FOOD PRESERVATION QUARTERLY

Vol. 25 No. 1 CSIRO March 1965

REGISTERED IN AUSTRALIA FOR TRANSMISSION BY POST AS A PERIODICAL

CSIRO Food Preservation Quarterly

VOLUME 25

1965

Published by the Division of Food Preservation
Commonwealth Scientific and Industrial Research Organization
Sydney, Australia

New Methods of Freezing Foods

By J. Shipton

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

Economic methods for freezing foods faster are always of interest to the frozen food industry. This article* briefly reviews technical and economic aspects of two recently introduced methods, fluidized-bed freezing and liquid nitrogen freezing, both of which enable freezing rates of foods to be increased significantly.

FLUIDIZED-BED FREEZING

If a stream of air is passed vertically upwards through a bed of particles and the velocity of the air is gradually increased, a point is reached at which the particles become suspended in the air stream, and in this condition the bed is said to be fluidized. Beyond this point, particles become entrained in the air stream and so may be carried away from the bed.

In a fluidized bed the particles are in continuous motion and the suspended product assumes flow characteristics similar to those of a true fluid. Also, because the surface of each particle is fully exposed to the air stream, heat exchange between the particles and the air stream is far more efficient than can be achieved in a static, non-fluidized bed. These principles are the basis of the fluidized-bed freezer, one type of which is illustrated in the diagram on page 3.

Technical Advantages

The primary benefit resulting from the superior heat transfer efficiency of fluidized-bed freezing is a significant increase in freezing rates. From this, several secondary advantages accrue:

- The high freezing rates achieved by fluidized-bed freezing greatly increase freezer capacity, thereby reducing the floor area required per unit of production.
- Since the freezing time is reduced, there is a lower extraneous refrigeration load (e.g. heat leakage through walls) relative to the product.
- There is less opportunity for water vapour from the product to migrate and form frost on the refrigeration coils and thereby impair their efficiency. More important, since product desiccation is less, there is a greater yield of frozen product from a given weight of starting material.

The ability of the products to flow while they are being frozen dispenses with the need for mechanical conveyors, with a consequent saving in power requirements and much simplification in design and construction of the equipment. Moreover, since products in the fluidized state have no tendency to aggregate during freezing, the frozen product also has free-flow characteristics. Handling convenience to the consumer is thus another benefit derived from fluidized-bed freezing.

Types of Equipment

The range of food products that can be fully fluidized is limited, although it includes such diverse products as peas, sweet corn, cut green beans, strawberries, and Brussels sprouts. However, provision is made in many fluidized-bed freezers for non-fluidizable products to be handled also. This flexibility is achieved by incorporating a mechanical conveyor system, a wire mesh belt being most commonly used. When used with non-fluidizable material, such units virtually operate as through-draught blast freezers.

* Based on a lecture to a meeting of food processors held in Melbourne in November 1964.

The simplest type of machine might be called a static fluidized-bed freezer, since it depends wholly on the flow characteristics of the air-levitated commodity to convey the product through the machine. Such a unit has been described by many authors (Lance 1962; Trauberman 1962; Anon. 1962*a*, 1962*b*, 1963*a*, 1963*b*, 1964*a*), and can be used only with foods that can be fluidized efficiently. The basic features of this type of freezer are illustrated in the diagram. The unit employs sprays of propylene glycol to defrost the refrigeration coils continuously, eliminators being provided to prevent glycol contamination of the product.

One modification of the fluidized-bed freezer, which extends its range of application, incorporates a series of reciprocating plates so as to enable the freezer to handle partially fluidizable products, such as frozen French-fried potatoes (Anon. 1962*c*). Another type has a mechanically driven perforated belt (Anon. 1962*d*, 1963*c*); with the belt stationary, the machine can handle materials that can be efficiently fluidized, and transport of less tractable products is effected by driving the belt. In this type, refrigeration coils installed along the unit are defrosted in sequence by means of water sprays.

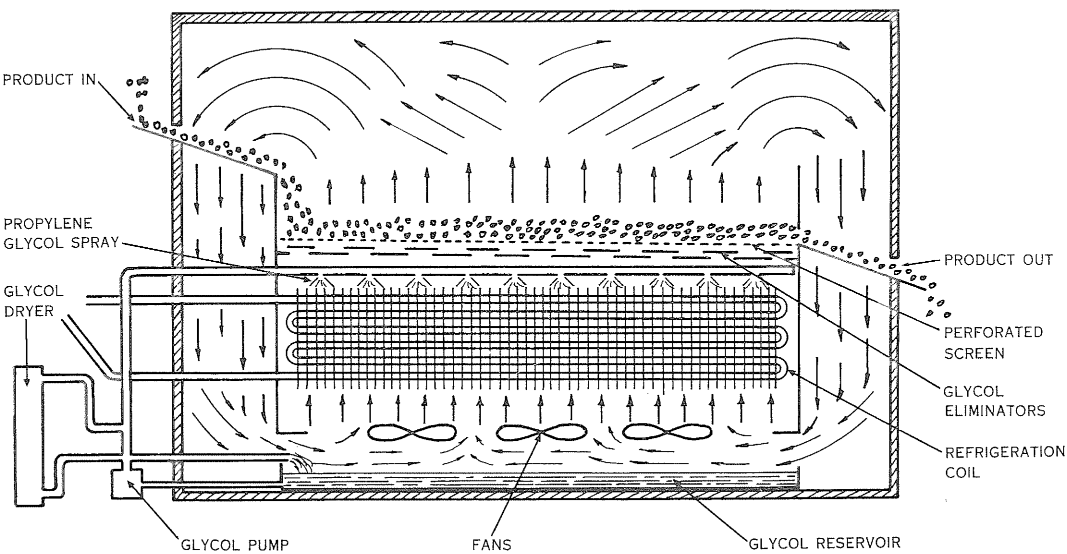
There is a type of freezer that combines features of those already mentioned. It has one section that relies on the flow characteristics of fluidized commodities for their transport, and another section in which the product is moved by either a belt or trucks. Both sections are served by the same refrigeration and air flow systems.

Freezing Times

Freezing times achieved with fluidized-bed freezers are indicated in the table below. These data were obtained in the United States (Anon. 1963*c*) and pertain to the reduction of product temperature from 70°F to 0°F. For comparison, the freezing time for peas in a conventional blast freezer would be 15–20 min.

Freezing Times with Fluidized-bed Freezing

Product	Freezing Time (min)
Peas	3
Cut corn	3
Strawberries	9–13
Lima beans	4–5
Cut green beans	5–12
French fries	8–12
Diced carrot	6
Fish sticks	15
Fresh fillets (up to $1\frac{1}{4}$ in. thick)	30



Schematic diagram of a static fluidized-bed freezer.

Economics of Fluidized-bed Freezing

In estimating the relative costs of freezing peas with a static fluidized-bed freezer and with a blast freezer, Trauberman (1962) made the following assumptions:

Total production	5,000,000 lb/annum
Temperature reduction	42°F to 0°F
Operational time	135 hr
No. of labour shifts	180
Power cost	1·5 cents/KWh

On the basis of a capacity of 5500 lb/hr for each type of plant, floor space required was estimated by him as 360 sq ft for the fluidized-bed freezer and 1120 sq ft for the air-blast freezer, while installation costs of the former would be only 85% of those of the latter. Power requirement for the fluidized-bed freezer, having an operating factor of 95%, would be 45 hp, with a cooling-down time from ambient temperature to −20°F of only ¾ hr. In contrast, the air-blast freezer (operating factor 85%) would require 53 hp and the cooling-down time over the same range of temperature would be 3 hr.

Trauberman (1962) also estimated that for the operating conditions assumed, there would be an annual saving of over 6000 U.S. dollars in amortization, maintenance, and running costs for the fluidized-bed freezer as against the air-blast freezer, and that the increased weight yield of product would result in a further saving of $10,000 per annum.

Clearly, therefore, fluidized-bed freezing offers technical and economic advantages for a range of frozen food products, and merits the consideration of processors contemplating new installations or new outlets.

LIQUID NITROGEN FREEZING

Until recently, liquid nitrogen was an exotic refrigerant, the use of which was largely restricted to research laboratories. However, in the United States the installation of large-scale liquid oxygen plants to provide rocket fuels made available considerable quantities of nitrogen for which there was no immediate use. In seeking outlets for this surplus of nitrogen, one of the potential applications investigated was its use in liquid form as a refrigerant for the food industry.

