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Stability of Moist-pack Apricots in Storage

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The Division of Food Preservation, CSIRO, recently completed storage trials on 'moist-pack' apricots (22% water content) to compare their keeping quality during ordinary storage conditions with that of the traditional drier fruit (12–16% water content). Re-processing of the sun-dried fruit and packing in a moister and softer condition did not adversely affect the storage life of the fruit, provided the sulphur dioxide level was adequate and the storage temperature not too high. This article gives an account of these experiments, and a few important factors affecting the economics of the now widely used moist-pack system are discussed.

ANNUAL production of dried apricots in Australia averages about 2500 tons and returns about $A2 million to growers, most of whom operate relatively small, irrigated orchards in the Upper Murray River area in South Australia. The apricots are harvested throughout December and January, each grower usually harvesting his own crop and preparing and drying it. Because of the hot, arid conditions common in the region during the harvesting season, sun-drying is the simplest and least costly method available for preparing dried apricots, which, until comparatively recently, were distributed and marketed as 'fully dried' apricot halves.

As with most other types of fruit preserved by drying, it is invariably the practice before sun-drying apricots to 'sulphur' the halved and stoned fruits by exposing them to fumes of burning sulphur in an enclosed chamber. Much of the sulphur dioxide (SO_2) absorbed by the pieces at this stage may be lost by the fruit before, during, and after completion of the ensuing sun-drying operation. Nevertheless, sufficient sulphur dioxide remains in the fruit to prevent excessive browning during both drying and subsequent storage of the dried product.

After sun-drying, the fruit contains about 12–16% of residual moisture; in this 'fully dried' condition it may be held by the grower-producer for a week, or perhaps a month, before it is sent to a packing house.

The packing houses, cooperatively financed and managed with the support of local fruit growers and dried fruit producers, grade the dried fruit for quality and size, 'dry' clean it, and resulphur or process it in other ways if this is desirable. The dried fruit is finally packed in paper-lined wooden boxes or cardboard cartons, of 28 lb capacity, for distribution to retail outlets or to export markets.

Most packing houses now subject some or all of the dried apricots they handle to an aqueous dipping or spraying treatment before packing. Such a process may, if metabisulphite is added to the water, be used to increase the SO_2 content of the dried fruit; but the main purpose is to raise the moisture content of the fruit from 12–16% to about 22%. Fruit thus conditioned reconstitutes more easily on cooking, and is soft enough, as purchased, to be eaten as a confection. Dried fruit moisture-conditioned in this way is known as 'moist-pack' fruit.

Some packers hold apricots in the sun-dried state after grading them for quality and size, preparing the moist-pack fruit only to order. But in recent years the majority have adopted the practice of moist-packing in February and March all apricots harvested and dried during the preceding December and January. The moist-pack fruit is usually held at ambient temperature until sold, and this holding period can extend almost to the next drying season. Clearly, therefore, if the production of dried apricots were at any time to increase substantially without a concurrent increase in demand, storage periods would exceed one year.

The advantage of processing and packing all dried apricots as moist-pack fruit during February and March is that all apricot processing is cleared before the influx of dried vine fruits in early April. It was pertinent, therefore, to determine whether moist-pack apricots containing 22% moisture deteriorated more rapidly in storage than the drier material containing 12–16% moisture.

Two storage trials undertaken by the CSIRO Division of Food Preservation were specifically designed to provide an answer to this question. An account of these trials is given in the present article, and the results are discussed in relation to some earlier investigations on factors affecting the storage characteristics of dried apricots.

Test Materials and Storage Conditions

Trial No. 1

For the first storage trial, apricots that had been dried in January and moist-packed in March were obtained from a commercial packing house in May 1964; no corresponding dry-pack apricots were available. The colour of the fruit in this consignment was not uniform, and the fruit was sorted into two quality grades, one comprising reddish halves devoid of visible brown discoloration, and the other grade consisting of halves with slight but definite darkening. In March the fruit was processed to contain 22% water, but by May the first-mentioned grade contained 17·5%, and the latter 18·3% moisture. The sulphur dioxide contents were 2500 and 2300 p.p.m. respectively.

A number of 250-g samples from each of these two grades were sealed in cans, and stored for various periods up to 36 weeks at temperatures ranging from −20°F to 86°F.

Trial No. 2

Apricots obtained from another packing house in July 1964 were used in a second trial. They had been held in the dry state since the previous January, and on request, some were moist-packed. Samples of the dry and of the moist apricots were thus available at the same time. The dry fruit contained 13·4% moisture and 3150 p.p.m. SO_2, while the moist fruit contained 23·4% moisture and 3400 p.p.m. SO_2. Each was divided into subsamples, which were stored in cans for various periods up to 48 weeks at temperatures ranging from −20°F to 86°F.

Assessing Deterioration

The principal index for assessing deterioration of the apricots at each set of storage conditions was the degree of browning or darkening in them, as determined by the method of Nury and Brekke (1960). In applying this method, 15-g samples of well-minced fruit were soaked in 200 ml of 50% ethanol for 20 hr, and the colour of the resultant extracts was measured by their optical absorbances at 440 mμ in a 1-cm cell.

Loss of sulphur dioxide from the stored apricots provided a second index for assessing deterioration of the fruit during storage. Total SO_2 was determined by the Monier–Williams method modified by Shipton (1954).

The results of these two methods of assessment and some conclusions derived from them are considered below.

Browning Rates

Figure 1 shows the rate of development of brown pigment in apricots at the five storage temperatures and over the 36 weeks' duration of the first trial. In the second trial, absorbances of the ethanolic extracts of the samples stored at −20, 32, and 45°F remained constant and for this reason were not plotted in Figure 2, which shows only the absorbances at 68, 77, and 86°F over the 48 weeks of the trial.

Indicated Storage Life

Nury and Brekke (1963) considered that dried fruit had reached its limit of acceptability when the absorbance of its ethanolic extract was 0·3 at 440mμ. After removal from storage, dried apricots in excess of those needed for chemical analyses were kept at −20°F (at which temperature further changes would be negligible), and all samples were examined visually at the one time at the conclusion of the tests. This comparison showed that for our test material also, an absorbance value of 0·3 was a practical guide to the limit of acceptability. At this stage of deterioration the dried apricots showed moderate browning, in addition to the natural reddish pigmentation, and the degree of darkening was such that we considered a prospective customer might hesitate to buy the fruit. Nevertheless, when these samples were reconstituted and cooked,

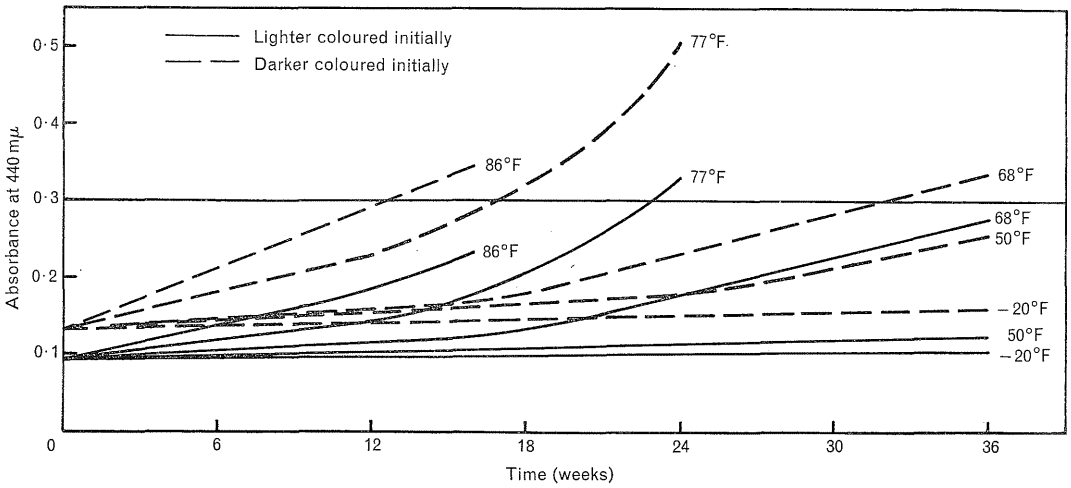

Fig. 1.—Development of browning in stored dried apricots at different temperatures.

dilution of the brown colour occurred and only a slight burnt taste or off-flavour was evident. A limit line at the 0·3 absorbance level is shown in Figures 1 and 2. Using this limit the estimated storage lives at different temperatures given in Table 1 were derived.

