the basis of pounds solids per ton or box is well established in the United States. At present this value is determined indirectly from juice yield and soluble solids content, but recent investigations in Florida (Ting and Blair 1965), repeated in Australia, have indicated that this procedure may be replaced by a single and simple measurement on the intact fruit. These investigations showed that the pounds solids in a consignment of fruit may be assessed by measuring the average specific gravity (S.G.) of the fruit. The determination of the S.G. is a simple measurement which does not require expensive equipment or technical skill. The fruit contained in a perforated basket is weighed by means of a steelyard, then the basket is hoisted into a tank of water and weighed again. By application of Archimedes' principle,

S.G. of fruit = wt. of fruit in air/(wt. of fruit in air − wt. of fruit in water),

and thus the S.G. of the fruit could be determined in a packing shed or a processing plant at the point of arrival of the fruit. Once the relation between the two factors is established, the pounds solids per ton would then be read off a chart from the S.G. obtained.

The results so far indicate that this method is not only more direct, but also more accurate than the present procedure of calculating pounds solids per ton from the juice yield and sugar content. The U.S. workers obtained a relation between S.G. of Valencia oranges and the pounds solids per ton, with a correlation coefficient of 0·801, significant at the 1% level. Our investigations showed that if the true yield of solids was 110 lb/ton, S.G. measurements would predict a value between 106 and 114 lb/ton, i.e. within ±4 lb solids/ton.

Bitterness in Orange Juice

One quality factor that has not been written into specifications is bitterness, which is of such importance that virtually one-third of the orange crop is excluded from utilization in the production of high-quality juice and concentrate. Bitterness is due to limonin, a comparatively insoluble compound present in the albedo or white of the orange, particles of which are included in juices prepared by all commercial methods of extraction. Bitterness does not develop immediately but only on standing or on pasteurization, and can reach such objectionable levels in the juice of Navel oranges that these fruit cannot be used in the production of straight juice or concentrate, although fruit juice blends and cordials may provide an outlet. Valencia oranges, particularly those obtained from trees grown on rough lemon rootstock, may also yield bitter juices. In order to ensure that a juice from Australian Valencias is not bitter without actually testing the juice for bitterness, the fruit must be obtained from trees grown on certain rootstocks, of which trifoliate orange is the most important (Kefford and Chandler 1961; Bowden 1968).

An empirical procedure for testing oranges for the potential bitterness of their juice was described by Higby (1941), and reliable chemical methods are now available for determining the bitter principle content of orange juice (Chandler and Kefford 1966; Wilson and Crutchfield 1968). The analytical procedures have not the simplicity of the methods for sugar and acid determinations, but they permit the fixing of a limonin content of 7·5 p.p.m. as an upper limit for an acceptable non-bitter juice. From experiences at North Ryde, this standard would be met by juices from all Valencias grown on trifoliate orange stock, about 85% of Valencias grown on sweet orange stock, about 45% of Valencias grown on rough lemon stock, about 60% of Navels grown on trifoliate orange stock, and about 10% of Navels grown on rough lemon stock.

Essential Oil Content

Another minor fruit constituent, which nevertheless has an important influence on juice flavour, is the essential oil that provides the distinctive aromatic character of orange juice. Some essential oil, about 0·01%, is necessary for full juice flavour, but excess oil results in an oily taste and may lead to the development of off-flavours in storage; the Commonwealth Food Specifications Committee (1952*a*) set an upper limit of 0·04% recoverable oil in export-quality orange juice. The determination of oil content can be made by a steam distillation method (Association of Official Agricultural Chemists 1965) or by a recently developed volumetric titration procedure, which is more accurate and less time-consuming (Scott and Veldhuis 1966; Scott 1968).