As a food refrigerant, liquid nitrogen has many attractive technical characteristics, but its economic acceptability is less certain.

Technical Aspects

Liquid nitrogen has a boiling point of −320°F, a latent heat of vaporization of 85 Btu/lb, and a specific heat of 0·25 Btu/lb. Nitrogen is chemically inert, colourless, odourless, and tasteless, and can therefore be used in direct contact with food.

The very low boiling point of liquid nitrogen, coupled with the fact that the liquid can be brought into direct contact with the food, enables ultra-fast rates of freezing to be obtained. Measurements made on individual strawberries immersed in liquid nitrogen showed that the average temperature drop exceeds 100°F/min. Larger pieces of food have a slower average cooling rate, since the thermal conductivity of the food becomes a limiting factor, but even so they freeze more rapidly with this method than by conventional freezing methods.

The extremely rapid freezing rates attained through the use of liquid nitrogen may cause undesirable effects with some foods. When a product at ambient temperature is immersed in liquid nitrogen, a thermal gradient of about 400°F is established in the product. This temperature difference creates severe physical stresses, which may cause some foods to shatter. The problem may be circumvented in various ways, e.g. by thoroughly precooling the product, by starting the freezing process in cold nitrogen gas before exposing the food to liquid nitrogen, or by freezing the product only after it has been packaged.

The total refrigerating capacity of liquid nitrogen comprises the latent heat of vaporization of the liquid and the sensible heat required to raise the gas from −320°F to, say, 0°F, these being almost equal. Consequently, thermal efficiency demands that the potential for absorption of sensible heat be utilized as fully as possible. This requirement may be met by using the cold effluent gas from the freezer for precooling the product or for refrigerating storage rooms.

The use of liquid nitrogen in direct contact with the food obviates the need for heat exchangers in the freezing equipment. Apart from consequential simplification of freezer design, elimination of the pumps or fans associated with heat exchangers removes a significant non-product refrigeration load.

In conventional freezing, particularly in the case of unpackaged foods, desiccation of the food may cause a loss exceeding 5% of its weight. Apart from reducing product yield, the water lost from the food by desiccation accumulates on the refrigeration coils, impairing their efficiency and necessitating periodical defrosting. With liquid nitrogen freezing, however, no significant product desiccation occurs and, since there is no accumulation of frost in the equipment, continuous operation is possible.

It has not been possible to freeze a number of food products successfully by conventional freezing methods, but some of these products, e.g. tomatoes, have proved satisfactory when frozen with liquid nitrogen (Gelber 1964). Some foods that are widely frozen (e.g. strawberries) are claimed to be of superior quality when frozen with liquid nitrogen (Webster, Benson, and Lucas 1962).

Freezing Equipment

Both immersion and tunnel freezers have been used successfully for freezing foods with liquid nitrogen.

The immersion freezer is simply an insulated tank fitted with a perforated basket. In the United States a unit of this type, occupying a floor area of 4 ft by 3 ft, was reported (Webster, Benson, and Lucas 1962) to freeze strawberries at a rate in excess of 1250 lb/hr. The freezing time for each charge was approximately 1 min.

The tunnel freezer (Anon. 1964*b*–*e*) is an open-ended insulated cabinet equipped with a conveyor belt. Liquid nitrogen sprays are located towards the exit end of the tunnel and the effluent gas is vented out near the inlet end. Part of the sensible heat capacity of the cold gas is used to reduce the product temperature relatively slowly, prior to the application of liquid nitrogen from the sprays. Nevertheless, a considerable amount of sensible heat can still be absorbed by the effluent gas, and for economic operation it is essential that this capacity be utilized, e.g. for other cooling purposes. An exception is where liquid nitrogen is generated on site and the cold effluent gas can be returned to the generator.

Economic Aspects

Liquid nitrogen freezing of food has many virtues, and although additional information might be required to define the optimum procedures for specific products, the process itself does not appear to pose any major technical difficulties. It is clear, however, that the commercial development of the process will be determined by economic and not technical considerations.

In Australia, there is presently only one commercial producer of liquid nitrogen. The cost to the user could range from 10*d*/lb for quantities of 1–2 tons per day to 4*d*/lb for amounts of 100 tons per day, and these charges would include delivery within a 25-mile radius of the supplier's factory and the provision of bulk storage facilities on the customer's premises. With on-site generation, which would apply only to large-scale continuous demand, the cost could be reduced to 2*d*/lb.

The amount of liquid nitrogen required to freeze a given food will depend mainly on the moisture content of the food, since the latent heat of freezing imposes the major refrigeration load. Garden peas used for freezing have a moisture content of about 85%, and to freeze 1 lb of such peas (assuming an initial temperature of 70°F and a final temperature of 0°F) involves the removal of approximately 170 Btu. The thermal capacity of liquid nitrogen (−320°F to 0°F) is 170 Btu/lb, and Gelber (1964) found the thermal efficiency of liquid nitrogen freezing to be 80–85%. These data show that 1·25 lb of liquid nitrogen would freeze 1 lb of peas; if the sensible heat requirement could be more efficiently utilized and the effluent gas were discharged at 70°F, only 1·13 lb would be needed. Since under practical conditions the figure of 1·25 lb of liquid nitrogen per pound of peas would be more realistic, the minimum cost of liquid nitrogen for freezing peas on current Australian figures would be 2·5*d*/lb.

Although it has not been possible to obtain accurate refrigeration costs for freezing peas by conventional methods, such evidence as is available suggests that in large-scale production it is not more than 1*d*/lb. Consequently, there appears to be little prospect in Australia of any general application of liquid nitrogen freezing of foods, unless a substantial reduction occurs in the cost of liquid nitrogen. There may, however, be limited application of this technique to high-cost foods (e.g. oysters, mushrooms, prawns) for which the freezing cost is a relatively small factor in the selling price; or to foods (e.g. tomatoes, strawberries) which can be frozen more satisfactorily with liquid nitrogen than by conventional freezing methods.

REFERENCES

ANON. (1962*a*).—Introducing Flo-Freezing: new processing method cushions products on cold air. *Froz. Fds.* **15**: 435-6.

ANON. (1962*b*).—Foods float on air in beltless system: Swedish unit freezes 5,000 lbs per hour over a 15 ft by 4 ft perforated tray. *Fd. Can.* **22**(10): 32.

ANON. (1962*c*).—Flo Freeze plant is now able to handle French fries. *Froz. Fds.* **15**: 795.

ANON. (1962*d*).—Belt updraft achieves four minute freeze. *Fd. Can.* **22**(10): 30–1.

ANON. (1963*a*).—New quick-freezing method for peas. *Fd. Process. Packag.* **32**: 371–5.

ANON. (1963*b*).—Flo-Freezers at Eskimo factory: installation 'the world's biggest'. *Froz. Fds.* **16**: 539–40.

ANON. (1963*c*).—"Fluidized" belt freezing of IQF products gains wide acceptance. *Quick Froz. Fds.* **25**(6): 36–7.

ANON. (1964*a*).—Quick freezing at Breda. *Fd. Process. Packag.* **33**(390): 100–3.

ANON. (1964*b*).—Chr. Salvesen's new freezing plant at Grimsby. *Fd. Trade Rev.* **34**(8): 39.

ANON. (1964*c*).—New quick-freezing plant for producers in Grimsby. *Froz. Fds.* **17**: 443–4.

ANON. (1964*d*).—Salvesen's new building for fluidized freezing. *Mod. Refrig. Air Control* **67**: 798–800.

ANON. (1964*e*).—Freezes whole mushrooms in liquid nitrogen. *Fd. Engng.* **36**(9): 148.

GELBER, P. (1964).—Ultra fast freezing. *Fd. Process.* **25**(10): 63–4.

LANCE, P. (1962).—Whiteford freezes vegetables with new Swedish air tunnel unit in Maryland. *Canner/Pckr.* **131**(13): 40–1.

TRAUBERMAN, L. (1962).—Simple fluidizing freezer cuts costs, guards quality. *Fd. Engng.* **34**(8): 46–9.

WEBSTER, R. C., BENSON, E. J., and LUCAS, W. H. (1962).—Liquid nitrogen immersion freezing may upgrade frozen berry quality. *Quick Froz. Fds.* **25**(5): 35–7.

Mechanical Harvesting of Fruits and Vegetables

By J. D. Casimir

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

The enormous rate at which modern food processing plants can utilize raw material has created a major labour problem in the harvesting of produce in sufficient quantity for their needs. Most crops are seasonal, and many fruits and vegetables require harvesting within the period of a particular optimum stage of maturity if they are to be suitable for processing.

