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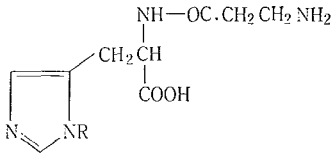
The Editors are pleased to welcome Dr. E. C. Bate-Smith, Superintendent of the Low Temperature Research Station, Cambridge, as a contributor to the C.S.I.R.O. Food Preservation Quarterly.*

Carnosine and Anserine in Meat

CARNOSINE was first isolated from ox muscle by Gulewitsch and Amiradzibi (1900). Much later Baumann and Ingvaldsen (1918) and Barger and Tutin (1918) showed that it was β-alanyl histidine. The isolation of anserine from goose muscle followed and it was shown to be the analogous β-alanyl-*N*-methyl histidine (Ackermann, Timpe, and Poller 1929; Linneweh and Linneweh 1930). The structure of both substances is shown in the figure below. Numerous attempts, still

Carnosine, R = H
Anserine, R = CH_3



continuing, have been made to discover the reason for the presence of these nitrogenous compounds in muscle, most of them inspired by the discovery of the dramatic role which constituents such as creatine and adenosine play in the intimate metabolic chemistry of muscle.

The earlier methods of isolation of these dipeptides were laborious and far from quantitative, so that it was quite a while before reliable information with regard to their concentration and distribution in different muscles and different species could be obtained. Zapp and Wilson (1938) were the first to devise methods which, at any rate, gave results of the right order of magnitude for the components. The method for carnosine, depending on diazotisation of the histidine residue, was more reliable than that for anserine, which was a difference method depending on the increase in α-amino nitrogen resulting from the hydrolysis of the peptides. The reliability of the results obtained was, however, supported by calculations based on the buffering capacity of muscle extracts over the range of pH6–7·5 (Bate-Smith 1939). These calculations were based on the fractional contribution of the few constituents of muscle extracts which are capable of acting as buffers over this range of pH. These are inorganic phosphate and certain phosphate esters, lactic acid (weakly and, to an extent, diminishing with increasing pH), and the histidine dipeptides. Given accurate analyses of these phosphorus compounds, lactic acid, and carnosine, the concentration of anserine can be calculated by assuming that the buffering capacity not then accounted for is mainly due to anserine. It has subsequently been proved that this assumption is quite well-founded.

The ability of these substances to act as buffers in the region of pH 7 is indicated by the pK of their dissociation constants. Inorganic phosphate has $pK_2 = 6{\cdot}8$, carnosine $pK_2 = 6{\cdot}83$, and anserine $pK_2 = 7{\cdot}04$. The symbol pK represents the negative logarithm of the acidic dissociation constant of the group indicated by the subscript; the one concerned in the dipeptides is that of the protonated tertiary nitrogen in the histidine residue. When pH = pK, the buffering capacity of the group concerned is at its maximum, approximately 90 per cent. of the buffering of which it is capable being carried out over the pH range $\pm$ 1 on either side of the pH = pK. Lactic acid, pK = 3·9, exerts very little of its total buffering effect between pH 6 and 7·5, but it is present in dead muscle in such a high concentration

By E. C. Bate-Smith

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— A Biochemical Conundrum

that its effect has to be reckoned with in adding together the fractional contributions of the different constituents. Carnosine and anserine, by contrast, have pK values in the middle of the range, so that their buffering effect is exerted to the full. It is worth while noting at the same time that their pK values coincide very closely with the pH values found in resting muscle.

The results given by these somewhat inaccurate methods of analysis indicated a wide variation, not only in the sum of the dipeptides in the muscles of different species, but also in the relative amounts. The original idea that mammalian muscles tended to contain for the most part carnosine, and avian muscles for the most part anserine, was not borne out either by this or by subsequent work. There is some indication of a species difference—horse and ox muscle having mostly carnosine; rat, rabbit, whale, and pigeon muscle mainly anserine; while the muscles of some species of fish contain instead a lot of free histidine and 1-methyl histidine. In the case of whale, the values for anserine (1–3 per cent.) obtained by Bate-Smith and Sharp (1946) using the Zapp and Wilson method were so high that they were qualified by printing "anserine" in inverted commas; but, as will be seen, they were quite within the range of values that has since been found by the reliable methods now available.

From 1946 onwards the search for a possible function for the dipeptides in the intermediary metabolism of muscle intensified. Russian workers showed that carnosine and anserine have a very pronounced accelerating effect on a number of enzymic reactions involving the anaerobic breakdown of glycogen in muscle. The phenomenon was observed equally well in muscle homogenates, in muscle extracts, and in preparations of the purified glycolytic enzymes. It was also shown that phosphorylated carnosine prepared in the laboratory was hydrolysed by aqueous extracts of muscle. Goodall (1956), in the United States, obtained further proof of this and also showed that carnosine phosphate, presumably by phosphorylating adenosine diphosphate, could supply energy for the contraction of glycerinated muscle fibre models.

In 1954 C. L. Davey, of the New Zealand Defence Scientific Corps, began work at the Low Temperature Research Station at Cambridge on post-mortem changes in the phosphate esters in muscle, and one of his lines of research was an attempt to detect and isolate such phosphate esters of carnosine and anserine, if in fact they existed. In this task Davey's first objective was to apply the techniques of ion-exchange chromatography to the analysis of carnosine and anserine in muscle. This he achieved, but only with the help of diethyldithiocarbamate added to the eluting buffers to suppress the copper ions present in the resin, which otherwise would have held back the dipeptides and reduced the yield. The method was then applied to the analysis of some typical muscles (Davey 1957*a*). Some of the results are given in the table on p. 44. These show that the values obtained by the earlier methods were reasonably reliable except that the values for the whale would seem to be in contradiction to those Sharp and I obtained. However, when Davey (1957*b*) examined blue and fin whalemeat, he found that the same high values as we had estimated were present—48–50 μ mole/g anserine and 0·4–4·3 μ mole/g carnosine. The surprising

amounts, especially of anserine, in whalemeat (Davey's figures work out at more than 1·2 per cent.) are therefore confirmed. The reason for their presence is a puzzle still to be solved.

