Vol. 39 No. 1 March 1979

STEELE

CSIRO Food Research Quarterly

Impact of climate variability on food processing

By J. F. Kefford

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

This article was prepared for a Conference on Impact of Climate on Australian Society and Economy, which was held at Phillip Island, Victoria, on 27–30 November 1978.

Introduction

It is customary to regard the farm gate as the border between agriculture and food processing, but in practice it is difficult to make a rigid division at this point. Accordingly, while I regard effects of climate variability on, for instance, crop yields as falling within the province of agriculture, there are impacts of climatic conditions before and during harvest that affect the quality of crops for processing and that fall as much upon the food processor as the farmer. My survey of the impact of climate variability on the food processing industries in Australia will therefore begin a little way inside the farm gate.

Most of the examples that I shall use are drawn from plant crops, since this is the area with which I am most familiar. If justification is required for this treatment it could be said that of all the raw materials for food processing, those of plant origin are most sensitive to climatic impacts. It is well known that climatic variables — incident solar radiation, temperature of air and soil, wind, rain, and atmospheric humidity — influence the production of plant crops, but they may also profoundly affect their quality and composition — the nutritive value, the levels of desirable and undesirable components, the colour and appearance, the flavour and aroma, and the texture.

Climatic impacts on raw materials for processing

Fruit crops

For reasons associated with the history of settlement in Australia; for instance, soldier settlement, and with the overriding influence of capital city markets, some subtropical and tropical fruit crops are grown in areas close to the southern limits of their acceptable climatic zones. As growing conditions in these areas are marginal, these fruit crops provide good examples of activities where a persistent trend or shift in climate might have a major effect by significantly extending or restricting the present production areas.

Bananas

The major portion of the Australian banana crop is grown not in Queensland (31 000 t) as might be expected, but in northern New South Wales (79 000 t). Indeed, in terms of value, bananas are the principal fruit crop grown in N.S.W. In N.S.W. bananas are produced in a cooler average climate than that in any other banana-growing area in the world; but they are subject to low temperature injury in the field that affects both plants and fruit.

Pineapples

Most of the Australian crop is grown in southern Queensland, where two crops a year are produced. The summer crop is of satisfactory quality but the winter crop is subject to the disorder known as *black heart*. The mechanism of the disorder is not known but it is initiated by low temperatures in the field. It is therefore never encountered in Hawaii as a field disorder but only as a storage disorder when pineapples are cold stored.

Citrus

Thirty years ago Barnard (1946) analysed the distribution of citrus growing in Australia in relation to climate. For comparative purposes he used an index of available heat that was calculated by summing the mean daily temperatures above 13 °C — the minimum temperature for citrus growth. He showed that the heat index for good Navel orange areas in Brazil, California, and South Africa fell in the range of 3000–3400, and that Berri in the lower Murray Valley, an area noted for good Navel oranges, had a heat index of 3020.

On the other hand, good grapefruit areas in California, Florida, Israel and the West Indies have heat indices in the range 6000–6700. To enter this range in Australia we have to go as far north as Gladstone (6030). Present areas where most Australian grapefruit are grown, e.g. Murray Valley 3020, Murrumbidgee Irrigation Area 3200, fall far short of the range; so it is not surprising that our grapefruit tend to be sour and bitter.

Further there is a general problem in the composition of Australian oranges that may be due largely to climatic deficiencies. The palatability of orange juice is largely determined by the balance between sweetness and acidity, which is expressed as the ratio between the sugar content and the citric acid content. Australian orange juice commonly has low sugar/acid ratios compared with orange juices from other countries. Thus in two seasons 168 samples of Florida orange juice showed an average ratio of 14.9 while 155 samples of Australian orange juice tested in our Division gave a ratio of 8.8.

American workers have made extensive studies of the influence of climate on the quality and composition of citrus fruits. For instance Reuther *et al.* (1969) investigated Valencia oranges grown in six regions in California, Arizona, Texas, and Florida to determine the times from blossoming for the fruit to reach a sugar/acid ratio of 9 which is recognized as the lower limit for marketability in the U.S.A. The times ranged from 8 months in Weslaco, Texas to 15 months in Santa Paula, California. These workers were unable to define simple relations between rate of ripening and regional climatic parameters, but high temperatures, particularly high night temperatures in the autumn and winter, had a strong influence on rate of ripening.

There have been no parallel studies in Australia but it is clear that our conditions generally lie towards the cooler extremes since Valencia typically require 14–15 months to ripen here.

Although Australian citrus may be grown in regions that are cooler than optimum, it is also true that our citrus regions are spared the gross extremes of cold that lead to disastrous 'freezes' in other citrus areas, notably Florida. The most severe freezes will kill trees and when less severe may adversely affect the quality of the fruit, leading to shrinkage, desiccation, loss of weight, and reduced juice content. In 1977 the National Weather Service in Florida inaugurated a new computerized freeze prediction system linked to GOES 1 (Geostationary Orbital Environmental Satellite) (Anon. 1977). From satellite data plus information from 14 ground stations, computers will predict up to 8 hours in advance and within 1 deg C when low temperatures will fall in areas as small as 6475 ha. The value of such predictions may be gauged in relation to the estimated cost ($5 million) of heating Florida citrus groves on one frosty night.

Frost is not a frequent hazard in Australian citrus areas; it may be a somewhat more serious hazard for the vine fruits industry where frosts at critical times may reduce yields by up to 20%. The Commonwealth Bureau of Meteorology maintains television frost prediction services in the Sunraysia district and the Goulburn Valley. The prediction of a frost hazard is based on the combination of a number of climatic factors, including the relative humidity at 3 p.m., the expected wind movement, and the extent of cloud cover. There may, however, be occasions when an unexpected combination of climatic conditions develops at short notice and a frost occurs although it was not predicted. Such was the case when severe frosts affected vines in the late spring of 1977 in places as far apart as Great Western and the Yarra Valley. In some vineyards, particularly those at low elevations, the crop was completely lost. When the warning service predicts a frost it is possible for growers to attempt some control over temperatures in the orchard or vineyard by means of wind machines, water sprinklers, or frost pot heaters, although the latter are now discounted because of cost and atmospheric pollution.

Vegetable crops

The fruit crops about which we have been talking are tree crops which once planted provide a fixed pattern of production, even if it may be widely variable according to the influences of the seasons. Vegetable crops for processing, however, are mostly annual crops which require a planned production schedule each year. A succession of crops is planted so as to provide production at the required rate and for the required period, which is generally restricted and of the order of 90 days. The earliest planting date, the time to maturity, and the total length of the season are all determined by climatic factors as assessed from accumulated past experience.

It follows that such a production schedule can be seriously disrupted if the climate in a particular season departs significantly from past patterns, e.g. as a short-term effect, rain on a scheduled planting day may set back an entire production cycle. Variability in rainfall during the season is frequently evened out by irrigation. Variability in ambient temperatures is more serious and may advance or retard estimated dates of maturity and harvesting. In most fruit and vegetable crops for processing, maturity at harvest is the most significant factor determining quality in the processed product. Accurate prediction of maturity is therefore vital to the food processor for the organization of harvesting and processing and for the maintenance of quality standards.

Effects of bad weather at harvest

Bad weather, generally meaning rain, or threatened bad weather, at harvest times may affect the quality of crops in several ways:

- It has already been said that harvesting at the right time is critically important for quality. When bad weather delays the harvest it means that the product when harvested is overmature. For example, with increasing maturity peas and sweet corn accumulate starch instead of sugar, asparagus becomes more fibrous, and quality is downgraded. If the harvest is delayed for days the crop may be suitable only for seed. On the other hand, threatened bad weather may cause a grower to harvest early so that the product is immature. It may then be undersized, lacking in colour, flavour and aroma, and unacceptable in texture.
- Owing to shortage of picking labour, mechanical harvesting is essential for most crops for processing and is currently most widely used in Australia for peas, tomatoes, sweet corn, beans, prunes and grapes. It is obvious that mechanical harvesting cannot begin unless the equipment can get on to the field, and some of this equipment is very heavy. So rain near harvest time leading to boggy field conditions can be disastrous for mechanical harvesting. Further, even when mechanical harvesting is possible under wet conditions, pick-up of mud on the product may place an unreasonable burden on cleaning processes in the factory and so give rise to hazards such as 'mud balls' in canned and frozen peas.
- Another effect of wet conditions at harvest, and even high atmospheric humidities, is encouragement of fungal growth. Thus fungal rots in soft fruits, e.g. brown rot in peaches, transit rots in apricots, and downy mildew in grapes, are more serious in humid than in dry summers. A survey during the years 1949–56 demonstrated a close relation between rainfall during the maturing period and losses due to brown rot in canning peaches in the Goulburn Valley (Brown Rot Research Committee 1957–62). For instance, very heavy losses amounting to 30–100% of fruit from individual orchards occurred in the 1956 season when the rainfall in January was three times the average, and in March four times the average. On a long-term basis losses from brown rot in Victorian canning peaches amount to about 5% (1200–1500 t).

The Bureau of Meteorology provides a brown-rot weather alert for the Murrumbidgee Irrigation Area and the Young district in N.S.W. The warning is given when rainfall, humidity and temperature conditions are favourable for an outbreak of brown rot and it enables growers to apply protectant sprays in advance.

An interesting case history is provided by the peanut crop in the Kingaroy district in the 1977 season. Unusually dry conditions before harvest caused cracking of the shells underground and permitted entry of the fungus *Aspergillus flavus.* Subsequently the nuts were lifted and left to dry on the bushes in the field according to usual practice. However heavy rain at this stage inhibited drying and encouraged fungal growth on the nuts inside the shells. This fungal growth was especially serious because *A. flavus* produces aflatoxin which is toxic to humans and animals. Aflatoxin was in fact found in Kingaroy peanuts at levels up to 400 $\mu g\ kg^{-1}$, far in excess of permitted limits (15 $\mu g\ kg^{-1}$). A very costly salvage operation was mounted involving electronic and hand sorting and about half the crop was recovered for human consumption, rejected nuts being processed for oil. The total economic loss amounted to several million dollars.

