FOOD PRESERVATION QUARTERLY

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Editor
W. A. EMPEY

CONTENTS

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THE DIVISION OF FOOD PRESERVATION AND TRANSPORT
COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH
ORGANIZATION, HOMEBUSH, NEW SOUTH WALES, AUSTRALIA

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A Cold Store for Fruit

By

C. E. B. Cooper

Editor's Note

We are very glad to print the following article by Mr. C. E. B. Cooper, a senior technical officer of the South African Perishable Products Export Control Board, Capetown, in which a novel design of cool store incorporating a very efficient pre-cooler is described. Several stores of this design are now in operation in South Africa. We invited Mr. Cooper to contribute this article because we considered that operators and designers of pear stores in Australia should be aware of this design, which may be very suitable for stores for sensitive fruits in some localities in Australia.

In the Union of South Africa, deciduous fruits are produced primarily for export to European and American markets; the various phases of railage to coast ports, pre-cooling at quayside installations, and refrigerated transport overseas come under the control of a statutory body, the Perishable Products Export Control Board.

The Technical Adviser to the Board is responsible for the technical efficiency of the pre-cooling and transportation processes and, in addition to forming the link between research organizations and the Board, has at times to undertake research himself. Thus, in 1937–39, the late Dr. A. J. M. Smith, then Technical Adviser, carried through an extensive series of tests from which emerged the prototype of the "tunnel" pre-cooling units which are now standard for new construction in Union pre-cooling stores and which, in practice, halved the time required for the commercial cooling of most deciduous fruits, as compared with earlier methods.

Although export is of major importance there is, in the Western Cape Province, a considerable production of apples and pears destined for Union markets or for the canning plants. There are many co-operative groups of fruit farmers who own and operate cold stores for their crops; these are often linked to central packing depots or canning plants.

In 1939, the late Dr. Smith was requested by a leading co-operative group to design a cold store for fruit, principally for apples and pears. This request provided an opportunity to consider designs in which the new pre-cooling technique could be blended with efficient cold storage.

In the Union, climate, costs of timber and insect pests have influenced the choice of materials used in the design of most industrial buildings. Reinforced concrete and brick constructions are used in place of timber. For cold stores, heavy insulation and efficient waterproofing are required, as external temperatures are high. Thus quite simple industrial buildings, such as cold stores, are relatively high in first cost. One of the most common defects in country fruit stores is an inability to cool arrivals with sufficient speed and without drastic interference with temperature uniformity of fruit already in store. Work of stacking arrivals goes on for weeks at a time in large cold-store rooms with consequent interruption to cooling, heavy additional refrigerating load, both as sensible and latent heat, and the necessity for frequent defrosting of coolers. It is not easy to convince growers that temperature fluctuations and condensation on stored fruit can be minimized, if not eliminated, by adequate pre-cooling of arrivals ; the general attitude is that the larger refrigerating plant is an expensive luxury. Obviously, therefore, any design which sets out to provide first class pre-cooling facilities must show some other features in which economies, and not alone superior performance, are possible.

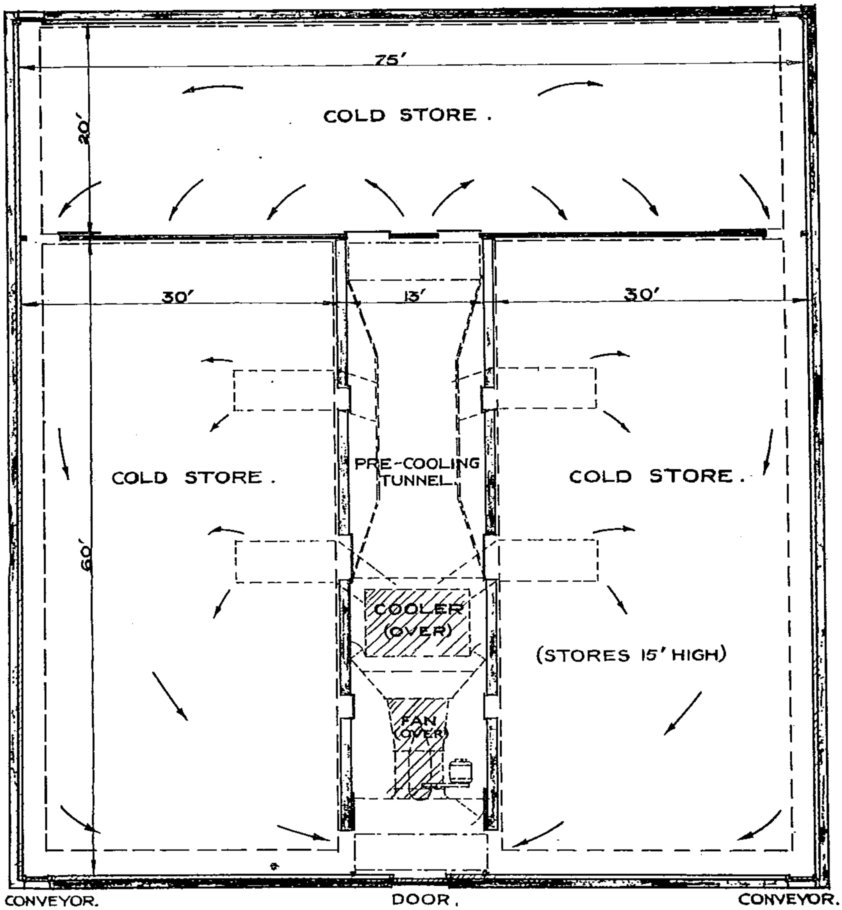

Fig. 1.