Davey first disposed of the idea that they were present in the living muscle in combination with phosphate. Synthetic phosphate esters of the dipeptides had been prepared by both Russian and American workers, but Davey was unable to find any trace of such compounds in extracts of muscle. Nor was he able to confirm reports regarding the activation of certain reactions of glycolysis by the dipeptides, although he could account for these reports by the effect the dipeptides might have had as buffering substances or as chelating agents for heavy metals.

The Content of Anserine, Carnosine, Histidine, and *N*-Methyl Histidine of Muscles from a Number of Animal Species

Animal and Muscle	Anserine (μ mole/g)	Carnosine (μ mole/g)	Histidine and *N*-Methyl Histidine (μ mole/g)
Rabbit			
L. dorsi	19·3	3·2	0
Psoas	21·8	2·3	0
Heart	0	0	0
Semi-tendinosus	Trace	0	0
Liver	0	0	0
Pigeon			
Pectoral	4·4	1·0	0
Leg	0	0	0
Sperm Whale			
L. dorsi	4·9	9·1	0
Horse			
L. dorsi	0	25·5	0
Chicken			
Pectoral	43·5	12·3	0
Leg	7·4	2·2	0
Rat			
L. dorsi	8·9	3	0
Gastrocnemius	6·7	0	0
Heart	0	0	0

The best pointer in the direction of an answer to the conundrum is provided by a consideration of the kinds of muscle which show such large differences in concentration of the dipeptides. At first sight it might appear that red muscles contain less, and white more; but this falls to the ground when we consider instances such as blue and fin whalemeat, which are exceptional in their depth of colour. The answer, as Davey points out, would seem to lie in a consideration of the *function* of the muscle, as deduced from the life-habit of the animal. Consider, for instance, the pectoral muscles of the pigeon, which is strong on the wing, and those of the hen, which "flies" infrequently but vigorously. The nearest functional comparison is with the respiratory activity of the muscle, and this shows on the whole an inverse relationship with the concentration of dipeptides. The picture we can form is consistent with the view that muscles are provided with carnosine or anserine in amounts proportional to the intensity or duration of anaerobic activity that they are called upon to endure.

This is altogether consistent with the view that these substances act as buffers in the muscles. The outstanding feature of anaerobic metabolism in muscle is the production of acid (lactic acid), and the capacity of muscle to perform efficiently is impaired as the pH falls. It would, therefore, seem an advantage for muscles, especially those which are required to support either severe or prolonged anaerobiosis, to be provided with buffers *which are not themselves involved* in the metabolic or mechanical events associated with contraction; and of all the substances present in muscle which act as buffers in the neighbourhood of pH 7, only carnosine and anserine have no known function with respect to muscular contraction.

Davey (1957*b*) considers the different cases of pigeon, chicken, rat, horse, sperm whale, and blue and fin whale skeletal muscle, and of heart muscle from this point of view. By taking into account also what is known of the respiratory activity of these muscles, he comes to the conclusion that this is, in fact, the answer to the conundrum. It cannot, of course, be regarded as a *final* answer, because it carries the reservation, "in the absence of any other ascertainable function". But is it not in itself a perfectly satisfying answer?

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ADDRESS TO MEATWORKS CONVENTION, GOULBURN, APRIL 1958

The Transport of Carcass and Offal Meats

By E. W. Hicks

Division of Food Preservation and Transport, C.S.I.R.O., Homebush, N.S.W.

THERE are three main types of refrigerated vehicle used for the transport of meat in New South Wales, namely, refrigerated road trucks and two types of railway wagon, the M.R.C. and the T.R.C. Each of these can be regarded as a small cold store on wheels. They are mobile insulated containers with some kind of cooling system inside them.

Although a number of different insulating materials are used, the efficiency of the insulation in the various vehicles does not vary very much. They are all rather lightly insulated according to the standards usually adopted in large cold stores. There are sound economic reasons for this and it seems to be generally agreed that the designs usually used represent a satisfactory compromise.

The cooling systems in the three types of vehicle are quite different and, as a result, the best ways of using them are rather different. An understanding of the manner in which the cooling systems work can be very helpful in planning ways of using the vehicles to best advantage.

REFRIGERATED ROAD VEHICLES

The road vehicles in which we are interested employ mechanical refrigeration in much the same way as in butchers' rooms and many larger stores. They employ forced air circulation over finned evaporator coils. Conventional air distribution systems will provide reasonably uniform cooling over the whole of the cargo space so long as the cargo is

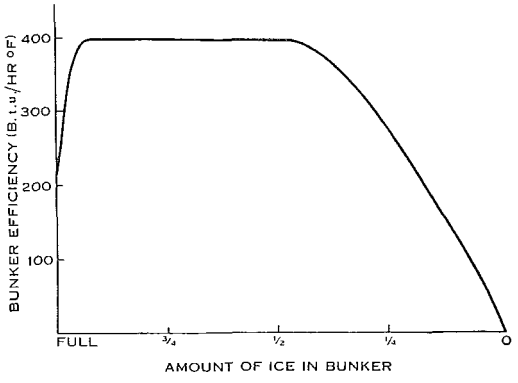
stowed in a way which will not seriously distort the air distribution. Cargoes of carcass meat will almost inevitably be open enough in structure to ensure satisfactory air distribution, but care may be necessary with packaged goods. With cargoes which are thoroughly precooled the main requirement is to ensure adequate air flow over all the outer faces of the stacks.