It is clear from Figure 1 and Table 1 that at all temperatures used in the first storage trial the apricots that were slightly darker at the start had a faster rate of browning. This was unlikely to be due to the slightly lower level of SO_2 in the darker-coloured fruit, and probably reflected the influence of some field or processing factor on the apricots before they left the packing house. The higher initial SO_2 level in the apricots for the second trial resulted in that fruit having a longer storage life than the fruit used in the first trial.

Influence of Temperature

The trials have indicated that providing dried apricots initially contain 3000 p.p.m. SO_2, or slightly more, a storage life of about 5 months at 86°F, 9 months at 77°F, or 1 year at 68°F, can be expected. Since at and below 50°F deterioration was very slow, storage times well in excess of 1 year may be expected under such conditions. This prediction is in accord with observations by Nury and Brekke (1960), who showed that dried apricots stored either at 35°F or at 50°F were still in excellent condition after 16 months.

Trout and Hall (unpublished data, 1945) and Stadtman *et al.* (1946*a*) demonstrated the rapidity with which browning may

Table 1

Estimated Times for Dried Apricots to reach Limit of Acceptability* when stored at Temperatures between −20 and 86°F

Temp. (°F)	Estimated Storage Life (wk)	
Trial No. 1	Lighter Fruit	Darker Fruit
−20	36+++	36+++
50	36+++	36+
68	36+	33
77	23	17
86	17	12
Trial No. 2	Low Moisture (13·4%)	High Moisture (23·4%)
−20	48+++	48+++
32	48+++	48+++
45	48++	48++
68	48+	48+
77	34	38
86	18	20

Plus signs indicate extent by which estimated storage life exceeded total time of trial: +++, far in excess; ++, moderately in excess; +, just in excess.

* Absorbance of ethanolic extract 0·3 at 440 mμ.

Table 2

Q_{10} Values for Browning Rate in Stored Dried Apricots between 68 and 86°F

Description of Fruit	Q_{10} Value at			
Trial No. 1	4 wk	8 wk	12 wk	16 wk
Lighter	2·5	3·2	3·3	4·6
Darker	7·4	4·9	4·9	4·6
Trial No. 2	12 wk	24 wk	36 wk	48 wk
High moisture (23·4%)	10	21	28	26
Low moisture (13·4%)	3·0	5·7	7·6	7·7

develop at relatively high temperatures. Trout and Hall, working at the CSIRO Division of Food Preservation, stored apricots at 65, 86, and 98°F, and judged the effective storage life of the fruit by comparing the stored fruit against nine standard samples whose colours, ranging from apricot to black, were specified in terms of Lovibond tintometer readings. These experiments demonstrated that at a storage temperature of 98°F (36·7°C) the storage life of the fruit was less than half that of similar fruit stored at 86°F (30°C); the corresponding Q_{10} value, which represents the factor by which the rate of deterioration increased over a rise of 10 degC (18 degF), was 3·3. Stadtman *et al.* showed that rates of darkening of dried apricots increased about four times for every 10 degC rise over the range 22–49°C (72–120°F), the deterioration in colour being assessed by comparing the colour of 50% ethanolic extracts against specified colour standards.

Table 2 shows Q_{10} values for the temperature range 68–86°F (20–30°C) at the end of various storage times in the present trials. The high Q_{10} figures obtained for moist-pack fruit in the second trial were due to the high rate of browning at 86°F relative to the low rate of browning at 68°F (Fig. 2); the remaining values ranged between 2·5 and 7·7, with the average just below 5. Considered in conjunction with the earlier findings cited, the results emphasize the adverse effect of high temperature on the quality of stored dried apricots.

Influence of Moisture Content

Figure 2 indicates that dried apricots deteriorated at a rate that was not to any practical degree dependent upon the moisture content within the range 13·4 to 23·4%. In the earlier study of Trout and Hall it was reported that 'there is no evidence that storage life is related to the moisture content over the range 13·0% to 20·1% for sun-dried apricots'. But Stadtman *et al.* (1946*a*) later demonstrated that at moisture contents in excess of 10% the rate of deterioration of dried apricots depended on the availability of oxygen. They found that in the absence

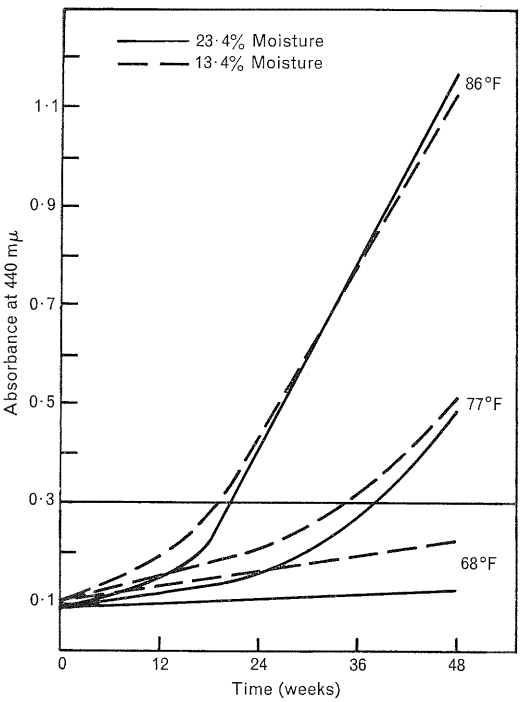

Fig. 2.—Development of browning in stored dried apricots at different temperatures.

of oxygen the rate of deterioration was lower at the higher moisture contents; but as oxygen availability increased, the beneficial influence of high levels of moisture was progressively less evident, until ultimately it was negligible.

In the present trials, about 60 mg of oxygen were available per 100 g fruit in the sealed cans. The data of Stadtman *et*

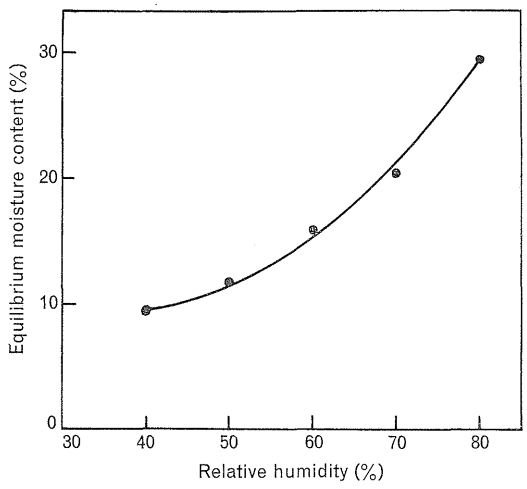

Fig. 3.—Relation between moisture content and relative humidity for dried apricots at 25°C.

al. (1946*a*) show that at this or higher levels of available oxygen the influence of moisture content on storage life is of little practical significance. Thus all results suggested that with present packing methods there would be no reason to expect a decrease in storage life if the apricots were moist-packed shortly after being sun-dried. It would, however, be futile to moist-pack unless water loss from the product was controlled.

Figure 3, which indicates the relationship between the equilibrium moisture content of dried apricots and relative humidity, shows that fruit with a moisture content of 22% will neither lose nor gain moisture if the surrounding air has a relative humidity of 72%. However, relative humidity is often below this figure in the regions in South Australia where dried apricots are packed and stored. Under these conditions, moist-pack fruit will lose moisture to the air.

If the moisture content of the fruit fell from an initial 22% to 16%—a common commercial occurrence—a carton of 28 lb of apricots would lose 2 lb, which at 50c per lb would represent a financial loss of $1 per carton or 3·6c per lb. Such losses could be reduced by the use of inner liners of heat-sealable plastic film in the present wooden cases or cardboard cartons.

