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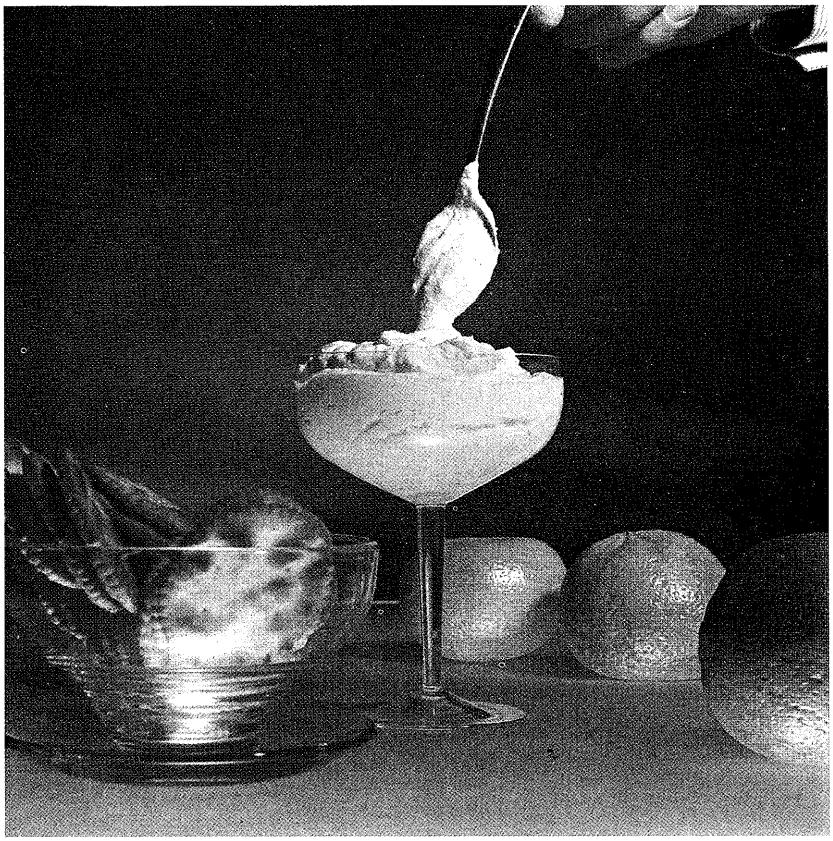

Quarg has many uses. It may be used in plain form or for savouries and salads or may be fruit-flavoured.

Quarg: A Different Approach

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A new way of making an old product enhances the nutritional value of quarg, while retaining the traditional flavour.

Quarg, sometimes called Quark in Germany and neighbouring countries, and Tworog in Russia, is probably the simplest to produce and the oldest of all cheese varieties in those parts of Europe. Its other names include 'cottage cheese', 'farm cheese', or 'fresh cheese'.

Its origins go back to the very old practice of allowing fresh milk to stand in a cool place and settle so that the milk fat would rise to the top. The farmer's wife would then skim off the fat or cream to make butter. The remaining milk solids, now clotted as a result of 'natural' acid development, would be poured into a permeable cotton-cloth bag which would allow whey to drain off while retaining the curd.

When, after some hours, the dripping of the whey had stopped, the bag would be put on a wooden table and a plank of wood placed on top of it. A brick or a stone might also be placed on the plank to add weight. More whey would be forced out in this manner and the curd in the bag would become 'caked'. On removal from the bag the curd, now quarg, could be sliced, mashed, or spooned to feed the family or to sell in the nearest market town.

In the last four decades the manufacture of quarg has shifted from the farm to dairy factories. There, particularly in the 1950s, the rather primitive process of making quarg underwent rationalization and mechanization; centrifugal machines for the separation of whey replaced the cloth bags and the primitive pressing of the curd (De Laval Separator Co. 1954; Westfalia Separator A.G. 1963*a*,*b*). The composition of quarg, particularly in terms of the solids content, has also been defined. Thus, according to regulations in West Germany, skimmed milk quarg should contain not less than 18% by weight of milk solids. Fat-enriched variants, also, have become popular, with products being marketed that contain 10%, 20%, or 40% fat in the dry matter.

More recently, following similar trends with yoghurt, quarg variants flavoured with fruit or flavour essences have been increasingly preferred by the consumer and the consumption of such products has risen spectacularly to parallel the phenomenal increase in consumption of American-style cottage cheese in recent years in the U.S.A.

A glance at the composition of the product shows that, whether it is low-fat or fat-enriched, quarg that is made in the traditional way by syneresis has only about twice the solids content of milk, and has actually lost many valuable components of milk, such as whey proteins, lactose, and water-soluble vitamins and minerals. These are lost along with the whey and simply present a pollution problem.

While dehydration of milk solids by syneresis, the basic process in quarg-making, might have been in the past the best way of collecting and preserving the solids in a semi-concentrated form, modern food technology can provide better means of attaining the same objective. In particular, since the now-popular variations of quarg, flavoured with fruit or with essences, are distinguishable from similarly flavoured yoghurt only by their greater solids content, we considered that it would be possible to make a product resembling quarg by a modification of the yoghurt process. Skimmed milk powder was added to whole milk to build up the protein to the required level and then the reinforced milk was inoculated with suitable bacterial cultures and incubated as in yoghurt manufacture. This process gives a very attractive product which differs from traditional quarg only in its greater content of lactose and its complete retention of all whey constituents. In other respects it compares favourably both nutritionally and organoleptically with commercially produced quarg of high quality.

The Process

A product with a consistency and protein content approaching those of traditional

quarg may be made from a base mixture containing 32–38% total solids. A fat content of 3% in the product should be aimed for, but products without fat or, as mentioned later, with higher fat contents can be prepared.

Preparation of the Mix

The mixture is prepared by one of the following methods:

(1) Add skim milk powder to whole milk and heat the mixture in a batch vessel. A swept surface agitator is helpful in preventing 'baking-on'.
(2) As in (1) but heat the mixture in a plate heat exchanger, taking care to keep the temperature differential between the heating plates and the mix to a maximum of 2 degC.
(3) As in (1) but heat the mixture in a closed vessel with a continuously swept surface, in which it can stand ultra-heat treatment.
(4) Add high-heat skim-milk powder to whole milk which has already been heat-treated. In this case additional prolonged heat treatment, other than pasteurization, is not necessary.
(5) Recombine the mixture from high-heat skim-milk powder and butter oil; only pasteurization of the mix is required.
(6) Concentrate whole or standardized milk which has been heat-treated at 88 °C for 30 min before or after evaporation.

The heat treatments given to these mixtures are similar to those used in yoghurt manufacture, and are equivalent to holding the mixture at 88 °C for 30 min.

If higher fat contents are required in the product, cream or butter oil is added while preparing the base mix, or before the second homogenization, or after the second homogenization in the form of a rich cream containing 50–60% fat.

First Homogenization

Single-stage homogenization at 13·8 MPa (2000 psi) is adequate for mixtures made from whole milk and powder, or concentrated milk. For wholly recombined mixtures, two-stage homogenization at 10·3 MPa (1500 psi) and 3·5 MPa (500 psi) is recommended.

Addition of Starter and Incubation

The temperature of the mixture is adjusted to 32–34 °C before adding the starter.

(1) For overnight incubation add 1% of a DRC culture of *Streptococcus diacetilactis* and 0·5% of YB culture of *Lactobacillus bulgaricus*.
(2) For an incubation period of about 6 hr add 2% of the DRC culture and 1% of the YB culture.

During incubation the pH drops to about 4·3–4·4 and is largely self-regulating. At higher incubation temperatures the mixture becomes more firmly set (and more difficult to handle) and the pH drops much lower.

Second Homogenization

After incubation the set mixture is gently agitated and then pumped through a lobe or gear pump to a single-stage homogenizer operating at about 2·1 MPa (300 psi). It should emerge as a viscous fluid which sets firmly within about 5 min of homogenizing.

The temperature of the product leaving the homogenizer is affected by the initial temperature, the firmness of the set, the design of the particular homogenizer, and the pressure used. It is usual for the temperature to rise by 5 to 7 degC during homogenization. The optimal balance of temperature, pH, firmness of curd, and homogenizing conditions must be arrived at by experiment in each case.

Holding and Conditioning

At the higher temperature following homogenization, the pH of the quarg should drop by about 0·3 pH unit because of the activity of the YB culture, and the gel should become firmer. The required final pH of about 3·9–4·1 can be achieved by collecting the product in cans or other large vessels and allowing these to cool to ambient temperature overnight.

Adding Flavourings or Fat

Additives such as fruit preparations and cream can be mixed into the quarg at any time after the second homogenization, either by continuous metering or by batch mixing, but it is preferable to make the additions after the product has been held overnight. The mixture can then be filled into containers and finally firmed in storage at about 4 °C.

Packaging, Storing, Usage

This product can be packaged in plastic tubs similar to those used for American-style cottage cheese. The storage life under refrigeration is 4–6 weeks. Quarg has a wide range of uses, e.g. as a spread on bread or savouries, as an ingredient of salads, or as a base for dips.

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Controlled-atmosphere Stores for Fruit

The Blanket System

By R. Atkins
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Most cool stores used at present for controlled-atmosphere (C.A.) storage of fruits have the gas barrier attached to the insulated structure. There are disadvantages in this kind of construction regardless of whether the gas barrier is on the inside or outside surface of the insulation. Many of these disadvantages are avoided in the 'blanket' system for C.A. stores described in this article.

The disastrous effect of moisture in the insulation of refrigerated stores has been known for a long time but the introduction of C.A. storage with its demand for 'gas-tight' enclosures has put additional emphasis on the need to exclude moisture. A decade ago Lorenzen and Blanpied (1963) found that 'excessive moisture from condensation within wall and ceiling components is a prevalent condition in C.A. apple storage structures'. More recently, Ulrich and Sainsbury (1971) reported that 'the most serious problem encountered with commercial C.A. fruit storages is deterioration of the structure and gas seals due to moisture build-up behind the seal in rooms where the gas seal is placed on the inside face of the insulation'.

These comments highlight the risks involved in ignoring the fact that water vapour will migrate to the point of lowest vapour pressure in the store, usually the cooling coil. If migration is blocked by an impervious gas seal on the inside surface of the insulation, water vapour may condense or freeze in the insulation, depending on the temperature. In Australia, where for all practical purposes the vapour pressure of the external air is always higher than the vapour pressure within the store, vapour dams must be avoided in stores which are kept under refrigeration for extended periods. In stores built on the jacket system the jacket lining forms the gas barrier, leaving a space between itself and the insulation through which the primary cooling air circulates. This eliminates condensation within the insulation. Jacketed stores are expensive to build, however, because of the need to provide an air space under a load-bearing floor.