M.R.C. CARS

These vehicles are cooled by means of ice (or ice and salt) in basket bunkers at the ends of the car. The air flow is by natural convection. Air enters each bunker at the top and flows through the ice, being cooled as it goes. Cold air flows out the bottom of the bunker and along the floor, and rises up through the cargo as it absorbs heat.

In these cars the temperatures are lower near the floor than near the meat rails; in an M.R.C. carrying a chilled cargo a difference of 5°F between the top and the bottom is fairly typical.

The cooling surface in an M.R.C. is the surface of the ice in the bunker which is exposed to the circulating air, and the performance of the cooling system may be expected to vary substantially with the amount and form of the ice. It is usual to load M.R.C. bunkers with "chunk ice" produced by breaking up blocks as they are put in. Experiments have shown no important variation in performance with the size of the pieces, but, if many whole blocks are allowed to go in, the quantity of ice which can be loaded into the bunker may be reduced considerably. Finely crushed ice behaves quite differently and will be discussed later.



Relation of bunker efficiency to amount of ice in bunker. (Bunker efficiency is the amount of heat in B.t.u. absorbed by the ice per hour per degree Fahrenheit difference in temperature of cargo and ice.)

The effect of the quantity of ice in the bunker is large and of great practical importance. Experiments carried out by the Division have shown that the efficiency of a bunker as a cooler varies with the amount of ice, as shown in the figure below. A freshly charged bunker performs rather poorly at first but its efficiency steadily increases until it reaches a maximum in a few hours. Channels through which the air can flow freely are being formed in the mass of ice during this initial lag period. After the initial lag the bunker continues to perform with its maximum efficiency until about half the ice is used. Thereafter the efficiency decreases sharply, though not usually so smoothly as shown in the diagram, which represents an average. The long period of maximum performance may seem surprising, but if a bunker is inspected just before the end of this period it will seem at first glance to be almost full. However, there are large air channels through the ice, the mass soon collapses and its efficiency as a cooler is reduced greatly.

It is evident that the best conditions for the meat will be provided if the car reaches its destination before much more than half the ice is used. It is quite feasible to achieve this with chilled meat on most journeys in New South Wales so long as it is thoroughly chilled before loading. With a thoroughly precooled load it is usually about three days before the efficiency of the bunkers is reduced enough to permit the temperatures to rise appreciably. If meat is loaded warm, ice is consumed much faster, and the cooling system will lose efficiency much sooner.

When chunk ice is used air channels are formed through the mass of ice, giving a relatively large area of cooling surface exposed to the air streams. When finely crushed ice is used it compacts into a solid mass which melts from the outside only, and the area of cooling surface is less. The performance pattern of an M.R.C. bunker loaded with fine ice is similar to that shown

in the figure, except that the maximum output is reduced to about half the values shown. Consequently the use of finely crushed ice is generally unwise and introduces unnecessary risks. On some very long journeys (well over three days), where re-icing is not possible, there may, however, be some advantage in using crushed ice because a bunker working at half efficiency will maintain that efficiency for twice as long as a bunker operating normally.

T.R.C. CARS

The T.R.C. is also cooled by ice but, like a domestic ice chest, it has the ice above the storage space and is cooled from the top. This results in much greater uniformity of temperatures than in an M.R.C. It is necessary to break the ice into fairly small pieces to get a full charge into T.R.C. tanks, and finely crushed ice has advantages over chunk ice for a T.R.C.

The ice in a T.R.C. is in shallow tanks which cover most of the roof of the vehicle. Water (or brine) is retained in the tanks so that the cooling medium is a mixture of ice and water. The cooling surface exposed to the air stream is the exposed surface of the tanks. When a vehicle with unsalted tanks is moving, and the mixture is well stirred, the tank surfaces are kept close to 32°F. If the vehicle stands still for some time the ice floats on the water and the tank surface temperature rises. (Water has its maximum density at a temperature of 39·5°F.) Consequently the cooling system of a T.R.C. works a good deal better when it is moving than when stationary.

The cooling system of a moving T.R.C. works at full efficiency until almost all the ice is used up, so that as a rule nothing is gained by having a large amount of ice left at the end of a journey. It is often a waste of ice and manpower to fill T.R.C. tanks to their full capacity for a relatively short journey. Cars sometimes stand in Sydney for a day or more before unloading. When this occurs there are advantages in re-icing T.R.C. cars to maintain a fairly high ratio of ice to water in the tanks.

CHILLED MEAT CARGOES

The average temperatures maintained in chilled meat cargoes in the two types of rail car are very similar. The design of road vehicles is not standardized, so that a general statement about them would not be warranted. However some of them are capable of maintaining somewhat lower temperatures than the rail cars. Vehicles of all three types are capable of maintaining conditions which are satisfactory for chilled meat on all normal journeys in New South Wales.

Reference has already been made to the importance of thorough chilling of meat before loading. The Division has been involved in investigations of many cases of microbial spoilage of chilled meat during transport, and in practically every instance the cause was found to be inadequate chilling before loading. It should always be remembered that our transport vehicles are designed as mobile holding rooms, not as chillers. It is recognized that market conditions sometimes favour shipment of meat before chilling is complete. An occasional calculated risk may be justified, but regular shipment of partly chilled meat from the more distant works should be recognized as bad practice.