Starting, therefore, with the basis of a tunnel pre-cooler of daily capacity 2,500 bushel cases of apples, a search was made for a design in which cooling equipment costs could be minimized and waste space eliminated inside the insulation ; the designed gross capacity for holding fruit to be in the neighbourhood of 40,000 bushel cases. After consideration of several designs it seemed feasible to propose an arrangement of a combined cold-storage and pre-cooling tunnel in which the whole installation could be operated by one fan and air-cooler, and in which air ducts would be almost eliminated. This proposal embodied (Fig. 1) a pre-cooling tunnel placed centrally in the building with an air-cooler and fan mounted above the tunnel but still inside the insulated envelope, thus securing the most advantageous position for the coldest portion of the system. Around the pre-cooling tunnel were the cold storage chambers, one on either side and one placed transversely across the tunnel outlet. When pre-cooling, most of the air was circulated through the tunnel, fan and cooler in a circuit arranged in a vertical plane. When cooling the cold stores only, the air was delivered by the fan to the cooler and thence to the transverse storage chamber at the far end of the tunnel; in this chamber the air divided into two streams which circulated along the side storage chambers before returning to the fan suction plenum at the inlet end of the tunnel, thus completing a double gyratory circuit in a horizontal plane. Varying proportions of air for "pre-cooling" and "storage" requirements could be arranged by the adjustment of a single control flap. When the building was filled, the last tunnel load of fruit could remain for storage in the pre-cooling tunnel.

The co-operative's design envisaged three chambers, each of about 13,000 case gross capacity and each cooled by separate cooler and fan, with one room equipped with additional refrigerating capacity for pre-cooling. The possibilities for economy in the gyratory design will be clear from Table 1.

TABLE 1

Comparison of Conventional and Gyratory Designs of Cold Stores

	Conventional Design.	Gyratory Design.
Volume of insulated structure ..	82,000 c.ft.	82,000 c.ft.
Loss of space for coolers and fans	7,000 ,,	3,000 ,,
Loss of space for air ducts ..	3,300 ,,	Negligible
Loss of space for internal walls	2,200 ,,	800 c.ft.
Loss of space for aisles in stack	7,700 ,,	6,200 ,,
Total losses	20,000 ,,	10,000 ,,
Volume available for fruit ..	62,000 ,,	72,000 ,,
Estimated net capacity for fruit in bushel cases	30,000 cases	35,000 cases
Air cooler for pre-cooling room ..	2,500 sq. ft.	3,000 sq. ft.
Air coolers for two storage rooms	2 × 600 sq. ft.	Nil
Fans for pre-cooling room ..	30,000 c.ft./min.	50,000 c.ft./min.
Two fans for storage room ..	2 × 13,000 c.ft./min.	Nil
Estimated air H.P. for fans ..	14·6	14·2

Thus from an equivalent insulated "shell", it is possible to provide rapid pre-cooling and to increase the storage accommodation by about 16 per cent., using a "gyratory" system as compared with the conventional system of coolers for each chamber.

Support for the idea of a small central pre-cooling tunnel came from a knowledge of the practical difficulties associated with the operation of a large, lofty cold storage room as a pre-cooler for small amounts of two to three thousand cases, added daily. Air cannot be induced to penetrate individual boxes, and much less a stack of boxes, if space exists for short circuits in a partially filled chamber. In the tunnel method, however, as long as sufficient boxes are available to fill the cross-section, and this is a small amount, then pre-cooling is both rapid and uniform.

The gyratory system provides for economies in heat transfer plant and fan power also, although these are not so marked as the above-mentioned economies in space. A rough comparison of coolers and fans is given in Table 1.

The chief advantage of tunnel pre-cooling chambers over those with the conventional ceiling to floor circulation is, of course, that a high velocity horizontal air-flow is possible, the cross-section of the tunnel being so much smaller than the plan area of an equivalent room. Another advantage is the virtual disappearance of ducts for the distribution of air, in designs where fan and cooler are mounted in a loft above a single tunnel. Resistance to air-flow set up in a duct system with graded apertures leads to a loss of efficiency and should be, wherever possible, converted into resistance to air-flow through a stack of fruit, in which case the air is more usefully put to work. For instance, in an existing cold store, it was found possible to convert an air circulation system, without alteration to the fan, cooler or the insulated shell of the chamber, so that a circuit resistance in air ducts of no less than 0·8 in. of water gauge was replaced by a fruit stack resistance of 0·9 in. of water gauge in the tunnel design which eliminated the air ducts.