Features of the Blanket System

In the blanket system the gas barrier is separated from the insulated surfaces of the cool store by the primary air space (Fig. 1). The development of this system depended on the belief that it was not necessary to have an air space under the load-bearing floor.

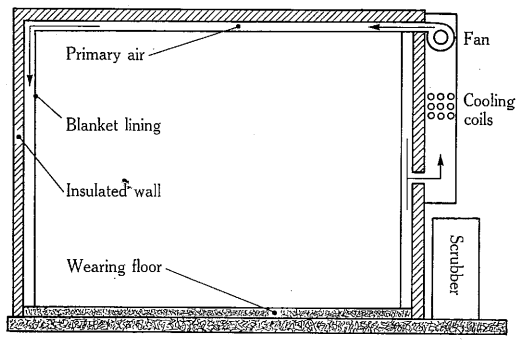

Fig. 1.—Section of blanket cool store.

The principal features of the blanket system are:

- A complete blanket of primary cooling air encloses all but the floor of the fruit storage space.
- Cold primary air does not contact the fruit during storage.

- The presence of the large secondary cooling surfaces comprising the walls and ceiling of the blanket allows a high R.H. to be maintained in the storage space because the system will operate with a small temperature difference.
- The blanket lining provides an ideal gas barrier for C.A. storage of fruit.
- The gas barrier is accessible for inspection and maintenance.
- The gas barrier does not form a vapour dam in the insulation, and so any moisture which penetrates the external vapour barrier is carried away to the cooling coils by the primary cooling air.
- Secondary circulating fans in the storage space ensure uniform temperatures throughout the load.
- Warm fruit may be precooled by opening the blanket, so that the colder primary air may enter the storage space and be circulated by the secondary fans until the fruit is cooled to the desired temperature; the blanket would then be sealed.

Plastic Tents as Gas Barriers

A blanket system using a prefabricated plastic tent as the gas barrier was developed in New South Wales by Holligan and Scott (1971) and similar rooms are in use in most States for C.A. storage. This approach is recommended as the best means of converting existing air stores to C.A. operation (Atkins and Holligan 1972).

However, if a new construction is planned the use of plastic tents may not be the most economical approach. The working life of a plastic tent is not certain, and it may be better to use a more durable construction so that maintenance is reduced in the long term.

Experimental Blanket C.A. Store

A blanket C.A. store having a capacity of 80 tonnes (4000 bushels) was recently built at the CSIRO Division of Food Research, North Ryde. This store is equivalent to a small-scale commercial store since the capacities of many Australian fruit cool stores range from 40 to 200 tonnes (2000 to 10,000 bushels) (Beattie 1968). The internal dimensions of the store are 8·75 m × 6·7 m × 5·8 m high (29 ft × 22 ft × 19 ft high) and it is designed to allow the use of forklift trucks for loading and unloading bulk bins and pallets. The gas barrier was built from 5-mm rotproof plywood.

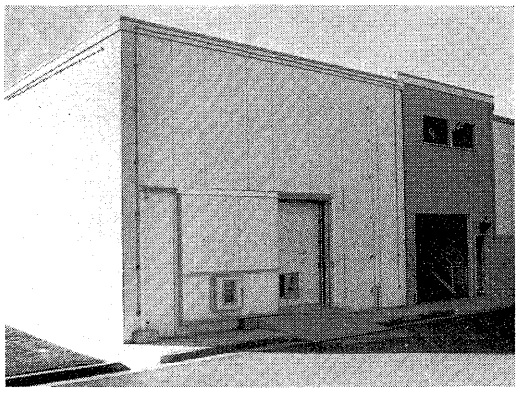

Fig. 2.—80-Tonne cool store.

Considerations in the design are discussed below.

Insulated Construction

The prefabricated panel-type structure of this size was self-supporting and was compatible with adjacent structures on the North Ryde site (Fig. 2). For the unshaded structure on the North Ryde site a thickness of 100 mm (4 in.) of foamed polystyrene was used in the walls and ceiling.

The need for floor insulation has long been a subject for debate (Sainsbury 1959). In the absence of information on ground temperatures and ground water levels any decision is arbitrary. The provision of floor insulation together with a concrete sub-floor represents a significant cost item and its elimination would therefore be of direct benefit to the industry.

Refrigeration

The amount of refrigeration required depends on the heat gain of the room, the cooling load of the fruit, the heat of respiration of the fruit, and also on the heat produced by fans, ventilation and scrubbing equipment, people, lighting, and heat entering the stores through opening of doors and infiltration.

Heat Gain of the Room

The recommendations for insulation (Atkins 1970) were based on an allowed design heat gain of 11 W/m^2 (3·5 Btu/hr ft^2). The external area of the insulated structure is 334 m^2 (3590 ft^2), so the heat gain of the room is 3674 W (12,500 Btu/hr) under design conditions.

Cooling Load of the Fruit

The recommended cooling rate is 25% of store capacity to be cooled at an average rate of 0·4 degC (0·75 degF) per hour (Hall, unpublished data 1965). Assuming the specific heat of the fruit is 4000 J/kg degC (0·95 Btu/lb degF) the fruit cooling load was 9000 W (31,000 Btu/hr).

Heat of Respiration

The heat released by the respiring fruit during the cooling period was taken as 72 W/t (250 Btu/hr ton) at 15°C (59°F), so that during cooling of 25% of the store capacity, the heat released from this source was 1440 W (4900 Btu/hr).

During long-term C.A. storage at 0°C (32°F) the heat of respiration is taken as 13 W/t (46 Btu/hr ton), so that the heat released by the full load of fruit was calculated to be 1040 W (3500 Btu/hr).

Heat from Fans

Both the primary and secondary fans and their motors are in the cooled air streams, and so all power used by them is a load on the refrigeration plant:

Primary fan	1860 W (2·5 hp)
Secondary fans	373 W (0·5 hp)
Total	2233 W (3·0 hp)

For a significant part of the long-term storage period, ambient temperatures are low and the rate of air circulation in the store may be reduced by about 50% with a saving in fan power.

Heat from Ventilation and Scrubbing

The consumption of oxygen by the stored fruit is estimated to be 0·057 m^3/t (2 ft^3/ton) per day. Therefore 20 m^3 (700 ft^3) per day of air will be needed to supply this oxygen, the refrigeration load being negligible. Similarly, the refrigeration load imposed by the process of scrubbing out excess carbon dioxide (CO_2) may be neglected.

Heat from People, Lighting, and Infiltration

These sources of heat are significant if cool stores are loaded and unloaded daily. However, C.A. stores are seldom opened and these heat loads may be neglected.

The total heat loads, including 10% safety margin, are 17,000 W during loading and cooling of the fruit and 8000 W during storage.

Selection of Equipment

The refrigeration load is heaviest when the store is being loaded with warm fruit during the summer harvest. At this stage accurate control of temperature and humidity is not practical, but when the fruit has been cooled to the desired storage temperature, precise temperature control and high humidity conditions are essential, and may be achieved with the blanket system.

A condensing unit of 9000 W (31,000 Btu/hr) was selected for the North Ryde installation for long-term storage and two such units were used for initial cooling.

Blanket Air Space

Air Paths

In the blanket system as distinct from the jacket system, there is no provision for air circulation below floor level. Cooled air from the fan/coil unit is directed across the ceiling to the far end wall where it passes down and across to the side walls and along these to the near end wall and back to the fan/coil unit.

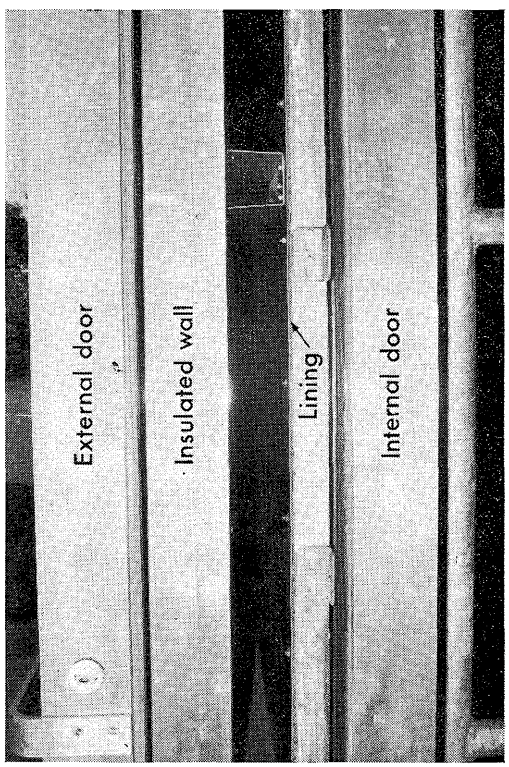

Fig 3.—Primary air space.

Air Temperatures

The work of Lentz (1960) and of others reported by the International Institute of Refrigeration (1966) indicates that the rise in the temperature of the air passing around the blanket should be between 1 and 2 degC. It was arbitrarily decided to limit the rise in air temperature within the blanket space to 2 degC during the storage period.

Air Volume

To control the temperature rise to 1–2 degC in the North Ryde store primary air was circulated at a rate of 1700 l/s (3600 cfm). For experimental purposes a primary fan was installed which was capable of handling twice this volume of air.

Air Velocity

Lentz and Anquez (1963) showed that air velocities from 0·7 m/s (140 fpm) to 5 m/s (1000 fpm) have been used in jacket systems and so an arbitrary decision was taken to adopt an air velocity of 2 m/s (400 fpm) for the North Ryde store. The blanket air space was treated as a rectangular duct of high aspect ratio and the air path width was calculated to be 90 mm (3·5 in.) (Lentz and Nakano 1961). This is the width of the air space between the insulated wall and the blanket lining (Fig. 3).

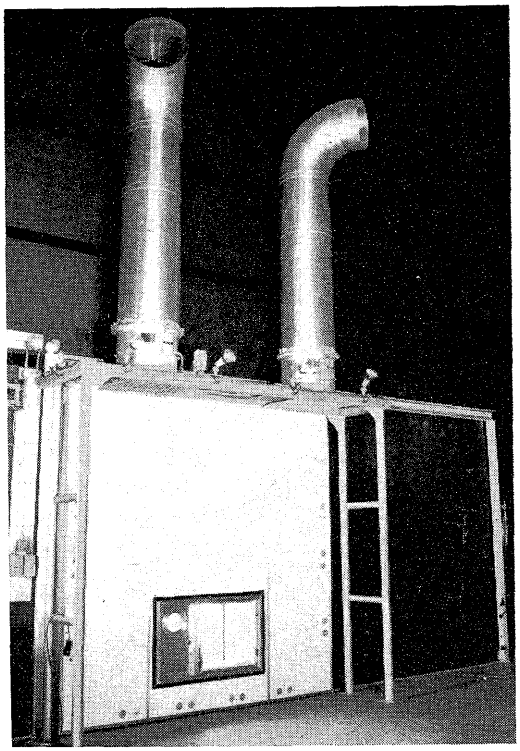

Fig. 5.—Secondary air fans.