Some packing houses have already tested this principle by using gusseted liners made from 0·001 in. polyethylene in corrugated cardboard containers. Instead of being heat-sealed, the tops of the pouches are carefully folded over before the carton is closed. Tests have shown that this procedure restricts water loss to small amounts. Each liner costs 3c, and if we assume that an operator receiving wages of $1.20 per hr inserts and folds two liners a minute (a slow rate indeed), labour costs would be 1c per carton. Thus material and labour costs for each 28-lb carton of apricots would be 4c, or about 0·15c per lb of moist-pack fruit.

Alternatively, cartons could be made in which the inner surface consists of a Saran-coated heavy paper, though gluing might be necessary to ensure adequate sealing of the container. A third possibility is the packing of the moist fruit directly into suitable heat-sealable plastic pouches of 8, 12, or 16 oz capacity. Sealed cans are too expensive for commercial use but were employed in the storage trials for convenience.

While low water vapour permeability is the main requirement for packages for moist apricots, the results of Stadtman *et al.* (1965*a*) previously quoted indicate that a container capable of restricting the supply of oxygen to the fruit might have additional advantages, particularly for long-term storage.

Loss of Sulphur Dioxide

The function of SO_2 in dried apricots is to retard the browning that results from a series of complex chemical reactions involving naturally occurring sugars, amino compounds, and organic acids. As a general rule, SO_2 level declines during the storage of dried fruits, some being converted to sulphate and some probably volatilizing. This loss of total SO_2 is often taken as a guide in assessing deterioration rate.

Figures 4 and 5 show the fall in SO_2 levels during the two present storage trials. In these graphs, values have been plotted only for 68, 77, and 86°F, since losses at 50°F and lower are negligible. Both graphs indicate that losses increase as temperatures are raised, and Figure 5 shows that there is a more rapid loss of SO_2 from fruit with the higher moisture content. In a second paper, Stadtman *et al.* (1946*b*) showed that the rate of oxidation of SO_2 depended upon oxygen availability, and since high-moisture fruit consumed oxygen more rapidly than fruit

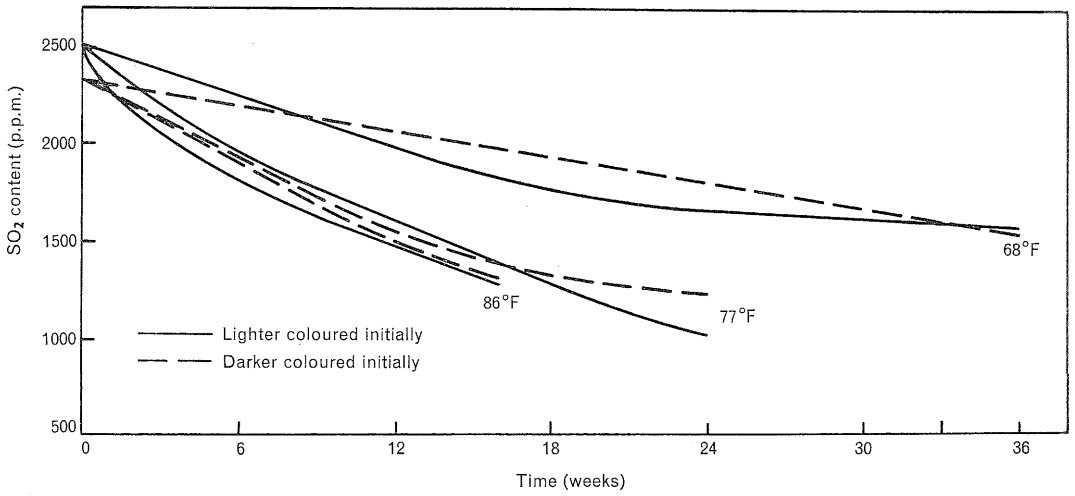

Fig. 4.—Loss of SO_2 from dried apricots at different temperatures of storage.

with a lower moisture content, part of this increased oxygen usage might account for the observed faster decline in SO_2 level.

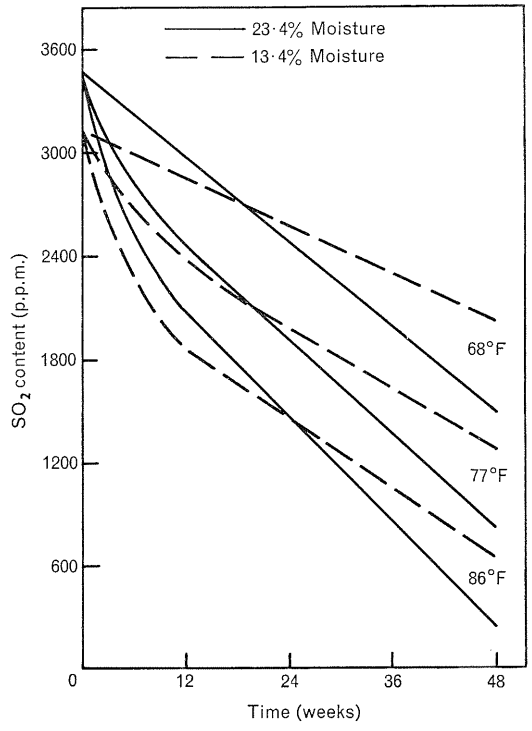

Fig. 5.—Loss of SO_2 from dried apricots at different temperatures of storage.

The same authors showed that the rate of disappearance of SO_2 from stored apricots increased fourfold for each 10 degC rise in temperature. Q_{10} values calculated from SO_2 contents from the present trials are listed in Table 3. In each trial, Q_{10} values were higher in the early stages of storage, subsequently stabilizing at values close to 2. Trout and Hall found that over the range 65°F to 86°F the rate of loss of SO_2 increased by a factor of 2·2 for a temperature increase of 10 degC.

Need for High and Uniform SO_2 Content

These and earlier investigations demonstrate the marked influence of sulphur dioxide content on the storage life of dried apricots, and confirm that initial values should be as close as possible to the upper limit of 3000 p.p.m. legally permissible within Australia.

Most packing houses in Australia have neither facilities nor staff for determining SO_2, and the haphazard mixing of consignments of dried apricots of similar appearance frequently occurs. After processing and storage, such mixed samples often appear 'piebald' due to the rapid rate of darkening of material which had lower SO_2 contents initially. This variability in the SO_2 level in apricots is one of the main problems confronting the dried fruit industry. Although standardization of sulphuring procedures, on

Table 3
Q_{10} Values for Rate of Loss of SO_2 from Stored Apricots between 68 and 86°F

Description of Fruit	Q_{10} Value at			
Trial No. 1	4 wk	8 wk	12 wk	16 wk
Lighter	3·0	2·3	1·9	1·9
Darker	4·5	3·4	3·7	2·3
Trial No. 2	12 wk	24 wk	36 wk	48 wk
High moisture (23·4%)	3·1	2·3	1·8	1·7
Low moisture (13·4%)	4·6	2·8	2·3	2·3

which research is continuing, will reduce variations, it will not obviate the need for packing houses to determine SO_2 in consignments before blending.

Practical Implications

These storage trials showed that the present common practice of moist-packing dried apricots in February and March is unlikely to cause a reduction in the potential storage life compared with that of fruit stored in the dry state. This conclusion is supported by earlier Australian and U.S. investigations.

Observations on the water relations of dried apricots indicated the futility of moist-packing fruit and then leaving it free to lose, by evaporation, all or a large part of the absorbed water. A number of prospective packaging materials capable of preventing water loss are available; one film has already been successfully tested on a commercial scale by technical staff of a major packing house. Some of these materials would also limit the supply of oxygen to moist-packed apricots and this could have some advantage during lengthy storage periods.

The rate of darkening of apricots increased about fourfold for the 10 degC (18 degF) rise in temperature from 68°F to 86°F, emphasizing the damaging influence of high temperatures. Immediately after the fruit is dried it is normally stored in open boxes at the orchards, frequently in galvanized iron sheds and sometimes directly in the sun. As ambient temperatures are almost invariably high — sometimes approaching 110°F — holding the dried fruit under such conditions, even for short periods, will undoubtedly cause a considerable reduction in its storage life. Consequently, whether at the orchard or at the packing house, freshly dried apricots should be stored in the coolest place available.

In line with recent U.S. observations, cool storage at temperatures not above 50°F should be used if good quality is to be maintained in dried apricots for a year or more. However, in view of the high Q_{10} values, any reduction in storage temperature will prolong storage life by reducing the rate of development of browning.