In the past, the oil content of oranges has not been considered a factor in determining their suitability for processing, since the amount of oil included into the juice during extraction depends largely on the extractor used, and furthermore the recovery of orange oil as a by-product from processing wastes is not an economically important operation. However, with the recently developed interest in comminuted orange drinks, the oil content of the comminuted fruit is important in the formulation of the final product, and interest in this aspect of orange quality has grown considerably in recent years. In the production of comminuted juices, skin thickness and skin colour also determine the choice of raw material and the formulation of the product. Assessment of skin colour has been mentioned before, and measurement of skin thickness can usually be bypassed by determination of yield or fruit density.

Insoluble Solids, Juice Colour, and Vitamin C Content

As with essential oil content, the insoluble solids content of orange juice depends upon the method of extraction rather than the raw material. These insoluble solids, also known as pulp or cloud, contribute to the 'body' or 'mouth-feel' of the juice, but excessive amounts are associated with texture and flavour defects; the Commonwealth Food Specifications Committee (1952*a*) set an upper limit of 15% pulp by volume for export-quality citrus juices. Pulp is usually measured by a simple centrifugation procedure (Kefford 1956) and modifications to this method have been proposed (Maraulja and Barron 1967). However, greater accuracy has recently been claimed for a procedure involving acetone precipitation (Dupaigne 1967).

Although associated with the insoluble solids, juice colour is a factor that can be used in assessing the suitability of the raw material for processing. The colour of citrus juices is due to carotenoid pigments carried in the chromoplasts, which form part of the suspended cloud. Because the pigments are not in solution, colour measurement is difficult, and the use of plastic colour standards (Ingle 1957; Edwards *et al.* 1966; Hunter 1967) was recently written into the U.S. specifications for canned orange juice, thus avoiding expensive instrumentation (U.S. Department of Agriculture 1963, 1964). In general, Australian juices have such excellent colour that they would have no difficulty in meeting the U.S. colour standards, and there are no such Australian specifications.

Similarly, the vitamin C content of Australian oranges is satisfactorily high and, if properly handled, our juices have no difficulty in meeting the requirement of 40 mg/100 ml set down by the Commonwealth Food Specifications Committee (1952*a*) for export-quality citrus juices. The determination of vitamin C, for which a volumetric procedure was developed 30 years ago, with no great modification since (Kefford 1957*b*), is also frequently used to assess the deterioration of juices during processing and storage.

Special Quality Considerations for Lemons and Grapefruit

Similar standards to the above operate for all citrus fruit, but in addition there are quality factors specific to grapefruit and lemons for which no standards have been set. The maturity of lemons, for instance, is important in the selection of fruit for processing, since the high acid and high pectin contents of immature fruit can cause gelling, resulting in problems in pasteurization and in the preparation of cordials (Fig. 2). Immature grapefruit must also be avoided because such fruit contain high concentrations

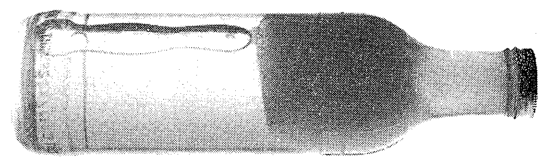

Fig. 2.—Large plug of gelled material in lemon cordial made from immature fruit.

of naringin, the main bitter principle of grapefruit, which can cause excessive bitterness in processed grapefruit products. Obviously some bitterness is desirable in grapefruit juice but the acceptable level is reached at a concentration of 0·03–0·07% naringin. Above 0·10% the bitterness becomes objectionable, and the high naringin contents can result in the deposition of unattractive crystal aggregates in juice (Fig. 3), or muddiness in segments. Although the methods are not specific, the simple procedures of Davis (1947) and Hendrickson, Kesterson, and Edwards (1958) are suitable for routine naringin analysis. Special empirical standards that may be used in assessing the maturity of Australian grapefruit have been outlined recently by Fethers (1968).

For the production of grapefruit segments, ease of separation of the segments is a desirable quality which is largely dependent on variety. In general, heavily seeded varieties are more suitable for the preparation of grapefruit segments, while seedless varieties are preferred for juice production. Total area under grapefruit has expanded by 20% over the past five years, compared with a 5%

expansion for oranges, and it may well be that greater attention will be paid in the future to quality factors involved in the selection of grapefruit for processing in this country.