Storage Air Conditions

The heat to be removed from the storage space during long-term storage includes heat of respiration, heat from the secondary fans, and heat gained through the floor. This heat is removed through the blanket lining and Figure 4 illustrates the factors involved. The major resistance to heat flow is due to the air films immediately adjacent to the plywood surfaces, and not to the plywood itself.

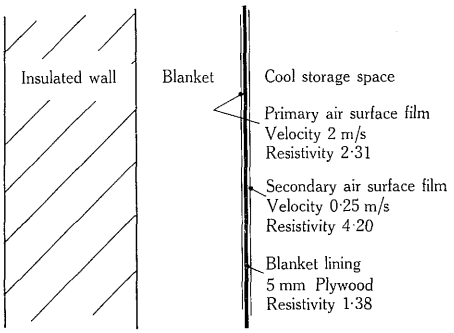

Fig. 4.—Heat transfer factors.

The mean temperature difference between the primary air and the air in the storage space should be about 1·5 degC, so that for a mean storage temperature of −0·6°C the initial temperature of the primary air should be about −3°C. The relatively low temperature difference across the blanket lining will result in the R.H. of the storage atmosphere being of the order of 90%.

Internal Air Circulation

The difference in temperature between different fruits within the storage space should not exceed 0·5 degC (Hall, unpublished data 1965). To maintain these conditions in the North Ryde store, secondary air was circulated at a rate of 1200 l/s (2500 cfm), or 0·015 l/s.kg (0·625 cfm/bus) of fruit. The movement of the air is affected by the stacking pattern of the load and for experimental purposes fans have been selected to provide air circulation rates up to 0·026 l/s.kg (1·0 cfm/bus) of fruit (Fig. 5).

Precooling

One of the alleged disadvantages of the blanket system is its supposed inability to handle high pull-down loads. It is planned to demonstrate that the combination of a large area of cooling surface, i.e. the walls and ceiling of the blanket, and adequate air circulation will give acceptable rates of initial cooling. Close control of conditions during pull-down is not important and so it is intended to investigate the effect of allowing primary cooling air to circulate within the storage space. This will be done by opening the door in the blanket until the bulk of the fruit has been cooled to the desired temperature.

Experimental Facilities

Floor Insulation

For experimental purposes floor insulation has been installed in the form of a 100-mm (4 in.) thickness of Foamglas* under a reinforced-concrete wearing slab of 125-mm (5 in.) thickness. To study the effect of the absence of floor insulation in commercial stores, Pyrotenax† floor heating cables have been embedded in the wearing slab, making it possible to impose a load of up to 2 kW (6824 Btu/hr), i.e. over twice the floor heat load likely to be met with in practice with an uninsulated floor.

Refrigeration

To cater for the possibility of carrying out experiments involving unusually heavy heat loads, e.g. produced by a high heat of respiration or by heat-producing equipment, a third refrigeration unit was provided in the North Ryde store to give a total refrigeration capacity of 27,000 W (92,000 Btu/hr).

The fan/coil unit is located outside the insulated structure for ease of maintenance. It is provided with triple-glazed inspection windows so that the frosting condition of the coils and the effectiveness of the water defrosting system may be observed.

* Registered trade name of Pittsburg Corning (U.S.A.).
† Registered trade name of Pyrotenax Ltd (U.K.).

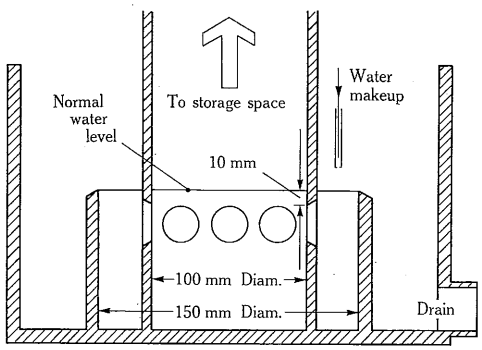

Fig. 6.—Pressure relief device.

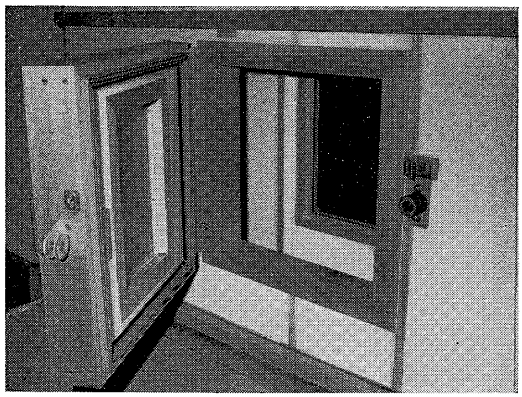

Fig 7.—Escape hatches.

Instrumentation

In addition to the usual facilities for monitoring temperature within the fruit stack and fan/coil unit, provision is made for measuring air temperatures and velocities in each section of the blanket, and ground temperatures under the centre of the floor slab at depths of 0·6 m and 2 m (2 ft and 6 ft). Equipment is provided to measure the pressure inside the C.A. space and to withdraw samples of the C.A. atmosphere for analysis of oxygen and carbon dioxide.

Safety

The sealed storage space is gas-tight so that fluctuations in barometric pressure greater than about 1 mb (0·4 in. WG) must be relieved; a pressure relief device was provided for this purpose (Fig. 6).

For safety of personnel, escape hatches were provided in both the inner and outer large doors (Fig. 7). Triple-glazed windows were fitted for observation of the store interior, and internal lighting is provided with a master switch located inside the store.

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Spoilage by Preservative-resistant Yeasts

By J. I. Pitt and K. C. Richardson

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Recently, Australian food manufacturers have complained of an abnormally high incidence of fermentative spoilage of carbonated beverages, cordials, and tomato sauce. A number of the outbreaks were investigated at the CSIRO Division of Food Research and in each case spoilage was found to be caused by yeasts which were not inhibited by the preservatives used. The authors describe some of the outbreaks and the characteristics of the most important yeasts involved, and give details of possible preventive measures.

Outbreaks of Spoilage

Carbonated Beverages

We have found that spoilage has occurred in both canned and bottled carbonated drinks; in two of the outbreaks containers exploded, resulting in injury and damage to property.

The canned product was a pulpy fruit-based beverage of 12 °Brix and pH 3·2, packed at a low carbonation level (1·7 to 1·9 vols) and preserved with the maximum permitted concentration of benzoic acid (400 mg/kg). Two species of yeast were isolated from spoiled product, sometimes both from a single can and at other times in pure culture. The yeasts were identified as *Saccharomyces bailii* (more commonly known as *S. acidifaciens*) and *Torulopsis holmii*.

The spoiling bottles examined were from the same production run as some which had exploded during storage at high summer temperatures. The beverage was of pH 3·25 and 13 °Brix; it had been packed at a low carbonation level in 26-oz containers. It was preserved with a low level of sulphur dioxide plus the maximum permitted additional concentration of benzoic acid. When examined the spoiled bottles were under very high CO_2 pressure and typically contained about 10^6 cells/ml of *Saccharomyces bailii*.

Cordials

The samples examined were of a raspberry-based cordial (pH 3·05 and 35 °Brix), packed in plastic bottles. Despite the presence of more than 600 mg/kg benzoic acid, the yeast *Saccharomyces bailii* was causing a vigorous fermentative spoilage.

Tomato Sauce

Several manufacturers in Sydney and Melbourne have recently experienced spoilage in tomato sauce. A number of different yeasts were apparently involved. In one case a confluent film of yeasts was visible on the sides of half-consumed bottles. Several yeasts were isolated, the predominant one being *Pichia membranaefaciens*, a well-known cause of spoilage in acid and pickled products. In other instances the spoilage caused the bottles to explode from the pressure of carbon dioxide produced by the fermentative yeasts. The case histories in this type of spoilage were frequently curious; the bottles had been stored for months uneventfully but when they were first opened, consumers reported that they were under slight pressure. After reclosing, the bottles were usually stored at ambient temperatures; they exploded only a few days later. One manufacturer reported that the spoilage was sporadic, at the rate of about one bottle per million produced. Samples of sauce from exploded bottles contained very high yeast cell populations, typically of *Saccharomyces bailii*, but sometimes of an undescribed *Pichia* species.

In another outbreak occurring in sauce packed in sachets for single-portion servings, fermentative spoilage caused the sachets to burst. Two yeast species were isolated, *Candida krusei* and *Torulopsis stellata.*

Alcoholic Products

In recent months, spoilage of alcoholic cider and some wines has occurred, due to the formation of an undesirable sediment. In some of the cases this has been shown to be caused by *Saccharomyces bailii.*

Cultivation and Examination of Yeasts

Traditionally yeasts have been cultivated on malt extract (5%) agar (2%), but yeast extract (0·5%) glucose (2%) agar (2%) is also suitable. Yeast isolates should be purified by streaking: the most satisfactory results are obtained if the inoculum, a small loopful of cells, is first dispersed in about 3 ml of sterile water.

Microscopic examination can be made satisfactorily with unstained cells if they are dispersed in a drop of water on a slide; this is then covered with a cover slip, and surplus water is removed with a tissue. Although phase-contrast optics give best results, yeast cells mounted in this manner may be readily observed using normal bright-field optics.

It is important to know whether a particular yeast isolate is able to ferment, i.e. whether it is able to grow in the absence of oxygen, because a non-fermentative yeast cannot spoil carbonated beverages or unopened vacuum-packed sauces. Yeasts growing anaerobically always produce carbon dioxide and this may be detected by the standard bacteriological test for gas, using a Durham tube. A suitable medium for testing for yeast fermentation is yeast extract (0·5%) glucose (5%); other sugars may be substituted for glucose if desired.