FROZEN CARGOES

The requirements for frozen cargoes vary with the product and with its ultimate destination. Frozen meat shipped to the coast for export should be delivered to the ship in hard frozen condition. A bone temperature of 18°F is often quoted as a desirable upper limit for export meat. It is particularly important to prevent any softening of packaged and bagged meats and offals, because these can be stowed rather tightly in ships' chambers. It may therefore be difficult or impossible to recool these products fast enough to prevent deterioration. Ships' officers are sometimes prepared to allow a little latitude in the condition of frozen carcass meat because it can usually be rehardened quickly and easily, but they dare not accept softening packaged meat products. It is not so easy to detect softening in part of a consignment of packaged meat as in carcass meat, and this is a further reason for care with the packaged products. Frozen meat sent to Sydney or another city for immediate consumption or processing may be allowed to warm up during transport and some softening may even be an advan-

tage. Thus, with frozen meat for export, it is desirable to keep the cooling systems working as efficiently as possible whereas, with meat for local use, it will often be satisfactory to use the vehicles as insulated boxes with little or no cooling provided.

Ice melts at 32°F, so that plain ice cannot prevent the warming of a cargo at 10°F. Plain ice in the bunkers of an M.R.C. loaded with frozen cargo will absorb some of the heat flowing through the ends of the car and so reduce the heat input to the cargo a little—but only a little. Plain ice in the tanks of a T.R.C. is somewhat more useful because the heat flow through the roof is much greater than through the ends, and absorption of even part of this in the tanks is of some value. It is, however, much more useful to add salt to the ice in the tanks, so that it will melt at a lower temperature.

If salt is added to ice, some of the ice will melt at once, salt will dissolve, and the whole mass will be cooled. If the mixing is thorough and there is enough salt, it will cool to −6°F. If 30 lb of salt is used per 100 lb of ice, all the ice will melt at −6°F, as the mixture absorbs heat from the surroundings. If a smaller proportion of salt is used, melting will continue at −6°F until all the salt is dissolved and then the temperature will rise gradually as the brine becomes weaker.

Use of Salt in T.R.C. Cars

The T.R.C. is particularly suitable for frozen cargoes when the tanks are properly salted. With cargoes loaded at about 0°F it is usual to add 25–30 lb of salt per 100 lb ice, so that practically all the ice melts below 0°F. The life of a full charge of ice and salt under these conditions is a little over 40 hours in average weather. The mixing in the tanks is not quite perfect in practice, and the average bunker surface temperature is usually close to 0°F until all the ice is used. It rises higher if the car is stationary for long periods.

Frozen meat products are usually loaded at about 10°F and it would generally be unwise to use 25 per cent. salt with them. The ice would be used up relatively fast in cooling the load and, if it were exhausted long before the end of the journey, the top of the load would tend to warm up rapidly. There is little advantage to be gained by cooling frozen meat below 10°F during transport, but it is very important to prevent any part of a load intended for export from warming enough to soften.

When less than 30 per cent. salt is used, the bunker temperature varies as the ice melts and the prediction of the most suitable amounts of ice and salt in a particular case becomes difficult. Ten pounds of salt per 100 lb ice is often a satisfactory compromise for frozen meat in a T.R.C. Where regular shipments of frozen meat are made it is probably profitable to determine the optimum icing more exactly. Ideally the cars should reach their destinations with the temperature of the brine below 15°F and with only enough ice left to constitute a reasonable safety margin to cover delays etc. If cars arrive consistently with a large amount of excess ice and with brine temperatures around 10°F or lower, the quantity of ice employed can safely be reduced and the proportion of salt kept the same. If cars commonly arrive short of ice after having been fully iced at the loading station, it will usually be wise to reduce the proportion of salt until there is always a small residue of ice at the destination. The ice consumption will vary with the weather and it will usually be wise to use more ice or less salt in summer than in winter.

Use of Salt in M.R.C. Cars

Ice and salt cannot be used as effectively in the M.R.C. as in the T.R.C. and, when a choice is possible, the T.R.C. should be preferred for sensitive frozen cargoes. In an M.R.C. the brine formed as the ice melts runs to waste immediately. When a low proportion of salt is used the brine which flows away at first is quite concentrated, so that the salt is washed out of the bunker fairly quickly. When 5 or 10 per cent. salt is used on a long journey, all the salt is generally washed out during the first day and plain ice is left in the bunker for the remainder of the journey. This may be advantageous with a chilled cargo in some circumstances, e.g. after a transhipment at a State border, because additional cooling is provided to counteract quickly the rise in temperature which occurs during loading. For most chilled meat cargoes in New South Wales, however, the use of salt is unnecessary

and, in many cases, more likely to be harmful than beneficial.

Loading of Frozen Cargoes

It is extremely difficult to prevent substantial rises in temperature in some parts of the stack during the loading of frozen cargoes. These "loading losses" are usually more important than the subsequent temperature rises on journeys not exceeding about two days. The temperature rises during loading are mainly in the top layer of cargo, and more particularly near the ends of the car where the stacks are completed first. The author has seen parts of low-grade mutton carcasses on the top layer actually thawed before the doors were closed. This was an extreme case; the loading conditions were rather poorer than usual but the very rapid thawing was due mainly to the thinness, and low thermal capacity, of the carcasses. Nevertheless "loading losses" are usually substantial under the best practicable loading conditions. To minimize loading losses steps should be taken to keep the time of exposure of frozen cargo to warm air, inside or outside the car, as short as possible, and to restrict the flow of warm air into the car as much as possible. Thus cars should be filled and closed as fast as possible. Only one pair of car doors should be opened. (One or two portable lights are usually needed in a car with only one pair of doors open). The loading platform should be as well sheltered as possible: large increases in loading losses occur in windy weather at exposed loading platforms.

Rises in temperature on the top of the stack during loading tend to be rather greater in an M.R.C. than in a T.R.C. with salted tanks. Moreover the meat on the top of the load in an M.R.C. continues to rise in temperature fairly fast for some hours after the doors are shut. In a T.R.C. with well-salted tanks there is some recovery of the loading losses during the first 12–24 hours of the journey.