▶ Again, bad weather at harvest may have some very immediate effects on the quality of crops. Thus rain may cause split skins on peas, grapes (see below), and tomatoes. Hail may bruise and discolour cherries in such a way that they are unmarketable. This is a good example of the dire effects of episodic events. The cherry crop is a specialized crop with a short season, grown only in a few isolated areas such as Young, N.S.W., and a hailstorm at the wrong time may destroy virtually an entire crop. Forecasting of hail would probably not be very helpful. The use of hail nets has been considered but the cost is prohibitive.

Hail is also a hazard to the vine fruits industry in the Murray Valley and adjacent areas where it may cause both loss of yield and loss of quality. The Australian Dried Fruits Association has taken out hail insurance for its members; the premiums quoted are \$170 000 for \$1 million cover, and \$276 000 for \$3 million cover. For growers this means a premium of \$3.75 per ha, but only 40% of growers are covered. In October 1977 the Sunraysia area was hit by a hailstorm causing an estimated loss of \$13 million. Again, in October 1978, a more restricted hailstorm caused damage amounting to about \$2 million.

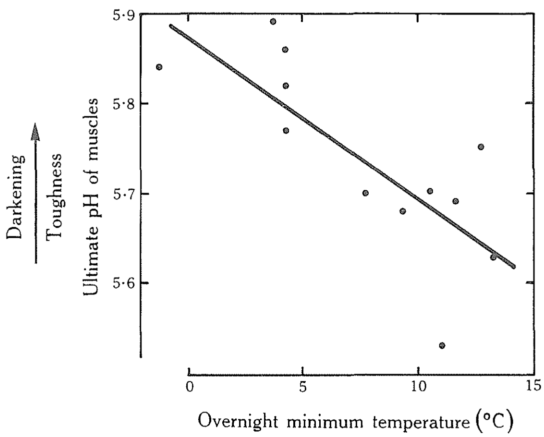


Fig. 1. Effect of minimum temperature during the night before slaughter on ultimate pH of muscle. Each point corresponds to one slaughter date and represents the mean pH of 3 muscles for each of 6 to 20 lambs. (From Furnival *et al.* 1977.)

Weather damage to wheat

Damage to wheat before harvest by frost or hail, and lodging caused by wind and rain, are agricultural problems, but what is commonly called 'weather damage' causes the wheat to be unsuitable for bread making. This weather damage is the effect of rain near harvest leading to premature germination in the ear. It may affect as much as 10% of the crop in some years and therefore cause significant loss of income to wheat growers since the affected wheat is suitable only for feed. Wetting of the grain initiates enzyme activity which causes a loss of baking quality that is usually blamed on starch degradation by α-amylase. However, proteolytic enzymes appear to act more quickly and therefore protein degradation is the more likely cause of poor quality.

Animal products

In order to broaden the story a little, beyond merely plant products, two examples may be given of climatic influences on the quality of meat and dairy products.

Heat stress in cattle has been widely studied as an animal production problem, but one present example refers to a specific effect of heat stress on the composition of milk.

In a recent experiment (Pan *et al.* 1978), Jersey and SahivalxJersey crossbred cows were subjected to the following temperature regime: two weeks at 16–18 °C, then two weeks at 40 °C, then two weeks at 16–18 °C. During the hot period both breeds showed a decrease in the protein content of their milk, both the casein and the whey proteins being affected. This milk also showed a high pH; which, together with the lowered casein concentration, might cause difficulties in the making of cheese.

The other example refers to cold stress, or more precisely to ambient temperatures immediately before slaughter, on the quality of meat. When animals awaiting slaughter are cold enough to shiver, the shivering reduces the glycogen concentration in the muscles and hence the production of lactate after slaughter, and so increases the ultimate pH of the muscles. Figure 1 shows the relation between minimum temperatures on the nights before slaughter and the ultimate pH of the muscles of lambs (Furnival *et al.* 1977). The significance of this effect on meat quality is that as the pH increases over the range 5.5 to 6.0 the meat increases in toughness and becomes darker in colour. Thus climatic conditions leading to high rates of heat loss from animals may induce shivering and result in tougher and darker meat.

Climatic impacts on processing operations

Once the raw materials are inside the factory, food processing operations are in general not sensitive to climatic conditions.

This is not true, however, of the dried fruits industry — the sundrying of vine fruits: sultanas, raisins, and currants, and tree fruits: apricots, peaches, and pears — an industry that is concentrated in the Murray Valley in Victoria and South Australia and is worth $80 million a year. This industry might be described as a rather surprising survival of a peasant industry, in the sense that there are some 3000 growers who employ family labour and carry out the drying operations on their own farms. The vine fruits are dipped in an oil emulsion to accelerate drying, then dried on covered wire racks, so that the drying is in fact, shade drying by warm, dry air. The tree fruits are 'sulphured' and dried by direct exposure to the sun, at least in the early stages.

It is obvious that this industry is heavily dependent upon weather conditions for successful processing. Ideal conditions are a hot, dry summer without rain or dust for a period of three months.

The Australian industry was pioneered by Californians — the Chaffey brothers — and conditions in the Murray Valley match California fairly well but with less stability and predictability. For year after year California can count on no rain for three months in the summer. The greater reliability of the climate there has indeed given rise to a different technology: the fruit is not dipped and it is exposed not on covered racks but on paper on the ground between the vines.

But even there the occasional disaster occurs, as in the 1977 season when heavy rain fell on the exposed fruit. A mammoth rescue operation followed, when the fruit was washed with high pressure sprays to cut away rotting material, and the remaining sound fruit was dehydrated. In this way some 150 000 t were recovered from a total crop of 250 000 t. Again in September 1978, 76 mm of rain fell in the Central Valley of California shortly after the fruit had been spread on the ground, and losses are likely to reach 60%.

In Australia rain during the harvesting and drying period is not uncommon, with losses around 10–20% of the crop, and rising to 50% in bad years. In grapes, splitting occurs when the turgor pressure of the berries exceeds the critical turgor, defined by Considine and Kriedemann (1972) as the turgor at which 50% of the berries will split. This value varies with variety and is particularly low for drying varieties Zante Currant and Sultana, i.e. 14×10^5 to 15×10^5 Pa compared with 50×10^5 Pa for Muscat Gordo Blanco. Also Zante Currants and Sultanas will split at a sugar concentration of about 10° Brix, compared with Gordo which has to reach about 26° Brix before splitting occurs. Rainfall exceeding 25 mm has fallen during January in about one-quarter of the years since 1890 at Mildura, creating conditions when splitting may occur. In an attempt to circumvent the effects of rain damage, the Division of Horticultural Research, CSIRO has released the variety 'Carina', which resembles the Zante Currant in most respects but is less prone to splitting.

A statistical study by Considine (1973) has shown the importance of rain damage. After eliminating the variation due to long-term trends — mainly changes in acreage and yield per acre — nearly half the non-trend variation in sultana production from year to year is caused by rainfall in March; a third of the variation of currant production is caused by rain during the first half of January (due to berry splitting) and the first half of February (due to mould), and one-third of the variation in the yield of raisins is caused by rain during the second half of March.

The quality of dried vine fruits also varies according to the amount of harvest rain. Sultana quality is graded from 7 crown (the best) to 1 crown (the poorest), mainly according to colour shade and uniformity. The weighted mean crown grade of sultanas for the seasons 1958–75 shows a highly significant regression on the amount of rain between 1 February and 21 March which explains 87% of the seasonal variation in crown grade. This relationship is sufficiently close to predict the likely average crown grade of the sultana crop at a time when deliveries to the packing house are just commencing (May, personal communication).

To help the situation in a wet year most growers have simple rack dehydrators, i.e. plastic curtains that enclose the racks, and oil-fired blowers to circulate warm air over the fruit. It is generally accepted however that it is beyond the resources of the industry to provide enough dehydration capacity to handle the whole crop; too great a volume of fruit comes in over too short a period.

A more subtle climatic impact on this industry is the effect of cold nights in the summer leading to uptake of water by nearly dry fruit during the night. If the night temperature falls to around 10°C the relative humidity rises even when the absolute humidity is low, and the fruit then absorbs water. The water absorbed in one cool night may take one to two days to evaporate again, and the fruit may darken and lose quality.

Forewarnings of low night temperatures and high humidities analogous to frost warnings would help grower-dryers to avoid this hazard.

Climatic impacts on transport, storage, and distribution of processed foods

When processed foods leave the factory and enter wholesale and retail distribution they are subject to many climatic impacts. However, the foods broadly described as perishable demand storage at controlled temperatures and should therefore escape climatic impacts provided they are properly handled.

Proper packaging is an integral part of the processing of foods and a main function of packages is to protect foods against some climatic impacts, notably against atmospheric moisture. This means that for what might be called the normal shelf lines of processed foods, the ambient temperature is the significant climate variable.

Temperature effects on storage life

A simple example of the problems encountered in this area is in the marketing of chocolate biscuits, because chocolate coatings tend to soften in hot weather. The practice in the industry is to restrict the supply of chocolate biscuits to retailers 'when the weather starts to warm up' as they put it. Thus supplies would generally be withheld from country stores in the summer but not from supermarkets with air-conditioned stores. Each year the manufacturers are faced with decisions as to when to stop full-scale manufacture at the approach of summer and when to start up again in the autumn. Some use is made of weather forecasts but decisions are mainly determined by accumulated experience.

The shelf life of foods is a matter of much topical interest because of pressure by consumer groups on regulatory authorities to require compulsory date marking of foods. While there is some justification in the claim of consumers that they are entitled to know how old a food is, there are pitfalls in date marking because the quality of a stored food is determined not only by the time but also by the conditions of storage, and primarily by the temperature of storage. So in speaking about the keeping quality of foods it is customary to use the term 'Time–Temperature Tolerance'.

In the foods with which we are concerned quality changes during storage are due to chemical reactions subject to the Arrhenius relation between temperature and reaction rate (k):

$k = Ae^{-E/RT}$ where E is the activation energy.

In storage studies this relation is often expressed in the form:

$$\log Q_{10} \text{ i.e. } \log \frac{\text{storage life at } (T+10)^\circ K}{\text{storage life at } T^\circ K} = \frac{2.189E}{T(T+10)}$$

For many chemical reactions Q_{10} is about 2, that is, the rate is approximately doubled for each 10 deg C rise in temperature. Now we may apply this relation to the condition in several Australian cities as in Table 1.

In well-insulated stores and in stores in large buildings the average temperature will be close to the annual outside average; and the worst condition likely to be encountered is an average storage temperature 5 deg C above average outside temperature.