SINCE in any area the period of optimum maturity of fruits and vegetables may be quite short, labour requirements during that period usually far exceed the local supply and it is necessary to employ itinerant or part-time workers who have neither the skills nor the experience for the task.

Social problems often arise in the community through the sudden influx of itinerants. Members of the picking teams vary widely in their proficiency and are consequently paid on a piece-work basis, with all the disadvantages that this entails. For instance, many pickers are tempted to harvest the greatest amount in the shortest possible time, with the consequence that the crop may be picked indiscriminately without regard to quality aspects such as size, colour, freedom from defects, or the need for gentle handling. This results in additional labour being required for grading.

Mechanization of some or all of the harvesting operations should alleviate some of the problems mentioned above, and a great deal of research and development directed towards this end has been carried out over the last decade or so. For mechanization, it is usually advantageous to consider the removal and collection of the produce from the growing plant as the principal harvesting operation, and to regard separation of extraneous and defective material, and quality grading, as separate subsequent stages. Mechanical harvesters tend to carry out the operations in this sequence, i.e. the machine reaps the crop (with or without destruction of the plant) and a cleaning operation follows to remove at least a portion of the extraneous unwanted material. Current thought favours grading the produce for quality while it is on the harvester, but it remains to be seen whether colour-sorting and other types of grading devices will operate satisfactorily under field conditions, or whether it will be necessary to carry out quality grading at the factory site as at present.

Much of the development work on mechanical harvesters is being carried out by universities and similar institutions and by food and agricultural machinery manufacturers and processing firms. The successful application of mechanized harvesting equipment comes within the field of the agricultural engineer, the food technologist, the horticulturist, and the plant breeder. The agricultural engineer is chiefly interested in the design and function of mechanisms capable of removing the crop from the plant at economic recovery rates without adversely affecting its processing quality. The food technologist has to consider the maturity of the crop at the time of harvest, and needs to know the qualities of the raw material entering the food processing line. He must also have a knowledge of the physiological and microbiological condition of the harvested material and of the effects of departures from usual procedures for cleaning and grading, because this information is needed to devise satisfactory techniques for handling and storing the mechanically harvested product. The horticulturist aims to produce optimum yields from plants that may have to be spaced in the field to suit the character of the harvesting mechanism; and the plant breeder's contribution is to produce plants that lend themselves to mechanical harvesting. For instance, a narrow maturity spread of the whole crop is desirable, and it is advantageous if the spatial distribution of that portion of the plant to be harvested is such that it can be cleanly and efficiently removed by the harvesting mechanism.

The mechanical harvesting of peas, beans, and corn is now common commercial practice in many parts of the world, whereas only in certain areas is the mechanical harvesting of crops such as tomatoes and gherkins practised extensively. Crops such as asparagus, cabbages, and grapes have as yet been mechanically harvested only on an experimental basis.

BEANS

In many areas it is already usual commercial practice to harvest both the green and yellow varieties of snap (French) beans mechanically. Mechanical removal of the beans from the bush is effected by means of metal fingers attached to a rotating cylinder which moves the fingers in a short upward arc through the bush to flip off the beans (Fig. 1). Lima beans have hitherto been harvested by cutting the whole plants and threshing these in a "viner", as is done with peas (see below). Dry beans are often harvested with a two-cylinder pick-up combine after they have been reaped and placed in wind-rows to dry out. It now seems feasible, however, that pods of Lima beans and dry beans could be harvested with the same type of equipment as is used for snap beans. The dry bean pods could then be threshed in a small thresher attached to the picking machine and the Lima bean pods could be fed to a viner.

Fig. 1.—"Hi-Boy" mechanical bean harvester. (Photo: Chisholm-Ryder Co., Niagara Falls, N.Y., U.S.A.)

Mr. J. C. Ward, of the Ward Canning Co., Mt. Vernon, N.Y., has been credited with first using metal fingers on a rotating cylinder as a means of plucking beans from the plant. The Chisholm-Ryder Co., of Niagara Falls, N.Y., became interested in the mechanical harvesting of beans on the bush in 1950. This firm built five units for the 1952 season, 20 for the 1954 season, and by 1964 had built altogether over 800 units. Other firms now producing mechanical bean harvesters include Hughes Company Inc., of Wisconsin, U.S.A.; Mather and Platt of Manchester, England; August Herbort Factory, West Germany; and the Ter Borg and Mensinga Co. and G. Ploeger, both of the Netherlands (Duncan 1963).

In many machines the harvesting and cleaning mechanism is mounted directly on the tractor. Some firms, however, prefer to mount the mechanism on a drawn trailer having its own power unit, so that the tractor may be freed for other uses; this takes several hours with tractor-mounted units. Beans from the picking machines are either bagged or discharged into a bulk bin or bulk truck, the carrying capacity of which depends on the variety of bean. The bulk density of the yellow varieties of beans tends, for instance, to be lower than that of the green varieties, because pods of the former are more bent in shape and consequently pack down less easily. The palletized wooden bulk bins generally used hold 500–600 lb of beans and are handled in the fields by a tractor fitted with a fork lift.

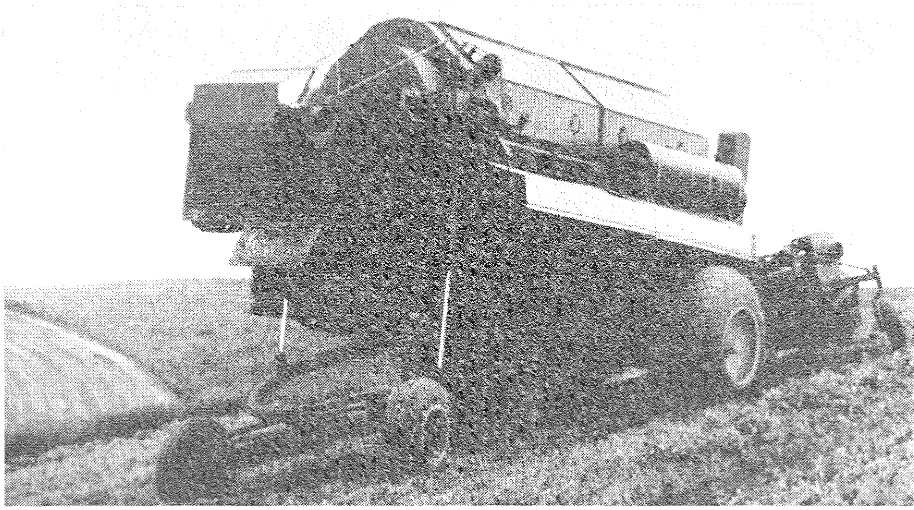
The CRCO "Hi-Boy" Model of the Chisholm-Ryder Co. (Fig. 1) includes a number of improvements over their previous model. These include the addition of a nylon brush that rotates counterwise to the picking finger reel to strip the beans from the picking fingers. This modification reduces breakage of snap beans and diminishes the "throw-out" problem encountered with Lima beans. The finger reel is normally run at 140–180 r.p.m. (the nylon brush being run slightly faster to give the brushing action) and is driven by a hydraulic motor, its speed being indicated by a tachometer visible to the operator. Hydraulic height control incorporated on the picking reels permits recovery of beans borne low on the plant, and a fan provides an air blast that blows the stripped beans onto the rear conveyor, any stones present falling out at this stage. Recoveries of up to 95% are claimed for the CRCO "Hi-Boy" harvester and double rows of Lima beans, spaced at 36 in., can be harvested at the rate of approximately $1\frac{1}{2}$ ac/hr. Snap beans in rows with a similar spacing can be harvested at about $1\frac{1}{4}$ ac/hr.

One British firm (Mather and Platt) is now marketing a single-row harvester after earlier attempts to produce a four-row bush bean harvester. There are several interesting refinements in the single-row machine. For instance, the entire mechanism is mounted ahead of the tractor so that it is in full view of the operator; also, the picking fingers are attached to a belt so that they move through the bean vines vertically rather than in a short upward arc, as in the reel system. The single-row machine is capable of operating efficiently on rows spaced only about 16 in. apart.