Frozen Cargoes in Road Vehicles

In a road vehicle with forced air circulation and cold air delivered over the top of the load, it is possible, if the refrigeration system has enough capacity, to recover the loading losses quickly and maintain quite low temperatures in the cargo. However, it would be uneconomical to provide enough refrigeration capacity to do this in a vehicle designed primarily for carrying chilled cargoes which are precooled before loading. Detailed information on the capacities of the road vehicles in use in Australia is not readily available, but it is clear that a large proportion of the refrigerated road trucks in America are not very suitable for frozen cargoes. It is also clear that, both in the United States and Australia, vehicles which have been designed specially for frozen cargoes can provide very good conditions for the transport of frozen meat.

PRECOOLING OF VEHICLES

If a vehicle is not precooled a substantial amount of heat is removed from the insulation and other parts of the structure during the early part of the journey and much of it is absorbed by the cargo. Precooling of the vehicle will reduce this effect. Thorough precooling is necessarily a rather slow process. Rail cars are generally precooled by icing some time before loading. The rate of removal of heat is rapid at first and then decreases steadily so that more useful work is done in the first four hours than in any later four-hour period. In both the M.R.C. and the T.R.C. precooling is virtually complete in about 24 hours. The quantity of heat removed in complete precooling is much greater in an M.R.C. than a T.R.C. because the M.R.C. has a larger thermal capacity than the T.R.C.

Precooling of the vehicles always provides an additional safeguard for the cargo, but it is not always easy to arrange for it to be carried out. The practical importance of precooling varies with the cargo and the vehicle. It is more important in an M.R.C. than a T.R.C. because of the higher thermal capacity. It is much more important for frozen cargoes than for chilled meat. It is reasonable to insist on precooling before loading frozen meat intended for export, particularly if an M.R.C. is used, but to regard precooling as desirable but not always essential for chilled cargoes. Cars are sometimes precooled by circulating cold air through them. The air is cooled by a battery of pipes connected to a refrigeration plant. The air temperature in the car can be reduced

very rapidly with such a system and this accelerates the removal of heat from the insulation. A few hours precooling in this way will achieve more than the same period of precooling by means of ice in the bunkers, but many additional hours are required to precool a car completely by the circulation of cold air.

USE OF DRY ICE

Dry ice (solid carbon dioxide) has been used occasionally as the sole cooling medium in refrigerator cars in Australia but the cost of doing this is generally unwarranted. The use of a small amount of dry ice to supplement the water ice is not uncommon.

The quantity of heat which must be absorbed by a pound of dry ice to turn it into carbon dioxide gas and warm the gas to 32°F is only a little over twice as great as the quantity of heat required to melt a pound of water ice. Thus, at present prices, dry ice is a much more expensive cooling medium than water ice. However, the cost of using a relatively small amount of dry ice as a supplement to the bunker ice is sometimes justified. Dry ice can be distributed over the top of the load to give rapid local cooling early in the journey, and this can be valuable when the journey is unusually long or in certain other special circumstances. However the use of 100 lb or so of dry ice per car is not a satisfactory substitute for proper chilling of meat before loading.

The rate of air leakage from a T.R.C. is relatively low and there appears to be some possibility of using dry ice in these cars for building up a concentration of carbon dioxide high enough to restrict the growth of microorganisms on the meat. Further investigations would be necessary before any recommendations could be made. It may be worth further consideration if the export of chilled beef from any of the more distant inland works is contemplated.

MOIST SURFACES

It is not uncommon for mutton and lamb to arrive in Sydney with the surfaces damp and clammy. During the early stages of the cooling of meat there is a high rate of evaporation and the surfaces become dry. As it cools, the rate of evaporation decreases and water diffusing from deeper layers to the surface will ultimately more than compensate for the evaporation, and the surface will become moister. The extent of rewetting will depend on the relative humidity of the air around the meat. The relative humidity in a rail car or refrigerated truck is inevitably high, and it is also high, as a rule, in holding rooms or chillers used as holding rooms. This rewetting process is a slow one, and meat which is loaded with the surfaces moist will be less attractive on arrival in Sydney than meat loaded while the surfaces are still dry. Holding rooms in the city commonly have humidities which are low enough to bring about substantial redrying of the surfaces.

Rewetting of the surfaces is a real problem in marketing meat but it does not, as has sometimes been supposed, indicate that the meat is deteriorating appreciably more rapidly than it should. Experiments carried out by Dr. J. R. Vickery a few years ago showed that the life of mutton and lamb, between slaughter and the time when loss of bloom becomes serious enough to affect the selling price, was practically identical in country-killed lamb and that killed at Homebush. The life of country-killed mutton and lamb, after it reaches the Sydney market, is often less than that of locally killed meat because the country-killed meat is already a few days older than the local meat when it reaches the Meat Hall.

Rewetting of surfaces is rarely a problem with beef because layers of fatty tissue restrict the movement of water to the surface. For the same reason it is less marked in fat lamb carcasses than in those with less fat.

Vitamins in Foods — Stability

By F. E. Huelin

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THIS article follows an introductory review of vitamins in foods in the last issue of the Food Preservation Quarterly.* It is concerned with the stability of the different vitamins, and with the fundamental chemical factors that determine their retention in processing and storage. The large mass of data on the retention of vitamins in different foods will not be presented here, for it can be consulted in a number of papers and reviews. The retention of vitamins in canned foods was reviewed by Clifcorn (1948), and further data were obtained by Brenner, Wodicka, and Dunlop (1948). Vitamin retention was investigated in dehydrated meats by Whitmore *et al.* (1946) and Orent-Keiles, Hewston, and Butler (1946), and in fresh and frozen vegetables by Crosby *et al.* (1953). The thermal destruction of vitamin B_1 in a variety of foods has been reviewed by Farrer (1955), and more recently Mapson (1956) has published a general review on the effect of processing on vitamin content.