Testing Procedures in Florida

In Florida, maturity tests are used in two ways (Soule and Lawrence 1958, 1959). As the picking season approaches, periodic samples are collected from each grove, and tests on this fruit provide information on the progress of maturity and indicate the optimum times for picking. With the present heavy emphasis on the highest possible quality for fruit, both for hand eating and processing, spot pickings are often made several times before a final clean picking is made. Then, as the harvested fruit is delivered to the packing house and processing plants, official tests for maturity are made on each lot. Samples from at least the smallest and the largest size in each lot are tested by a government inspector to ensure that the lot meets the minimum legal standards before certification for shipment, or conversion to juice.

Fig. 3.—Crystals of naringin from grapefruit juice.

Adequate and random sampling is essential to the successful application of quality standards. The Florida specifications set an official sample for testing as 10 oranges, except for colour examination, which calls for 50 fruit; for the solids per ton determination by specific gravity, approximately 150 fruit would be required. Fruit for testing should preferably be drawn by means of an automatic sampling device on a conveyor or elevator, and not by picking the top fruit off the top box in a load.

These tests can be made at any stage from the grove to packed boxes ready for loading, and, if the inspector desires, can be run on all sizes, grades, and other divisions of the lot. They must be made only by a duly authorized inspector and without any interference. Each packing house and processing plant must provide a suitable place, with running water, a sink and drainboard, lights, power outlet, and adequate desk space, where the inspector can carry out maturity tests, but the equipment and chemicals for maturity tests are furnished by the Florida Department of Agriculture. Such inspection ensures that only sound wholesome oranges that meet legal maturity standards are processed. At the same time, by means of these tests the processor determines whether the fruit is suitable for concentrate production, how the oranges or the juice therefrom should be blended with other oranges or juice in order to maintain a uniform product, and, finally, the payment to the grower.

No doubt the citrus industry in Florida is more advanced and better organized than the industry here, but perhaps the day will come in Australia also when every packing house and processing plant can afford to set up a quality testing laboratory, and when the departments of agriculture can afford to employ and equip inspectors to carry out such routine examinations. If and when that day comes, the Australian citrus industry will be the better for it.

References

ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS (1965).—"Official Methods of Analysis." 10th Ed. p. 302, 19.111.

BASKER, H. B. (1966).—Presumptive specific gravity of concentrated citrus juices. *J. Sci. Fd Agric.* **17**, 539–41.

BOWDEN, R. P. (1968).—Processing quality of oranges grown near north coast area of Queensland. *Qd J. agric. anim. Scis* **25**, 93–119.

CHANDLER, B. V., and KEFFORD, J. F. (1966).—Chemical assay of limonin, the bitter principle of oranges. *J. Sci. Fd Agric.* **17**, 193–7.

COMMONWEALTH FOOD SPECIFICATIONS COMMITTEE (1952*a*).—Citrus juice, canned. CFS 4–2–3. (Dep. Primary Ind.: Canberra.)

COMMONWEALTH FOOD SPECIFICATIONS COMMITTEE (1952*b*).—Fruit, fresh. CFS 4–6–1. (Dep. Primary Ind.: Canberra.)

DALL, M. (1961).—Australian citrus industry. *Q. Rev. agric. Econ.* **14**, 116–27.

DALL, M. (1962).—Outlook for frozen orange juice concentrate. *Q. Rev. agric. Econ.* **15**, 131–41.

DAVIS, W. B. (1947).—Determination of flavanones in citrus fruits. *Analyt. Chem.* **19**, 476–8.

DUPAIGNE, P. (1967).—An objective method for evaluation of the content of pulp in suspension in fruit drinks. (In French.) *Fruits* **22**, 305–8.