Sulphur dioxide level has an appreciable influence on the storage life of dried apricots and efforts should be made by packing houses to segregate fruit on the basis of SO_2 content. Three thousand p.p.m. of SO_2, the permissible legal limit within Australia, is essential for long-term storage. Many importing countries limit SO_2 in dried fruits to 2000 p.p.m.; losses during transport to such countries should be ascertained so that fruit may leave Australia with an SO_2 content which ensures the highest possible quality on arrival and still complies with statutory requirements.

Acknowledgments

Grateful acknowledgment is made to Mr. L. Traeger, of the Berri Co-operative Packing Union, and to Mr. McKinnon, of the Loxton packing house, who arranged for the supply of dried apricots for these trials.

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Technology of Banana Marketing

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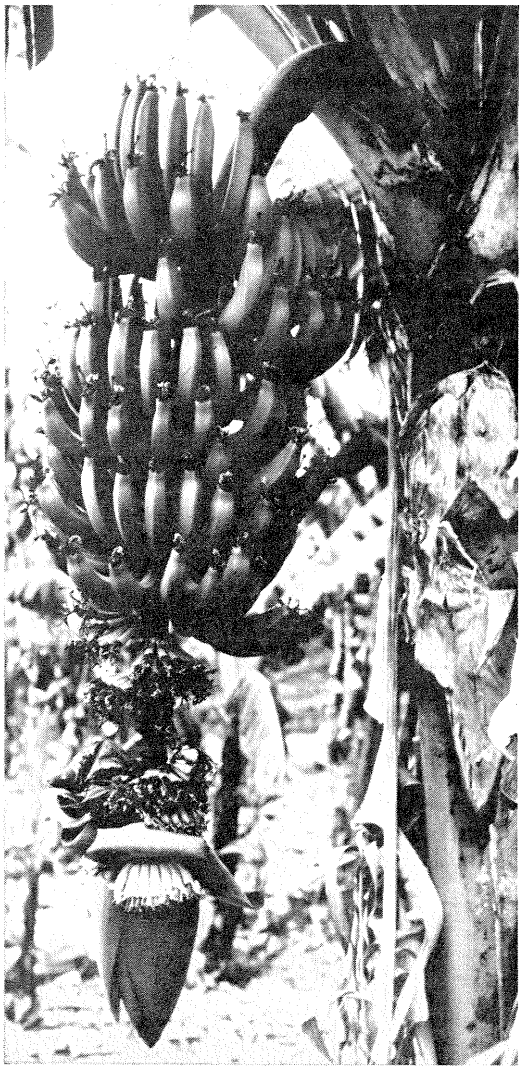
In Australia, bananas are grown in Queensland and northern New South Wales and to some extent in Western Australia. This article, based on a paper delivered to the Sixteenth Annual Convention of the Institute of Food Technologists, Australian Sections, held in May 1966, discusses the technological problems involved in marketing bananas in the main population centres, hundreds of miles away from the plantations.



THE BANANA belongs to the genus *Musa*, most species of which bear inedible fruit. Only two have given rise to edible varieties—*Musa acuminata*, from which the well-known Gros Michel variety and the Cavendish group of varieties are derived, and *Musa balbisiana*, from which plantains derive some of their characters. In common usage, however, starchy cooking fruits are called plantains and dessert fruits bananas. Nearly all bananas grown commercially in Australia are Cavendish types.

Botanically the banana is a clumped, perennial herb with an adventitious root system and a sympodial, underground stem best described as a 'corm'; the aerial stems are tall and supported by closely packed leaf sheaths which form pseudostems. The vegetative growth of each shoot is terminated by transformation of the growing point into a large inflorescence which grows downward and develops successive flower clusters, each within a bract which later falls away. The basal (top) flowers are female and from these the fruits develop parthenocarpically. The distal flowers are male and deciduous.

Each cluster of fruits, of which there may be 10 or more on the bunch, is known as a hand. Under tropical conditions the time from when the inflorescence appears, i.e. the time the bunch is 'thrown', to the time when the fruit is ready to harvest is 80–90 days.

In Australia bananas are mostly grown out of their normal tropical environment, in a warm-temperate or subtropical climate.

Fig. 1.—A growing banana bunch showing the remains of male flowers at the lower end, and the pendant terminal bud or 'bell'.

The time for the bunch to develop varies throughout the year, and in New South Wales it ranges from 3 months in the summer to 6 months in the winter. Commonly, the life of each stem, from when it first appears as a sucker to maturation of the fruit, varies from about 9 months in the tropics to as long as 15 months in warm-temperate regions. As new shoots arise at any time, a banana plantation produces fruit the year round. In Australia, however, production is mainly in the summer.

Bananas, mostly cooking types, are grown in very large quantities over vast areas of the tropics, in many of which they form the staple diet. The annual world production of table bananas, although difficult to estimate, is probably of the order of 20 million tons, of which about 4 million tons, mainly from Latin America, are exported, mostly to the United States of America. In Ecuador, production, which is controlled by the U.S.A., is approaching 1 million tons, principally for export.

The banana is by far the most important horticultural food crop. World production of table bananas is greater than that of either citrus fruits or apples, and is exceeded only by that of grapes.

By world standards the production of bananas in Australia is very small, but the annual production of about 125,000 tons is third in importance among fruits marketed fresh, being exceeded only by apples and oranges. Bananas are grown mainly on the North Coast of New South Wales from Coffs Harbour northwards, on sheltered frost-free hillsides facing the sun, and to a lesser extent in south-eastern Queensland. As transport to markets in southern Australia improves, production on river flats and on the coastal plain in tropical north Queensland is increasing rapidly.

There is also a small area of bananas grown under irrigation near Carnarvon, W.A., which now supplies most of the requirements of Western Australia.

Basis of Artificial Ripening

Bananas will ripen naturally either on or off the plant, but such natural ripening is irregular and too variable to be relied upon for orderly marketing.

Bananas for commerce are harvested while hard and green, in which condition they may be safely handled and transported over long distances, commonly for periods up to 2 weeks. Under carefully controlled conditions this may be extended to 3 weeks. The green fruit is then ripened, or part-ripened, artificially in special ripening rooms before distribution to retailers.

The artificial ripening of bananas, now an essential part of the banana trade, can be traced back to the ancient practice of ripening fruit in Chinese temples, in the warmth of which uniform ripening was readily initiated. In the United States of America ripening rooms were initially heated with kerosene-fired heaters, which, it was found, stimulated the ripening of bananas and certain other fruits. Research by Denny (1924) and others in the Boyce Thompson Institute showed that the stimulation of ripening in these rooms was mainly due to the presence in the air of small amounts of ethylene, produced by partially choked kerosene burners, rather than to warmth, and that in the temples ethylene was produced by the burning of incense. In fact, recent investigations in this laboratory (McGlasson, unpublished data) and at the Food Preservation Research Laboratory of the Queensland Department of Primary Industries in Brisbane (Blake, unpublished data) have shown that even at ideal ripening temperatures, bananas can be kept in the hard green condition for as long as 40 days in the absence of ethylene. In practice it is very difficult to ensure that no ethylene is present, and it is now known that as little as 0·1 p.p.m. in the air will initiate ripening. The other unsaturated low hydrocarbons, acetylene and propylene, will also stimulate ripening, but only at considerably higher concentrations.

Ethylene is of special interest as it is produced by many fruits and appears to be a universal endogenous ripening hormone. This has been demonstrated at the University of Miami by Stanley and Ellen Burg (1962), whose work is of profound importance for workers in post-harvest physiology. They showed that ethylene is always present in a fruit before the respiratory climacteric begins, and that ripening appears at first to be prevented by an inhibitor from the shoot system. This inhibitor probably ceases to operate when the fruit reaches a late stage of maturity on the plant.

In the banana the internal ethylene content rises from about 0·1 p.p.m. in the hard, green, pre-climacteric fruit to about 1 p.p.m. at the climacteric peak of respiration, at which stage the fruit has begun to soften and the dark green colour of the hard pre-climacteric fruit is becoming lighter. The fruit is now said to be 'sprung', because it is no longer rigid, but springy. From this stage on, ripening proceeds rapidly and inevitably.