While this article is concerned mainly with destruction of vitamins, it should be pointed out that loss of water-soluble vitamins during processing is also due to leaching. This can be reduced by using the minimum quantity of water for blanching, cooking, and other processes, or preferably by using steam wherever possible.

The destruction of vitamins is influenced by temperature, oxygen, pH, mineral salts, heavy metals, and a variety of organic substances. As the rate of all chemical reactions increases with rising temperature, vitamin destruction will be greater at higher temperatures—*if all other factors are constant.* The last point needs emphasis, as variations in other factors are readily overlooked. For example, vitamin C may be destroyed more slowly in a boiling fruit or vegetable product than during standing at lower temperatures. The relative stability in the boiling medium is due to the lower solubility of oxygen and the exclusion of air from the surface by the blanket of steam.

* **Vitamins in Foods—Occurrence, Structure, and Function.** F. E. Huelin. *C.S.I.R.O. Food Pres. Quart.* **18**: 22.

VITAMIN C

Aerobic Destruction of Ascorbic Acid

Destruction of ascorbic acid during cooking, dehydration, freezing, and preparation for canning is due to atmospheric oxidation. Below pH 9 oxidation is dependent on the presence of free copper ions or enzymes, and the copper-catalysed oxidation increases with increasing pH. Typical results in phthalate buffer (Huelin and Stephens 1948*a*) are shown in Table 1. The solutions were kept saturated with air and the first order velocity constant k was calculated (as min^{-1}). Phthalate buffer was chosen because the copper is mainly present in the free ionic form and exerts its maximum catalytic effect. Fruits and vegetables contain organic acids, thiol compounds, and other substances which form complexes with the copper and reduce its catalytic effect. The effect of such "protective" substances in certain fruit and vegetable suspensions is shown in Table 2 as the ratio k_s/k_b. The term k_s is the velocity constant in the suspension of fruit or vegetable, and k_b is the

Table 1.—Oxidation of Ascorbic Acid in Phthalate Buffer at 40°C

Initial ascorbic acid concentration, 0·2 mg/ml. Data after Huelin and Stephens (1948*a*)

pH	$k \times 10^2$	
	Control	Copper, 1 p.p.m.
2·2	0·0	0·2
3·0	0·1	1·2
4·0	0·4	5·3
5·0	1·4	14·4
6·0	1·9	25·1

Table 2.—Protective Effect of Fruit and Vegetable Suspensions on Ascorbic Acid

Data after Huelin and Stephens (1948*a*)

Suspension	pH	k_s/k_b
Apple	3·2	1·07
Orange juice	3·6	0·48
Rose hip	3·6	0·52
Tomato	4·3	0·62
Orange rind	5·1	0·19
Onion	5·3	0·00
Parsley	5·5	0·06
French bean	5·5	0·04
Potato	5·7	0·04
Cabbage	6·0	0·04
Asparagus	6·0	0·08
Swede turnip	6·0	0·12

velocity constant in a phthalate buffer of the same pH. Both contained 1 p.p.m. of added copper. The effect of protective substances varies considerably in different products, and is very pronounced in onions. Protection in this product is probably due to volatile sulphur compounds. However, copper still exerts a marked catalytic effect in most products, and it is desirable to avoid copper contamination by using stainless steel equipment where possible. Where copper equipment is used it should be kept clean (i.e. as free as possible from oxide film), and the product should not be left standing in it unnecessarily.

The protective effects shown in Table 2 were obtained in previously boiled suspensions. Many fresh fruits and vegetables contain enzymes (Huelin and Stephens 1948*b*) which promote rapid oxidation of ascorbic acid in sliced or disintegrated tissue. The short preliminary exposure to boiling water or steam, known as blanching, is usually adequate to inactivate these enzymes.

As catalytic effects cannot be entirely eliminated, oxidation of ascorbic acid during processing can only be reduced to a minimum by excluding oxygen as far as possible. This can often be done very effectively in canning processes by proceeding from one operation to another without delay. For example, in preparation of jams minimum delay between operations has given nearly 100 per cent. retention, while long periods of delay have caused the destruction of most of the ascorbic acid.

Anaerobic Destruction of Ascorbic Acid

Destruction of ascorbic acid is due mainly to atmospheric oxidation during preparation for canning, but not during subsequent storage of the canned product. The oxygen content of canned foods with a minimum headspace becomes negligible within a month after canning, and subsequent destruction of ascorbic acid is due to anaerobic decomposition. This is a comparatively slow reaction, whose velocity constant does not exceed 0·1 per cent. of that of the oxidation in the presence of 1 p.p.m. of copper. The anaerobic decomposition also has a different relation to pH, being maximal at pH 3–4 in citrate–phosphate and phthalate buffers. It is accelerated by fructose and its derivatives, but not by copper. Typical data (Huelin 1953) are shown in Table 3. It appears that fructose is most effective in the furanose form (as fructose diphosphate has a much greater effect) and that the effect of sucrose is due to fructose liberated by hydrolysis. The times for half destruction corresponding to these values of k vary from 6 months to $7\frac{1}{2}$ years at 30°C. Retention of ascorbic acid in canned orange juice is approximately the same as in the corresponding buffer (first column of Table 3), while that of fruits canned in syrup is closer to the values shown in the second column. The accelerating effect of fructose is probably responsible for the poorer retention in concentrated juices.