EDWARDS, G. J., WENZEL, F. W., HUGGART, R. L., and BARRON, R. W. (1966).—Comparison of subjective and objective methods for determining the color of reconstituted frozen concentrated orange juice. *Proc. Fla St. hort. Soc.* **79**, 321–5.

FETHERS, G. D. (1968).—Maturity standards for grapefruit. *Aust. Citrus News* **44** (April), 14.

HENDRICKSON, R., KESTERSON, J. W., and EDWARDS, G. J. (1958).—Ultraviolet absorption technique to determine the naringin content of grapefruit juice. *Proc. Fla St. hort. Soc.* **71**, 194–8.

HIGBY, R. H. (1941).—Canning Navel orange juice. *Calif. Citrogr.* **26**, 360, 380, 382.

HUNTER, R. S. (1967).—Development of the citrus colorimeter. *Fd Technol., Champaign* **21**, 906–11.

INGLE, G. W. (1957).—Plastic models are replacing colour grading charts. *Fd Pckr* **38**(8), 19, 42.

KEFFORD, J. F. (1955).—Laboratory examination of canned foods. VIII. Indirect estimation of solids content. *CSIRO Fd Preserv. Q.* **15**, 52–7.

KEFFORD, J. F. (1956).—Laboratory examination of canned foods. X. Insoluble solids content. *CSIRO Fd Preserv. Q.* **16**, 7–10.

KEFFORD, J. F. (1957*a*).—Laboratory examination of canned foods. XII. Acidity and pH values. *CSIRO Fd Preserv. Q.* **17**, 30–5.

KEFFORD, J. F. (1957*b*).—Laboratory examination of canned foods. XIII. Ascorbic acid content. *CSIRO Fd Preserv. Q.* **17**, 42–7.

KEFFORD, J. F., and CHANDLER, B. V. (1961).—The influence of rootstocks on the composition of oranges, with special reference to bitter principles. *Aust. J. agric. Res.* **12**, 56–68.

MARAULJA, M. D., and BARRON, R. W. (1967).—An improved method for measurement of pulp content of citrus juices. *Proc. Fla St. hort. Soc.* **80**, 284–8.

PILNIK, W. (1959).—Determination of concentration factor of citrus concentrates. (In German.) *Fruchtsaft-Ind.* **4**, 17–21.

SCOTT, W. C. (1968).—Collaborative study of recoverable oil in citrus juices by bromate titration. *J. Ass. off. agric. Chem.* **51**, 928–31.

SCOTT, W. C., and VELDHUIS, N. K. (1966).—Rapid estimation of recoverable oil in citrus juices by bromate titration. *J. Ass. off. agric. Chem.* **49**, 628–33.

SOULE, M. J., Jr., and LAWRENCE, F. P. (1958).—Testing oranges for processing. Circ. Fla agric. Ext. Serv. No. 184.

SOULE, M. J., Jr., and LAWRENCE, F. P. (1959).—What every citrus grower should know—Maturity tests for fresh fruit. Circ. Fla agric. Ext. Serv. No. 191.

STEVENS, J. W., and BAIER, W. E. (1939).—Refractometric determination of soluble solids in citrus juices. *Ind. Engng Chem. analyt. Edn* **11**, 447–9.

TING, S. V., and BLAIR, J. G. (1965).—Relation of specific gravity of whole fruit to the internal quality of oranges. *Proc. Fla St. hort. Soc.* **78**, 251–60.

U.S. DEPARTMENT OF AGRICULTURE (1963).—Scoring colour of orange juice products. U.S. Dep. Agric., Agric. Marketing Service, Washington, D.C.

U.S. DEPARTMENT OF AGRICULTURE (1964).—U.S. standards for grades of canned orange juice. U.S. Dep. Agric., Agric. Marketing Service, Washington, D.C.

WENZEL, F. W., and MOORE, E. L. (1964).—Increased utilization of oranges through improvement in quality of processed products. *Proc. Fla St. hort. Soc.* **77**, 110–18.