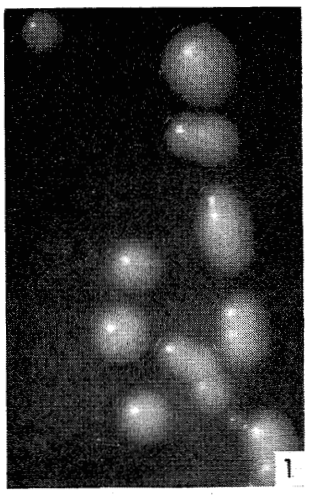
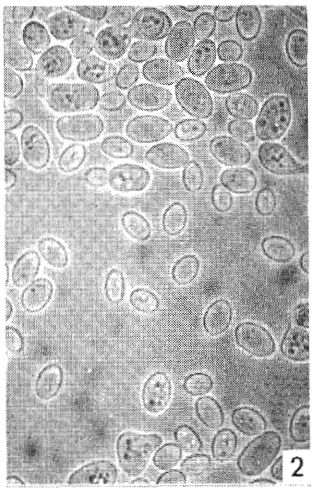
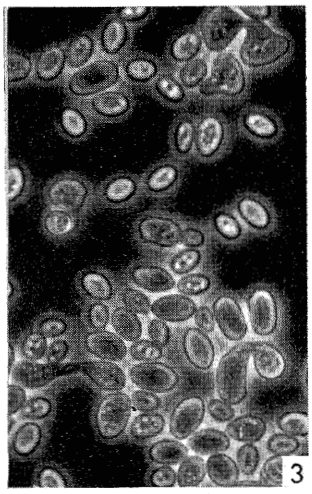
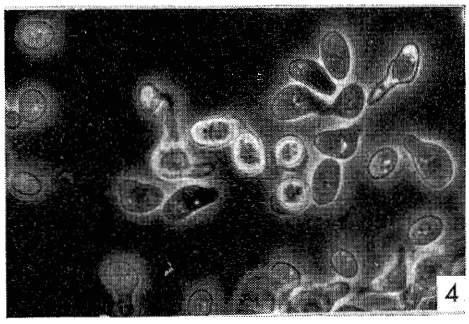
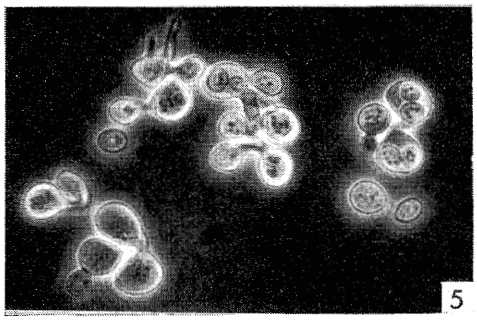
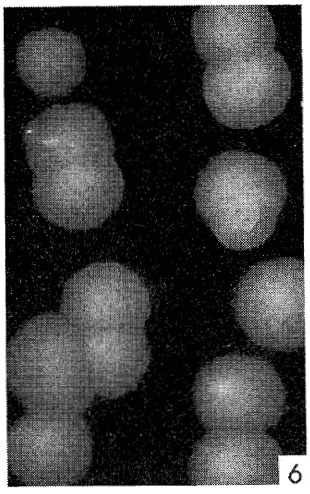
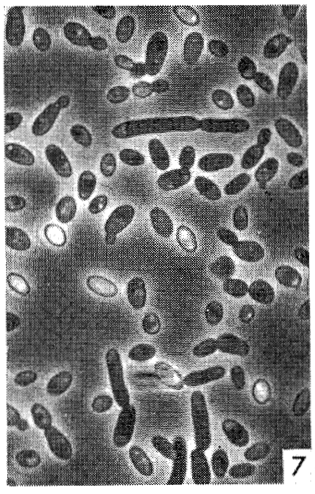
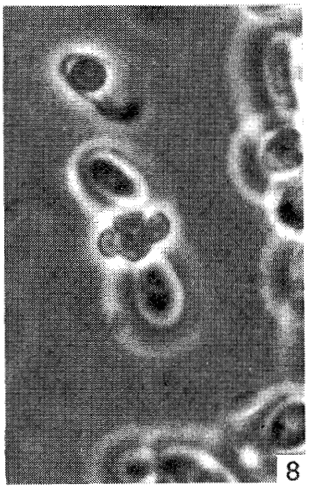
Selective Media

Although many kinds of yeast can occur in food processing plants, it is often more useful to monitor levels of potential spoilage yeasts than total numbers of all species. The use of selective media is recommended for this purpose. If a food plant manufactures products containing acetic acid, it is suggested that malt extract agar containing acetic acid (0·5%) be used. The acid should be added to the medium just before pouring. For products containing benzoic or sorbic acid, the malt extract agar is acidified just before pouring, to about pH 3·5 (1 ml of 4% H_3PO_4 per 100 ml medium is suitable), and 200 mg of benzoic acid per kilogram of medium (2 ml of 1·2% sodium benzoate per 100 ml) is added. The preservative-tolerant yeasts which are likely to cause spoilage will grow well on these media but most other microorganisms will not.

Significant Spoilage Yeasts

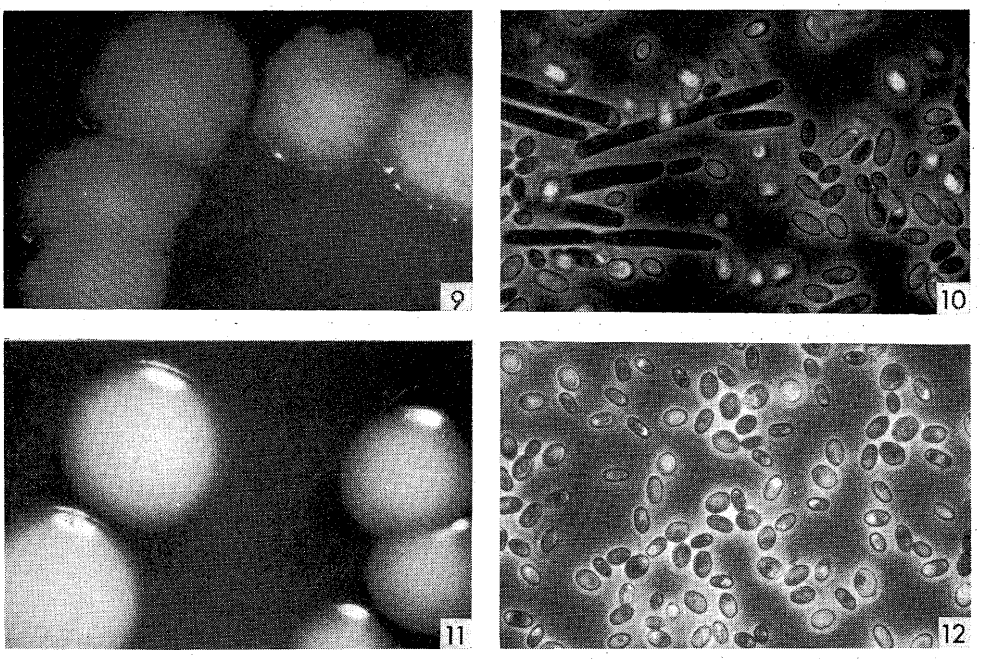
The identification of yeast isolates is difficult and in general must be left to specialists. Only a few species, however, cause economically significant spoilage, and it is possible to identify these with fair reliability from their morphology and ability to grow on media which contain preservatives.

Saccharomyces bailii is undoubtedly the

Figs. 1-5.—*Saccharomyces bailii.* Fig. 1.—Colonies on malt extract agar after 3 days at 25°C.× 5.5. Fig. 2.—Cells, bright-field optics. × 675. Fig. 3.—Cells, phase-contrast optics. × 675. Figs. 4 and 5. —Conjugating cells, asci, and ascospores. ×675.

Figs. 6-8.—*Pichia membranaefaciens.* Fig 6.—Colonies on malt extract agar after 3 days at 25°C. ×5.5. Fig. 7.—Cells, phase-contrast. ×675. Fig. 8.—Ascospores adhering in a clump. ×1675.



Figs. 9-10.—*Candida krusei*. Fig. 9.—Colonies on malt extract agar after 3 days at 25°C. × 5.5.
Fig. 10.—Cells, phase-contrast. ×675.
Figs. 11-12.—*Torulopsis holmii*. Fig. 11.—Colonies on malt extract agar after 3 days at 25°C. ×5.5.
Fig. 12.—Cells, phase-contrast. × 675.

most troublesome spoilage yeast in Australia at present. It is able to grow at pH 3·2 under 60 p.s.i.g. carbon dioxide in the presence of either 600 mg/kg sorbic acid, 700 mg/kg benzoic acid, 2% acetic acid, or 15 mg/kg free sulphur dioxide.

Saccharomyces bailii colonies grown from streaks on malt extract agar are always small; after 3 days' incubation at 25°C they are less than 2 mm in diameter and after a week they are still smaller than 3 mm in diameter. The colonies are almost hemispherical, with a circular margin and a glistening surface (Fig. 1). Mounted in water and examined with bright-field (Fig. 2) or phase-contrast optics (Fig. 3), the cells are large and ellipsoidal, typically 5–8 μm × 3–5 μm, and only rarely adhering in chains. Unlike most yeasts, typical *S. bailii* strains will sporulate on malt extract agar within 1 week at 25°C. The asci (sporulating cells) are distinctive; they are formed by conjugation (union) between two vegetable cells and have dumb-bell or more bizarre shapes. Under high magnification, the asci can be seen to contain one to four spheroidal to ellipsoidal spores (Figs. 4 and 5). In fermentation tests, typical strains of *S. bailii* produce gas from glucose, and sometimes a small amount from galactose, but not from maltose, sucrose, lactose, or raffinose.

On malt extract agar containing 0·5% acetic acid, or 200 mg/kg benzoic acid at pH 3·5, growth of *S. bailii* is only slightly slower than on malt extract agar alone.

Pichia membranaefaciens

At 3 days, colonies on malt extract agar are typically 2 to 3 mm in diameter, with an irregular margin (Fig. 6). They are convex but not hemispherical, with a matt or sometimes glistening surface. Many cells are small (Fig. 7) with larger ones cylindrical, 7–10 μm × 3–4 μm. Sporulation does not usually occur on malt agar, but has been regularly observed on malt extract agar containing 0·5% acetic acid. Asci are formed from a single cell and usually contain four tiny spores shaped like a bowler hat. Asci quickly rupture but the liberated spores frequently adhere in clumps (Fig. 8). In fermentation

tests, *P. membranaefaciens* slowly produces gas from glucose only.

On malt extract agar containing 0·5% acetic acid or 200 mg/kg of benzoic acid at pH 3·5, growth is slower than on malt extract agar alone, but colonies are macroscopic at 3 days. In fact, such colonies are formed in 3 days even in the presence of 1% acetic acid.