Day-to-day variability in air temperatures will make little difference to the storage lives of processed foods in warehouses and stores,

Table 1. Relative storage life of processed foods in Australian cities

City	Average annual temperature (° C)	Relative storage life
Melbourne	15	100
Sydney	17.5	84
Brisbane	20.5	68
Cairns	25	50
Darwin	28	40

and long term trends or shifts are unlikely to be of a magnitude to affect distribution practices in the food industry.

It is doubtful whether the industry is at present sufficiently aware of the effects of temperature on the storage lives of processed foods. Many companies make a practice of withdrawing stock that is older than a specified limit, e.g. 16 weeks for packaged biscuits, but such limits tend to be the same for all Australian markets. Only a few companies recognize the effects of higher storage temperatures and enforce shorter withdrawal times in, for instance, Darwin.

Condensation on canned foods

A particular problem in the storage and transport of canned foods is condensation of water on the exterior of the cans. This water causes wetting and collapse of cartons, rusting of cans, and mould growth on labels. The contents of the cans are not affected but the damaged batches may be unsaleable because of the external appearance, or they may require expensive re-labelling.

Condensation is a simple manifestation of the physical phenomenon that water will condense on surfaces that are colder than the dewpoint of the surrounding air. It occurs in such circumstances as the following:

- cans that are cold after storage through the winter are shipped out on a warm, humid spring day, or the doors of the warehouse are opened to admit outside air on such a day. Condensation in these circumstances is more often a problem for Victorian canners than for canners in N.S.W. and Queensland
- cans may be loaded into a shipping container which is closed and left in an exposed position on a cold night. Condensation then occurs on the inside of the roof of the container and drips onto the cartons. There is sufficient moisture in the fibreboard cartons to cause damaging condensation
- in an opposite situation, a container loaded with canned food in cartons may be exposed in the sun on a hot day. Moisture may then migrate from the hot cartons in the upper layers and condense on the cooler cans in the lower layers.

It is recognized that solutions to these problems cannot be found in any manipulation of climatic factors, but they indicate an area where the food industry needs to be sensitive to the influence of climatic conditions and to govern its storage and transport practices accordingly.

Refrigerated transport of foods

An example of an operation in this area is the transport of frozen beef in insulated shipping containers fitted with refrigeration units, the temperature of the beef being kept at -18 °C. The effects of ambient temperature on heat load and refrigeration capacity for a typical shipment with the container moving or stationary are shown in Fig.2. As the ambient temperature increases over the range 20–40 °C the safety margin (refrigeration capacity – heat load) decreases dramatically.

Designs of refrigerated transport equipment for Australian conditions tend to specify larger, heavier and more expensive refrigeration systems than in some other countries so as to cope with our extreme temperatures.

The chain of operations in the freezing, storage, and distribution of frozen foods is commonly called the 'cold chain'. Ideally the temperature of frozen foods should not rise above -18 °C throughout this chain. In 1975–76 this Division surveyed frozen food temperatures in the cold chain in Australia, and Table 2 summarizes observations in

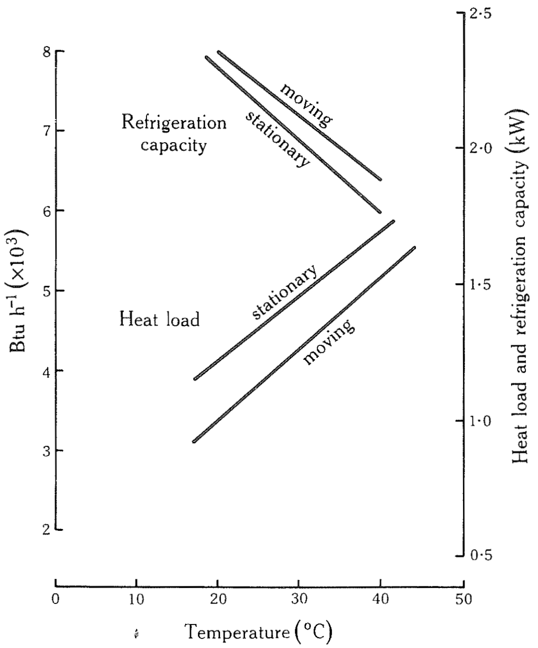


Fig. 2. Effects of ambient temperature during transport of frozen beef in refrigerated shipping containers.

Sydney in summer and winter (Irving and Sharp 1976).

Table 2 indicates that the performance of the cold chain is sensitive to ambient temperatures, and that there are difficulties in maintaining desirable product temperatures even under normal seasonal conditions, and particularly in summer.

Some impacts of episodic climatic events

The following are a few examples of the serious consequences for food industries that may result from sudden climatic episodes:

- power failures following severe storms may stop the continuous processes of many food processing operations. At the least a tonnage of product may be ruined, and, sometimes health hazards may arise when continuous sterilizers are stopped. Similar consequences of loss of product and health hazards may arise when power failures affect refrigerated stores
- flooding of plant and warehouses may cause rusting of unused and filled containers and fungal spoilage of stored materials
- problems in waste disposal may occur as a result of excess rainfall. Spray irrigation systems and aerobic lagoons are designed to lose water by evaporation, but in the event of inordinately high rainfall they may gain water and thus be unable to accept incoming waste waters.

Climatic impacts on market demand

When processed foods reach the retail market the rate at which they are purchased by consumers may be subject to climatic influences. Some broad seasonal differences in demand must be expected, e.g. more soup sold in winter, more ice-cream in summer (Fig. 3). In addition, however, the summer lines, such as ice-cream and soft drinks, are subject to large fluctuations in demand according to the incidence of hot weather.

As has already been described, the climatic influence is felt not only at the point of final demand but throughout a chain of interlocked demands. Thus at some time, perhaps months before the summer, manufacturers must plan and commence production of their summer lines. In order to plan their production they must place orders with suppliers, among which the most critical are probably the suppliers of containers — cans, bottles, etc. Further along the chain, retailers of all types, from supermarkets to corner shops, must place orders based on their anticipated sales.

If the summer is unusually hot or prolonged, or even if a particular weekend is very hot, the chain of supply may break down at one point or another. On the other hand if the summer is unusually cool, stocks accumulate seriously all along the chain.

In the 1977–78 season, sales of soft drinks in Victoria were down 15–20%. Some attributed this drop to the intrusion of 'Big M' flavoured milk, but the Managing-Director of Cadbury Schweppes Soft Drinks Division is reported to have said that it was rather 'a result of poor weather'.

Table 2. Frozen food temperatures in summer and winter

	Summer	Winter
Loading temperatures (°C)		
Average	-16.5	-17.0
% of measurements:		
at or below -18°C	6	37
at or below -15°C	90	82
Unloading temperatures (°C)		
Average	-12.0	-13.5
at or below -18°C	15	45
at or below -12°C	60	67

Conclusions

From this account it may have been possible to discern a general picture of the extent to which the food processing industry is sensitive to climatic influences. The most important points of impact are:

- on the quality of some raw materials
- on production planning
- on the operation of sun-drying of fruits
- on the storage and distribution
- on the demand for summer products.

The food industry is aware, but generally not sufficiently so, of the effects of climatic variables.

Improved weather forecasting may be useful to the food industry in the following directions.

- *Long-term*

  Attention has been drawn to the long chain of events in the production and processing of annual crops that is dependent upon the weather. Predictions of seasonal weather trends — warmer than average, wetter than average, etc. — would assist in the scheduling of planting dates and in all the successive links in the chain.

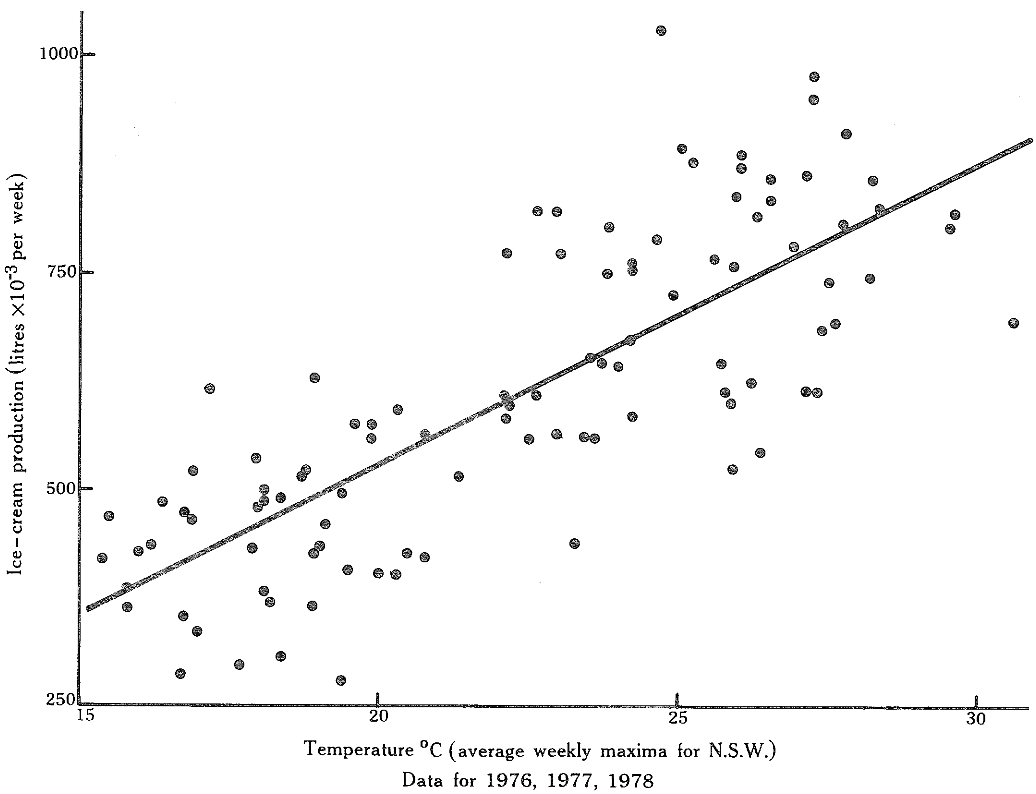


Fig. 3. Ice-cream production by a N.S.W. company in relation to weekly maximum temperatures.

Likewise, predictions of the intensity and duration of hot and cool summers would assist planning in the soft drink and ice-cream industries.