WILSON, K. W., and CRUTCHFIELD, C. A. (1968).—Spectrophotometric determination of limonin in orange juice. *J. agric. Fd Chem.* **16**, 118–24.

Condensation in Cargoes of Canned Foods

In 1962, water damage to Australian canned fruits shipped to Great Britain and Canada had become a major problem, and the Australian Canned Fruits Board asked CSIRO to investigate the causes and methods of preventing this damage.

Mr. J. Middlehurst and Mr. J. F. Kefford, of the Division of Food Preservation, undertook a study of the water damage to canned fruit in cartons during transport from the Goulburn Valley, Vic., to ports in Britain. The report on this study has been issued as a Technical Paper,* which may be obtained from the Librarian, Division of Food Preservation, P.O. Box 43, Ryde, N.S.W. 2112 (Telephone 88 0233).

During the transport and distribution of canned goods condensation of water frequently causes damage to cans, can labels, and corrugated fibreboard containers (commonly referred to as cartons).

Cans rust when wet for more than a few days. The seams rust first but eventually all of the tinplate surface may be affected. Printed paper labels wrinkle, inks fade, varnish blooms, and finally severe discoloration of the label may be caused by mould growth and rusting under the label.

The flaps of a wet carton loosen and when it is lifted, the bottom opens and the contents fall out. In addition, carton board is softened by wetting and tears and breaks easily. On drying, the carton shows discoloration in the form of 'bleached' areas and 'high-water' marks caused by movement of water-soluble dyes in the board. Mould may discolour damp cartons; staples may rust and cause further discoloration. Finally, the surface layer of the board may be severely damaged when damp cartons rub together.

Generally the contents of water-damaged cans are unaffected, but the packages are unsalable and the importer must repack cartons and clean and relabel cans.

*Middlehurst, J., and Kefford, J. F. (1968).—Condensation in cargoes of canned foods. CSIRO Aust. Div. Fd Preserv. tech. Pap. No. 34.

In brief, the investigation showed that condensation occurred on canned food cargoes when the dew point of the air surrounding the cans exceeded the temperature of the cans.

In approximately 90% of condensation damage investigated, the air of high dew point came from outside the ship through the ventilating system; in approximately 10% the high dew point was caused by moisture from another cargo; and in perhaps 1% the moisture came from the cartons themselves.

The procedures recommended for preventing condensation are as follows:

- Outside air must not be permitted to enter the hold if its dew point is greater than the temperature of the coldest carton.
- Water vapour from other cargoes must not reach canned food cargoes.
- The difference in temperature between the warmest and coldest cartons in a stack must not exceed 7°F.

The following common practices in stowing and transporting canned food cargoes were found likely to increase risk of condensation damage and must be avoided:

- Blowing air of high dew point over cold cartons.
- Sealing cold cartons in a hold with warm moisture-containing cargo.
- Stowing together cartons that have come from different rail vans or road trucks and are at different temperatures.
- Inadequate use of waterproof barriers in the hold.
- Incorrect operation of hold-drying and hold-recirculating systems.
- Stowing large blocks of canned foods near a source of heat, such as an engine-room bulkhead or the side of the ship.

NEWS FROM THE DIVISION OF FOOD PRESERVATION

Appointments

Mr. B. Y. Johnson has been appointed to the position of Information Officer at the Division's Meat Research Laboratory at Cannon Hill, where he will prepare technical reports and extension material, answer technical inquiries, and maintain liaison with the meat industry. Mr. Johnson graduated in Agricultural Science from the University of Melbourne in 1957. After two years as a food technologist with Kraft Foods, he joined the meat industry and became a branch manager in Thomas Borthwick & Sons in 1967.

Dr. Maureen Franek, a graduate in chemistry from the University of Queensland who took out her Ph.D. at the Australian National University in 1968, has joined the staff at Divisional headquarters to assist the Chief of the Division with research on the effect of the state of water and its structure on the activity of hydrolytic enzymes.