The introduction of mechanical picking of beans has raised certain problems at the processing plant. These include efficient removal of dirt and plant fragments, satisfactory separation of the bean clusters, and the problem referred to in the industry as "brown end colouration". This is a discolouration that appears at broken ends and on bruised sections of snap bean pods after storage. It survives processing treatments and, because the appearance downgrades the processed product, the affected sections must be removed on the inspection belt before processing. Factors influencing the severity of brown end colouration have recently been discussed by Cooler and Lopez (1963).

Current commercial bean harvesters are designed to pick either one or two rows at a time. Although multi-row harvesters have been built, they have proved unsatisfactory in service owing to the difficulty of lining up the several picking reels with the rows of the crop. Means for automatically lining up each individual row with respect to the picking reel seem to be required for such machines, and ideally the machines should also be able to harvest rows that have been spaced with regard to optimum horticultural practice. In the U.S.A., where row spacings are stated to be dictated by harvester dimensions rather than by agronomic considerations, this may not be of prime importance.

Fig. 2.—Self-propelled mobile viner (combine), with levelling mechanism. (Photo: Green Giant Co., Le Seur, Minn., U.S.A.)



PEAS

The Vining Machine

Since early this century peas have been harvested commercially by cutting the whole vines, these then being fed into a viner to recover the peas from the vines and pods. The viner is designed to thresh the peas from pods still attached to the vines; threshing is by mechanical beaters, and the liberated peas are separated from the trash by means of a perforated reel and cleaning apron. Since the viners are normally stationary and situated at the processing factory, the entire vines have to be transported from the fields to the site and then laboriously fed into the machine.

Mobile Viners

Although progress has been made by mechanizing the feed to stationary viners, it was inevitable that the potentiality of mobile viners should have been examined. In some early types, the vines were dragged across metal grids or bars in order to shell out the peas, but this procedure did not prove entirely satisfactory and production of this type of mobile harvester was discontinued.

In recent years, four firms (Mather and Platt of England; Hamachek, and the Scott Viner Co., of the U.S.A.; and Ameliorair of France) have produced mobile harvesters which operate successfully on the same principle as the stationary viner. The viners are tractor-drawn (the latest models are self-propelled) and pick up the vines after they have been mown and placed in rows in the field. The peas from the vines are usually collected in a hydraulically operated dump hopper, while the trash is discharged back onto the field. The best practical use of these combines seems to be made when they are operated in batteries of 3 to 10 units and when areas of less than 20 acres are avoided. The average harvesting rate of the units is better than ½ ac/hr, and over 650 of them were operated in the U.S.A. and in Canada, Australia, New Zealand, and Europe during the 1962 pea season.

On low and flat land the performance of ordinary mobile viners is generally satisfactory, but they cannot cope with hillside crops. Recently, two American firms extensively modified their mobile harvesters to permit the units to be levelled on slopes up to 25% fore and aft and 35% sidewards, thereby achieving a performance on hillsides comparable to that attained on level land (Fig. 2). This feature is a major step forward and permits mechanical harvesting of practically all pea fields. However, there still remains the problem of pea damage, which is a consequence of removing the peas from the pods by means of beaters (Casimir *et al.* 1964). Besides reducing yield, such damage has been shown to be conducive to the development of "delay" off-flavours (Makower and Ward 1950). The use of mobile viners may actually aggravate the development of off-flavours, since the shelled-out peas have still to be transported to the factory.

Pod-pickers

To overcome this problem, attention has recently been focused on the development of pod-picking machines (Fig. 3), which first reap the vines and then remove the pods from them as they move through the field. Because the peas do not suffer damage and are still contained within the pods after removal from the vines, the peas can before processing be held in storage for considerable periods without developing undesirable off-flavours.

The CRCO pod-picker uses a cutter bar and pick-up reel to mow the pea vines, and behind this is a steep stone-eliminating elevator. The elevator feeds the vines and attached pods into an inclined race that has the bottom and top slatted in the direction of travel of the vines. Mechanically operated hooks dip between the slats and through the vine mass and thus lift the vines, which are cut into fragments as the hooks are drawn through the upper slats. The hooks also cause the vines and pods to progress towards an inclined belt, from which the material is discharged into an air blast. This blast separates the vine fragments from the pods and the fragments are discharged through the fan onto the field.

The pod-picker needs no levelling mechanism and will operate on slopes up to 30%. Estimates of harvesting rate on a machine having an 8 ft cut vary from $\frac{3}{4}$ to $2\frac{1}{2}$ ac/hr, depending upon the crop and conditions. The proportion of peas that "shell out" increases with crop maturity and has been found to be about 5%. As quality deterioration could be expected in peas that have escaped from their pods and are thus likely to be bruised, such peas may need to be separated from the whole pods and processed promptly to ensure uniformly high quality in the whole crop.

Pea Shelling

The removal of peas from mechanically picked pods may be effected by slight modifications to the conventional viner. The pods have to be fed into the upper section of the reel and the pitch of the beaters at the input end of the viner has to be increased to give a more rapid progression of the pods, so as to distribute the load more evenly along the separation reel. When the viner is used in this way for shelling picked pods it has a considerably greater capacity owing to the absence of the bulky vine material. Consequently, it is also necessary to increase the slope of the main apron in order to prevent carry-over under this heavy loading.

As indicated previously, one disadvantage of all viners working on the beating principle is that the beating action results in bruising and other physical damage to the peas, and such damage can occur whether the peas are shelled out from the pod-vine mass or from the pods alone. Removal of the peas from the pods without damage has, however, been accomplished by a shelling device operating on an entirely different principle. This machine was developed by CSIRO research workers at the Division of Food Preservation and is now being manufactured under licence. In the CSIRO pea-sheller, the peas are ejected from the pods by feeding the heat-softened pods end-on to the nip of a set of rubber-covered rollers. When the ends of the pods are nipped between the rollers the peas are ejected undamaged and are discharged down a gap in front of the rollers.

Sufficient evidence is now available to show that a combination of the pod-picker and the pea-sheller will allow the production of clean, undamaged peas. Since such peas are free from the off-flavours associated with vining damage and vining delay, they are comparable to hand-shelled peas of the highest quality.

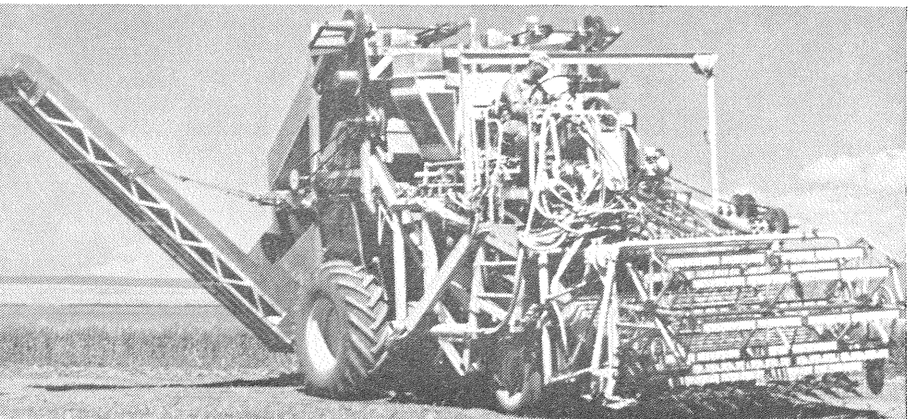


Fig. 3.—CRCO pod-picker. (Photo: Chisholm - Ryder Co., Niagara Falls, N.Y., U.S.A.)

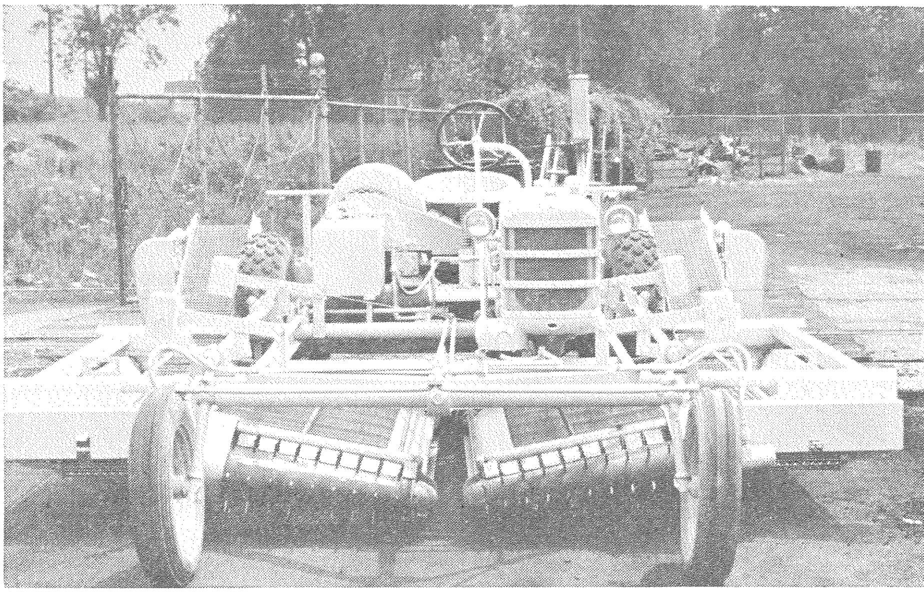


Fig. 4.—CRCO mechanical pickle picker. (Photo: Chisholm-Ryder Co., Niagara Falls, N.Y., U.S.A.)