▶ *Short-term*

Greater precision and longer lead times in the prediction of rain and its duration would assist in the operations of planning, harvesting, and sun-drying.

Forecasts that included estimates of the probability of occurrence of various climatic events would be expected to be valuable to the food processing industry, but the industry would need guidance as to how to best use such forecasts to assist in forward planning.

Among meteorologists at the Conference opinion was divided as to the likelihood of providing a reliable seasonal forecasting service. In Australia there is little current activity directed towards seasonal forecasting. What is required is much computer calculation from past records and real progress in climatological research with modern aids.

References

Anon (1977). Heating Florida citrus. *HortScience* **12**(4), 291.

Antcliff, A. J. (1975). Four new grape varieties released for testing. *J. Aust. Inst. Agric. Sci.* **41**, 262–4.

Barnard, C. (1946). Climate and the distribution of citrus. *J. Aust. Inst. Agric. Sci.* **12**(4), 134–8.

Brown Rot Research Committee (1957–1962). Report of the Research Work on Brown Rot of Stone Fruits. (Commw. Govt Printer: Melbourne.)

Considine, J. F. and Kriedemann, P. E. (1972). Fruit splitting in grapes: determination of the critical turgor pressure. *Aust. J. Agric. Res.* **23**, 17–24.

Considine, J. F. (1973). A statistical study of rain damage of grapes for drying in Victoria. *Aust. J. Exp. Agric. Anim. Husb.* **13**, 604–10.

Furnival, E. P., Corbett, J. L., and Shorthose, W. R. (1977). Meat properties of lambs grown to 32 kg at various rates on phalaris or lucerne pastures and an apparent effect of pre-slaughter ambient temperature. *J. Agric. Sci.* **88**, 207–216.

Irving, A. R. and Sharp, A. K. (1976). The temperature of frozen foods during local distribution in Australia: a survey. *Food Technol. Aust.* **28**(8), 288–94.
Pan, Y. S., McLean, D. M., Graham, E. R. B., and Ellis, N. J. S. (1978). Effect of heat stress on the protein composition and manufacturing properties of milk from two diverse breeds of dairy cattle. Presented to 20th Int. Dairy Congr., Paris.
Reuther, W., Rasmussen, G. K., Hilgeman, R. H., Cahoon, G. A., and Cooper, W. C. (1969). Comparison of maturation and composition of Valencia oranges in some major subtropical zones of the United States. *J. Am. Soc. Hortic. Sci.* **94**, 144–157.

Trial use of CO_2 to control insects in exported, containerized wheat

By A. K. Sharp and H. J. Banks*

CSIRO Division of Food Research, North Ryde, N.S.W. and *CSIRO Division of Entomology, Canberra, A.C.T.

Introduction

A controlled atmosphere transport trial was carried out to assess, under export conditions, the feasibility of using CO_2 during transit to kill insects in grain carried in containers. An earlier trial (Banks and Sharp, unpublished data) had shown that in suitably gastight containers it was possible to maintain adequate levels of CO_2 to ensure disinfestation of grain in transit by rail. A level of gastightness corresponding to a leakage rate of 6×10^{-3} m^3 s^{-1} at a pressure difference of 250 Pa was found to be adequate, provided that CO_2 was added throughout the disinfestation. This was done by allowing dry ice to sublime in an insulated box made of foamed polystyrene, in order to compensate for gas leakage from the container. It was also shown that such a level of gastightness is met by some general-purpose containers used in the Australian trade, and by most bulk containers.

This trial was carried out under a special exemption from the Export (Grains) Regulations which, except for specific trials, prohibit the export from Australia of wheat and some other grains if they have not been inspected by the Department of Primary Industry and found to be free from infestation. Furthermore, except in special cases, such as that reported here, all wheat exports are dealt with by the Australian Wheat Board.

Procedure

Grain handling and transport

A general-purpose container of suitable gastightness was selected by pressure testing (see Fig. 1). It was loaded at Botany, N.S.W., with bagged, pesticide-free wheat destined

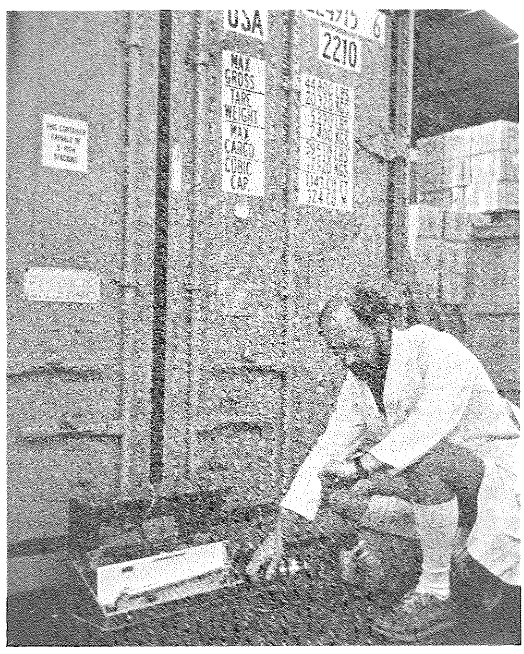


Fig. 1. Pressure testing a container for gas tightness.

Table 1. Details of the trial

Container:	
external dimensions	6.10 x 2.59 x 2.44 m (20′ x 8′6″ x 8′)
internal capacity	33.9 m^3
construction	Steel frame, plywood walls and ceiling coated both sides with glass fibre reinforced polyester, plywood floor.
Load (wheat in 50-kg bags)	18.0 tonnes
Estimated gas volume in loadspace	12.2 m^3
Estimated headspace volume	9.0 m^3
Total gas volume	21.2 m^3
Insulated box:	
interior dimensions	250 mm x 350 mm x 500 mm
wall thickness	75 mm
CO_2 dosage:	
directly onto wheat stack	30.4 kg
in insulated box	31.3 kg
Pressure test:	
pressure test parameters	$b = 2.13 \times 10^{-5}$
where $Q = b\Delta p^n$	$n = 0.86$
Δp = pressure difference (Pa)	
Q = leakage rate ($m^3\ s^{-1}$)	
leakage at 25 Pa	$3.4 \times 10^{-4}\ m^3\ s^{-1}$
leakage at 250 Pa	$2.5 \times 10^{-3}\ m^3\ s^{-1}$

for the 'health food' market in West Germany. Details of the container and load are given in Table 1. During loading, the grain was sampled for any existing insect infestation and cages containing test insects were arranged as shown in Fig. 2.

After the container had been loaded, 61.7 kg dry ice pellets were added; approximately half (30.4 kg) was scattered over the bag stack near the doors and the remainder put in the foamed polystyrene box on top of the stow (see Fig. 2). This box provided a release rate of about 3 kg gaseous CO_2 per day. For 1.3 h after dosing with CO_2, excess pressure was vented through the fumigation nozzle, which had been enlarged by drilling to 5-mm internal diameter. The container remained in the open for 155 h before being taken by road to Balmain Container Terminal (20 km), where it was placed under cover. After a further 97 h it was loaded on the M.V. *Abel Tasman* for shipment to Hamburg. The total period for which the loaded container remained on land was 252 h.

On arrival in Hamburg the residual CO_2 concentration was measured. The container was then opened and checked by the quarantine authorities for insect infestation. It was then reclosed and transported by road to about 100 km south of Hamburg, where the wheat was unloaded and the cages of test insects recovered.

Instrumentation

While the container was being loaded, 16 thermocouples (copper-constantan) and gas-sampling lines (3-mm external diameter nylon) were placed in the container at positions indicated in Fig. 2.

Temperatures (± 0.5 °C) were recorded automatically throughout the trial by a multi-point Grant Model D temperature recorder carried on top of the stow (see Fig. 3). CO_2 concentrations ($\pm 0.2\%$) were measured manually with a Riken Model 18 interferometer. They were corrected for temperature and pressure according to the manufacturer's instructions and converted to give total CO_2 present using CO_2 density calculated from 1.845 kg/m^3 at 15 °C/100 kPa and the free space volumes given in Table 1.

Bioassay

Sitophilus oryzae (CSO231) cultures were used as test insects. Laboratory cultures of 1.6 g insects on 800 g grain (12% moisture content) at 30 °C/60% relative humidity (RH) were set up weekly. At the end of one week the adults were removed and the cultures allowed to develop. Cultures aged

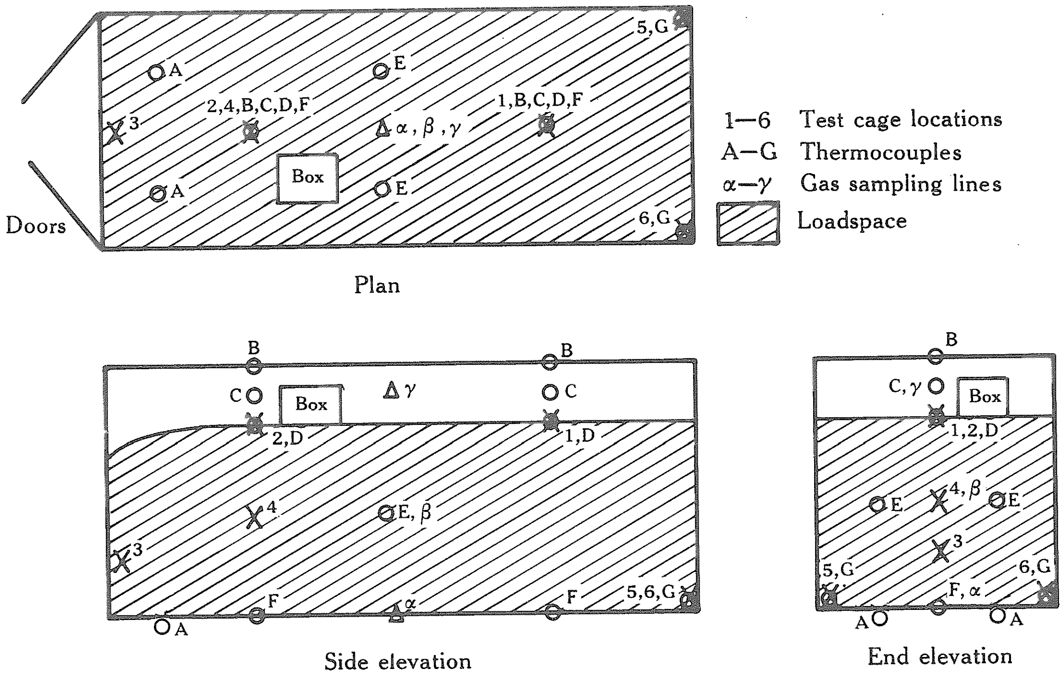


Fig. 2. Positions of thermocouples, test insect cages and gas sampling lines in container.