Table 3.—Anaerobic Decomposition of Ascorbic Acid in Citrate–Phosphate Buffer at 30°C

Initial ascorbic acid concentration, 1·76 mg/ml.
Data after Huelin (1953)

pH	$k \times 10^7$			
	Control	Fructose, 0·5M	Sucrose, 0·5M	Fructose Diphosphate, 0·05M
2·2	8·3	8·8	8·8	—
3·0	9·8	12·1	11·9	9·8
4·0	8·9	13·0	10·9	9·8
5·0	3·6	8·4	3·6	10·6
6·0	1·8	7·6	1·8	25·4

Dehydroascorbic Acid

Studies on vitamin C retention are usually confined to the determination of reduced ascorbic acid to the exclusion of the oxidized form. Although the latter has full vitamin C activity it is relatively much less stable (Huelin 1949), and its contribution can generally be ignored except in the case of frozen products. Even at 0°C the period of half destruction is only 2 weeks at the optimum pH of 2·0–2·5 and 1 day at pH 7. At 100°C the corresponding periods are 17 minutes and less than 1 minute. In non-acid canned foods any dehydroascorbic acid formed during preparation would be destroyed in the heat sterilization.

VITAMIN B_1

The factors concerned in the thermal decomposition of vitamin B_1 have been thoroughly investigated. In pure buffer solution the rate increases with increasing pH but varies considerably between different buffers (Farrer 1945*a*). Data for decomposition of thiamin at 100°C in a number of buffer solutions are given in Table 4. The rates in phosphate buffer are appreciably less than those in phthalate or citric acid–phosphate buffer. The rates in succinic acid–borate buffer are lower still. Increasing the concentration of buffer salts increases the velocity constant (Farrer 1947*b*, 1949); but increasing the concentration of thiamin itself has a stabilizing effect and tends to reduce it (Farrer 1948).

Copper and oxygen can also affect the rate, although they do not play the same role as in the destruction of ascorbic acid. Free copper ions increase the velocity constant, but complex copper-containing anions (in tartrate, citrate, or glycine buffers) may decrease it (Farrer 1947*a*). Oxygen increases the rate at temperatures greater than 70°C (Farrer and Morrison 1949).

Sulphur dioxide promotes rapid destruction of thiamin, and is not desirable as a preservative for foods which are major sources. It has been reported by Hasegawa (1955) that some phenolic compounds promote decomposition.

The rates of decomposition in buffer solutions, which are given in Table 4, refer to free thiamin. Vitamin B_1 is also present as thiamin pyrophosphate (or cocarboxylase)

Table 4.—Decomposition of Thiamin in Buffer Solutions at 100°C

Initial thiamin concentration, 5 μg/ml. The values of k are interpolated from those of Farrer (1945*a*), assuming a linear change in log k between neighbouring values

pH	$k \times 10^3$			
	Phthalate	Phosphate	Citric acid–Phosphate	Succinic acid–Borate
3·0	1·1	—	1·1	—
4·0	2·2	—	2·7	—
5·0	3·4	1·5	5·0	1·1
6·0	6·3	2·2	8·4	1·4
7·0	—	17·7	21·3	5·5

Table 5.—Decomposition of Vitamin B_1 in Canned Vegetables at 100°C

Data after Farrer (1953)

Vegetable	pH	$k \times 10^3$		Time of Half Destruction (hr)	
		Vegetable	Phosphate Buffer	Vegetable	Phosphate Buffer
Cabbage	5·4–5·6	2·6–2·8	1·5–1·6	4·1–4·4	7·2–7·7
Carrots	5·7	2·1–2·3	1·7	5·0–5·5	6·8
Potatoes	5·9–6·0	2·0–3·2	2·0–2·2	3·6–5·8	5·2–5·8
Peas	6·5	2·1	4·6	5·5	2·5

and in combination with protein. The pyrophosphate is less stable (Farrer 1945*b*), and at pH 5–7 it decomposes at about 2–3 times the rate of free thiamin. Combination with protein appears to increase the stability of thiamin. Hence when the vitamin is present in all three forms its overall rate of decomposition may approximate to that of free thiamin.

Velocity constants for the thermal destruction of vitamin B_1 in canned vegetables have been calculated by Farrer (1953), and these are compared in Table 5 with figures for phosphate buffer of the same pH. Although there are appreciable differences between the two sets of figures, phosphate buffer gives a much better comparison than any of the other reference buffers. From available figures it appears that destruction in cereals is similar to that in phosphate buffer. The increased destruction at higher pH and its importance in baking hardly needs emphasis.

The enzyme thiaminase, which occurs in certain species of fish and other marine organisms, also promotes decomposition. However this type of destruction has no nutritional importance, as raw fish is not normally mixed with thiamin-rich foods.

OTHER B VITAMINS

The stability of riboflavin (vitamin B_2) reaches its maximum between pH 2 and 5 and falls away at lower and higher pH

Table 6.—Decomposition of Pantothenic Acid in Buffer Solution at 60°C

Initial ascorbic acid concentration, 1 per cent. Data after Frost (1943)

pH	Per cent. Retention after 15 Days
3·9–4·2	23·3
4·4–4·7	27
4·9–5·2	52·7
5·6–5·9	76·6

(Farrer and MacEwan 1954). Riboflavin is also decomposed by light. Nicotinic acid, pyridoxin, and pantothenic acid appear to be relatively stable, and are generally well retained in processed foods. However, pantothenic acid shows appreciable decomposition on prolonged heating, and is less stable at low pH (Frost 1943). Data are given in Table 6.

The stability of choline and inositol has not been studied appreciably in relation to foods. Biotin appears to be fairly easily oxidized and is inactivated by peroxides associated with incipient rancidity of fats (Pavcek and Shull 1942). Its inactivation by the native avidin of egg-white is of a different character, as it is reversed by heating.