CUCUMBERS FOR PICKLING

The Chisholm-Ryder Co. has also developed a highly successfully mechanical harvester for cucumbers for pickling. This unit differs from other mechanical harvesters in that it is not a "once-over" unit and is able to remove the fruit from the vine without destroying the living vine. Consequently the harvester may be used for a number of successive harvests on the same crop.

The cucumber-picker shown in Figure 4 lifts the aerial part of the vines by means of rubber fingers attached to picker reels located on opposite sides of the row. The lifted runners are then stretched out to one side or the other of the machine by a series of parallel rods or rollers on a conveyor, which moves upwards from the centre line of the machine over the "picking beds". As the machine passes down the row, the runners are dropped back from the picking beds onto the field in a herring-bone pattern. The removal of the cucumbers from the vines as the machine traverses the row is accomplished by tubular rollers which travel upwards along the picking beds as the vines progress through the harvester. The travelling rollers tend to stretch the vine out but, being capable of rotation, they travel under the vines without causing them undue injury and without placing undue stress on the vine roots. The rollers are positioned in such a way that they cause the vines to bounce, and this shaking causes the cucumbers to hang downwards and be snapped off in due course by the upward moving rollers. When detached, the cucumbers drop onto the picking bed, which discharges them onto a delivery conveyor equipped with cleaning blowers to eliminate leaves and other debris.

It is usual to run the machines over the rows before the fruit have formed, in order to orient the vines in a herring-bone pattern, as this facilitates pick-up of the vines by the fingers when the fruit are harvested later.

The cucumber or "pickle" harvester is reported to cover about 1 ac/hr on rows spaced 6 ft between centres, and successive crops can be harvested at approximately 3-day intervals.

OTHER VEGETABLES

Tomatoes

The Food Machinery Corporation (U.S.A.) has two commercial models designed to harvest tomatoes. These machines cut the tomato vines just below the ground surface and feed them, together with any loose fruits lying on the ground, up an inclined slatted conveyor that allows fall-out of small particles of soil and other debris. The loose tomatoes, together with the larger debris, are then discharged onto an inspection belt for hand sorting, while the vines with tomatoes attached pass onto a shaking section. The tomatoes separated in the shaking stage fall to a second conveyor for hand sorting. Each harvester requires up to 12 persons for sorting, and various models are available which will handle rows spaced from 40 to 60 in. apart.

Cabbages

Although not yet in commercial production, a number of experimental cabbage harvesters are being developed. Figure 5 shows one of the experimental units in upstate New York harvesting cabbage for sauerkraut production. The cabbages are raised by two slatted elevating conveyors running up an inclined ramp, which have the effect of pulling the cabbage plants from the soil. The stem, together with some of the lower leaves, is then cut off by a large revolving knife. After separation of the cut lower leaves, the cabbages are elevated to a bulk truck for transport to the processing plant.

Fig. 5.—Cabbage harvester undergoing trials.

Root Crops

The harvesting of crops such as potatoes and onions is usually partially mechanized, but the operation can be completely mechanized if bulk handling is used. The procedure consists simply of lifting the plants, together with associated soil and debris, onto a transverse rod conveyor. This conveyor serves to separate the product from the soil prior to collection of the former in lug boxes, crates, or bulk trucks.

Carrots, beetroot, and other similar crops first have their tops clamped between two belts which move up an incline and thus lift the roots from the loosened soil. The tops are next cut off and the roots pass along a conveyor which separates out the remaining soil.

Asparagus

Asparagus is a crop with a large labour requirement and a very rapid maturation rate at harvest time. A number of processors and food machinery firms have prototype harvesters at various stages of development, but others have discontinued developmental work on this type of harvester.

The experimental Chisholm-Ryder harvester for green asparagus uses a series of photoelectric detectors directed across the ridge bed, and these devices actuate the lowering of a cutting wire when an asparagus spear is detected. In this way the cutting mechanism operates only when a spear having a preselected height is detected. This ingenious approach to the mechanization of green asparagus harvesting appears most promising, and it may not be long before harvesting by such devices is a commercial operation.

Investigations into the possibility of mechanically harvesting white asparagus, which commenced in California in 1951, are still continuing; recent work is reported by Kepner (1965). The harvester uses a band saw, mounted on a high-clearance tractor, to cut all spears 8 to 9 in. below the surface of the asparagus beds. A series of three rollers behind the saw blade lifts the cut spears so that a mesh conveyor can be run

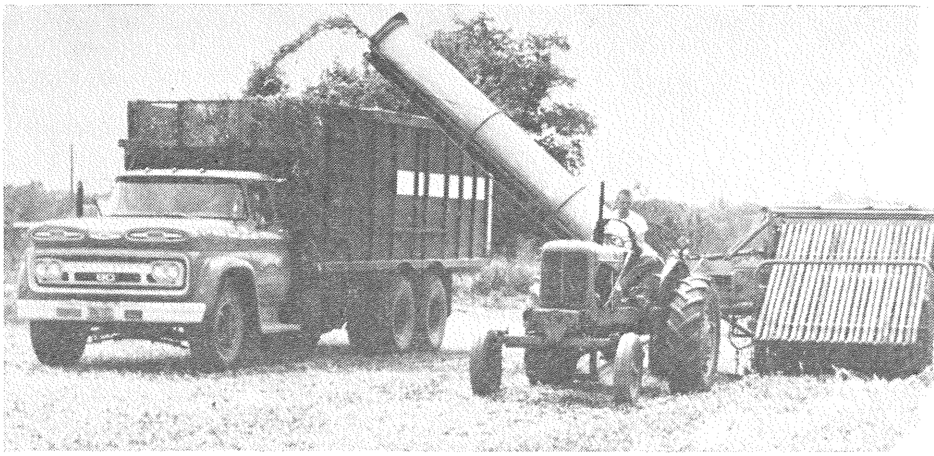


Fig. 6.—Porter-Way cutter loader operating on a pea crop.

beneath them. This conveyor serves to separate the soil from the spears, which are discharged from the rear of the conveyor onto the top of the bed and collected by hand. In a 1964 trial on a peat soil, the yield of good white asparagus obtained from machine-harvested rows was 72% of that obtained from comparable hand-harvested rows.

Cost analysis indicates that cost savings at these yields make mechanical harvesting economically feasible.

Spinach

The Porter-Way cutter-loader, shown in Figure 6, is manufactured by the Porter-Way Harvester Manufacturing Co. of Waterloo, N.Y., and is used for cutting and loading up to 100 tons per day of crops such as spinach, turnip greens, kale, mustard, or beet greens for processing. As the crop is cut, the leaves are carried upright into a machine, and all stems lie together on an inclined flight-reel assembly. A vibrating tubular ramp beneath the flight reel shakes unwanted hearts, yellow leaves, and dirt through to the ground. The crop then goes to a conveyor and elevator belt for loading.

Lettuce

A partial mechanization of the harvesting of lettuce is being used (Anon. 1964) in which the person picking the lettuces places them directly onto a conveyor belt traversing the field. After inspection, the lettuce heads are transferred to another belt, from which they are film-wrapped by girls as the unit moves across the lettuce fields.

MECHANICAL HARVESTING OF FRUITS

The mechanical harvesting of fruits is a relatively new concept, and interest in this field has increased rapidly since the late 1950s. Blueberries, prunes, plums, and sweet and sour cherries are now being harvested mechanically in commercial practice, and the mechanical harvesting of grapes, blackberries, dates, apples, clingstone peaches, and pears is in the experimental stages. Fruit harvesting costs can amount to as much as 50% of total production costs and mechanization offers one means of reducing these costs. For this reason we can expect much activity and progress in this sphere as better equipment and methods are developed.