Physiology and Biochemistry

The green banana is predominantly starchy, containing about 20% of starch. During ripening the starch is rapidly hydrolysed, and the ripe fruit contains about 12% sucrose, 3% glucose, 3% fructose, and small amounts of other sugars. The marked astringency of the green fruit also disappears during ripening, the 'tannin' content falling by about four-fifths. The protein content of 0·5–1·0% and the 0·2% of fat change little. During ripening the volatiles increase 5–20 times, and the fruit develops its characteristic flavour and aroma, a conspicuous component of the aroma being amyl acetate. Other changes include a fall in pH from 5–5·5 to 4·2–4·8 and a twofold increase in titratable acidity. In green fruit the principal acid may be oxalic, but in ripe fruit malic acid predominates. During ripening at a temperature of about 65°F the respiration rate rises from about 25 mg CO_2/kg/hr in the hard green fruit to about 150 at the so-called climacteric peak, and later falls to about 100 at the end of the ripening process. As the skin changes in colour from green to yellow there is a sharp decrease in chlorophyll and a small increase in its content of carotene.

Bananas are particularly sensitive to temperature. After harvest they will ripen well only over the narrow range 58–70°F. On exposure to higher temperatures ripening becomes unsatisfactory, and the fruit shows symptoms of 'boiling', that is, the skin remains green, the pulp softens rapidly and breaks down, and normal development of flavour does not occur. Slight overheating during ripening may show only as soft pulp and tender skins. At temperatures below about 52°F bananas become 'chilled'. In green fruit the symptoms are often merely the occurrence of brown, subepidermal streaks, subsequent ripening being satisfactory. On the other hand, ripening may be abnormal—a soft pulp may develop in a green skin, or a hard pulp in a coloured skin, or the fruit may merely develop a dull colour and poor flavour. In addition, starch hydrolysis may be slow and the tannin content may remain relatively high. The extent of either boiling or chilling depends on both the actual temperatures and the duration of exposure, and ripening fruit is more sensitive than green fruit.

Bananas also respond more strongly than most fruits to changes in the carbon dioxide and oxygen content of the atmosphere, and thus keep well in 'controlled atmosphere' or 'gas' storage *provided that external ethylene is not present.* In the CSIRO Division of Food Preservation Dr. W. B. McGlasson has kept fruit hard and green for more than 100 days in an atmosphere of 5% CO_2 and 3% O_2, at the optimum ripening temperature of 68°F.

Harvesting and Transport

Bananas can be harvested at almost any stage of maturity and subsequently made to ripen quite normally by exposure to ethylene. There is no good practical guide to the maturity of hard green bananas other than the 'fullness' or thickness of the fruit, but under the marginal climatic conditions under which the fruit is grown in Australia, the degree of fullness is not always a reliable indication of maturity. An immature fruit is quite angular in cross-section and a mature, 'full' fruit is more or less rounded. For distant marketing and in hot weather the fruit should be cut at an earlier, less full, stage. The stage at which the fruit is cut is the most critical factor in determining whether it will reach the market in the hard green condition required by ripeners. Current research indicates that packing in sealed polyethylene film bags may be a valuable aid in long-distance transport (Scott and Roberts 1966).

A temperature of 55°F is ideal for transport and is essential for long journeys. For shorter journeys, which are common in Australia, higher temperatures do no harm, provided that the fruit has been cut at the correct stage for the particular market and that it is not exposed to ethylene (e.g. from ripening fruit) before or during the journey. The ripening and transport of bananas in Australia were extensively studied in the early 1930s by

officers of the Council for Scientific and Industrail Research and others (Young *et al.* 1932; Hicks and Holmes 1935), and this work laid the foundation for the commercial practices operating today. It was also shown that bananas lose water relatively freely through evaporation, so that where air can circulate freely through the load, as when bananas are transported in standard wooden boxes in louvred rail vans, fruit temperatures quickly approach wet-bulb temperatures and, even in hot weather, rarely rise to damaging levels.

Until recently all bananas in Australia were packed singly in bulged, wooden boxes. The mechanical pressure exerted during the lidding operation often caused considerable physical damage to the bananas (Fig. 2), and frequently led to the development of fungal infections on them during ripening. The broken stem is a major avenue of infection, leading to development of 'squirter' disease (*Nigrospora musae*) and to 'black end', i.e. finger-stalk rots. The latter rots are mainly due to *Gloeosporium musarum*, which also causes anthracnose (the characteristic spotting of fully ripe fruit), and are a problem generally only in summer. Squirter is mainly confined to the winter months.

In the last few years the packing of hands of fruit in smaller fibreboard cartons (Fig. 3) has become a feature of the industry. These hand-packs considerably reduce stem infections of individual fruits and mechanical damage to the fruit, and result in a longer shelf life. Mechanical injuries are not readily seen on green fruit but as the fruit ripens, they develop through desiccation, discoloration, and infection. They can thus seriously blemish ripe fruit.

The use of cartons has accentuated problems of temperature control, mainly during transport. The cartons have flat sides, and unless special, and possibly expensive, precautions are taken they stack tightly together, allowing virtually no movement of air through the load. Investigations are proceeding to determine the relative merits, for long-distance transport of bananas in cartons, of precooling the fruit before transport, or venting the cartons and using open stowage. There are similar problems of ventilation and temperature control in ripening rooms, but they are more easily dealt with because maximum utilization of space is not as important as in transport vehicles.

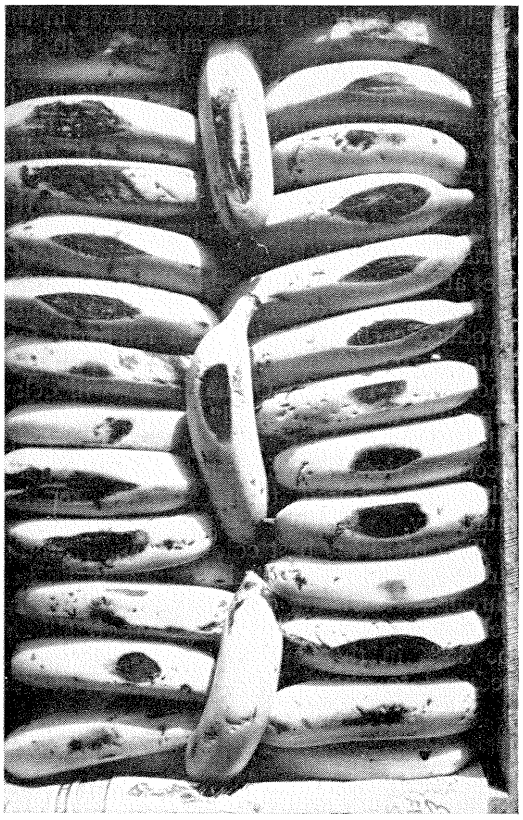


Fig. 2.—A wooden case of single bananas, showing severe bruising and case rub.

Ripening Technology

General Requirements

The ripening of bananas is carried out in special rooms, mostly located in the capital cities, in which temperature, humidity, and the carbon dioxide content of the atmosphere are controlled, and a ripening stimulator, preferably ethylene, is present.

The early research work in Australia (Anon. 1948; Young *et al.* 1932) showed that the winter fruit ripened well when the fruit temperature was 66°F, and summer fruit was best ripened at 68°F. At higher temperatures, although colour is still good, flavour tends to be poorer and the fruit has a shorter shelf life; fruit temperatures above 70°F should be avoided during ripening and temperatures above 73°F are damaging. Depending on the speed of ripening and the

shelf life required, fruit temperatures in the range 58–64°F are generally used in the U.S.A. Although ripening is slower, eating quality is just as good and the shelf life is longer when ripening is carried out at these lower temperatures. When slower ripening is required, such lower temperatures may be used with Australian fruit but, except in the early stages, fruit temperatures should preferably not be below 60°F and they should not at any stage be allowed to fall below 55°F.

Bananas, in common with other fruits, produce carbon dioxide at a relatively fast rate during ripening. A concentration of more than 1% of CO_2 in the air will delay ripening, and it is usually necessary to ventilate the ripening rooms to prevent its accumulation. Admission of fresh air may also be required to reduce the relative humidity.