0–6 weeks were bulked and partitioned by grain divider to give subsamples of an artificial culture containing approximately equal numbers of each age group of the developmental stages. The subsamples (~ 400 g) were combined with fresh grain (200 g) and placed in test cages (Perspex cylinders, 200 x 70-mm internal diameter, closed at each end with fine brass gauze (60 mesh)).

The test cages were divided into three groups:

- laboratory controls (2 cages) cultured in the laboratory at Canberra and retained there
- field controls (2 cages) taken to Botany with the test insects and returned to Canberra after loading
- test insects (12 cages) taken to Botany and placed at six selected locations (indicated in Fig. 2) while the grain was being loaded. They were recovered on outloading in Germany. Survival was assessed by the West German Plant Inspection Service by holding the cultures at 30°C/60% RH and sieving weekly to remove adults, which were counted and discarded.

Grain samples taken during loading were sieved to assess natural infestation. The sieved samples were then incubated at 30°C/60% RH in 1 kg lots and sieved again after 31 and 50 days. The adult insects present were removed and counted.

Results and discussion

CO_2 concentrations within the container rose rapidly after dosing. The total mass of gaseous CO_2 within the gas space reached a steady value after 9 h. At this time a substantial concentration gradient existed (see Table 2), with a higher level at the floor than in the headspace. However, by 23 h after dosing, the CO_2 concentrations at the three sampling locations were the same and remained within 1% of each other throughout the remainder of the period before loading on ship, except on one occasion (47 h, see Table 2).

The calculated total mass of gaseous CO_2 and the mean concentration of CO_2 in the gas space within the container during the holding period are plotted in Fig. 4. It can be seen that the total amount of CO_2 gas present remained approximately constant while the container remained unshaded. It rose to a slightly higher value when the container was placed under cover. This indicates that the container was adequately sealed with the insulated box providing sufficient CO_2 to

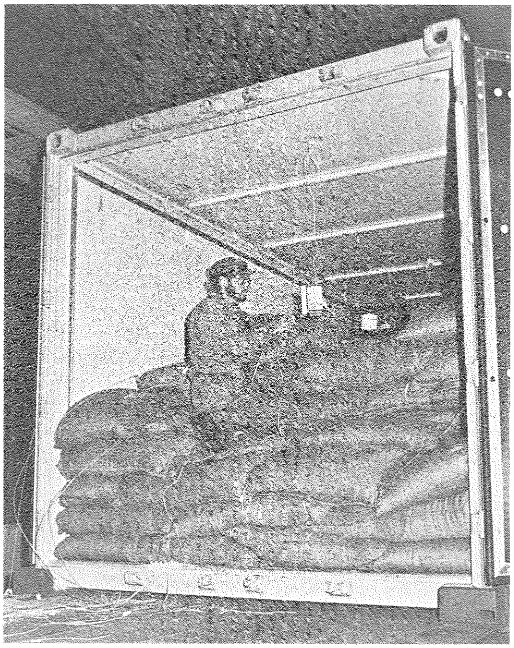


Fig. 3. Placing recorders to measure temperature and pressure of the grain and gas space before grain is exported.

Table 2. Corrected CO_2 concentrations at three points in the container during the holding period

Time after dosing(h)	% CO_2 Sampling points α	β	γ
0.25	27.8	14.7	1.3
0.38	35.4	14.9	2.0
0.75	40.3	21.5	2.0
1.17	46.0	28.9	3.8
5.3	54.4	46.9	20.7
9.2	55.0	42.6	38.2
23.1	45.8	44.9	44.6
30.2	45.6	45.7	45.6
47.4	46.9	44.9	42.3
73.2	47.0	46.0	45.9
100.7	43.0	43.0	43.3
124.3	48.4	48.4	47.9
144.7	48.4	48.0	48.0
147.3	47.6	47.1	47.6
173.6	49.8	50.1	49.6
190.2	50.6	51.0	50.7
215.7	50.7	51.3	50.9
224.0	50.6	51.1	50.6
240.7	49.4	49.8	49.4

compensate for losses. The CO_2 level on arrival at Hamburg was 7.5%, demonstrating a low rate of gas loss during the voyage.

The mass of 17 kg CO_2 present in the gas phase at 9 h represents a purging efficiency of 71%, calculated on the basis of free mixing.

The sublimation of 3 kg per day of CO_2 from the insulated box maintained a concentration of about 45% CO_2 during the first six days, over which time the rate of absorption of CO_2 by the grain and fluctuations in the headspace temperature were high. During the last four days, after the container had been placed under cover, the concentration was maintained at about 51%. These values indicate an apparent interchange rate of 2 m^3 per day during the initial part and 1.6 m^3 per day during the latter part of the holding period (see Appendix).

Variations in ambient temperature and in the temperatures at various locations within the container are given in Fig. 5 for the holding period and in Fig. 6 for the whole shipment period. Throughout the holding period, headspace and ceiling temperatures showed large daily cycles and during daytime substantially exceeded ambient shade temperature, but the bulk temperature remained approximately constant. The bulk temperature rose during the initial part of the voyage as the ship passed through the tropics, to later fall as the ship entered the northern hemisphere winter.

The load at export had a light infestation of various species as detected in the incubated samples (Table 3). However, no live insects were found on sampling the load using normal quarantine procedures at outturn.

On inspection at Hamburg there was no indication of condensation damage and the load was accepted as undamaged by the importers.

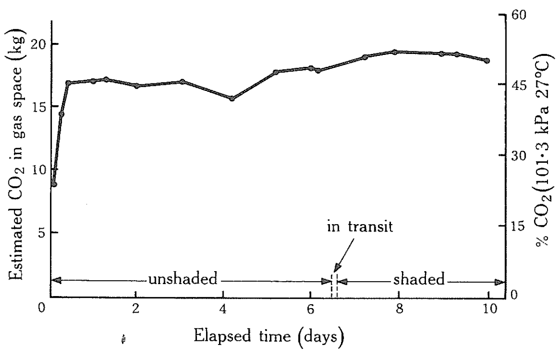
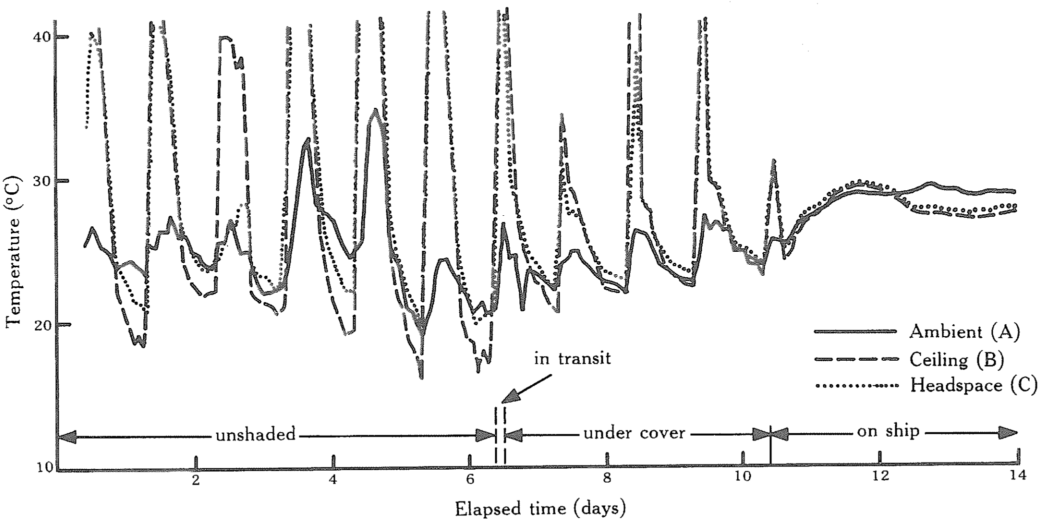


Fig. 4. Total mass of gaseous CO_2.



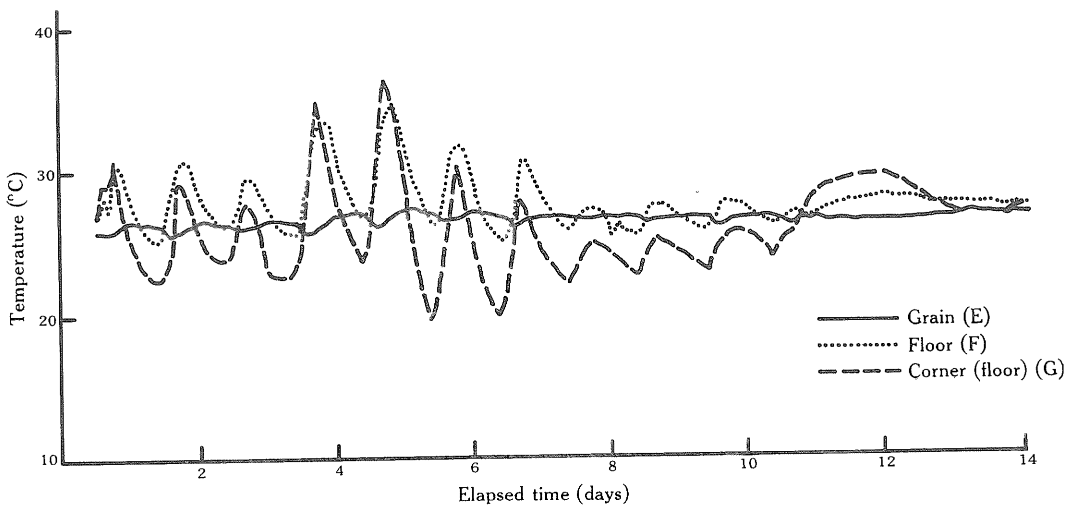


Fig. 5. Temperatures within the container during the holding period in Sydney.

Table 3. Insects found in grain samples taken on loading and after incubation of the samples at 30 °C and 60% R.H.