Tree Fruits

The mechanical harvesting of tree fruits is a shaking and collection process, and similar equipment is being used for all tree fruits. Investigations to date have been concerned with the development of shaking mechanisms, either mechanical or hydraulic, and with the design of clamping devices that will transmit vibration to the tree without damaging it, particularly at the point of attachment of the clamp. Adoption of new pruning methods is essential for the development of tree shapes most suitable for mechanical harvesting. Collecting frames for catching the falling fruit are now self-propelled so that they may be quickly moved from tree to tree with the minimum of labour.

The chief factor militating against successful mechanical fruit removal is the amount of fruit injury incurred when the fruit hits a limb or another fruit as it falls through the tree, or when the fruit hits the collecting frame. Much has been achieved by the use above the catching frame of pads and decelerating strips designed to eliminate catching and collection injuries. Whitney, Mohsenin, and Tukey (1963) have suggested training the trees on a plateau system and using a variable-height catching frame, to permit fruit trees to be harvested sectionally and thus reduce the distance of drop and the likelihood of collision. However, as the fruit trees in existing plantings have not been pruned with a view to mechanical harvesting, the introduction of developments of this type will require many years. Trees for mechanical harvesting should have several not too flexible branches positioned for easy access by the gripping clamp, and the clamp should be attached at 90° to the branch for minimum bark damage.

Fruit bruising is more likely to be important in soft fruits and in fruits, such as apples, that may be stored for considerable periods prior to processing.

GRAPES

Two approaches have been made to the mechanical harvesting of grapes. In California (Lamouria *et al.* 1958), the approach is to train the vine on a multi-wire angle-top trellis so that the bunches of grapes all hang downwards at one level and may be cut by a mower blade run beneath the vine canopy and below the supporting wires. Bunches of grapes for raisin production fall onto a strip of paper placed on the ground beneath the rollers by the harvester as it moves along the row.

The Californian harvester is intended to reduce the labour requirement at harvest time, but this advantage is partly offset by the increase in labour required to prune and train the vines in such a way that the bunches are correctly positioned for the harvester cutter-bar.

The other approach was developed at Cornell University for the harvesting of the Labrusca grape varieties of New York State. It was found that the principle used in the Californian harvester was not applicable in harvesting the Concord grape variety, primarily because of the short cluster stems. The Cornell harvesting system (Shepardson *et al.* 1962) uses a vibratory means of detachment, each individual berry being separated from its pedicel by a vibratory motion.

Initial horticultural investigations showed that the Concord grape can be grown satisfactorily on an "L-top" trellis with a single supporting wire offset 18 in. from the post and trunk row. The supporting wire is positioned on an offset hanger attached so that it will lift and allow a 4–5-in. vertical movement to be imparted throughout the length of the support wire by the shaking mechanism of the harvester.

The grape harvester (Fig. 7) carries a spoked wheel mounted on a slight incline, so that it automatically feeds under the support wire as the harvester moves along the row. This wheel is vibrated with a stroke of about 4 in. at a frequency of 425–450

Fig. 7.—Mechanical grape harvester developed by the Agricultural Engineering School, Cornell University, U.S.A.

cycles/min and imparts to the support wire and vines the vibratory motion that causes detachment of the grapes, mainly as individual berries. The berries fall into a catching trough located beneath the vine curtain and are removed by a conveyor belt running along the bottom of the catching trough. They then pass through an air blast which removes leaves and other light debris. Usually the berries are fed into a stemmer-crusher and the grape pulp is pumped into a bulk container.

The 1963 prototype unit produced by the Chisholm-Ryder Co. does not crush and pump the grapes but, by means of an elevator, discharges the relatively whole berries into a bulk container. Investigations are under way to evaluate the relative qualities of grape juices prepared from grapes subjected to these two handling procedures and to compare them with juice prepared from hand-harvested grapes.

The removal of soil and spray residues from grapes is also under investigation. It seems likely that if washing is found to be necessary the fruit will be washed on the vine in the vineyard, since the quantity of "free-run" juice from the harvested berries makes in-plant washing uneconomical.

The future of this grape harvester appears very promising. However, horticultural investigations on New York State varieties have shown that there is such a large increase in yield when using a "T-top" trellis in place of an "L-top" trellis that redesign of the harvester to handle crops grown in this way is an economic necessity.

THE FUTURE OUTLOOK

For certain crops harvesting costs have been estimated as equal to all other production costs, and the food processing industry cannot afford to ignore the economic gains and convenience offered by mechanization of harvesting procedures. As mechanical harvesting progresses and the supply of farm labour becomes more restricted, other operations concerned with the large-scale growing of crops will need to be further mechanized. These operations include seeding, planting, pruning or training, and other horticultural practices.

Mechanical harvesting is of more importance from the standpoint of quality in crops whose rate of maturation is rapid and where, consequently, the operations must be completed within a very limited period for the products to be harvested at optimum maturity. Peas, asparagus, and sweet corn are perhaps the most rapidly maturing crops used for processing.

"Once-over" harvesting procedures present special problems, particularly regarding segregation of the produce according to maturity. The introduction of colour-sorting and other maturity-grading equipment is therefore assuming particular significance.

Since the flexibility of mechanical harvesting operations allows more even matching of the supply of raw materials to production capacities, the introduction of such techniques will certainly reduce the time interval from field to processed product, a period during which much quality deterioration can occur. Mechanical harvesting is still in its infancy, and there is no doubt that the search for better equipment and methods will continue. Progress will depend upon the extent to which the agricultural and food engineer, the food technologist, the horticulturist, and the plant breeder cooperate.

REFERENCES

ANON. (1964).—Where will we package produce? *Agric. Mktg.* **9**(9): 10.

CASIMIR, D. J., MITCHELL, R. S., LYNCH, L. J., and MOZER, J. C. (1964).—The influence of vining on the tenderization of green peas. 24th A. Meet. Inst. Fd. Technol., Washington, D.C. Pap. 169.

COOLER, F. W., and LOPEZ, A. (1963).—Progress report on snap bean brown end coloration. *Md. Fd. Processor's Rep.* **9**(6): 6.

DUNCAN, A. A. (1963).—Bean harvesters on the march. *Am. Veg. Grow.* **11**(9): 8.

KEPNER, R. A. (1965).—Mechanical harvesting feasible for white asparagus. *Calif. Agric.* **19**(1): 2.

LAMOURIA, L. H., WINKLER, A. J., ABERNATHY, G. H., and KAMPKE, C. R. (1958).—Designing a grape harvester. *Agric. Engng., St. Joseph, Mich.* **39**: 218.

MAKOWER, R. V., and WARD, A. C. (1950).—Role of bruising and delay in the development of off-flavor in peas. *Fd. Technol., Champaign* **4**: 46.

SHEPARDSON, E. S., STUDER, H. E., SHAULIS, N. J., and MOJER, J. C. (1962).—Mechanical grape harvesting. *Agric. Engng., St. Joseph, Mich.* **43**: 66.

WHITNEY, J. D., MOHSENIN, N., and TUKEY, L. D. (1963).—An elevating mechanical harvester for apple trees trained to the plateau system. *Proc. Am. Soc. Hort. Sci.* **83**: 175.

Fruit Salad Cherries

By B. V. Chandler

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

A few artificially coloured cherries are customarily included in canned fruit salad, to provide a pleasing colour contrast and enhance its consumer acceptability, but this object is defeated if the colour subsequently bleeds out of the cherries and stains adjacent fruit or discolours the syrup. This problem should not arise if the cherries are dyed correctly and if the salad is properly formulated.

THE maraschino cherries commonly added to fruit salads before canning are artificially coloured with edible food colours, their natural pigments having been bleached with sulphite.

CHOICE OF DYESTUFF

Cherries for use in canned fruit salad packs may be dyed satisfactorily with the permitted acid-fast food colour Erythrosine, which is a dye (Colour Index Code No. 45430) of the xanthene class usually used in the form of its disodium or dipotassium salt. The Ponceau Reds, which are food dyes of the monoazo class, and also certain other red colouring materials frequently used for foods, are not suitable for dyeing fruit salad cherries, either because their stability is poor or because they bleed out too readily under the acid conditions. However, cherries dyed with some of these other colouring materials may be used in foods such as bakery products.