To obtain the best colour during ripening and to minimize the development of blemishes through the drying out of skin injuries, the relative humidity in the ripening room should be 85% in the early stages. It should be reduced to about 75% when the fruit has started to colour, otherwise the peel may become soft and even split, although it retains a good colour, and fungal infections may increase.

Ethylene Concentration

Suitable ethylene concentrations for ripening rooms are 1 part in 10,000 of the empty volume of the room during winter, and 1 part in 20,000 in summer.

The higher concentration of ethylene is needed in winter to obtain a good colour. The gas should be added to the room twice daily, until ventilation is commenced at the 'colour shows' stage. The amount added will depend greatly on the 'leakiness' of the rooms. If there is not enough ethylene, ripening may be slow to start, the skin colour will be pale, and it will develop slowly. Pronounced and persistent green tips are a common indication of insufficient gas: if these symptoms are present, double the above concentrations of ethylene or add the gas 3–4 times a day. Higher concentrations do not hasten ripening, and more than 1 part of ethylene in 1000 parts of air can damage the fruit, causing a spotted

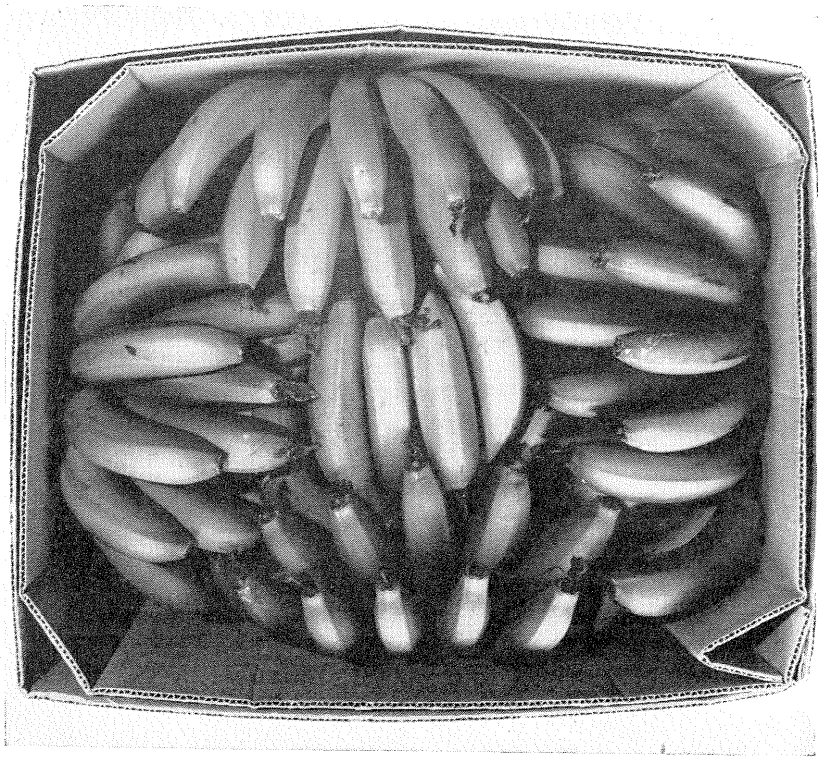


Fig. 3.—The modern pack—hands of bananas in a fibreboard carton, which greatly reduces injury to the fruit.

browning of the skin before the pulp ripens.

Ethylene is explosive at concentrations of from 2·7 to 29% in air, but the minimum explosive concentration is more than 100 times greater than the maximum needed for ripening. Ethylene is a colourless gas with a faint, sweetish odour which is readily detected in low concentrations. It is harmless to human beings and animals in concentrations of less than 1 in 1000.

For many years it was the practice to use coal gas (town gas) to ripen bananas. It was effective because it contained 2½–3% of ethylene, and a concentration of 1 in 1000 was recommended. Modern town gas contains a considerable proportion of petroleum gas from oil refineries and the concentration of the unsaturated hydrocarbons ethylene and propylene, which act as ripening agents, is 6–7%, so that only half as much gas (i.e. 1 in 2000) is needed nowadays. However, unburnt town gas is explosive in concentrations of more than 5%: indeed, over the years there have been several fatal explosions in ripening rooms. Therefore the use of coal gas, town gas, or acetylene (which is much less effective and more dangerous) is no longer recommended.

In any event, switches and other electrical equipment in the ripening room should be flame-proof, the room should be fitted with an explosion port, and there should not be any naked flame in the room. These safety precautions are required by law in New South Wales.

Ethylene must be admitted to the ripening room as soon as the room is loaded with fruit. If gas is not introduced until there are signs of 'springing' in some fruit, ripening will be retarded and uneven. If the fruit is hot when loaded it should be cooled to 70°F or lower before gassing. If the fruit is cool (but not below 55°F) and rapid ripening is desired, gassing should be started immediately; otherwise it is best to warm the fruit first.

In commercial practice bananas are usually removed from the rooms long before completion of ripening. Consequently ripening is commonly completed at temperatures which are too low in winter and too high in summer and poor-quality fruit results; in the spring and autumn ambient temperatures are generally more favourable. This is an aspect of its marketing practices to which the banana industry should give serious attention.

Storage

An air temperature of 54°F is the optimum for the storage of green bananas, but storage for more than about three weeks is rarely practicable, because it is difficult to prevent the accumulation of ethylene in the storage space. Attempts to precool green bananas, prior to shipment, in rooms used for ripening have sometimes led to fruit injury, due apparently to exposure to ethylene at low temperatures for too long a period.

Despite the presence of ethylene, ripening fruit may be held for a few days longer in the ripening rooms by reducing the pulp temperature to a minimum of 56°F. This is also the lowest safe temperature for holding ripe fruit, but such fruit cannot be kept for more than 3–4 days.

Fruit Rots

The development of fungal infections in ripening fruit has always been a problem. Squirter disease, in which infection by the fungus *Nigrospora musae* through the broken stem of the fruit causes the pulp rapidly to become a liquid mess, can be serious in winter fruit. It can be controlled by dipping the fruit in a 0·15% solution of sodium salicylanilide (Shirlan[R]). In Australia dipping immediately before or after packing is compulsory. Black end, another stem-end infection, and anthracnose rotting, both caused by *Gloeosporium musarum*, are serious in warm humid weather. Salicylanilide has little effect on them but a new fungicide, not yet approved by health authorities, appears likely to be an effective control for black end and other *Gloeosporium* infections occurring through injuries. The stem infection black end is usually serious only in warm humid weather. Packing the intact hands greatly reduces fruit infections, but under the higher humidity which commonly obtains in cartons 'cushion' rot, i.e. rot of the base of the hand, mainly due to *Gloeosporium*, is often considerable.

Current Developments

Marketing and Research

The Australian banana industry is in a period of rapid change in the technology, and therefore also the organization, of marketing. This was stimulated, if not initiated, by the introduction of hand-packs in cartons a few years ago, following their success in the Central American trade to U.S.A. They were

used in Central America when the Gros Michel variety was replaced by Cavendish-type bananas, which are resistant to Panama disease. Gros Michel is a big, attractive fruit which carries well and is quite suitable for transport and ripening in bunches. Cavendish bananas, which have better eating quality, are more easily damaged and cannot be transported satisfactorily in the bunch.

When wooden boxes are used, every grower is his own packer, but hand-packs in cartons are much more suited to central packing house operation. A large central packing house has been operating successfully in Brisbane for some time, packing exclusively in cartons, and two others are now operating in New South Wales. For this form of presentation the fruit must be clean. The necessary washing and other treatments are most readily carried out in a suitably equipped central shed.

Serious consideration is being given to setting up more central packing houses, mainly because of the high cost of labour for packing on plantations but also because of the increasing demand for hand-packs in cartons. Only in a packing house with a large throughput can the full benefits of mechanization be obtained. Further, modern self-service chain-store merchandising requires long lines of produce that are uniform in quality and price, and only large, central, and efficiently operated packing houses can provide these.