Total weight of samples	16.8 kg
Moisture content (Marconi)	10.0-10.3%
Live adult insects present and removed before incubation	3 *R. dominica* 1 *C. pusillus*
Live adult insects present and removed after 31 days incubation	2 *R. dominica* 2 *C. pusillus* 1 *E. cautella* 1 *T. castaneum*
Live adult insects present after 50 days incubation	152 *R. dominica*

The emergences of insects from the laboratory and field control groups are given in Fig. 7. The approximately linear increase in total numbers over the first 38 days of incubation shows that, as intended, approximately equal numbers of all immature stages were present. The close agreement between the two sets of controls indicates that no mortality resulted from transportation of the insects to the loading site. The controls give an estimate of just over 3000 insects per test cage.

No live insects were detected from the test cages at outturn, either on initial inspection

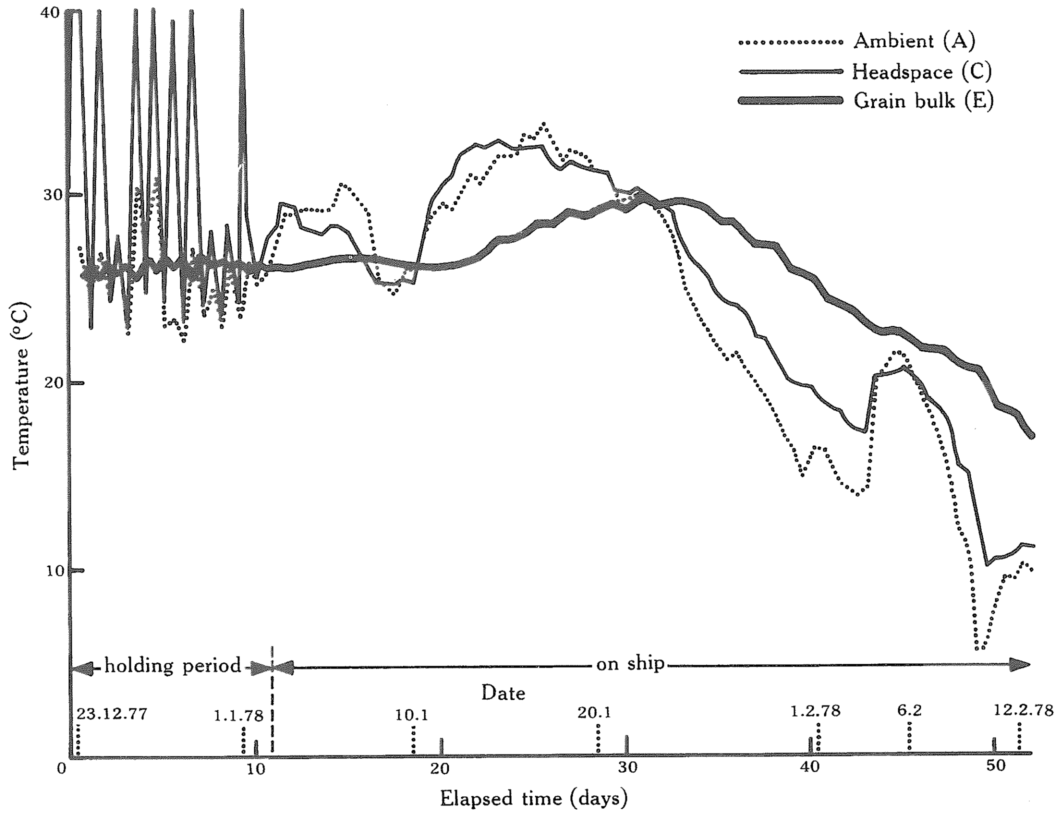


Fig. 6. Temperature variations in the container during the holding period and voyage.

or after incubation. Numbers of *dead* adult *S. oryzae* from the test cages are given in Table 4. These are similiar to the number of live adults initially present in the control cages. A slight contamination of the cultures with *Rhyzopertha dominica* was noted. This averaged less than 1 insect per test cage. None were found live.

Conclusion

This trial confirms that it is possible to disinfest grain in selected containers using CO_2 added as dry ice. The level of gastightness of the container used was within a previously suggested specification of a leakage not exceeding 6 x 10^{-3} m^3 s^{-1} at 250 Pa. The total dosage used, *c.* 60 kg dry ice, was adequate. Maintenance of an approximately constant CO_2 concentration throughout the holding period, while ambient and internal temperatures cycled greatly, shows the value of providing a slow release of CO_2 gas from an insulated box.

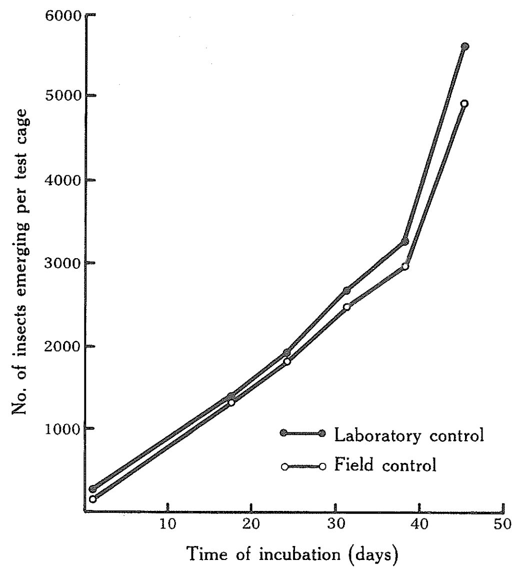


Fig. 7. Emergence of control insects per test cage on incubation at 30 °C, 60% R.H., *Sitophilus oryzae* (CSO231).

Table 4. Dead adult *S. oryzae* found in each test cage on outturn. No live insects were present either on outturn or following incubation.

Cage position (Fig. 2)	1	2	3	4	5	6
Number of cages at position	2	3	2	3	1	1
Number of adult *S. oryzae* (dead)	195;219	172;191;215	180;200	205;212;178	230	160

The stability of temperatures in the headspace after loading on ship and the high residual concentration of CO_2 on arrival in Hamburg leave no doubt that if the container had been loaded directly after dosing, an adequate CO_2 concentration would have been maintained to ensure complete insect disinfestation by the time the load arrived. Because of the small temperature fluctuations and associated leakage, if the container were loaded directly after dosing with CO_2 and stowed below deck, an insulated box of dry ice might not be required, but this needs confirmation by further experiment.

Appendix

Calculation of equilibrium air exchange rate while CO_2 is being generated internally.

At equilibrium the rate of air interchange can be obtained from the rate of generation of gaseous CO_2 and the concentration of CO_2 leaving the container (which equals the concentration of CO_2 within the container).

If Q_{in} = flow rate of air into the container

$Q_{CO_2\,gen.}$ = volumetric rate of generation of gaseous CO_2

Q_{out} = total flow rate of gas from container

and C_{CO_2} = concentration (%) of CO_2 within container

then a flow rate balance for CO_2 gives

$$Q_{CO_2\,gen.} = Q_{out}\,[C_{CO_2}/100] \qquad (1)$$

and a flow rate balance for air gives

$$Q_{in} = Q_{out}\,[(100 - C_{CO_2})/100] \qquad (2)$$

Dividing (2) by (1) and re-arranging

$$Q_{in} = Q_{CO_2\,gen.}\,[(100 - C_{CO_2})/C_{CO_2}].$$

Anti-scald agent permitted in U.K.

British regulations promulgated from 1 March 1978 permit the application to apples and pears of diphenylamine (DPA) at levels not exceeding 10 mg kg^{-1} for the prevention of the cool storage disorder superficial scald, in accordance with a recommendation of the Food Additives and Contaminants Committee in 1974. Among the countries to which Australia may export apples and pears, only West Germany and Singapore do not permit the presence of DPA on fruit.

Symposium announcement

The 4th International IUPAC Symposium on Mycotoxins and Phycotoxins, co-sponsored by the World Health Organization and the Swiss Society for Analytical and Applied Chemistry, will be held in Lausanne, Switzerland, 29–31 August 1979.

The program on the fungal and algal toxins includes plenary lectures and poster sessions on the following topics:

- biogenesis, chemistry and analysis
- occurrence in foodstuffs and feedstuffs
- fate of mycotoxins/phycotoxins during food processing and storage
- decontamination procedures
- toxicology and implication of mycotoxins/phycotoxins in human and animal health.

A round-table discussion will review recent problems on peanut and corn crop contamination and shellfish poisoning.

For participation and poster presentation, please contact Professor P. Krogh, Department of Veterinary Microbiology, School of Veterinary Medicine, Purdue University, West Lafayette, Indiana 47907, U.S.A. or Professor D. Reymond, IUPAC, Case postale 88, 1814 La Tour de Peilz, Switzerland.

Simple reversing gearbox for food processing equipment

By J. N. Huntington

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

Introduction

One of the research programs currently being undertaken in the Division is counter current extraction of foods. In this process, the food to be extracted is conveyed slowly by a mechanically driven screw along a heated trough inclined upwards. Soluble solids from the food are extracted by a solvent, usually water, which flows under gravity in the opposite direction.

During the development of a pilot scale thermoscrew it was found that periodic reversal of the motion of the screw helped to loosen the compacted material which otherwise restricted the flow of solvent.

This article describes a slow, variable speed reversing gearbox for use on this and possibly other types of processing equipment. For operation of the thermoscrew in countercurrent extraction processes, the following variables were required in the gearbox:

- the speed of the final drive shaft to be the same in forward and reverse directions and to be variable between 1–10 revolutions per hour
- the extent of the reverse motion to be variable between 0–1 revolutions of the final drive shaft
- the reversing action to be initiated at any selected point in the rotation of the final drive shaft.

Bevel gear reversing system

A bevel gear (see Fig. 1) was chosen for the reversing system because its robust nature can withstand the high shock load encountered with each change in direction of the final drive. It also assists in achieving the slow speed required for the final drive. Two pinion gears mounted on a common sliding shaft, operating across the centre axis of the bevel gear provide the forward and reverse drive mechanism. These pinions are spaced on the shaft so that only one pinion can be engaged with the bevel gear at one time. When the shaft is rotating anti-clockwise and the right-hand pinion is engaged, the bevel gear is driven in a clockwise direction (Fig. 2) and when the left-hand pinion is engaged, the bevel gear is driven anti-clockwise (Fig. 3).