Candida krusei

At 3 days, colonies on malt extract agar are typically 3–4 mm in diameter, with an irregular lobate margin (Fig. 9), and a convex, matt surface. After 1 week the colonies are distinguished by their large size (5–8 mm diameter), filamentous margins, and wet, fungal appearance. Cells if small are oval (3–4 μm × 2–3 μm), but long cylindrical cells (10–25 μm × 3–4 μm) are also characteristically present (Fig. 10). Ascospores are not usually formed. *Candida krusei* is able to ferment only glucose.

Growth in the presence of 0·5% acetic acid, or 200 mg/kg of benzoic acid at pH 3·5, is as rapid as on malt extract agar. Growth is also strong in the presence of 1% acetic acid.

Torulopsis holmii is a rapidly growing yeast; colonies at 3 days are 4–5 mm in diameter, circular with a smooth margin, and have a low convex glistening surface (Fig. 11). Cells are typically small and nearly globose (3–5 μm diameter), adhering in short chains (Fig. 12). Elongated cells are also formed by some strains. Ascospores are not produced as a rule. *Torulopsis holmii* ferments glucose, galactose, sucrose, trehalose, and raffinose.

In the presence of 0·5% acetic acid or 200 mg/kg of benzoic acid at pH 3·5, *T. holmii* grows relatively poorly, and it does not produce macroscopic colonies within 3 days in the presence of 1% acetic acid.

Measures for Factory Control

Tomato Sauce

Tomato sauce is heated before filling and so opportunities for contamination by viable yeast cells are minimal. The preservative-resistant yeasts discussed above are not unusually heat-resistant and temperatures reached in the manufacture of tomato sauce (82–88°C) will kill any yeast present in the ingredients.

The source of contamination in this product may then be either the cap of the bottle or the cooling water through which the filled, capped bottle is passed. Inverting the sealed bottle after filling so that the hot product pasteurizes the cap is an effective procedure provided the hot sauce is in contact with the cap for sufficient time; 60 s would be adequate. When this procedure is not feasible, as with high-speed production lines, the caps should be heated with live steam before being placed on the bottle. Strict attention should be paid to the installation and operation of the steaming equipment to ensure it is performing satisfactorily.

The greatest source of contamination after processing is the water in which the bottles are ultimately cooled. No capping process currently in use can guarantee absolute sealing efficiency and even momentary leakage due to temperature stress or physical abuse can pose a potential spoilage hazard.

Cooling water must be of a high standard bacteriologically and comparable to that recommended for canneries. The need to use high-quality water for cooling has not received enough attention from many processors because it is wrongly supposed that tomato sauce is protected by its high acetic acid content. It is now clear that while most post-processing contaminants could not proliferate in tomato sauce, a low inoculum of the yeasts described in this article may spoil the product.

It is recommended that the cooling water be disinfected by the use of chlorine gas or hypochlorite solution. However, experience in the canning industry has shown that although chlorination is reliable a number of conditions must be met before satisfactory disinfection is achieved. The water should have 2–5 p.p.m. free chlorine when it reaches the point of use and it should have been in contact with the chlorine for at least 30 min before use.

Addition of the requisite amounts of chlorine is usually carried out by the use of automatic dosing equipment. Care must be taken in the siting of these chlorinators and storage tanks to ensure that the necessary contact time always takes place before the chlorinated water contacts the bottles. Frequent testing of free chlorine levels is necessary and the water should be examined microbiologically to determine the efficiency of the chlorination treatment. Details of procedures for testing for free chlorine are

given by Thorpe and Everton (1968) and the National Canners Association (1968).

Carbonated Beverages

Plant sanitation in the soft drink industry has undergone a number of changes in recent years. In the past, washing of equipment followed by immersion in cold chlorinated water and then a cold water rinse was sufficient. When the industry began marketing drinks with a comparatively high fruit juice content and low carbonation, a stricter level of sanitation was needed to prevent spoilage. When these beverages were canned the risk of spoilage became still greater because sulphur dioxide could no longer be used as a preservative.

More stringent sanitation programmes were introduced. These now usually involve rinsing the equipment in cold water, washing it thoroughly in hot caustic solutions, rinsing it again in cold water, and then circulating cold chlorinated water through it. The time of contact of the chlorine with the equipment is important and the longer the contact time the better. The contact time will vary with the processing schedule of the plant but it should not be less than 30 minutes. To remove the chlorinated water, a cold water rinse is used before production starts.

Data obtained from commercial manufacturers indicate that in-place or manual cleaning of tanks, piping, and pumps can be effectively carried out on a routine basis. Proper quality control before mixing the drink will ensure a minimum initial microbiological load in the bulk product which in many cases can be reduced to nil. If in-plant sanitation is carried out properly and if the product has a low initial load of microbial contamination, spoilage should not occur.

When preservative-resistant yeasts are found in spoiled products a common source of contamination is the filler. Some fillers used in the soft drink industry are difficult to clean; in the past too little attention has been paid to this aspect when decisions were made to purchase machinery. It is often necessary to dismantle some parts of the filler to permit physical cleaning before washing and sterilizing. Usually the most difficult parts to clean are in the filling heads themselves where fruit pulp may remain for some time between shifts. The microbial population which builds up in the pulp progressively contaminates fresh product. Steam sterilization of these parts of the equipment should be carried out before re-assembling and chlorination.

How frequently the filler will need to be dismantled and sterilized should be determined by the quality control personnel after a detailed investigation of the microbial status of the equipment over a period of weeks during which normal cleaning procedures are followed. Production staff may be reluctant to introduce major sanitation operations especially during peak production periods, which usually occur in the summer months. Unfortunately this is the time when sanitation standards must be at their highest if serious losses from spoilage are to be avoided. Sanitation is one of the essential prerequisites for sound production in the food and beverage industries, and the costs of maintaining satisfactory sanitation standards are well warranted.

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THORPE, R. H., and EVERTON, J. R. (1968).—Post-process sanitation in canneries. Tech. Man. Fruit Veg. Pres. Res. Ass. No. 1.

A Relative Humidity Sensor

For Work at Low Temperatures and High Humidity Levels

By A. J. Carseldine

Division of Food Research, CSIRO, Cannon Hill, Qld.

The refrigerated storage of meat and meat products requires close control of both temperature and relative humidity to prolong storage life at optimum quality. A sensor with fast response and good stability has been developed which can be used to monitor and control relative humidity conditions in chillers and storage rooms.

In the measurement of temperature, the instruments used depend for their operation on an accurately known property which can be checked against accurate and reproducible fixed points. The measurement of relative humidity (R.H.), however, depends on the relationship between two properties, temperature and vapour pressure, either of which can vary independently of the other. The problem is made more acute by the usual temperatures at which chillers and cold stores operate; at temperatures near 0°C, a small change in either parameter results in a relatively large change in R.H.

Many methods have been devised for the measurement of R.H., and Szulmayer (1969) presented a good survey of instruments likely to be useful in food research and in the food industry. Unfortunately no device or instrument is available which includes all of the features desired for this particular application; the most important requirements include fast response, stability, low hysteresis, the ability to operate either from power supply or from batteries, and the ability to transmit the desired information to a remote point so that it can be monitored, recorded, and/or controlled (Carseldine 1972). We have now devised an instrument which meets most of the requirements for a good sensor, and which may prove extremely useful to the food industry.

Construction

Sensing elements are constructed using 35 mm × 22 mm grids of stainless-steel gauze as the electrodes, rigidly held in closely spaced relationship and insulated from each other. To ensure even spacing of the electrodes, and the maximum possible area of electric path at that spacing, electrodes are pressed flat in a hydraulic press after cutting to size. An electric lead is attached to each electrode, and they are then assembled in pairs with a spacing of 0·037 mm, care being taken to maintain the alignment of the interstices of the grids. A thin seam of epoxy resin adhesive is applied along each longitudinal edge of the assembly and allowed to cure.

Small electric plugs are attached to the elements and they are then coated with the active material. This material, Hydrocal

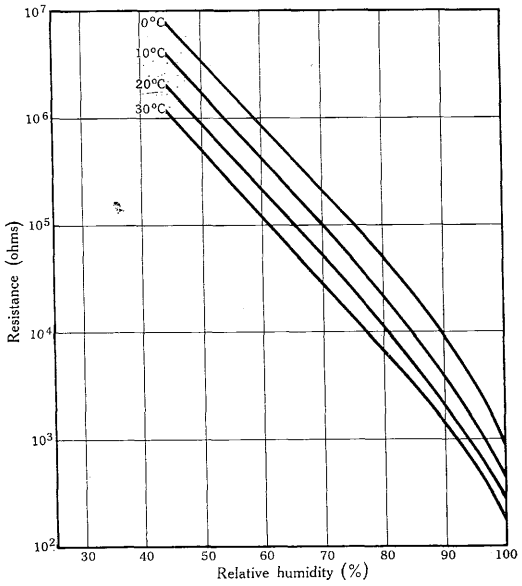

Fig. 1.—Typical resistance *v.* R.H. isotherms.

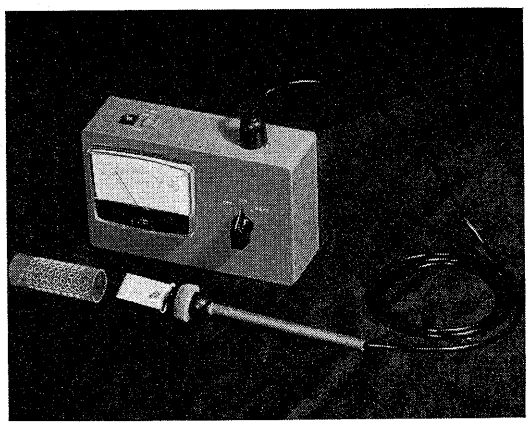

Fig. 2.—Relative humidity sensor and meter (protective cover removed to show sensor).

Gray,* is a commercial grade of gypsum which, on mixing with the correct amount of water, sets in a manner similar to that of plaster of Paris. As it is considered that the only useful material is that directly in the electric path between the opposing wires of each electrode, the material in the interstices of the grids is removed by blowing a stream of compressed air through the assembly, immediately after coating.

The electrodes are then placed over water in a closed container to allow setting without loss of water. After two days they are removed and allowed to age in room air for at least one month before calibration. Calibration is performed in a divided-flow humidity generator at temperatures between 0°C and 30°C at 10-degC intervals. R.H. is cycled in steps of 5% from 40% to 100% and back to 40%, the resistance of the sensors being recorded at each step; resistance *v.* R.H. isotherms is then plotted. A typical set of calibration isotherms is shown in Figure 1.