With hand stacking in a tunnel it is possible to increase the resistance to air flow to the point where the circulation of air is seriously reduced and uniformity of cooling is lost. A compromise, based on experience with fruit stacked on wheeled trolleys, requiring certain working side clearances, indicates that with a tunnel length of about 60 feet, the proportion of cross-section area of the tunnel occupied by the fruit boxes should be approximately 80 per cent. for optimum circuit resistance and rate of pre-cooling. The 20 per cent. free cross-section should be arranged as peripheral crevices and also as a series of vertical crevices between stacks of fruit. Fixed side and floor dunnage strips, arranged parallel to the flow of air, assist stackers to maintain these clearances.

For the tunnel design now described the fruit boxes are stacked with sides parallel to the air flow, eleven boxes wide and six high. The area occupied by the boxes in such a stack is 69·7 sq. ft. and with internal dimensions of 13 ft. wide by 7 ft. high the fruit stack occupies nearly 80 per cent. of cross-section, with inclusion of dunnage strips. It is possible to circulate nearly the full amount of air, 50,000 c. ft. per min., through the tunnels with an average crevice speed in excess of 2000 ft. per min., but with allowance for an amount sufficient to maintain temperatures in storage rooms simultaneously with pre-cooling, a crevice speed of from 1800 to 2000 ft. per min. is feasible. Under such conditions a stack resistance of from 0·8 in. to 0·9 in. water gauge for a tunnel of 60 ft. can be expected.

To transfer the heat of the 2,500 bushel boxes of apples, which could be stacked in the above tunnel and which are commonly received at 80° to 85° F. and need to be cooled at an average rate of some 2° F. per hour, sensible heat extraction at the average hourly rate of 190,000 B.T.U. is necessary. Adding to this the heat production by the fruit (which, of course, varies with the amount of stored fruit), the heat leakage through the insulated envelope, the heat input by fan-motor and such miscellaneous sources as heat from men working, lights and air infiltration, we find that the total refrigerating duty, while pre-cooling, can range from 300,000 to 350,000 B.T.U. hourly. When not pre-cooling, the refrigerating duty would be some 140,000 B.T.U. hourly.

The air cooler is specified to transfer sensible heat at the rate of 25,000 B.T.U. per hour per 1° F. mean temperature difference between refrigerant and air, when the air is circulated past the coils at the rate of 50,000 c. ft. per min. The heat-transfer surface is arranged in the form of a large number of steel tubes, $1\frac{1}{2}$ in. bore, running transversely to the flow of air and fabricated in the form of a series of flat pipe grids, held apart by steel bars of $\frac{3}{8}$ in. thickness and with staggered horizontal spacing of 6 in. to avoid a drastic effect on air flow through snow formation. The flat grids are grouped in suitable pipe circuits to permit the circulation of ammonia refrigerant on a "flooded" system, with liquid supply and gas return headers connected to a liquid separator vessel which is fitted with a float control valve for the admission of liquid refrigerant from the high pressure circuit. With a box velocity of 10 ft. per sec., the resistance to air flow of this cooler is nearly 0·7 in. water gauge.

The fan to circulate the air through the tunnel and over the cooler is a single-stage airscrew type, mounted horizontally between the point of air return from the tunnel and the air cooler. About 14 air horse-power is required to circulate the requisite 50,000 c. ft. per min. against the full circuit resistance of 1·75 in. water gauge and a 20 h.p. motor drives the fan through vee-belting. Advantage is taken of the non-overloading characteristics of the airscrew fan when the various adjustments are made to circulate air through the storage chambers and not through the tunnel; the flow of air is, of course, reversible. The fan is provided with a curved suction-adaptor and tapered delivery-diffuser. The connections between the ends of the tunnel and the fan and cooler are, as far as practicable, dimensioned to avoid abrupt changes of velocity in the moving air and to minimize turbulence at tunnel entrance and exit.

When pre-cooling is completed air is delivered to the first storage chamber, of dimension 75 ft. by 20 ft. by 15 ft., which lies across the end of the tunnel and communicates with it. The air circulated divides into two streams which move outwards and leave the room through ceiling and floor apertures in the partitions separating the room from the two larger storage chambers, each of dimensions 60 ft. by 30 ft. by 15 ft., and which lie on either side of the tunnel pre-cooler. The air returns along these chambers towards the suction end of the tunnel and enters the fan suction by way of doorways and return apertures in the tunnel side-walls. Two sets of shallow auxiliary ducts, of negligible volume, are arranged to feed a little air into these side chambers if required. Stacking aisles, in which conveyers can operate, are arranged along the outer sides of the chambers; these aisles and the ceiling clearance space act as air ducts to form a jacket of moving air over areas of greatest heat leakage. Correct stacking of boxes ensures reasonable uniformity of air flow through the two side chambers and a field test has shown that, even when the store is comparatively busy, a satisfactory balance in air distribution and a satisfactory uniformity of temperature can be maintained.

A list of the principal components of the refrigerating plant is given at the end of this description.