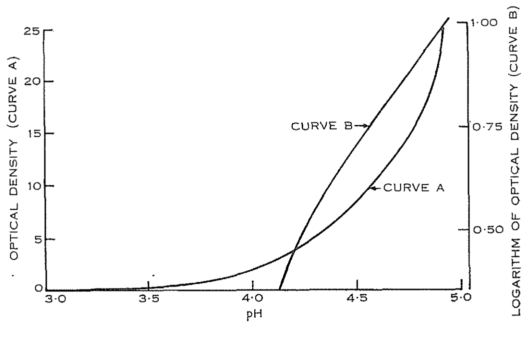
The technique of uniformly dyeing cherries with Erythrosine (examples of which are given later in this article) is based upon the fact that this dyestuff is readily water-soluble in the form of its alkali salts but is practically insoluble as the free dye-acid.

Solubility Characteristics of Erythrosine

The marked influence of pH on the solubility of Erythrosine is seen in the accompanying figure, in which the optical density of saturated Erythrosine solutions (curve A), and the logarithms of these optical densities (curve B) have been plotted as a function of pH. The various levels of pH were obtained by suitable adjustment of a dilute phthalate buffer solution in which the dyestuff was dissolved, and the optical densities were measured spectrophotometrically at 530 mμ.

For solutions of Erythrosine, the optical density at the wavelength chosen is a measure of the dye concentration, since the colour intensity of the dye solution is approximately linearly related to its concentration over a wide range of pH. Curve A on the graph shows that the optical density increases steeply as pH 5·0 is approached, indicating that there is a corresponding large increase in solubility of the dye, since the solutions are saturated. The intense colouration apparent at about pH 5·0 persists as the pH is raised further, but at very high alkalinity the relation between optical density and dye concentration no longer holds, as the colour is destroyed.

When the logarithms of the optical densities of the saturated solutions at various pH values below 5·0 are plotted against the corresponding pH, the points also lie on a smooth curve (curve B), which is practically linear between about pH 4·3 and pH 5·0.



Optical density at 530 mμ of Erythrosine solutions at saturation, as a function of pH.

A logarithmic scale for optical density has been chosen because the difference between any two values on this scale is the logarithm of the ratio of the corresponding optical densities: each unit difference is thus equivalent to a tenfold increase or decrease in solubility (log 10 = 1).

Curve B thus provides a useful summary of the solubility characteristics of Erythrosine. For instance, from the whole curve (not shown in the graph) it can be concluded that the solubility of Erythrosine at pH 3·1 is approximately one-tenth that at pH 3·4, one-hundredth that at pH 4·0, and one-thousandth that at pH 4·9. To the eye, saturated solutions at these pH values would appear respectively colourless, slightly pink, full pink, and deep red.

DYEING PROCEDURES

When cherries having a pH lying within the range 4·1–4·4 are immersed in a hot solution of Erythrosine Sodium, the dye penetrates easily into the tissue. A higher pH is avoided because this may cause darkening, whereas if the pH is lower the dye will precipitate on or within the fruit, or in the dyebath, before full penetration has been achieved. Acidification of the fruit only after it has been fully permeated by the dye solution ensures not only that the flesh is stained uniformly throughout its substance, but also that this colour is set so that it cannot easily be leached out again.

Fixation of the colour occurs through diffusion of the acid into the tissue, the consequent lowering of pH causing precipitation *in situ* of the dye within the tissue.

In practice the dyebath itself is not acidified, because this might cause local precipitation of dye and lead to its excessive deposition on the surface of the fruit. Instead, after thorough rinsing, the fully stained cherries are transferred to a fresh bath containing acid only (citric acid is usually used), in which they are boiled for a short period. If the cherries are to be candied, fixation may alternatively be effected in the candying bath, as described later. After the colour has been set the cherries are rinsed thoroughly.

Once the dyestuff has been fixed in the manner indicated above, no further migration of the dye into or out of the fruit tissue should occur, provided that the cherries are not later exposed to conditions conducive to an increase in their pH. For instance, if the cherries were placed in a medium of higher pH, or if the acid content of the cherries and the surrounding medium were insufficient to cope with any alkali diffusing from elsewhere (e.g. from lye-peeled fruit), the dye-acid could become converted to its soluble alkali salt and leaching out of the colour would almost certainly occur.

Recommendations for Dyeing and Fixing

Dyeing methods applicable to cherries preserved with sulphur dioxide have been described by Atkinson and Strachan in a publication (undated) of the Canadian Department of Agriculture entitled "The Preparation of Candied Fruits and Related Products". This document may be referred to if further details are required, but the following outline of some of the recommended procedures indicates how the principles previously discussed may be applied in practice.

Before dyeing, the cherries should be leached for 24–48 hr in running water and boiled at least once in fresh water for 10 min, or until the sulphur dioxide content is below 25 p.p.m.; if the residual sulphur dioxide exceeds this limit, blackening of the tinplate will occur in the final pack where the cherries contact the tin. The pH of the leached cherries should be adjusted to between 4·1 and 4·4, by the addition of citric acid if necessary, to facilitate dyeing and to prevent the darkening that would occur if the pH were too high. The leached cherries are dyed by simmering them for at least 45 min in a solution of Erythrosine (5–7 g per 100 lb of pitted fruit), and it is preferable to let them stand in the dyebath overnight to ensure full penetration. After the dye solution has been drained off, the fruit is rinsed thoroughly, preferably by boiling for about 2 min in fresh water.

Uncandied Cherries

In cherries that are not to be candied the dye can be fixed by immersing the fruit in citric acid solution (50 g citric acid per 100 lb of pitted fruit), in which they are boiled for 10 min. They are allowed to stand in this liquor for several hours (even up to two days) to ensure complete acidification of the fruit. The cherries should ultimately attain a pH of 3·0–3·4.

When dyed cherries are required to be stored for later use in fruit salad, it is advisable to can them in an acid solution (pH 3·5); they should be thoroughly rinsed with water immediately before use.

Fixing and Candying Simultaneously

The dyed cherries can be fixed and candied simultaneously in a single operation, and for full details the publication by Atkinson and Strachan cited earlier should also be consulted. In brief, the fruit is removed from the dyebath and covered with 30–40% syrup in a tank held at 140°F. Citric acid (115 g per 100 lb of pitted fruit) is added later, to set the dye. For candying, the pH of the syrup is held close to 3·6, by further additions of citric acid if necessary, and the sugar concentration of the syrup is raised 8–10% daily until a 72–74% syrup is obtained. The process is complete when the syrup maintains a sugar content of 50–60% for 24 hr after the last addition of sugar. The proportion of invert to cane sugar is then adjusted to 1 : 1 and the fruit carefully drained for packaging and storage. As before, the dyed cherries should be thoroughly rinsed with water before they are incorporated into a fruit salad pack.

PREPARATION OF THE FRUIT SALAD PACK

The general principles previously outlined may now be considered with particular reference to a fruit salad pack, which is a heterogeneous mixture of solid and liquid components of varying pH and acidity levels.

In a fruit salad pack several months may be required for the constituents to reach uniform acidity. Hence if a cherry is adjacent to a fruit piece of relatively high pH, such as an inadequately washed piece of lye-peeled peach or even a piece of pear (some pears have a comparatively high natural pH), the pH of the immediate environment of the cherry will rise. With the increase in pH of the surrounding syrup, the dye in the cherry may in due course become converted to its soluble salts, which will diffuse out into the syrup.

This may have a number of consequences. For instance, if in the vicinity of the cherry there are pieces of fruit with high internal acid contents or low in pH (such as pineapple pieces), the dye will be precipitated onto their surfaces. If, however, there is some distance between the cherry and the more highly acidic fruit pieces, acid diffusing from the latter may insolubilize the dye in the syrup at some intermediate point, where it may be deposited on other fruit. Since acids can migrate or diffuse through the syrup more rapidly than the soluble dye salts, precipitation of dye is always more likely on fruit pieces immediately adjacent to each cherry, even though such fruit pieces may not be inherently acidic in character. Clearly, if there are no acidic fruit pieces in the fruit salad, or if the syrup has too high a pH initially, the dye diffusing from the cherries will remain in solution in the syrup. Under appropriate conditions all of the phenomena mentioned can be observed simultaneously in one can of fruit salad.

The importance of controlling factors likely to affect the pH of the fruit and syrup in a salad pack now becomes evident; thus, lye-peeled peaches should be thoroughly washed before use, over-mature pears should be avoided, and pineapples should not be too ripe if advantage is to be taken of their natural acidity.