* Registered trade name of the U.S. Gypsum Co.

Operation

When the sensor is exposed to the atmosphere, the active material absorbs or desorbs water vapour to equilibrate with the water vapour pressure of the atmosphere. If an electric potential is impressed across the sensor, the current flow is proportional to the water vapour absorbed by the material. With devices of this nature, alternating potential must be used, since the use of direct current will cause polarization and permanent damage to the sensor.

Sensors are calibrated at 50 Hz, as this is the frequency of a.c. mains supply and it permits instruments in fixed installations to be operated from the mains supply. As the sensors have capacitive reactance as well as resistance, there would be a deviation from the original calibration, particularly in reading low R.H. values, if they were used at other frequencies.

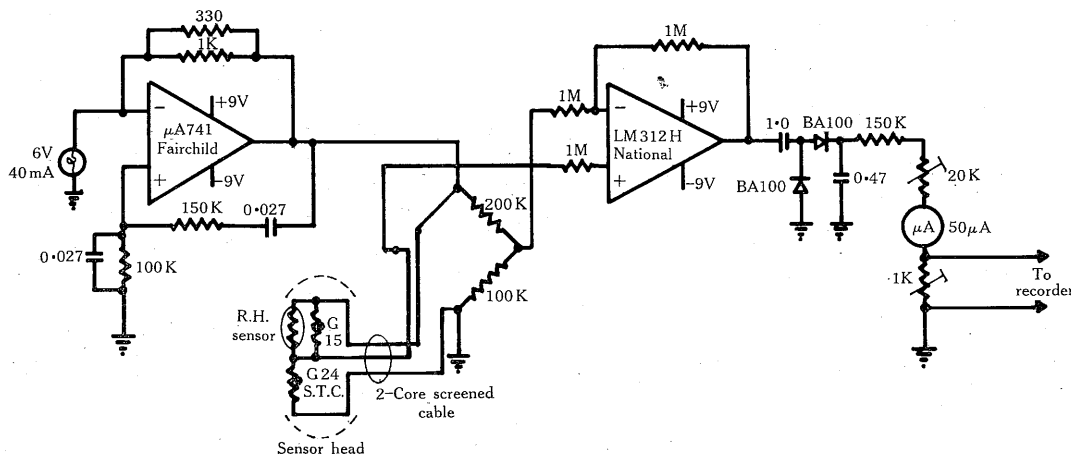

Fig. 3.—Circuit for humidity meter.

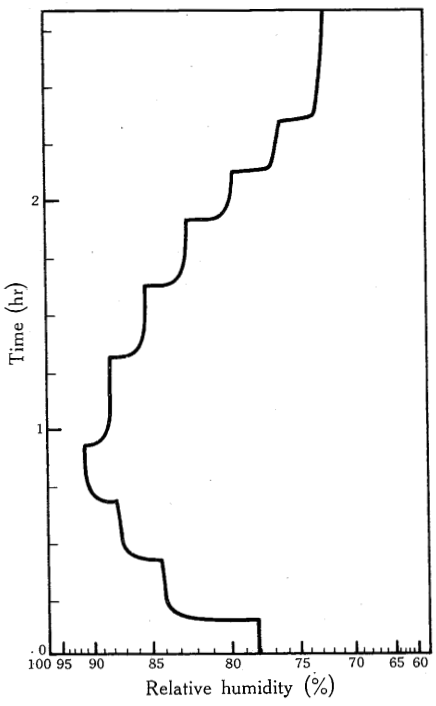

Fig. 4.—Response to step changes of R.H.

Portable meters have been built (Figs. 2 and 3) which can be operated either from a battery or from a.c. mains. In these instruments, thermistors are incorporated in the sensing head, adjacent to the sensor, to compensate for a shift in indicated R.H. of approximately 0·5% per degC change in air temperature. These meters indicate R.H. over the range of 60% to 100%, from 0°C to 30°C, with an accuracy of better than ±2%.

Provision is made for a d.c. output signal from the meter to operate a potentiometric recorder and/or a controller. In the majority of cases, the R.H. range that is of interest to the user is between 70% and 100%, and so the meters are calibrated with a lower limit of 60%.

Performance

The sensors have been subjected to extensive laboratory and field trials and have shown good stability and speed of response. As was to be expected, air speed over the sensor has a marked effect on time taken to respond. Figure 4 shows the response to step changes of R.H. at 0°C with an air speed of approximately 11 cm/min over the sensor. This recording was taken with the sensor in a divided-flow humidity generator, the R.H. settings being monitored with wet- and dry-bulb thermistors. The speed of response of the sensor was almost identical to that of the wet-bulb thermistor, when R.H. conditions in the generator were altered.

When the sensor is used for monitoring R.H. conditions in cold rooms, and is taken from normal ambient air into the refrigerated space, it will equilibrate in about 3 to 4 min—about the same time as that required by a mercury-in-glass thermometer.

A sensor is incorporated in the control system of a wind tunnel in this laboratory, to monitor and control R.H. conditions. It is capable of controlling atmospheric conditions to within ±0·5% of the indicated R.H. The device has been patented and negotiations are proceeding to have it manufactured under licence in Australia.

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SZULMAYER, W. (1969).—Humidity and moisture measurement. *CSIRO Fd Preserv. Q.* **29**, 27–35.

ERRATA

CSIRO Food Research Quarterly

Volume 33, Number 3, September 1973

Page 60, line 35: 'packing in PVC or in a wide range of substrates coated with PVC' *should read* 'packing in a wide range of substrates coated with PVDC.'

Page 64, third paragraph: 'Magnus Taylor' *should read* 'Magness-Taylor'.

Supplement, item on 'Sour Rot': '*Gleotrichum*' should read '*Geotrichum*'.

Gosford Citrus Wastage Research Laboratory

By E. G. Hall
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The Citrus Wastage Research Laboratory was opened in October 1948 to give urgent assistance to the industry in finding a remedy for mould wastage in oranges. Since its establishment, the Laboratory has worked on many problems of importance to the successful marketing of citrus.

Development of Gosford Laboratory

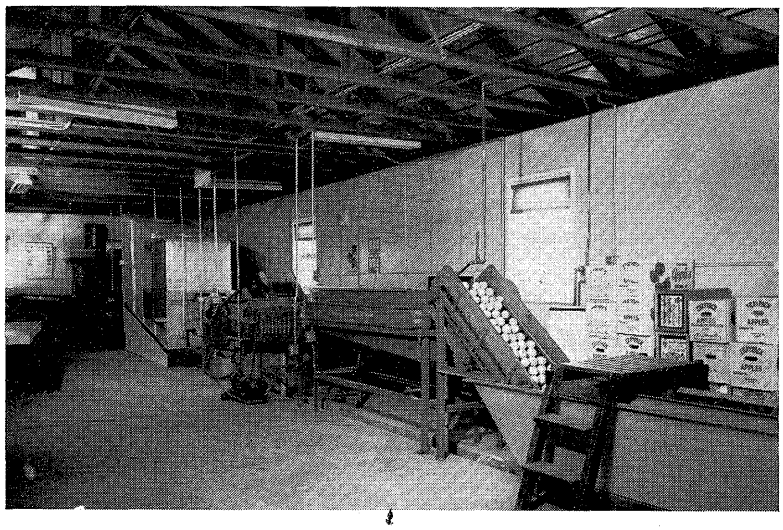
Citrus

The problems of wastage in fresh citrus fruits during marketing have been of major interest to the Division of Food Research and the New South Wales Department of Agriculture since before World War II. Attempts to establish the export of citrus to the United Kingdom were frustrated by frequent high wastage due to both rotting and cold injury; and mould wastage was frequently excessive on the established markets in New Zealand and Singapore. Under the direction of the Citrus Preservation Technical Advisory Committee, cooperative investigations were undertaken by CSIR, the forerunner of CSIRO, and the Departments of Agriculture in New South Wales, Victoria, and South Australia. The investigations defined effects of variety, maturity, and storage conditions on storage life of citrus fruits and studied the effects of various pre-storage treatments on fungal and physiological wastage. This work was reported by Huelin (1942).*

However, despite increasing use of borax, which had been shown in the early work to reduce mould wastage, attack by green mould on citrus fruits from the important coastal areas of New South Wales continued to cause serious losses on local markets.

In response to urgent requests from the industry, the CSIR Division of Food Pre-

* HUELIN. F. E. (1942).—The handling and storage of Australian oranges, mandarins, and grapefruit. Coun. sci. industr. Res. Aust. Bull. No. 154.



Experimental citrus washing and waxing plant where techniques of fungicide application are tested.

CSIRO Fd Res. Q., 1973, **33**, 89–92

servation (as it was then called) and the N.S.W. Department of Agriculture agreed to establish and operate a special laboratory at Gosford, N.S.W., to investigate problems of wastage in citrus fruits during marketing. The Citrus Wastage Research Laboratory was opened in October 1948 and was located in space made available in the Sungold Co-operative Citrus Packing House, Pacific Highway, West Gosford. In 1963 it was necessary to move the Laboratory into a new building on its present site on the opposite side of the highway. The permanent staff has been provided by the Department, and CSIRO has met building and running costs.

The broad objectives of the Laboratory have been to define the best methods of handling and treating citrus fruits destined for local or overseas markets. Areas of investigation have included cleaning of the fruit, control of mould wastage, waxing, degreening, and other treatments designed to maintain the fruit in sound, fresh condition. Effective control of green mould, due to attack by *Penicillium digitatum*, has been a major concern as it is the principal cause of wastage in citrus fruits after harvest. Another important project has involved the storage of lemons from the main crop in the winter until the summer, when returns are greater. Control of stem-end rot caused by *Diaporthe citri* has been extensively studied as it is the cause of considerable wastage in stored lemons and also in coastal oranges during storage or extended marketing.

Fruit Disinfestation

Since 1950 the Gosford Laboratory has been the base for cooperative studies to develop effective and safe methods for the post-harvest disinfestation of various fruits against the Queensland fruit fly (*Strumeta tryoni*). This fruit fly, which has a wide host-range, is widespread in eastern Australia and has penetrated into the Murrumbidgee Irrigation Area and parts of Victoria. Wherever it occurs, it causes serious disruption to the fruit trade with those Australian States and countries overseas that have quarantine barriers against the pest.