The method of handling is hand stacking, allied to the use of gravity roller-conveyers. Conveyer plugs are provided at the four corners of the building and insulated doors in the partitions and in tunnel side-walls give freedom of access to the various parts of the building; only one insulated door is required in the outer insulated envelope. Since the prototype store was constructed in 1940, developments in the use of pallets and battery-operated fork lifter trucks have rendered any other system of handling obsolete. Using lifter trucks, tunnels can be stowed and discharged in half the time taken by hand stacking, making available several extra hours of cooling daily. Transfer to the storage chambers is immensely accelerated and the bumping of individual boxes during stacking eliminated.

Dimensions throughout the storage chambers and pre-cooling tunnels have to be altered to conform with a system of mechanized handling of fruit on pallets; the floor must be true and level and doors wide enough to pass the pallets. A slight loss in capacity due to pallet stacking is more than compensated for by savings in labour costs and increased time for cooling. For prolonged storage under winter conditions, two-speed motors for the fan drive are advisable, and offer an opportunity for power savings when conditions are favourable and fruit quantities small.

The co-operative society has expressed satisfaction with the results obtained from working this store over a number of seasons; a token of its satisfaction was the construction of a replica of the store operated by the same refrigerating plant and situated near the original unit. Criticism has been offered of the size (2,500 cases) of the pre-cooling tunnels, which, it is said, are too small to contain a peak day's arrivals. Providing accommodation for peak arrivals is liable to be an expensive practice, however, and it is open to argument as to whether the full provision should ever be made. Unless a balance is kept it is felt that plant first costs, based on maximum fruit arrivals, will be so high that the financial success of the project will be endangered.

Summary of Refrigerating Plant Details for Fruit Cold Storage

1—Air Cooler—Cross-grid, dry, surface, direct expansion NH_3, flooded operation, 3,000 sq. ft. cooling surface, $1\frac{1}{2}$ in. bore, 7 S.W.G. solid drawn steel tubes. With headers and connections to:

1—Liquid Separator, fitted with float-control valve and auxiliary hand equipment.

1—Airscrew fan to circulate 50,000 c.ft./min. at $1\frac{3}{4}$ in. water gauge, belt driven by 20 h.p. squirrel cage motor, 380 volt, 3 phase, 50 cycle supply; with Star-delta starter and reversing switch.

1—Ammonia Compressor of two cylinder vertical enclosed single acting type, of capacity 600,000 B.T.U. per hour at +15° F. evaporation and +95° F. condensing temperature. Belt driven by 80 h.p. slip-ring induction motor off 380 volt, 3 phase, 50 cycle supply.

1—Ammonia Compressor similar to above, but of capacity 150,000 B.T.U. per hour at +15° F. evaporation and 100,000 B.T.U. per hour at 0° F. evaporation when operating on an ice tank circuit. Belt driven by 22 h.p. motor.

Condensers of atmospheric interlaced coil type, of 2,300 square feet surface, of $1\frac{1}{2}$ in. bore, 7 S.W.G., solid drawn steel tubing.

1—Receiver to hold 500 lb. ammonia (full charge 2,800 lb.).

1—Ice Tank of 60–100 lb. can capacity, with motor driven agitator, five can harvester, thawing tank, ice-tip and automatic can filler. Cooling coil 250 sq. ft.

2—Centrifugal pumps for circulation of cooling water over condensers and spray cooler, each pump 150 gal. per min. capacity and driven by 3 h.p. squirrel-cage motors.

1—Indicating Thermometer equipment of electrical resistance type, with eight thermometers.

By-products from Fish Waste

By

K. W. Anderson

When it is considered that the weight of scrap material (offal and trimmings) from a fish processing plant may amount to 30–35 per cent. of the weight of raw material received it is obvious that once production has exceeded a certain level, profitable utilization of the waste is an essential factor in the economics of the industry. With the exception of a limited production of meal and fertilizer no great attention has been given to the question by Australian processors mainly because of their relatively small individual throughput. A position can be envisaged when greater development of the industry may require treatment of the waste. It is therefore proposed to outline briefly some recent overseas trends in the technology of fish by-products.

Fertilizer and Fish Meal

Both fertilizer and fish meal are derived from fish waste, but the meal must be made from fresh raw material, the processing of which is strictly controlled.

Meal is used as a food supplement for stock and poultry. The principles of processing have not changed greatly in the last twenty or so years but the quality of the products has been improved by the introduction of continuous cookers, presses and drying tunnels, which have also greatly reduced the process times.

In a typical modern plant the offal is minced and fed through a load-regulating device into a steam injection horizontal cooker. The cooker contains a revolving worm to provide agitation and maintain flow of the material. On its journey through the cooker the fish scrap is subjected to steam pressure (5–10 lb. per sq. in.). The time of cooking is dependent among other things on the type of material, an average figure being fifteen minutes. The object of the heat treatment is to coagulate the protein and rupture the walls of the fat cells, thus facilitating separation of fat and moisture from the protein during pressing. The cooked material is discharged into the hopper feed of a screw press consisting of a worm of gradually increasing diameter turning inside a cylindrical screen with tapered holes, approximately $\frac{1}{16}$ in. inside diameter and $\frac{3}{16}$ in. outside diameter. The press cake is thus subjected to an increasing pressure as it approaches the discharge. The press liquors, oil, water and suspended proteinaceous material are collected for subsequent treatment. After pressing, the residue is conveyed through heated drying tunnels where its moisture content is reduced to less than 10 per cent. The composition of a typical meal is given in Table 1.