The components required for the operation of the bevel gear system are mounted on a 51 mm x 51 mm mild steel frame. The components of this system (see Fig. 4) are:

- a main gearbox containing the bevel gear, pinions and sliding shaft. The output shaft from this gearbox drives the thermoscrew through chain and sprockets
- a pneumatic ram that slides the shaft carrying the pinions within the main gearbox
- a timing mechanism determining the direction of operation of the pneumatic ram
- a main drive unit.

The main gearbox

The bevel and pinion gears, and sliding shaft are housed in an open gearbox

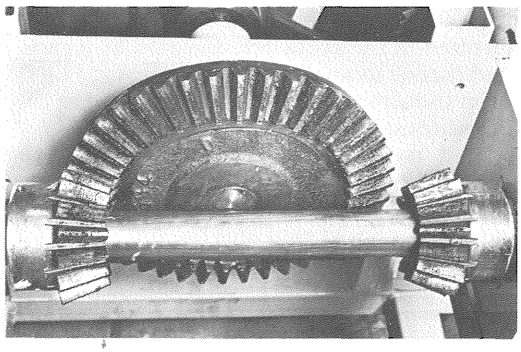


Fig. 1. Bevel gear and pinion engaged for anticlockwise operation.

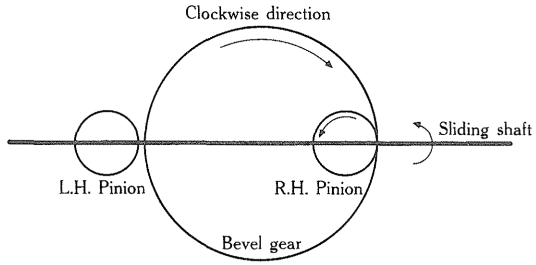


Fig. 2. Position of pinions for clockwise drive.

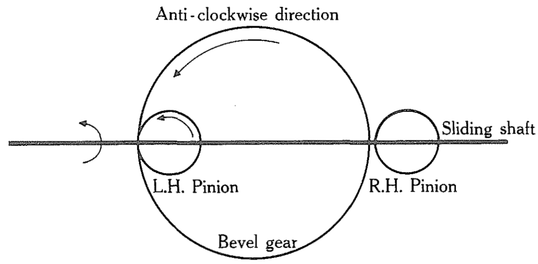


Fig. 3. Position of pinions for anticlockwise drive.

consisting of one faceplate and two end-plates made from bright mild steel. The end-plates are keyed to the faceplate so that the bearings of the bevel and pinion shafts can be positioned accurately. Since the two pinions' gears are spaced and fixed on the sliding shaft, accurate positioning of all bearings is essential to prevent jamming of the mechanism with change in direction of the final drive.

The sliding shaft is rotated by a sprocket which cannot be allowed to move laterally with the sliding shaft. This problem was overcome by fitting a captive boss and bearing at the sprocket.

The boss that is fixed to the sprocket is flanged to fit an externally-grooved bearing which is part of the same bearing that carried the sliding shaft through the main gearbox. The shaft is keyed to slide within the keywayed sprocket which is driven in an anti-clockwise direction.

The pneumatic ram

The sliding shaft in the main gearbox is connected to a pneumatic ram by a captive ball joint. The ram is operated by compressed air through an air cylinder. Air enters the system through an air filter, pressure regulator and oil lubricator. The air is then directed to the air switch operated by a cam and thence to an air control valve. One line from the air control valve is connected to the opposite end of the air cylinder to the ram. A second line is connected to the ram end of the air cylinder.

When the air switch is activated by the cam, the cylinder ram and the sliding shaft are driven forward to engage the pinion, which turns the bevel gear clockwise (see Fig. 5). When the air switch is in an 'off' position, the compressed air is automatically directed to the ram end of the cylinder and the shaft is thus moved in the opposite direction. The other pinion then engages the bevel gear and turns it anti-clockwise. The critical time of the direction change occurs when both pinions are in the same relative position on either side of the bevel gear, so that both are within the confines of the gear but not engaged with it. The pinion gear that is being engaged does not start to drive the bevel gear until the other pinion is clear. The precise time of change of direction in the final drive must occur when the teeth of the bevel gear to be engaged are parallel to the sliding shaft. This requires the incorporation of a fast, precise timing mechanism.

Timing mechanism

Precision timing is achieved by a cam

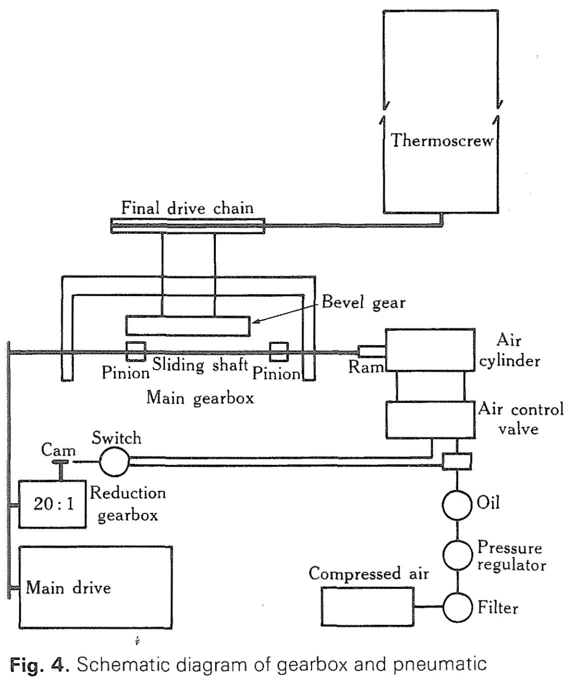


Fig. 4. Schematic diagram of gearbox and pneumatic control.

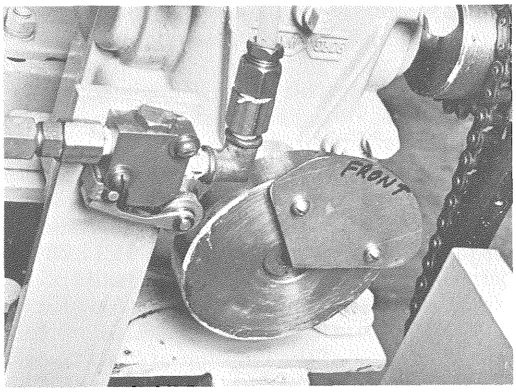


Fig. 5. Cam in position allowing screw to move in a forward direction.

mounted on a 20 : 1 reduction gearbox. The cam operates an air switch that determines the direction of the pneumatic ram. The switch is actuated when the teeth of the bevel gear are correctly positioned, and the rapidity of the mechanism allows smooth entry and withdrawal of the pinion gears. The size of the cam may be changed to vary the timing and duration of the reverse motion in the final drive.

Main drive unit

The main drive is a standard C. and H. 187 watt variable speed unit, Junior Model. In order to obtain the required speed of rotation of the thermoscrew, different sized sprockets were used on the main drive unit, reduction gearbox for the cam, sliding shaft and thermoscrew. The reduction gearbox and sliding shaft are connected to the main drive by one chain. A second chain, the final drive, connects the shaft of the bevel gear to the thermoscrew.

There are minimal mechanical requirements in this gearbox and it has given reliable performance in all forward and reversing operations.

Specifications

Main gear box

Bevel gear 42 tooth
Sonerdale GP 10534-2
Pinion gears 14 tooth
Sonerdale GP 10543-1
Sliding shaft 38.1-mm diam. mild steel, movement 39.5 mm.
All bearings bronze.
Main drive sprocket 113 tooth.
Final drive sprocket 95 tooth.
Frame face-plate
127 mm x 25.4 mm x 476 mm.
End-plates 127 mm x 19.1 mm x 165 mm.

Cam reduction gear box

Borg Warner 20 : 1 gearbox
Main drive sprocket 19 tooth

Pneumatics

Filter, regulator, lubricator 6.4 mm Arc.
Poppet valve, 3-way DP-381-3.
Air control valve PD8-710-5.
Non-cushioned air cylinder.
All components supplied by Pongrass Industries Ltd.

Main drive unit

C. and H. variable speed drive, 187 watt 0.113 watt-hour. Speed range 1.1 to 10.1 r.p.m.
Main drive sprocket 12 tooth.

News from the Division

Changes in CSIRO and in the Division

In 1976 the Commonwealth Government initiated a major assessment of CSIRO and this was carried out by an Independent Inquiry under the chairmanship of Professor A. J. Birch. The Birch Committee, though reporting favourably on the work of the Organization, made no fewer than 122 recommendations in its report to the Prime Minister. Only a proportion of these could be implemented by the CSIRO Executive, the remainder having to await the passing by the Parliament of the *Science and Industry Research Amendment Act* 1978.

Following proclamation of the Act, CSIRO has a new executive consisting of Dr J. P. Wild (Chairman), Dr N. K. Boardman, and Dr W. J. M. Tegart as full-time members, and five part-time members from primary and secondary industries.

Further, the Divisions of CSIRO are now grouped into five Institutes each with a Director.

The Division of Food Research and the Divisions of Animal Health, Animal Production, and Human Nutrition, the Wheat Research Unit, the Molecular and Cellular Biology Unit and the Centre for Animal Research and Development, Bogor, Indonesia, make up an *Institute of Animal and Food Sciences*, directed by Dr K. A. Ferguson.

Mr M. V. Tracey, formerly Chief of the Division of Food Research has been appointed Director of the *Institute of Biological Resources*, and Dr J. H. B. Christian is now Acting Chief of the Division of Food Research.

The other Institutes in CSIRO are the *Institute of Earth Resources*, the *Institute of Industrial Technology*, and the *Institute of Physical Sciences*. There is also a *Bureau of Scientific Services.*

In a move not connected with these changes Dr B. S. Harrap, formerly Assistant Chief and Officer-in-Charge of the Dairy Research Laboratory of the Division of Food Research, has joined the CSIRO Centre for International Research Co-operation (CIRC) in Canberra and Mr L. L. Muller is the Acting Officer-in-Charge of DRL.

M. V. Tracey

Michael Tracey was Chief of the Division for just over 11 years (27.11.67 to 14.12.78) a period covered in Part 3 of the recently published History of the Division (*Food Res. Q.* Vol. 37, No. 4). This period saw the amalgamation of the Division of Food Preservation with the former Division of Dairy Research and the creation of the Division of Food Research; the new Division with its three major constituent laboratories became the second largest in CSIRO.