A pack in which the pH of the syrup is only slightly higher than that of the dyed washed cherries (pH 3·0–3·4) may be satisfactory, but if the pH of the syrup is too high the addition of acidic fruit juices is recommended. This addition will inhibit any increase in pH of the syrup surrounding fruit pieces of high pH (low acidity), and hence will lessen the likelihood of dye being leached out from cherries nearby. As a general rule, the pH of the syrup should be as low as possible consistent with avoiding a product that is too acid to the taste.

Lemon, grapefruit, passionfruit, and pineapple juices are useful ingredients for fruit salads. These juices should not be added directly to the syrup tanks if the syrup is to be kept warm for any length of time. However, they may be added to the diced fruit before this is incorporated, and would partially inhibit the enzymic discolouration which occurs in such material during extended holding periods.

If the recommendations enumerated above are followed with due regard to the principles mentioned, food processors should have no difficulty in eliminating the problem of dyed cherries "bleeding" in fruit salad packs.

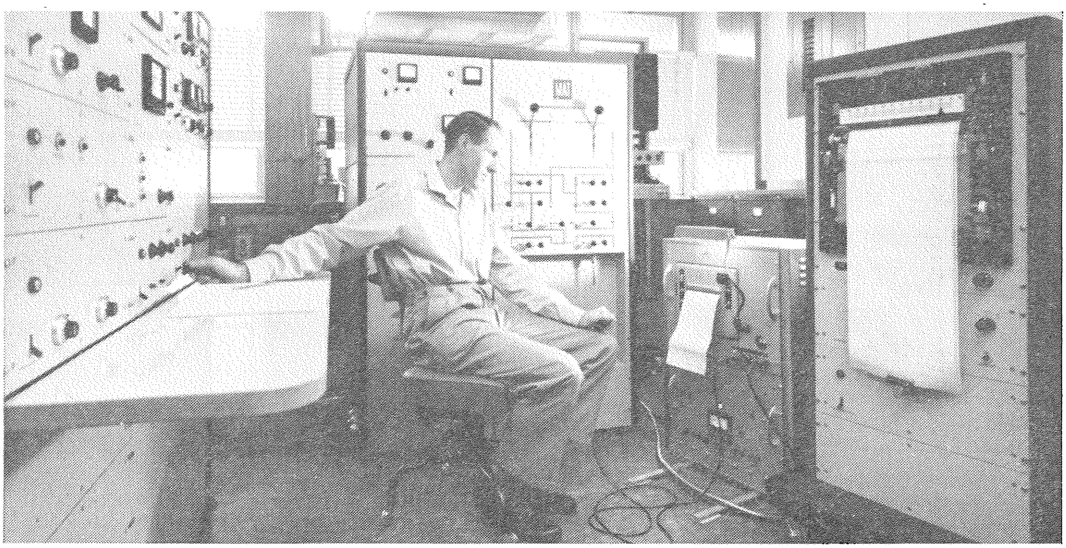
NEWS FROM THE DIVISION OF FOOD PRESERVATION

MASS SPECTROMETER FOR FOOD FLAVOUR RESEARCH

The mass spectrometer is probably one of the most powerful tools now available for the identification of organic compounds, and an Atlas CH4 model recently installed at the Division of Food Preservation (see illustration) will materially assist various research programmes of the Division. One of its principal applications will be in the identification of volatile compounds associated with food flavours.

The instrument chosen is equipped with various inlet systems designed to permit examination of samples of gases or low-boiling compounds, compounds of very low volatility (e.g. fat and wax constituents), and compounds relatively unstable to heat, and is thus highly versatile. A special feature is that the instrument is adapted for direct connection to a gas chromatograph column, in which the individual constituents of a complex mixture may be separated before being passed consecutively, along with the helium carrier gas, into the mass spectrometer. The spectrum of each compound (its "fingerprint", so to speak) is scanned and recorded while the compound emerges from the gas chromatographic column, and this time may be adjusted to as low as one second. Recording is by means of a high-speed oscillographic recorder.

It is now realized that vapours emanating from a food comprise an exceedingly complex mixture of compounds, whose number may perhaps be in the region of from 50 to 300. Identification of all of these is necessary in order to ascertain which of them contributes most to any characteristic flavour or off-flavour; previously, this requirement would have presented a major analytical problem. The combined use of gas chromatography and mass spectrometry not only now makes this possible, but also, because of the extreme sensitivity of the mass spectrometer, allows the chemist to work with the minute amounts of volatile flavour material that are present in only a few litres of air taken from above a sample of the food.



The Atlas CH4 mass spectrometer. From left to right, the units are: electronics console, analyser unit, direct-writing oscillograph recorder for fast scanning of spectra, and mass recording console.

APPOINTMENTS

Dr. C. J. Brady, formerly of the Fodder Conservation Section, CSIRO, Melbourne, has been appointed to the Division's Plant Physiology Unit, University of Sydney, as a Senior Research Scientist. He took up duty on February 8, 1965. Dr. Brady holds the degrees of M.Sc.Agr. (Sydney) and Ph.D. (Aberdeen) and has wide research experience in plant biochemistry, especially in relation to post-harvest changes occurring in nitrogenous constituents of plants.

Mr. G. Stanley, who was a member of the staff of the Division from 1951 to 1958, has rejoined it as an Experimental Officer to participate in studies in flavour chemistry. An Associate of Sydney Technical College, Mr. Stanley also holds the B.Sc. degree of the University of New South Wales. He commenced duty at the Division's North Ryde laboratories on February 2, 1965.

OVERSEAS TRAVEL

Dr. G. P. Findlay, Research Scientist, of the Division's Plant Physiology Unit, is overseas on a CSIRO post-graduate studentship. He left Australia in August 1964 to attend a conference of biophysicists at Tilton, New Hampshire, U.S.A., and to visit other research centres. He plans to spend from September 1964 to April 1965 with Professor J. Dainty, School of Biological Sciences, University of East Anglia, Norwich, England, and from May to July 1965 will be with Professor T. Teorell at the Physiological Institute, University of Uppsala, Sweden.

VISITORS

Professor H. D. Naumann of the Department of Animal Husbandry, University of Missouri, Columbia, U.S.A., is in Australia as a Senior Fulbright Scholar and is attached to the Division's Meat Research Laboratory at Cannon Hill, Qld. Professor Naumann, who is accompanied by his wife and family, arrived in Australia by sea on March 7.

Professor Naumann plans to study the reaction of Australian consumers to variations in meat quality occasioned by methods of production, transportation, and meat processing. Two types of tasting panel will be used in the study, namely, a laboratory consumer panel of trained tasters and a household panel consisting of a number of households of two adults. The results of the investigation are expected to provide the meat industry with a considerable amount of information on the likes and dislikes of meat consumers in Australia.

Dr. Maurice Ingram, Director of the United Kingdom's new Meat Research Institute, is spending a month in Australia from March 24. The purpose of Dr. Ingram's visit was to study the organization of, and facilities available for, meat research in Australia, and to visit institutions concerned with the breeding, production, and nutrition of meat animals. At the Division of Food Preservation, Dr. Ingram took part in discussions on the scope of meat research programmes planned to be undertaken in his research institute and in the new CSIRO Meat Research Laboratory. The latter laboratory is to be erected at Cannon Hill, Qld., and the U.K. Meat Research Institute will be accommodated in buildings to be constructed at Langford, near Bristol.

Prior to his present appointment, Dr. Ingram was Deputy Director of the Low Temperature Research Station at Cambridge. He is well known for his work on the microbiology of foods, on the science and technology of meat and meat products, and on preservation of food by cold.

RECENT PUBLICATIONS OF THE DIVISION

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

ANET, E. F. L. J. (1964).—3-Deoxyglycosuloses (3-deoxyglycosones) and the degradation of carbohydrates. *Adv. Carbohyd. Chem.* **19**: 181–218. (No reprints available.)

ANET, E. F. L. J. (1965).—Degradation of carbohydrates. V. Isolation of intermediates in the formation of 5-(hydroxymethyl)-2-furaldehyde. *Aust. J. Chem.* **18**: 240–8.

HOWARD, A. (1965).—The place of the taste panel in quality assessment (of meat). Symp. Carcase Composit. and Appraisal of Meat Anim., Melbourne, 1963. Pap. 15.

HOWARD, A. (1965).—The relation between physiological stress and meat quality. Symp. Carcase Composit. and Appraisal of Meat Anim., Melbourne, 1963. Pap. 11.