It has been claimed that fish meal is the only food which can, on its own, maintain adequate nutrition of poultry, and that it contains a "Factor S" apparently essential for the growth of chickens. Recent work by Scott *et al.* (1947) seems to have established the identity of this Factor S. Other reports have described an apparent toxicity in certain fish meals and this has been shown to be due to a substance " thiaminase " which inhibits the biological utilization of vitamin B_1. " Thiaminase " is destroyed by heating above 60° C. and will not be present in normal cooked meal prepared as described above.

The press liquors are cycled to an automatic desludging centrifuge such as the Sharples " Rotojector ", where they are separated into body oil, a further small quantity of meal and the " stickwater ". The use of centrifuges eliminates the use of the vibrating screens and gravity settling systems previously employed, giving higher yields and better products with shorter process times.

The preparation of meal from crayfish offal has been found to present specific problems. The interested reader is referred to the excellent and detailed report by the South Africans, Dreosti and Southall (1949).

TABLE I

Average Composition of a Typical Meal

Protein	60%
Minerals	20%
Moisture	Less than 10%
Fat	,, ,, 5%

Body Oil

The body oil as received from the centrifuges is generally in a crude form. The conventional techniques for refining have been outlined by Seaman (1949). The quality of an oil and its suitability for specific purposes is assessed from consideration of its odour, colour, iodine value, saponification value, and its content of free fatty acids, insoluble matter, moisture and stearin. Depending on these characteristics the refined product finds use in the food industries as a cooking, shortening, salad or canning oil, and in the manufacture of margarine. Other grades are incorporated into soaps, paints and varnishes, linoleums, oilcloths and leather, printing inks, rubber, synthetic detergents, rust inhibitors, etc. In general most body oils are too low in vitamin potency to be used alone for therapeutic purposes but they are often blended with liver oils and concentrates in preparing veterinary feeding emulsions.

Probably the two most important advances in refining techniques have been the Solexol process (Van Orden, 1946) and molecular distillation. The Solexol process depends upon the counter current extraction of the oil with liquefied gases at pressures above atmospheric. The solvents, of which propane is the most common, are completely miscible with the oil at low temperatures (160° F.) but as the temperature is increased in controlled steps certain component fractions of the oil precipitate out and can be removed. Various fractions such as free fatty acids, stearin and drying oils are thus isolated. Molecular distillation accomplishes a similar purpose by distillation of the molecular components across a short path in a highly evacuated chamber. Its development and practical applications have been reviewed by Hickman (1944).

Stickwater

Stickwater is the name given to the aqueous liquors received from the centrifuges. Although it was realized that it contained valuable amounts of nitrogenous material, it was largely rejected until comparatively recent years. A certain amount was made into glue by dialysis through a parchment membrane, or electrodialysis through a viscose sheet, to remove inorganic salts, followed by concentration of the dialysed liquors.

About 1945 it was found that the concentrated stickwater had excellent nutritional value, particularly for chickens. Many methods have subsequently been described for the production of these so-called "condensed fish solubles". The simplest involve concentration in a multiple effect evaporator to a syrup containing 50 per cent. solids which is added to the cooked and pressed fish meal preparatory to drying. Alternatively the "stickwater" may be adjusted to pH 4–5 with sulphuric acid, whereby a portion of the soluble protein is coagulated and some emulsified oil released. It is then passed through a centrifuge of the Sharples "Nozljector" type and the aqueous liquors, containing protein material and vitamins of the B complex, evaporated and incorporated into cattle and poultry feed.

Gunther and Sair (1948) claim that the point at which gel formation occurs in concentration of the stickwater is substantially delayed by using the enzyme papain. They concentrated their hydrolysate to 70 per cent. solids.

TABLE 2

Average Composition of Condensed Fish Solubles

Total solids ..	50%	Calcium ..	0·87%	Riboflavin (B_2)	8–9 mg./lb.
Protein ..	32%	Phosphates ..	0·85%	Pantothenic Acid	18 ,,
Fat	4%	Iron	0·025%	Thiamin (B_1) ..	1–8 ,,
Ash	9%	Magnesium ..	0·016%	Nicotinic Acid	150 ,,
		Sodium oxide	1·87%	Pyridoxin (B_6)	5 ,,
		Potassium oxide	1·93%	Choline	1500–1800 ,,

Lewis and his associates (1949) found during an investigation into the occurrence of the recently isolated vitamin B12 in natural materials that fish solubles were an excellent source of this factor. Vitamin B12 has been the subject of exhaustive inquiry during the last two years and it has been shown to be a necessary growth factor for chicks and certain animals and of value in the treatment of pernicious anæmia.