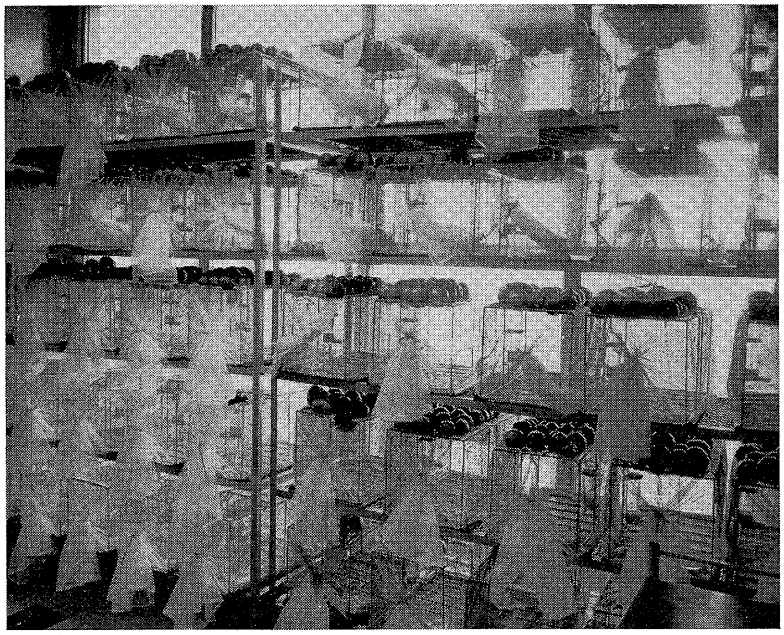
Work commenced at Gosford with an examination of the application to Australian citrus fruits of the vapour heat treatment being used in Hawaii against the oriental fruit fly in papaws. In 1955 investigations were intensified, and were extended to study treatment of citrus fruits by cold, by fumigation, and by gamma irradiation. They formed the major part of cooperative studies with the Departments of Agriculture in Victoria and South Australia and, later, with the Departments in Queensland and Western Australia. Since then the work has been extended to cover other host fruits important to trade. Quite recently, as a matter of urgency, and with the cooperation of the CSIRO Division of Entomology, investigations have commenced to develop a safe and effective treatment for apples and pears against the light brown apple moth (*Epiphyas postvittana*), whose presence in these fruits has disrupted a promising export trade with North America. Because of Japanese quarantine requirements work on treatments against the Mediterranean fruit fly is under way in Western Australia, where it is endemic; it no longer occurs in eastern Australia. All the work on disinfestation is now coordinated by a Commonwealth and States Fresh Fruit Disinfestation Committee.

In 1963, extensive alterations and additions were made to the laboratory at Gosford to cope with expanded work in the two fields of citrus wastage and treatment against fruit fly. This year, a large special building has been constructed to house all the post-harvest disinfestation investigations, including a large unit for breeding fruit flies, and this has greatly improved facilities for work in both fields.

Achievements

Citrus Fruits

In the principal work on fungicides, more than 150 compounds have been tested against green mould and stem-end rot, but very few have been both effective and safe. Although it can be phytotoxic, sodium orthophenylphenate (SOPP) has been both effective and safe when correctly used. The value to the industry of the double treatment with SOPP, developed by the Laboratory and recommended some 15 years ago, has been estimated at $1·5 million a year. However, safe use of SOPP is a somewhat troublesome procedure, requiring careful control of the pH of the solution, immersion of the fruit for two minutes, and subsequent rinsing, and so the search for a better fungicide has continued. Nevertheless, when combined with the use of individual fruit wraps impregnated with the



A colony of Queensland fruit fly infesting tomatoes, in experiments to test the efficacy of disinfestation treatments.

volatile fungistat diphenyl, export fruit has been well protected and the slight diphenyl taint has not worried most consumers.

In recent years, benzimidazole compounds have been shown to be more effective than SOPP, especially in longer storage, and they are free from risk of injury to the rind of the fruit. Current recommendations are for a flooding spray or dip treatment for 30 s with either thiabendazole (TBZ) at a concentration of 1 g/l or benomyl at 0·5 g/l. A somewhat similar compound, methyl thiophanate, is also very effective against green mould, and against stem-end rot and blue mould caused by *Penicillium italicum*. Unfortunately, all are virtually insoluble in water and have to be used as wettable powders; moreover, they are ineffective against the black centre rots caused by *Alternaria*, which can develop during long storage.

The laboratory has recommended best ways of waxing citrus fruits, to reduce shrinkage and improve the appearance and sales appeal of the fruit, by dip, foam, or spray application of water-based wax emulsions. Early in the season, Navel oranges and mandarins may become palatable before the rind has lost its green colour, and late in the season Valencia oranges may regreen on the tree. Such fruit can be de-greened by exposure to ethylene gas. Conditions for most effective treatment have been defined and special methods have been developed for control of mould wastage during de-greening.

Workers at Gosford in cooperation with others in the North Ryde Laboratories are achieving considerable success in the long storage of lemons by treating them with gibberellic acid (GA) and 2,4-D to retard aging, and with benomyl to control rotting; the fruit is then stored in an atmosphere that is kept free from ethylene (an active aging and ripening agent) by passing the storage air through special scrubbers. This work is being extended to the long storage of Valencia oranges as there could be considerable advantages in storing the fruit after harvest rather than holding it on the tree during summer where it competes with the developing next crop. The application of controlled-atmosphere (C.A.) storage to citrus fruits is also under study but the benefits have not so far been outstanding.

Fruit Disinfestation

The early cooperative studies by the CSIRO Division of Food Preservation and the N.S.W. Department of Agriculture showed that the

vapour heat treatment was not practicable because of fruit injury, and work on developing a cold treatment against fruit fly proceeded. In 1956 the New Zealand quarantine authorities decided to accept Australian oranges from areas where Queensland fruit fly was present provided the fruit had been treated by holding at $-0{\cdot}5\pm0{\cdot}5$°C for 14 days.

Fumigation of fruit with ethylene dibromide (EDB) for two hours had been shown in Hawaii and California to be a satisfactory disinfestation treatment against fruit flies. Investigations into the application of this method to Australian citrus fruits were commenced in 1956. Following extensive studies of dosage rates, temperature, and load in the fumigation chamber in relation to kill of flies and fruit injury, EDB fumigation was accepted by New Zealand authorities for unwrapped oranges in 1961 and for wrapped and packed fruit in 1964. As a result of three years' work by the Gosford Laboratory, United States authorities, in 1967, accepted a cold sterilization treatment for apples and pears imported from Australia. This treatment is now applied while the fruit is in transit in the refrigerated holds of ships. In other work, fumigation with EDB has proved satisfactory for Eureka lemons and Emperor and Beauty of Glen Retreat mandarins, but there has proved to be considerable risk of rind injury with Marsh grapefruit and Ellendale mandarins, our main export variety of this fruit.

More recent work has concerned bananas and tomatoes, mainly to assist interstate trade. Fumigation with EDB proved satisfactory for bananas but not for tomatoes, because of fruit injury at the higher dose levels required for this fruit. Dipping of bananas in the insecticide dimethoate, a treatment which would more readily fit in with industry practice, was found to be effective and practicable and both methods are now accepted by State authorities. Work with tomatoes is continuing and treatment with a rather high concentration of dimethoate is showing promising results.

Because of potential export markets in Japan, work on disinfestation of citrus fruits is being repeated to satisfy the special Japanese security requirements. These stipulate that three separate lots of 10,000 of the most resistant stage of the fruit fly must be treated, with no survivors, to prove the efficacy of the method.

The investigations to develop acceptable quarantine disinfestation treatments are slow and laborious as the fruits have to be artificially infested, and many thousands of flies have to be killed to prove a particular treatment. They are important to the fruit and vegetable industries because of constraints on interstate trade and denial of export markets, and they will be continued in cooperation with other states.

Studies to develop a treatment against the light brown apple moth were commenced in 1972 and already a combination treatment of fumigation with methyl bromide followed by cold storage has been accepted by Canadian authorities. The work is continuing in order to broaden the range of acceptable conditions of treatment, and to provide for treatment of the fruit after discharge in the U.S.A.

Expedition to the Great Barrier Reef

It was reported briefly in the September *Food Research Quarterly* that three members of the Division's Plant Physiology Unit, Drs Smillie, Bishop, and Graham, took part in an expedition to investigate photorespiration of plants in the marine tropical environment of the Great Barrier Reef.

The main support facility for the expedition was the R/V *Alpha-Helix*, a scientific research vessel of the Scripps Institute of Oceanography, La Jolla, California, funded by the U.S. National Science Foundation. The vessel, 133 ft long and with a displacement of 512 tons, carried a crew of twelve and twelve scientists from the U.S.A., Britain, Japan, and Australia. The laboratories aboard ship were set up on this particular expedition for biochemical and physiological research on marine

plants. Previous expeditions have studied such diverse subjects as tropical sea snakes, Antarctic fish and birds, and the Amazonian jungle. In addition to laboratory and collecting activities, an intensive programme of seminars and discussions is held aboard ship, enabling the scientists to exchange the latest information and ideas.

For the Photorespiration Expedition in April and May of this year the R/V *Alpha-Helix* was anchored close to Lizard Island about 150 miles north of Cairns in Queensland. An additional six Australian scientists were accommodated on the island at a temporary base financed by the Australian Department of Science, and this provided extra laboratory and support facilities for the whole expedition. Seven weeks were spent in the area collecting data on photorespiration in marine algae including the macroscopic algae (seaweeds), the phytoplankton, and the symbiotic algae of clams and reef coral.

During illumination most plants give out a large amount of carbon dioxide which represents a net loss of carbon to the plant. As much as 50% of the carbon 'fixed' in photosynthesis may be lost in this way. The process is called photorespiration and is distinct from the normal 'dark' respiration which occurs in plants and animals. Plants such as maize, sugar-cane, sorghum, and many tropical grasses do not exhibit this carbon loss to any significant extent, and they are thus able to grow much faster than plants such as wheat and most temperate-type crops. As a result the productivity of the tropical-type crops is much greater. The expedition was designed to determine whether or not tropical marine plants photorespired, and it found that all the many marine plants examined did show this property.

The information has filled an important gap in our knowledge of photorespiration and may provide new leads for research. The importance of work on photorespiration can be gauged from the prediction that control of the process by chemical or genetic means may lead to the next 'green revolution'. Readers interested in this prediction will find the idea amplified in an article in the *New Scientist* **57**(838), 657 (1973).

D. GRAHAM

News from the Division

Appointments

Dr R. D. Radford joined MRL in mid August, to initiate and supervise research programmes on mass transfer and water movement during chilling and freezing of meat and meat products. Dr Radford graduated B.Eng.(Chem.) with first class honours at Melbourne University in 1969 and was awarded his Ph.D. by the same university in 1973.