Miss Tatiana Orlova has been appointed to the Division to participate in an investigation of the composition of Australian honeys, and of the factors influencing the quality of honey. Miss Orlova graduated B.Sc. from the University of New South Wales in 1964, and has since had experience as an analytical chemist in industry, including the food industry.

Dr. A. K. Sharp has joined the Division to carry out research on heat and mass transfer, with special reference to the storage, transport, and processing of foods. Dr. Sharp was awarded his Ph.D. by the University of London in 1968. He took his B.E. degree at the University of Melbourne in 1963, and the degree of M.Eng.Sci. at Monash University, Vic., in 1965.

Research on Honey

The Australian Honey Board and the Commonwealth Government have agreed to provide $26,500 to enable the CSIRO Division of Food Preservation to undertake a three-year programme of investigations on honey for the purpose of improving the quality of the product, especially that offered for export, which amounts to about 15 million pounds per annum.

The characteristics of honey are influenced greatly by the plants from which it is derived and by its mode of extraction and processing, but no systematic study has been made of the effect of these factors on Australian honey. A survey is being made of the chemical composition of honey from a variety of floral sources. The techniques of extraction and processing are also being studied, and an examination made of the international standards for the composition and quality of honey.

Lipid Biochemistry School

The laboratories of the Division of Food Preservation at North Ryde were the venue for a summer school on lipid biochemistry from February 10 to 21, 1969. The school, sponsored by the Australian Biochemical Society, consisted of lectures by the staff of the Division and others on recent developments in the biochemistry of lipids and demonstrations of modern techniques for studying them. Among the topics dealt with were the role of lipids in cells, lipids as a source of energy, lipoproteins, the clinical and biochemical significance of steroids, and the biosynthesis of unsaturated fatty acids. Demonstrations were given of chromatography, radiochemical techniques, spectroscopy, mass spectrometry, and nuclear magnetic resonance.

Better Control of Fruit Rots

In a previous issue* brief mention was made of a new fungicide that has given outstanding results in controlling many of the rots that damage fruit after harvest. It is thiabendazole (TBZ), chemically 2-(4′-thiazolyl)benzimidazole, which has been marketed for some time as a veterinary anthelmintic under the trade name of Thiabendazole (Merck Sharp and Dohme (Aust.) Pty. Ltd.).

The very good fungicidal properties of TBZ have been demonstrated in several countries in the past three years. It has been found to have a very low phytotoxicity and so appears to be safe for many fruits, and, more importantly, the mammalian toxicity is low and there is no risk to consumers.

The United States Food and Drug Administration has approved it for post-harvest fungicidal treatment of bananas, permitting a maximum residue of 3 parts per million in the whole fruit and 0·4 p.p.m. in the pulp. Recently the Australian National Health and Medical Research Council recommended that the State Departments of Health approve it as a post-harvest fungicide for both bananas and citrus fruits, with a provisional maximum permissible residue of 10 p.p.m. in the whole fruit.

*Hall, E. G. (1968).—Atmosphere control in storage and transport of fresh fruit and vegetables. *CSIRO Fd Preserv. Q.* **28**, 2–8.

Cooperative research by the Division and State Departments of Agriculture has shown TBZ to be very effective against black-end rot,† crown rot, and squirter disease‡ of banana fruits and to be much more effective against black-end rot than salicylanilide,§ which is used at present.

TBZ is better than the currently used sodium orthophenylphenate (SOPP) for control of green mould and stem-end rots of citrus fruits|| and there is no risk of fruit injury from its use. It is also very effective against brown rot of stone fruits, blue mould of apples and pears, and grey mould (*Botrytis*), which has a wide host range. However, it is ineffective against transit rot (*Rhizopus*).

The development of TBZ as a safe and effective fungicide to control fruit rots is a major advance and is of considerable importance to the fruit industry.