Before Mr Tracey's appointment, the Division devoted a great deal of effort to the solution of pressing industry problems. As the Australian food industry expanded its own technological resources this role became less demanding and Mr Tracey's brief, on appointment, exhorted him 'to increase substantially the emphasis towards basic studies or long-term research . . .' While, as discussed below, he initiated many research programs which accorded with the brief, he was well aware of the need to maintain and, indeed, extend the Division's traditional close association with the food industry. His success in this direction was recognized in 1974 by presentation of the Award of Merit of the Australian Institute of Food Science and Technology.

Notable among the developmental and fundamental biological investigations launched during Mr Tracey's incumbency were such topics as temperature sensitivity of fruits and vegetables, utilization of waste and byproducts from abattoirs, canneries, and dairies; diet and human physiology; membrane structure and other physical properties of foods; membrane technology in food processing, for instance, cheese-making, improving the range, quality and packaging of meat products; and alternative uses of milk fat.

The Chief of a CSIRO Division is required to encourage new lines of work and to curtail others, and to make the optimum use of the available expertise; the management, in other words, of that particularly sensitive workforce, a team of scientists. If a Chief can, in addition, expand that workforce and provide it with sophisticated equipment and the means to operate it, his Division is fortunate indeed.

Under Michael Tracey's direction the Division of Food Research grew not only in numbers, but in stature and reputation, both in Australia and internationally. That others were also aware of this was indicated by his appointment, in 1978, as an Officer of the Order of Australia 'for services to science'.

The Division's good wishes go with Mr Tracey in his new post as the first Director of CSIRO's Institute of Biological Resources.

B. S. Harrap

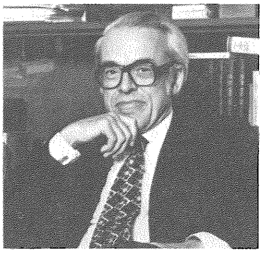
During his seven years as Officer-in-Charge of the Dairy Research Laboratory, Brian Harrap has been faced with many challenging problems because of the rapidity of changes in the Dairy Industry, which suffered from the effects of inflation and alterations in its markets. This led to many changes in the structure of, and product emphasis in, the manufacturing sector and required frequent re-evaluation of the research program of the Laboratory. Dr Harrap was very aware of the need to maintain a balance in the allocation of resources to both the short-term problems of industry and to those longer term aspects likely to provide advances in dairy science and the basis of development as the economic climate improved.

As well as representing CSIRO on a number of national committees concerned with dairying, Dr Harrap has been active in the professional bodies, has observed dairy manufacturing research overseas and has contributed widely to the field.

The depth of his scientific background and the leadership experience in his earlier activities, combined with rapid acquisition of understanding of the dairy industry and its research needs, qualified him very well to deal with the challenges of recent times. He leaves the Laboratory having established four research groups with most relevant sets of projects. These should provide a major contribution to dairy science and to the needs of industry in the next few years.

Obituary

Mr B. P. (Bernie) Byrne, Divisional Administrative Officer from 1951–70, died in Sydney on 21 November 1978.



M. V. Tracey

B. S. Harrap

Appointments

Mrs Lesley Wright, formerly a temporary Technical Officer in the Plant Physiology Group, was appointed an Experimental Officer in the Group in September 1978, to participate in a program on the responses of plant membranes to temperatures. Studies of plant mitochondria form an important part of the program. Mrs Wright is a graduate of the University of Queensland in Biochemistry and Plant Physiology.

Mr J. A. Lindsay commenced duty as an Experimental Officer in FRL's Food Safety and Quality Group in September 1978, and is engaged in biochemical and other studies on the development of heat resistance in bacterial spores. Mr Lindsay is an honours graduate of the Australian National University, Canberra, where he held a Postgraduate Scholarship from 1973–78.

In October 1978 Mrs Kathy Adams was appointed as Scientific Services Officer in the Liaison Section at FRL, to assist Mr Keith Richardson in technical liaison with the food industry. Mrs Adams graduated B.Sc.Ag. from the University of Sydney in 1972 and completed the requirements for the Master's degree in Environmental Studies, at Macquarie University in 1978. She worked as a bacteriologist with the N.S.W. Department of Agriculture from 1972–74 and with the State Pollution Control Commission from 1976–78, where her interests were in environmental management guidelines for rural industries.

Mr D. A. Jones joined DRL in November 1978, as an Experimental Officer to investigate the preparation of powders containing fat and non-fat milk solids in forms that can be stored for long periods, and that are suitable for the manufacture of a range of dairy products. Mr Jones has a first class honours degree in Microbiology from the University of New England, Armidale.

Visiting workers

Dr L. L. Morris, Professor of Olericulture, Department of Vegetable Crops, University of California, Davis, California, U.S.A. spent eight months in Australia from August 1978 while on sabbatical leave. After attending the XXth International Horticultural Congress in Sydney, Dr Morris, who specializes in the postharvest handling of vegetables, worked at the Queensland Agricultural College, Lawes, and at the Sandy Trout Food Preservation Research Laboratories of the Queensland Department of Primary Industries. From 3 November 1978 he was based at FRL where he participated in cooperative field trials conducted by the Plant Physiology Group and N.S.W. Department of Agriculture to evaluate F_1 hybrids of the *nor* tomato. Dr Morris also conducted a study of the handling methods for fresh produce at the wholesale–retail distribution level in Sydney.

Dr G. E. Hobson, Principal Scientific Officer, Glasshouse Crops Research Institute, Littlehampton, U.K. spent the period from 1 September 1978 to 2 February 1979 working at FRL in the Plant Physiology Group following his participation in the XXth International Horticultural Congress. Dr Hobson is a Plant Biochemist specializing in ripening in tomatoes and flowering in tulips. While at FRL he utilized e.s.r. techniques to examine changes in tulips associated with flowering, and participated in studies on non-ripening tomato mutants.

IUFoST

At the 5th International Congress of Food Science and Technology in Kyoto, Japan, in September 1978, Mr J. F. Kefford, Assistant Chief (External Relations) in the Division of Food Research was elected Secretary-General of the International Union of Food Science and Technology (IUFoST) for a term of five years.

IUFoST is a union with 42 member countries which seeks to promote international cooperation among food scientists, to encourage progress in basic and applied food science, to advance technology in the preservation, processing, and distribution of foods, and to stimulate education and training in food science and technology.

In addition to major international congresses held every four years, IUFoST has sponsored some 40 symposia on a wide range of subjects from the basic to the very practical. Many of these have resulted in published proceedings that are authoritative works in their respective fields. IUFoST is now concerned as to how the immense range of experience available in its member organizations can be harnessed for the benefit of developing countries.

Book notice

Bibliography of infant foods and nutrition 1938–1977

Compiled by Jane O. Henderson, Susan M. Collins, L. L. Muller and B. S. Harrap.

A comprehensive guide to the growing scientific literature on infant feeding has been compiled at the Dairy Research Laboratory, Division of Food Research, CSIRO. It contains 2259 selected references covering types of milk (511 entries), carbohydrate components (61), lipid components (161), protein and nitrogenous components (142), bacterial flora of faeces (78), fermented and acidified milks (129), mixed and weaning foods, (114), milk intolerance (125), special feeding problems (173), minerals and vitamins (276), nutritional and quality standards (180), and nutrition and disease (309). These broad sections are further divided into 113 subheadings in a systematic classification of the literature. An author and subject index, based on key words, complete the book.

This bibliography should be useful to anyone interested in the formulation, manufacture and properties of infant foods as well as to those concerned with infant nutrition and health. ix + 322 pages ISBN 0 643 00316 9. Recommended price $A16.00. Available from booksellers or CSIRO Editorial and Publications Service, P.O. Box 89, East Melbourne, Victoria, Australia, 3002.

Fresh produce for remote communities

Interest shown by the Western Australian State Committee of CSIRO in the supply of fresh fruit and vegetables to communities in remote areas of Australia prompted a survey by CSIRO officers which was followed up by a joint field study by Dr W. B. McGlasson (FRL) and Messrs J. E. Bleasel, J. C. A. Sayers, and R. W. Shuttleworth of the National Materials Handling Bureau of the Department of Productivity.

The report* of this study indicates that the quality of fruit and vegetables delivered to remote communities depends greatly on the initial selection, on handling, packaging, and transport methods, on the holding temperature, and on the transit time.

Smaller settlements and those furthest from sources of supply, as in the Kimberleys, receive produce of poorest quality. On the other hand, the quality of perishables supplied to the Pilbara is generally good because the road trip from Perth takes about two days, well within the expected postharvest life of most fruit and vegetables that are well handled and held at about 5 °C. Moreover, produce sent by sea to Darwin in refrigerated ISO containers, even though the transit time is 14 days, arrived in excellent condition.

Rail shipment from Adelaide to Alice Springs, then road transport to small Northern Territory communities and Darwin is another main route of supply. Here mixed loads constitute a major problem: refrigerated containers may be loaded with both cooled and non-cooled produce, and many smaller communities are supplied by partitioned road trucks which carry frozen foods, fresh produce and dry goods. Overland transport by road from Townsville is the third direction of supply.

The fibreboard cartons commonly used to contain produce are often damaged on the long journeys over rough roads. Returnable plastic crates are being used successfully in Western Australia and have significant advantages over cartons in strength, rigidity, ease of loading, and improved air circulation through the load. In sea transport wire cages that fit the ships' refrigerated lockers have improved the outturn quality of produce, but further improvement is possible by tarpaulin protection during dockside exposure.

The report sets out specific recommendations for cooling and handling fresh produce for remote areas. Adequate pre-cooling, accurate storage temperatures, and some control of humidity are emphasized, but suggestions are also made for compromise conditions for small mixed loads. Gross wastage and unacceptable quality observed in shipments carried under unsatisfactory conditions are described and illustrated.

In the remote communities concerned there are about 200 000 people and the overall value of the trade in fruit and vegetables is at least $25 million a year. There is potential for local ventures in fruit and vegetable growing but continuity of production cannot be assured and self-sufficiency in fresh produce is not in sight. So these communities must remain dependent on supplies from the south, and for good quality on sound systems of packaging, transport, and temperature control.

*The supply of fresh fruit and vegetables to remote areas of northern and central Australia, December 1977, 47 pp. illustrated, plastic comb binding. Copies available from Dr W. B. McGlasson (FRL).