Considerable attention has lately been given to the production of the so-called "food yeasts" (*Torula utilis* and *Rhodotorula gracilis*) which are rich sources of the B vitamins, protein and fat and are cultivated on artificial media. Likewise many of the antibiotics are produced on a commercial scale from organisms grown on fortified substrates. The available evidence (Table 2) seems to show that condensed fish solubles contain many, if not all, of the essential factors required for the growth of a wide variety of micro-organisms and it is conceivable that the product will find use as a culture medium.

Egg Albumen Substitutes

Production of egg albumen substitutes from fish began in Germany in 1934 and reached a peak during the "ersatz" period of 1943–44. The best quality products, suitable for edible purposes, are made from fresh white fish fillets or shrimp. A limited production of technical grade material may be possible from fish offal and trimmings though the yield would probably be low. The process has been described in detail by Beharrell *et al.* (1947). Fresh, skinned fillets are minced and treated with warm dilute acetic acid. It is claimed that this is essential to dissolve " connective tissue ". The fish is then washed, pressed and extracted with 95 per cent. alcohol to remove lipid material, and the solvent is removed under vacuum. The extracted meal is partially hydrolyzed by treatment with 2 per cent. caustic soda followed by neutralization of the excess alkali with acetic acid. Finally the hydrolyzate is spray-dried to a fine powder. The product is cream to brown in colour, has only a faint fishy taste if well prepared, and is soluble in water, giving an opalescent solution of good whipping qualities. Edible grades are used to replace egg albumen in the preparation of mayonnaise, salad cream, butter cream, whipped cream, ice cream, etc. Technical grades can be used in the production of plastics, paint, leather, in the textile industries and as a foaming agent in fire extinguishers. Analysis of the relevant data shows that economical production of technical grades from fish waste would be largely governed by the cost of processing. Norwegian chemists (Notevarp, 1949) claim to have simplified the plant procedure, but few details of their method are available. The following typical analyses for fish albumen (Table 3) are quoted by Beharrell *et al.* (1947) from a German source. Some doubt exists as to the reliability of the figures since no account is given of the sodium acetate content, which will undoubtedly be appreciable as a result of the neutralization in the last step of the process.

TABLE 3

Typical Analyses of Egg Albumen Substitutes

	Edible Grade	Technical Grade
Protein	93·9%	63–78%
Salt	0·09%	1·4–1·9%
Moisture	4·65%	4–14%
Total ash	0·80%	15–20%
Fat	Trace	Trace
P_2O_5	0·22%	3–6%

Miscellaneous By-products

The following substances are of technical interest, but their production in Australia will be possible only when larger supplies of fish wastes become available.

(1) *Tryptic Enzymes.* The pyloric caeca of fish, which are tubular sacs attached to the gut immediately below the stomach, are a good source of tryptic enzymes. A procedure has been published for recovery of these enzymes on a commercial scale (Bocciardo, 1947), and they are readily obtained in the laboratory in a yield approximating 5 per cent. by acetone drying of the comminuted caeca. Their properties are well described by Johnston (1936, 1937). Tryptic enzymes are chiefly used in industry as " bates " for the softening of hide leather, a process involving partial hydrolysis of the proteins, collagen and elastin. Several workers have shown that the preparations from the pyloric caeca of fish are as active as those from hog pancreas for leather treatment and for splitting casein to peptones.

(2) *Peptones.* Peptones are broadly classified as the products obtained by partial hydrolysis of proteins. Peptones prepared from meat are used in the formulation of microbiological media. The protein components of meat and fish muscle appear in many respects to be similar and it is possible that suitable peptones could be formed from waste fish muscle either by hydrolysis with hydrochloric acid or digestion with tryptic enzymes obtained from the fish itself. In this latter regard it is of interest to note (Montgomery, 1949) that an organism isolated in the laboratories of the Division of Food Preservation from the flesh of " milky " barracouta showed a high degree of proteolytic activity on fish muscle at 140° F.

(3) *Chitin.* The shells of crustacea contain approximately 20 per cent. of chitin, a polymerized acetyl glucosamine. Chitin has been suggested as an alternative to cellulose for the manufacture of adhesives, varnishes and wrapping materials. Glucosamine can be prepared from chitin by hydrolysis.

(4) *Guanine.* The lustrous appearance of certain fish scales is due to a thin deposit of small crystals of the purine, guanine, on the epidermis of the fish. A suspension of guanine crystals in a suitable solvent forms the pearl essence used in the preparation of artificial pearls (Carter, 1943). One claim (Anon., 1945) relates to the conversion of guanine obtained from fish scales into the chemically related compound caffeine, an extensively used pharmaceutical. Fish scales also apparently contain the amino-acid cystine in appreciable quantities.

(5) *Plastics.* The laboratory production from fish muscle of a plastic similar to the casein-formaldehyde resins has been described by Johnston and Beatty (1934). In a typical process minced flesh is dried at ordinary temperatures with acetone or alcohol, the dry meal mixed with 20 per cent. of ethyl lactate and compressed at 10,000 lb. per sq. inch and 220–240° F. for 10 hours. The plastic sheet is then treated with commercial formalin for at least two weeks, when chemical cross linkages between the protein chains are apparently formed producing a tough material known as " artificial horn ".