†Scott, K. J., and Roberts, E. A. (1967).—Control in bananas of black-end rot caused by *Gloeosporium musarum*. *Aust. J. exp. Agric. Anim. Husb.* **7**, 283–6.

‡Anon. (1967).—Control of squirter disease of bananas by thiabendazole. *Agric. Gaz. NSW* **78**, 604.

§Anon. (1967).—New post-harvest treatments reduce wastage in bananas during marketing. *Agric. Gaz. NSW* **78**, 605–7.

||Seberry, J. A., and Baldwin, Robyn A. (1968).—Thiabendazole and 2-aminobutane as post-harvest fungicides for citrus. *Aust. J. exp. Agric. Anim. Husb.* **8**, 440–3.

Recent Publications of the Division

Copies of most of these papers are available from the Librarian, CSIRO Division of Food Preservation, P.O. Box 43, Ryde, N.S.W. 2112 (Telephone 88 0233).

Anet, E. F. L. J. (1968).—Degradation of carbohydrates. Part IX. Penta-*O*-methyl-*aldehydo*-D-glucose. *Carbohyd. Res.* **7**, 453–9.

Anet, E. F. L. J. (1968).—Degradation of carbohydrates. Part X. 2,3,4,5-Tetra-*O*-methyl-D-glucose. *Carbohyd. Res.* **8**, 164–74.

Board, P. W. (1968).—Principles and practice of heat sterilization. 'Foreman in the Food Plant', 1968 Proceedings.*

Board, P. W., Britz, D., and Holland, R. V. (1968).—Improved method for using the Kóryta adsorption equation: adsorption of erythrosin. *Electrochim. Acta* **13**, 1633–9.

Board, P. W., Britz, D., and Holland, R. V. (1968).—Reduction of erythrosin at the dropping mercury electrode. *Electrochim. Acta* **13**, 1575–9.

Board, P. W., Holland, R. V., and Britz, D. (1968).—Dithiocarbamates, carbon disulphide and the corrosion of tinplate. *Br. Corrosion J.* **3**, 238–41.

Burley, R. W. (1968).—Experiments on the action of dinitrophenyl amino acids on muscle proteins. 3rd Symposium on Fibrous Proteins, Australia, 1967, pp. 175–8.

Davis, E. G. (1968).—Protective packaging of foods for export. *Aust. Packag.* **16**(2), 29.

Grau, F., Brownlie, L. E., and Roberts, E. A. (1968).—Effect of some pre-slaughter treatments on the *Salmonella* population in the bovine rumen and faeces. *J. appl. Bact.* **31**, 157–63.

Huelin, F. E. (1968).—Superficial scald, a functional disorder of apples. III. The concentration of diphenylamine in the fruit after treatment. *J. Sci. Fd Agric.* **19**, 294–6.

Huelin, F. E., and Coggiola, I. M. (1968).—Superficial scald, a functional disorder of apples. IV. The effect of variety, maturity, oiled wraps and diphenylamine on the concentration of α-farnesene in the fruit. *J. Sci. Fd Agric.* **19**, 297–301.

Johnson, A. R., and Holdsworth, E. C. (1968).—The effect of the antioxidant butylated hydroxy toluene on the lipid metabolism of the rat. *J. Nutr. Diet.* **5**, 147–53.

Lee, T. H., McGlasson, W. B., and Edwards, R. A. (1968).—Effect of gamma radiation on tomato fruits picked at several stages of development. *Radiat. Bot.* **8**, 259–67.*

Macfarlane, J. J., and Roberts, E. A. (1968).—Some effects of gamma radiation on Washington Navel and Valencia oranges. *Aust. J. exp. Agric. Anim. Husb.* **8**, 625–9.

Mellor, J. D., and Munns, A. S. (1968).—Freeze drying with cyclic vacuum pressure. *Aust. Refrig. Air Condit. Heat.* **22**(8), 20–9.*

Middlehurst, J. (1968).—Condensation in uninsulated ISO containers. *Aust. Packag.* **16**(9), 24–7.