With the formation of the Australian Banana Growers' Council, the banana industry in New South Wales, Queensland, and Western Australia has recently become centrally organized. At the same time the industry has recognized the need for more research to improve both the quality of bananas at the retail level and the efficiency of the marketing operations. Research into the technical problems of marketing has therefore been greatly expanded, with finance jointly provided by the industry and the Commonwealth Treasury. These new investigations are being carried out by the Queensland Department of Primary Industries, the N.S.W. Department of Agriculture, and the CSIRO Division of Food Preservation. Because of its interest in promoting the use of cartons, the paper industry is making a significant contribution to the study of problems associated with the use of the new packs.

Banana Products

Processing is still of little consequence to the banana industry. While fresh bananas can be consumed in quantity, dried or canned bananas or other banana products are, by their nature, mostly either a confection or a food additive and flavouring agent.

In large, central packing houses it is not costly to accumulate the poorer grades of fruit, and thus open up possibilities of economic processing. It is therefore of considerable interest that the United Fruit Company has been able to develop a good market in the U.S.A. for canned banana *purée* for use in baby foods and confectionery. This company has recently built a $US1 million plant in Ecuador, adjacent to their fresh fruit packing houses, for the production of the *purée*.

Banana beer, which is popular in parts of Africa, may also offer some promise as an outlet for bananas unsuitable for selling fresh. In addition, banana figs (dried banana strips) are an attractive confection, and the sun-dried article is popular in India. Banana flour and powder, which can be made without difficulty, are of some small interest in the confectionery trade; and there is now some promise of using more of them in ice-cream. A banana crisp, similar to a potato crisp, is another product which could become popular and there may be a market for freeze-dried banana slices as a component of cereal-based, ready-to-eat breakfast foods.

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Insulating Materials for Cold Stores

By R. Atkins and E. G. Hall

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The Division of Food Preservation receives frequent requests from the Australian food storage and processing industries for information about the construction of cold stores, one of the most important aspects of which is thermal insulation. This note lists the conductivity of some common insulating materials, and explains how to ensure that insulating efficiency is maintained.

THE main function of the insulating material in a cold store is to reduce the rate at which heat enters the structure. This determines to a large extent the refrigerating capacity required by the store, and the level of relative humidity that may be maintained in it without the provision of expensive humidifying apparatus. The insulating efficiency of a material is indicated by its k value, which is a measure of the rate at which heat can flow through the material under the influence of a known temperature gradient. The units of thermal conductivity commonly used for k are Btu/hr/ft^2/degF temperature difference/in. thickness of insulating material, and published data usually apply to conditions in which the mean temperature of the material is 60°F.

The value of k quoted by most suppliers of insulants is the value obtained by testing a relatively small sample under what might be considered ideal conditions, and such values need to be modified to allow a reasonable margin of safety if a cold store is to function with the intended efficiency.

Since still dry air is a very poor conductor of heat, the value of k for cellular insulants decreases (i.e. the insulating value improves) as the quantity of air that is incorporated in small cells in the material increases. The quantity of air in these materials and their k value are related to their density. Several other factors that are encountered in the practical use of insulants may affect their insulating efficiency. These include the mean temperature of the material, its moisture content, the way in which adjacent slabs of

Values of k for Some Solid Thermal Insulating Materials at Mean Temperature 60°F

Insulant	k (Btu/hr/ft^2/degF temp. diff./in. thickness)
Boards or slabs	
Corkboard	0·30
Expanded rubber, e.g. Onazote	0·24
Expanded polystyrene, e.g. Coolite, Isolite	0·26
Expanded polyurethane, aged, e.g. Korthane	0·17
Wood fibre, low density (15 lb/ft^3), e.g. Caneite	0·35
Compressed straw, e.g. Solomit	0·33
Mineral wool, resin binder	0·28
Blankets or batts (including paper backing and facing, if any)	
Mineral wool—rock, slag, or glass, e.g. Insulwool	0·27
Wood fibre	0·25
Cotton fibre	0·26
Loose fill	
Regranulated cork	0·30
Fibreglass wool or mineral wool	0·28
Sawdust or shavings	0·45
Expanded vermiculite	0·48
Other	
Cell concrete density 20 lb/ft^3	0·70
Cell concrete density 30 lb/ft^3	0·90
Hardwood	1·10
Softwood	0·80

material are joined, the method used to fix the insulant to the main structure of the store, and in some cases, the age of the material.

Ingress of moisture with consequent increase in the moisture content of the insulating material is one of the main causes of the gradual loss in insulating efficiency commonly found in cold stores. All insulants should be protected by an effective water vapour barrier *on the warm side* if the insulating properties are to be preserved. An effective vapour barrier is an essential part of any cold store if the capital outlay on insulation is not to be wasted. The material used for the barrier must be highly impervious to water vapour and it must also be applied to form a completely enveloping seal on the warm side of the insulation. Metal sheeting with properly constructed joints is effective and is used in some prefabricated units. Metal foil laminates and certain plastic film materials are also suitable for this purpose if all joints are well lapped and sealed in accordance with the manufacturer's instructions.

The table gives appropriate design data for a range of solid materials useful for insulating cold stores. It is also possible to use suitably spaced reflective sheet materials. The number of layers used will depend on their reflectivity and on the design temperature difference between the inside and outside of the store.

The specifications for the insulating material for a particular structure will depend on the design temperature difference between the inside and the outside and on what is considered to be an acceptable rate of heat transfer. Until recently average commercial practice allowed for a heat leakage rate of 4–4½ Btu/ft²/hr but modern cold stores are being built with heat transfer rates as low as 2½–3 Btu/ft²/hr, calculated on the external surface area of the insulation. For example, for a design temperature of 90°F outside and 30°F inside, which is desirable for fruit cool stores in most areas, and a heat leakage rate of 3 Btu/ft²/hr, a 6-in. thickness of an insulant with a k value of 0·30 Btu/hr/ft²/degF temperature difference/in. would be required.

Frozen Capsicums

By J. Shipton and J. H. Last

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Capsicums, also known as sweet peppers, are becoming very popular in Australia, possibly on account of the influx of migrants accustomed to eating them in their homeland. Investigations in the CSIRO Division of Food Preservation have shown that frozen capsicums are an acceptable convenience food.

MANY quite distinctive varieties of capsicum are used commercially. Those available in Australia and their agronomic characteristics have been described by Jessup (1964).

Immature capsicums may be deep green or pale yellow to gold, depending on variety, and it is at this stage that they have been most often used in Australia. At maturity all the varieties develop a brilliant red pigmentation which, possibly by analogy to the chilli, many people erroneously believe indicates 'hotness'. In fact the mature red capsicums are as mild as the immature green or yellow ones and lack the extreme pungency of the chilli, except for the seeds, which are normally removed during preparation for eating.

Capsicums are suitable for a wide range of culinary uses, and are nutritionally valuable as they have a very high ascorbic acid content. They may be used to add colour and flavour to vegetable salads, rice dishes, and stews. They are very palatable if cut into rings, dipped in batter, and deep fried. They are excellent for baking in conjunction with a variety of stuffings, and for pickle-making.

There is no established technique for the preservation of capsicums by freezing and little published information is available.

Table 1
Ascorbic Acid and Solids Content of Capsicums

Variety	Ascorbic Acid (mg/100 g)		Total Solids (%)
	Wet Weight Basis	Dry Weight Basis	
Immature green	75	1180	6·4
Immature yellow	150	2350	6·4
Mature green (red)	167	1860	8·9
Mature yellow (red)	183	2180	8·5

According to Tressler and Evers (1957), some processors in the United States favour blanching before freezing, but others claim that the unblanched product has adequate stability during frozen storage.

An investigation has been made into the influence of variety, maturity, and blanching on the storage behaviour of the frozen product.