During August, Miss V. M. Re, B.Sc., was also appointed to MRL to participate in a research programme on the synthesis, catabolism, and storage of protein in ruminant tissues.

Dr W. G. Nolan accepted a post-doctoral position in the PPU in mid July and is studying the relationship between structure and photosynthesis of chloroplasts. Whilst in the Botany Department of the University of California at Berkeley, he worked on the composition and function of the two types of photosynthetically active membranes found in chloroplasts.

Dr R. J. Pearce joined DRL in August to investigate the interactions between proteins in heated milk, in connection with the stability of concentrated milks during sterilizing. Dr Pearce came to Australia after post-graduate work at the Rheumatism Research Centre of the University of Manchester.

Visiting Workers

Professor W. Bertsch, of Hunter College of the City University of New York, is spending a year at the PPU at Macquarie University under the auspices of the National Science Foundation through the U.S. Australian Scientific Agreement. Dr Bertsch's main research has been on energy storage and energy conversion in photosynthetic mem-

branes. At PPU he is studying the effects imposed on plant structure by environment in terms of delayed light emission, a technique he previously developed.

FRL and TFRU were visited by Dr F. W. Beech late in August. Dr Beech is Head of the Cider and Fruit Juices Section of the University of Bristol's Research Station at Long Ashton. He attended a Technical Conference of the Australian Wine Research Institute in Adelaide, as well as making a comprehensive tour of the wine, cider, and fruit juices industries in South Australia, New South Wales, Victoria, and Tasmania.

Mr R. F. Mawson of the Industrial Liaison Service Section of the Meat Industry Research Institute of New Zealand spent about a month at FRL studying the properties of flexible film materials for packaging meat.

Retirement

Mr G. Coote, a Principal Research Scientist with the Division of Mathematical Statistics, retired on 29 June 1973 after 23 years' association with the Division of Food Research.

Mr Coote obtained a B.Sc. (Physics and Chemistry) in 1931 and a B.A. (Pure Mathematics) in 1939 from the University of Adelaide. In 1946 he joined the CSIR Section of Mathematical Statistics in Adelaide as an Assistant Research Officer and transferred to Sydney in 1950 where he was attached to the Division of Food Preservation and Transport at Homebush.

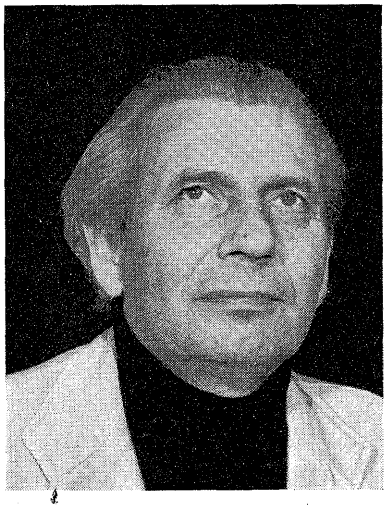
Since few scientists at that time had any training in statistics his task was to educate, to influence the design of experiments, to adapt statistical procedures, and to ensure that conclusions drawn were valid. The painstaking way he extracted experimental details from the researchers, his care with methods, and the precision of his work, contributed to his success in largely achieving these goals. Possibly his greatest contribution was in the area of design and analysis of taste panel experiments and he was a keen advocate of the method of paired comparisons. His work is recorded in more than 30 papers on such varied topics as bitterness in orange juice and bacterial growth on ox muscle.

Mr Coote is succeeded by Dr R. I. Baxter, formerly in charge of the statistics group at MRL, whose place has been taken by Dr D. Ratcliff.

Awards

Mr J. Czulak of DRL has been awarded an honorary degree of Doctor of Science by the University of Sadar Patel, Gujarat State, India, in recognition of his work on the manufacture of cheese from buffalo's milk.

In 1962 Mr Czulak was asked to help solve the problem of making cheese from buffalo milk and went to India under the Colombo Plan. He developed methods for the manufacture of Cheddar- and Gouda-type cheeses. As a result of his work, a cheese manufacturing industry has been established in India.



Dr J. Raison, PPU, FRL, is the winner of the Rivett Medal for 1973. The Medal is awarded by the CSIRO Officers' Association for 'outstanding research in the field of biological science carried out over the past 10 years' and is based on published work. Research staff under the age of 41 years are eligible.

Work Overseas

The leader of the PPU, Dr R. M. Smillie, is overseas for some 15 months; the first 12 months of this period will be spent as Visiting Professor in Professor von Wettstein's laboratory at the University of Copenhagen.

Dr June Olley, Leader of the Tasmanian FRU, is a guest worker in the Fishing Industry Research Institute of the University of Cape Town during the last three months of this year. She will return to Hobart at the end of September 1974. In Dr Olley's absence, the Tasmanian FRU will be in the charge of Mr D. G. James, who has recently also been overseas, as a member of the Australian delegations attending an ad hoc Consultation on Codes of Practice on Fish and Fishery Products and a Codex Committee on Fish and Fishery Products. Later in the year Mr James is to deliver a paper at an FAO Technical Conference on Fish Products in Japan.

General

MRL's Industry Section collaborated with the Australian Meat Board and the Australian Organization for Quality Control in running a Quality Assurance Seminar in Sydney during October.

Members of the Division again contributed lectures to the School for the Foreman in the Food Plant held at Hawkesbury Agricultural College late in July.

Selected Publications of the Division

Readers' attention is drawn to the fact that a new Circular, 'Mixed storage of foodstuffs' by Mr E. G. Hall of the Food Research Laboratory, is now available; copies of this and of most of the papers listed below are available from the Librarian of the Laboratory from which they were published.

From the Dairy Research Laboratory

Box 20, P.O., Highett, Vic. 3190 (Telephone 95 0333).

BUCHANAN, R. A., IRVINE, R. W.,* and TURTON, A. J.* (1972).—Chocolate milk drinks. *Aust. J. Dairy Technol.* **27**, 119–21.

MULLER, L. L. (1972).—The role of the dairy industry in environment pollution control. II. Whey utilization. *Aust. J. Dairy Technol.* **27**, 123–8.

From the Food Research Laboratory

Box 52, P.O., North Ryde, N.S.W. 2113 (Telephone 888 1333).

ANET, E. F. L. J. (1972).—Superficial scald, a functional disorder of stored apples. IX. Effect of maturity and ventilation. *J. Sci. Fd Agric.* **23**, 763–9.

BARNETT, D. (1972).—The determination of sulphur dioxide in meats. *Analyst* **97**, 937–9.

BOARD, P. W. (1973).—The chemistry of nitrate-induced corrosion of tinplate. *Fd Technol. Aust.* **25**, 15–16.

FAROOQI, W. A.,* and HALL, E. G. (1973).—Effect of wax coatings containing diphenylamine on apples and pears during storage and ripening. *Aust. J. exp. Agric. Anim. Husb.* **13**, 200–204.

MELLOR, J. D., and MIDDLEHURST, J. (1972).—The effect of cycling the vacuum pressure on the freeze-drying rate. Proc. 13th int. Congr. Refrig. 1971. Vol. 3, pp. 717–23.

MIDDLEHURST, J., RICHARDSON, K. C., and EDWARDS, R. A.* (1972).—Handling, distribution and retailing of frozen foods. *Fd Technol. Aust.* **24**, 560–1, 563–4, 567, 569–71.

PARKER, N. S. (1972).—Measurement of the dynamic mechanical properties of muscle during the development of rigor mortis. *Rheol. Acta* **11**, 56–60.

PAROZ, P.,* SEALE, P. E.,* and HARPER, K. A. (1973).—Textural breakdown in canned apricots. *Fd Technol. Aust.* **25**, 130–33.

SCOTT, K. J.,* and WILLS, R. B. H. (1972).—Ethylene produced by plastics in sunlight. *HortScience* **7**, 177.

SCOTT, K. J.,* and WILLS, R. B. H. (1973).—Atmospheric pollutants destroyed in an ultra violet scrubber. *Lab. Practice* **22**, 103–6.

SHARP, A. K. (1973).—Heating with humid air. *Fd Technol. Aust.* **25**, 18–20.

STANLEY, G., and KENNETT, B. H. (1973).—Reaction gas chromatography of microgram and submicrogram samples using sealed glass capillaries. *J. Chromat.* **75**, 304–7.

SZULMAYER, W. (1973).—A solar strip concentrator. *Sol. Energy* **14**, 327–35.

TRACEY, M. V. (1972).—Future food patterns—a matter of balance. *Fd Technol. Aust.* **24**, 616–17.

WHITFIELD, F. B., STANLEY, G., and MURRAY, K. E. (1973).—Concerning the structure of edulan I and II. Tetrahedron Lett. **1973**(2), 95–8.

WILLS, R. B. H. (1972).—Effect of calcium on production of volatiles by apples. *J. Sci. Fd Agric.* **23**, 1131–4.

WILLS, R. B. H. (1972).—Effect of hexyl compounds on soft scald of apples. *Phytochemistry* **11**, 1945–6.

WILLS, R. B. H., and SCOTT, K. J.* (1972).—Effect of water loss from apples during cool storage on the water content of the fruit. *J. Sci. Fd Agric.* **23**, 1135–6.

WILLS, R. B. H., and SCOTT, K. J.* (1972).—Reduction of low temperature breakdown in apples with gibberellic acid. *J. hort. Sci.* **47**, 389–94.

From the Food Research Unit, Hobart

CSIRO, Stowell Avenue, Hobart, Tas. 7000 (Telephone 23 2786).

OLLEY, June (1972).—Mercury in fish and the news media. *Aust. Fish.* **32**(12), 24–5.

OLLEY, June, and RATKOWSKY, D. A.* (1973).—The role of temperature function integration in the monitoring of fish spoilage. *Fd Technol. N.Z.* **8**(2), 13, 15, 17.

OLLEY, June, and RATKOWSKY, D. A.* (1973).—Temperature function integration and its importance in the storage and distribution of flesh foods above the freezing point. *Fd Technol. Aust.* **25**, 66–73.

From the Meat Research Laboratory

Box 12, P.O., Cannon Hill, Qld. 4170 (Telephone 95 2122).

PARK, R. J., and MINSON, D. J.* (1972).—Flavour differences in meat from lambs grazed on tropical legumes. *J. agric. Sci., Camb.* **79**, 473–8.

SHORTHOSE, W. R., HARRIS, P. V., and BOUTON, P. E. (1972).—The effects on some properties of beef of resting and feeding cattle after a long journey to slaughter. *Proc. Aust. Soc. Anim. Prod.* **9**, 387–91.

*Not a member of the Division.

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