Middlehurst, J., and Kefford, J. F. (1968).—Condensation in cargoes of canned foods. I. An investigation of condensation in canned fruit between Australia and Great Britain. II. The flow of water vapour in cargo holds. III. Mathematical treatment of condensation. CSIRO Aust. Div. Fd Preserv. tech. Pap. No. 34.

Mitchell, R. S., and Lynch, L. J. (1968).—Pea puncturing machine. Aust. Pat. 281,906. 28 Mar., 1968.*

Mitchell, R. S., Board, P. W., and Lynch, L. J. (1968).—Fluidized bed blanching of green peas for processing. *Fd Technol., Champaign* **22**(6), 59–60.

Montgomery, W. A., and Sidhu, G. S. (1968).—Current trends in prawn processing. *Aust. Fish. Newsl.* **27**(2), 13, 15.

Montgomery, W. A., and Sidhu, G. S. (1968).—Prawn preservation and processing. *Aust. Fish. Newsl.* **27**(1), 7, 9, 11.

Murray, K. E. (1969).—α-Farnesene: isolation from the natural coating of apples. *Aust. J. Chem.* **22**, 197–204.

Murray, K. E., and Stanley, G. (1968).—Class separation of flavour volatiles by liquid chromatography on silica gel at 1°. *J. Chromat.* **34**, 174–9.

Murray, K. E., Shipton, J., Whitfield, F. B., Kennett, B. H., and Stanley, G. (1968).—Volatile flavor components from green peas (*Pisum sativum*). I. Alcohols in unblanched frozen peas. *J. Fd Sci.* **33**, 290–4.

Myklestad, O. (1968).—Analysis of transient flow of heat and moisture during drying of granular beds. *Int. J. Heat Mass Transfer* **11**, 675–87.

Myklestad, O. (1968).—Controlled aeration of rice in bulk. *J. Sci. Fd Agric.* **19**, 41–6.

Myklestad, O., Christie, E. M., Coote, G. G., and McDonald, D. J. (1968).—Chemical, physical, and organoleptic properties of twelve varieties of rice. CSIRO Aust. Div. Fd Preserv. tech. Pap. No. 33.

Scott, K. J., and Roberts, E. A. (1968).—The importance of weight loss in reducing breakdown of Jonathan apples. *Aust. J. exp. Agric. Anim. Husb.* **8**, 377–80.

Smith, G. J., Christie, E. M., and Coote, G. G. (1968).—Effect of homogenized milk on acceptability of tea. *Aust. J. Dairy Technol.* **23**, 98–100.

Smith, M. B., and Back, J. F. (1968).—Studies on ovalbumin. III. Denaturation of ovalbumin and S-ovalbumin. IV. Trypsin digestion and the cystine peptides of ovalbumin and S-ovalbumin. *Aust. J. biol. Sci.* **21**, 539–58.

Szulmayer, W. (1968).—Selenium dioxide hygrometric probes. *J. scient. Instrum.* (II)**1**, 864–6.

Tracey, M. V. (1968).—The biochemistry of supporting materials in organisms. *Adv. comp. Physiol. Biochem.* **3**, 233–70.*

Tracey, M. V. (1968).—Forging a link between wheat producers and the wheat consuming industries. *Fd Technol. Aust.* **20**, 462–3, 465.

Vickery, J. R. (1968).—The recovery and utilization of edible proteins from blood and trash fish. *Fd Technol. Aust.* **20**, 315–19.

Wills, R. B. H. (1968).—Influence of water loss on the loss of volatiles by apples. *J. Sci. Fd Agric.* **19**, 354–6.

Wills, R. B. H., and McGlasson, W. B. (1968).—Changes in the organic acids of Jonathan apples during cool storage in relation to the development of breakdown. *Phytochemistry* **7**, 733–9.

*No copies for distribution.