Conclusion

In a world which is turning more and more to the utilization of industrial wastes as sources of raw materials for industry and for food, the position has been reached where the main barrier to such utilization is economic rather than scientific. There is little doubt of the potential value of a large number of marine by-products, but costs of production in many instances compare unfavourably with those of similar materials from alternative sources. Considerable attention is therefore being devoted to the introduction of modern plant and advanced techniques in an endeavour to simplify existing procedures.

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Answers to Inquiries

(1) WHAT IS THE BEST METHOD FOR MOULD CONTROL AND DEODORIZATION OF COOL STORES ?

The best method is fumigation with formaldehyde. The burning of sulphur is not particularly effective.

The room is first emptied and then thoroughly cleaned; this is best done by washing with a hot detergent solution. The room should then be thoroughly sprayed with a solution of chlorine (3,000 parts per million) or with a commercial chlorine preparation at the recommended strength. Finally the room should be fumigated with formaldehyde gas, using the following method:

A solution of two parts of commercial formalin and one part of water is allowed to drip slowly into a metal vessel containing permanganate (Condy's crystals). For every 1,000 cubic feet of air space half a pint of formalin and eight ounces of permanganate are required. The receptacle containing the permanganate should be large enough to hold about ten times the volume of formalin plus water, as there is a tendency for the mixture to foam, and it should be placed in the centre of the room. The reaction is rapid and the operator should retreat rapidly after starting the formalin dripping.

On the day after fumigation the rooms should be opened for a few hours and on the next day they can be loaded with produce.

Initial thorough cleaning is important. Spraying with chlorine deodorizes the room fairly effectively and has some fungicidal value, but the formalin fumigation is the important operation for mould control.

(2) IS OZONE AN EFFECTIVE DEODORANT AND FUNGICIDE FOR STORES HOLDING FOOD, ESPECIALLY FRUIT AND VEGETABLES ?

Ozone is widely used as a deodorizing agent because of its ability to oxidize many objectionable odours and gases into non-objectionable products. It is readily generated; in very dilute concentrations it has a pleasant, fresh smell; and it decomposes into a harmless gas, oxygen. However, in concentrations greater than about 0·5 part per million it is irritating and may cause headache and nausea. Further disadvantages are that it will rapidly oxidize rubber and fats, causing rancidity of the latter; it is unstable; it is ineffective in depth, and some fruits, e.g. peaches and bananas, are injured by very low concentrations, of the order of 1–2 parts per million.

Nevertheless, ozone has been used for many years in food stores in Europe and America. It is very commonly used in egg stores, in concentrations of 1–1·5 p.p.m., to reduce odours and control surface moulds and bacteria, and to a less extent in meat stores.

Its use in fruit and vegetable stores has been subject to conflicting opinions, but the present view is that ozone will control surface mould, especially on walls, boxes, etc., and to some extent will remove odours, but will not usually reduce actual rotting of the fruit nor the incidence of scald or other storage disorders.

Scupin (1938) reported that ozone was used in fruit stores in Germany to control fungal rotting, with satisfactory results, and that it did not increase the rate of ripening of the fruits. Control of surface moulds and some odour removal but failure to reduce fruit rots was reported by Smock and Watson (1941), using 1–2 p.p.m. for 1–2 hours daily. Similar results have been reported by other workers in both America and Canada. In later investigations (Uota and Smock, 1948; Smock, 1949) it was found that, although ozone undoubtedly controlled surface moulds and therefore odours from them, it was of little use in general odour removal; air purification with activated carbon was necessary for complete odour control. A detailed investigation of the use of ozone in apple cool stores was carried out by Schomer and McColloch (1948). They found that ozone in concentrations of 2 p.p.m. for 1–2 hours daily controlled surface mould, but did not necessarily kill it. Exposure of apples to a concentration of even 3·25 p.p.m. for several hours a day during storage failed to check decay. In their experiments superficial scald was reduced, but not controlled by 3·25 p.p.m. This concentration caused serious lenticel injury, the surface of some varieties became sticky and varnish-like, and the flavour of most varieties was adversely affected. The authors concluded that ozone in the concentrations employed has no influence on ripening. It is of interest that Smock and Watson (1941) found that 1–2 p.p.m. for only 1–2 hours a day caused a blackening around the lenticels of several varieties of apples.

Although no work has been done in Australia on the use of ozone in apple stores, there is little doubt that the above conclusions would apply. In stores with a high humidity (which is desirable to minimize shrinkage) surface mould is often troublesome; in such rooms the introduction of 0·5 to 1·0 p.p.m. of ozone for an hour or two daily may be useful. It is clear, however, that ozone will not increase the storage life of apples or pears either by reducing decay or by influencing fruit metabolism.

There is little information available concerning the effects of ozone on other fruits. Ewell (1946) considered that 2–3 parts per million for several hours daily would increase the life of grapes, small fruits and berries. He also claimed that exposure to low concentrations of ozone enhanced the flavour and aroma of aromatic fruits such as strawberries.