Experimental Procedures

Two varieties, one green and one yellow, were processed on the day of harvest at the immature stage and again at the full red stage. The capsicums were washed, stemmed, cored, and deseeded; the flesh was cut into pieces about half an inch by three-quarters of an inch. After samples had been taken for analyses of ascorbic acid and solids content, half the residual material of each variety was blanched for two minutes in an atmospheric steam blancher, cooled in a water spray, and drained. The other half was frozen unblanched. Owing to insufficient material all the mature (red) capsicums of the yellow variety were frozen unblanched. After freezing in dry ice, samples from each treatment were stored at 0°F and −35°F for periods up to one year. Samples were removed after 3 and 12 months for organoleptic evaluation. The immature green, immature yellow, and mature capsicums were tasted in separate sessions. The samples of each group were presented in random order to a taste panel of ten or eleven judges who rated them (good, fair, or poor) for colour, texture, flavour, and general acceptability. As a basis for numerical comparison, scores of 3, 2, and 1 were given to the ratings good, fair, and poor

Table 2
Mean Tasting Test Scores of Capsicums (Scale 1–3)

		Unblanched				Blanched			
Storage temperature		−35°F		0°F		−35°F		0°F	
Storage time (months)		3	12	3	12	3	12	3	12
Immature green	Colour	3·0	3·0	3·0	2·8	2·1	2·1	1·3	1·2
	Texture	2·8	2·8	2·3	2·5	1·3	1·7	1·4	1·3
	Flavour	2·1	2·5	1·8	2·0	1·5	2·0	1·4	1·3
	Acceptability	2·4	2·9	2·2	2·7	1·9	2·0	1·7	1·8
Immature yellow	Colour	2·5	2·4	2·6	1·3	2·1	2·8	2·4	2·2
	Texture	3·0	2·8	2·8	2·5	1·4	1·5	1·2	1·2
	Flavour	2·5	2·5	2·3	2·0	1·8	2·2	1·9	1·7
	Acceptability	2·6	2·8	2·5	2·7	2·4	1·9	2·2	2·1
Mature green (red)	Colour	3·0	2·7	2·9	2·8	2·2	2·6	2·2	2·5
	Texture	2·4	2·8	2·8	2·5	1·6	1·5	1·5	1·3
	Flavour	2·2	2·5	2·5	2·1	1·7	1·9	2·0	1·5
	Acceptability	2·7	2·5	2·6	2·5	2·2	2·4	2·5	2·0
Mature yellow (red)	Colour	2·9	2·9	2·7	3·0	—	—	—	—
	Texture	2·3	2·5	2·3	1·5	—	—	—	—
	Flavour	1·9	2·1	1·8	1·3	—	—	—	—
	Acceptability	2·3	2·4	2·1	2·0	—	—	—	—

respectively. Colour, texture, and flavour were assessed on capsicums that were untreated except for thawing, while general acceptability was assessed with the capsicums incorporated in a rice and tomato salad.

Results

The ascorbic acid and total solids content of the samples are given in Table 1. The mean scores from the tasting tests are shown in Table 2 and discussed below.

The unblanched capsicums were superior to the blanched capsicums, except the unblanched immature yellow capsicums, which discoloured during storage at 0°F.

Capsicums stored at −35°F were, in general, better than those stored at 0°F. This difference usually increased during storage.

All the capsicums stored at −35°F, and unblanched immature green capsicums stored at 0°F, showed no appreciable change in quality during storage.

Blanched immature green capsicums stored at 0°F were of poor initial colour and showed further colour deterioration during storage.

The unblanched immature yellow capsicums discoloured and developed a slight off-flavour during storage at 0°F.

The texture and flavour of blanched mature (red) capsicums of the green variety and unblanched mature (red) capsicums of the yellow variety deteriorated during storage at 0°F.

Conclusions

Capsicums are quite suitable for freezing. In contrast to the majority of vegetables they are better when processed unblanched. An outstanding feature of the unblanched product is that it retains the texture of the fresh product. The structure of the flesh appears to be unaffected by freezing and thawing.

In general the green capsicums gave a more acceptable product than the yellow variety. The difference was based partly on the greater colour appeal of the green type and partly on the greater apparent discoloration to which the yellow variety was susceptible on account of its lack of pigmentation at the immature stage.

Frozen capsicums, as an ingredient for salads or other dishes, merit some attention by Australian frozen food processors.

Acknowledgment

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International Congress on Canned Foods

The Fifth International Congress on Canned Foods, to be held in Vienna from October 3 to October 6, 1967, is being organized by the International Permanent Committee on Canned Foods (C.I.P.C.), Paris, with the cooperation of the Austrian food processing industry. The International Congresses on Canned Foods are held from time to time in order to review progress in can-making and in fields related to canning, and to disseminate the results of recent research.

Any interested person is eligible to attend if he registers his intention and pays the registration fee of 800 Austrian schillings (about $A28.00). Registration forms may be obtained from the C.I.P.C. Liaison Officer for Australia, Mr. P. W. Board, CSIRO Division of Food Preservation, Box 43, P.O., Ryde, N.S.W., Australia.

The programme for the Congress indicates that discussions on economic and technical aspects of processing, canning, and distributing foods will cover a wide field, including advertising of canned foods; training of technicians for the food processing industry; recent progress on can corrosion; progress in handling and packing cans; problems created by the speeding up of processing operations; dietetic foods; and lyophilization (freeze drying).

NEWS FROM THE DIVISION OF FOOD PRESERVATION

Honour for Chief

The Chief of the Division of Food Preservation, Dr. J. R. Vickery, has been elected Foundation President of the newly formed Australian Institute of Food Science and Technology, which is Australia's national organization of professional food technologists.

New Leader

Professor M. G. Pitman, who occupies a Chair in the School of Biological Sciences at the University of Sydney, has been appointed joint leader of the Plant Physiology Unit, which is operated by the CSIRO Division of Food Preservation and the University of Sydney within the latter's Biological Sciences building. Professor Pitman's co-leader is Dr. R. M. Smillie, Senior Principal Research Scientist in the Division of Food Preservation.

Appointments

Two appointments have been made to the research staff of the Division's Plant Physiology Unit in the first half of 1967.

Dr. J. K. Raison, who had gained experience in the CSIRO Wheat Research Unit and the Division of Plant Industry, joined a team engaged on the study of the aging processes in harvested plant tissue.

Dr. Miguel Vendrell, a graduate of the University of Barcelona, has been appointed to study the oxidative metabolism of plant tissues during senescence and storage. Since 1964, Dr. Vendrell has been engaged on research in plant biochemistry at Yale University, Connecticut, U.S.A.

Visits Overseas

Mr. R. S. Mitchell was seconded to the Department of External Affairs for the period March 14–May 2, 1967, to enable him to participate in the Australian South Pacific Technical Assistance Plan. Mr. Mitchell acted as technical adviser for the installation and testing of equipment in a food processing laboratory at Apia, in Western Samoa. The Director of the laboratory is Mr. L. J. Lynch, who retired from the CSIRO Division of Food Preservation in 1965.

Mr. D. G. James, an Experimental Officer of the Division, who was located at the CSIRO Tasmanian Regional Laboratory, Hobart, has been granted a scholarship by the Japanese Government. He left Sydney on March 16, 1967, to commence postgraduate study into problems of the preservation and processing of marine foods. Mr. James will be absent from Australia for about 10 months. He will conduct research at the Tokai Regional Fisheries Research Laboratory, Chuoku, Tokyo.

Mr. E. G. Hall, Principal Research Scientist in the Division's Fruit Storage Section, spent the three weeks commencing March 19, 1967, in New Zealand, where he studied developments in the handling, storage, and export of apples and pears. Mr. Hall also visited laboratories in the New Zealand Department of Scientific and Industrial Research and other research institutions.

Recent Publications of the Division

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

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COSTER, H. G. L. (1966).—Chloride in cells of *Chara australis*. *Aust. J. biol. Sci.* **19**, 545.

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* DE FOSSARD, R., and LENZ, F. (1966).—Controlled experiments reduce study time (by growing orange fruits on cuttings). *Citrus Wld* **2**(9), 20.

*HALL, E. G., and HALES, K. C.† (1965).—The influence of the package on the refrigerated carriage of apples and pears. Int. Inst. Refrig. Mtg Commiss. 8, pp. 247–58. (Annexe 1965–5 of *Bull. int. Inst. Refrig.*)

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KENNETT, B. H. (1966).—Simple versatile collection programmer for preparative gas chromatography. *Analyt. Chem.* **38**, 1962.

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* Reprints of this paper are not available.

† Shipowners' Refrigerated Cargo Research Association.

‡ Department of Agriculture, N.S.W., stationed at Division of Food Preservation.

§ Division of Mathematical Statistics, CSIRO, stationed at Division of Food Preservation.

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