There are some indications from the literature that ozone may be useful in mixed storage and may enable different types of fruits to be stored together. However, the information on this aspect is not sufficient for any recommendation to be made.

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C.S.I.R.O. Translations and Bibliographies

The following translations and bibliographies are obtainable from the C.S.I.R.O. Information Service, 314 Albert Street, East Melbourne, C.2. Photocopies of the translations are made available on loan. The bibliographies are of a limited character, having been prepared in the course of answering specific inquiries. Applicants for bibliographies are asked to state the reason for requiring them, as the numbers on hand are small.

TRANSLATIONS

No. of Translation	Author	Title	Periodical
1263	Wendland, Dr. G.	Vitamin Stability During Technical Processing of Foods. 4. Gas storage of dried natural products with special consideration of the vitamin stability.	1949. Zeitschrift fur Lebensmittel. Untersuchung und Forschung 89 (5): 397–404.
1251	Zalesskaya, M.	Synthesis of Riboflavin by *Aspergillus flavus* mycelium grown in a filtrate of brewing residue.	1950. Microbiologiya 19 (2): 127–136.

BIBLIOGRAPHIES

Number	Title	Number of Reprints
426	Use of Ozone for Air and Water Sterilization	19
413	Mixing Technology, with Equipment. Selected references	73
428	Industrial Design	43

Recent Publications by the Staff of the Division of Food Preservation

(1) Studies in the Preservation of Shell Eggs.

III. The Storage of Machine-washed Eggs. By J. M. Gillespie, W. J. Scott and J. R. Vickery. Aust. J. App. Sci. (1950), 1: 313.

IV. Experiments on the Mode of Infection by Bacteria. By J. M. Gillespie and W. J. Scott. *Ibid.* (1950), 1: 514.

V. The Use of Chemical Disinfectants in Cleaning Machines. By J. M. Gillespie, M. R. J. Salton and W. J. Scott. *Ibid.* (1950), 1: 531.

Notices of the first two papers in this series appeared in the FOOD PRESERVATION QUARTERLY (1950), 10: 72.

The third paper summarizes the results obtained in over 200 experiments with three types of cleaning machines. All three types of machine caused a greater amount of rotting in the stored eggs than did washing by hand. The amount of rotting was found to depend on the machine on which the eggs were cleaned, and to be independent of the farm of origin of the eggs and of the extent of soiling when the eggs were collected. The deleterious effects of machine cleaning were shown to be due to transfer of rot-producing bacteria from the machines to the eggs during cleaning.

The fourth paper presents evidence which shows that the bacteria causing rots penetrate immediately into the deeper layers of the shell during the washing process. Evidence of the effects of factors such as the temperature of the washing fluid, maintaining egg surfaces moist and shell quality is also presented. Other evidence indicates that penetration of bacteria from the shell into the albumen may be long delayed and some of the factors which may account for this delay are discussed.

The fifth paper describes the results obtained when various chemical disinfectants were used in cleaning machines. Very high concentrations were needed for the control of rotting to be effective. The repeated use of chemical disinfectants gave no indication of any cumulative benefit when hypochlorite solutions were used, and with cationic detergents a progressive deterioration in the control of rotting was observed.

(2) Studies in the Nitrogen Metabolism of the Barley Plant (*Hordeum sativum*). By H. S. McKee. Aust. J. Sci. Res. (1950), B3: 474–486.

This paper summarizes work carried out some years earlier at the Botany Department, University of Oxford. The changes in the "solid" nitrogenous compounds and in the soluble nitrogenous compounds, including ammonia, glutamine and asparagine were followed in detached leaves and in seedlings. The results were related to our knowledge of nitrogen metabolism in other plants.

(3) Studies in the Metabolism of Plant Cells.
VIII. Dependence of Salt Accumulation and Salt Respiration upon the Cytochrome System. By D. C. Weeks and R. N. Robertson. Aust. J. Sci. Res. (1950), B3 : 487–500.

The problem of the accumulation of salts in solution by plant cells has been studied for some time. This paper established that the accumulation and the respiration which accompanied it were dependent on the enzyme cytochrome oxidase. This was shown by the use of carbon monoxide as a specific inhibitor.

(4) Primitive New Guinea Fish Processing. By K. W. Anderson. Fisheries Newsletter (1951), 10 (1) : 4.

(5) Future of the Shark Liver Oil Industry. By K. W. Anderson. Fisheries Newsletter (1951), 10 (2) : 15.

(6) The Chemistry of Bitterness of Orange Juice. I. An Oxidation Product of Limonin. By B. V. Chandler and J. F. Kefford. Aust. J. Sci. (1951), 13 : 112.

From bitter juices and dried peels of Washington Navel, Valencia and Parramatta oranges, the bitter principles limonin ($C_{26}H_{30}O_8$) and *Substance X* ($C_{25}H_{30}O_{10}$) were extracted. *Substance X* has also been prepared by oxidation of limonin, and this reaction may throw some light on the chemical constitution of limonin.