Table 7.—Decomposition of Folic Acid at 100°C

Initial ascorbic acid concentration, 0·5 μg/ml. Data after Dick, Harrison, and Farrer (1948)

pH	Per cent. Retention after 1 Hour*
1	50
2	78
3	84
4	91
5	92
6	102
7	101

* Mean for different buffers.

The thermal decomposition of folic acid proceeds less rapidly as the pH is raised (Dick, Harrison, and Farrer 1948), and is negligible above pH 5, as shown in Table 7. The vitamin is also decomposed by light. The stability of the B vitamins is affected in very different ways by changes in pH. As the pH increases towards neutrality, thiamin and riboflavin become less stable, but pantothenic and folic acids become more stable.

FAT-SOLUBLE VITAMINS

The available information is mainly concerned with the oxidation of vitamin A and essential fatty acids by atmospheric oxygen. This reaction tends to be autocatalytic and proceeds more rapidly after an initial induction period. Oxidation of unsaturated fatty acids can promote oxidation of vitamin A in the same fat, through the intermediate formation of hydroperoxides (Lease *et al.*

1938). The oxidation is accelerated by traces of heavy metals, particularly copper, and can be retarded by adding anti-oxidants. The tocopherols are very effective natural anti-oxidants.

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A CENTRE FOR RESEARCH ON DRIED VINE FRUITS

Commonwealth Research Station,

The Commonwealth Research Station at Merbein, near Mildura, Victoria, on the irrigated lands along the River Murray, is in a district noted for dried vine fruits, of which £8 million worth are produced in Australia per annum. The industry has for over 30 years looked to the Merbein Station for technical help in its processing problems.

THE Merbein Station arose out of a well-attended meeting of irrigators in Mildura (Victoria) in December 1917. Spurred by the necessity arising from a wet season, the meeting elected the Mildura and District Research Committee. A voluntary levy on growers raised funds to fight the hitherto unknown fungus diseases which had suddenly ravaged their vineyards.

In 1919, a site for a research station was selected from land which was considered too poor for the proposed soldier settlement of Merbein at the end of World War I. This "poor land" proved its worth as a testing ground in later years when the salting and waterlogging problems of the Mallee irrigation areas needed detailed study. Mildura Vineyards Protection Board was formed soon after by the State of Victoria, with power to police entry into the isolated settlement of Mildura and to carry out research work. The Merbein Station came under the authority of the Board in 1920. The Board was financed by a number of bodies including the Commonwealth Institute of Science and Industry, so that when C.S.I.R. succeeded the Institute it was logical that it should assume full responsibility for the Station, which it did in 1927.

DIPPING SULTANAS

Sultanas form about three-quarters of all dried vine fruit varieties grown in the Murray Valley, so it is natural that most of the fruit processing investigations of the Station have been aimed at helping the sultana grower.

In some parts of the world, notably California, sultanas are dried in the sun without preliminary treatment. The product is a bluish colour and contrasts with the golden fruit of Asia Minor and Greece—and Australia.

Caustic Dip

The Murray Valley climate is not sufficiently dependable for the long drying period needed for "naturals", so some form of pre-treatment is necessary to speed the drying. When the Merbein Station was started nearly 40 years ago the boiling caustic soda dip was used. The fruit was picked into perforated "diptins" holding 15–20 lb and dipped into boiling lye strong enough to cause fine cracks in the skin after 2–3 seconds immersion. Although this fruit dried very quickly, it was an unpleasant dark colour, and the skin cracks allowed sugar solution to seep out, making the fruit form a sticky mass unpopular with grocers' assistants.

Cold Dip

Today the "cold dip" in use gives a bright golden fruit which commands a high price on local and United Kingdom markets, and is readily adapted to bulk handling methods. The dip appears to have been traditional in Greece, where ashes of vine prunings were

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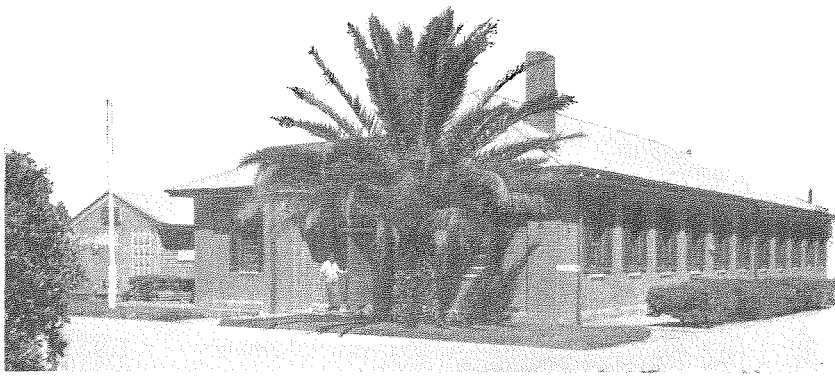
Merbein



Laboratory buildings at Merbein, Victoria.

leached to give a lye with which olive oil was emulsified to form the dip. Greek refugees after World War I brought the method to the Mildura district, but by this time they were using potassium carbonate instead of vine ash. The new method was investigated at the Merbein Station, and by 1927 it was possible to state in the First Annual Report of C.S.I.R.: "It has been estimated that the introduction of the cold-dip process for the drying of sultanas, which was introduced largely as the result of work at Merbein Station, represented a gain in quality of product which was worth about £30,000 to the industry during last season alone".

The method of preparation of the cold dip at that time was to stir the olive oil into a small quantity of 1 per cent. potassium carbonate solution. This produced an emulsion which was then poured into the 5 per cent. potassium carbonate solution of the dip.

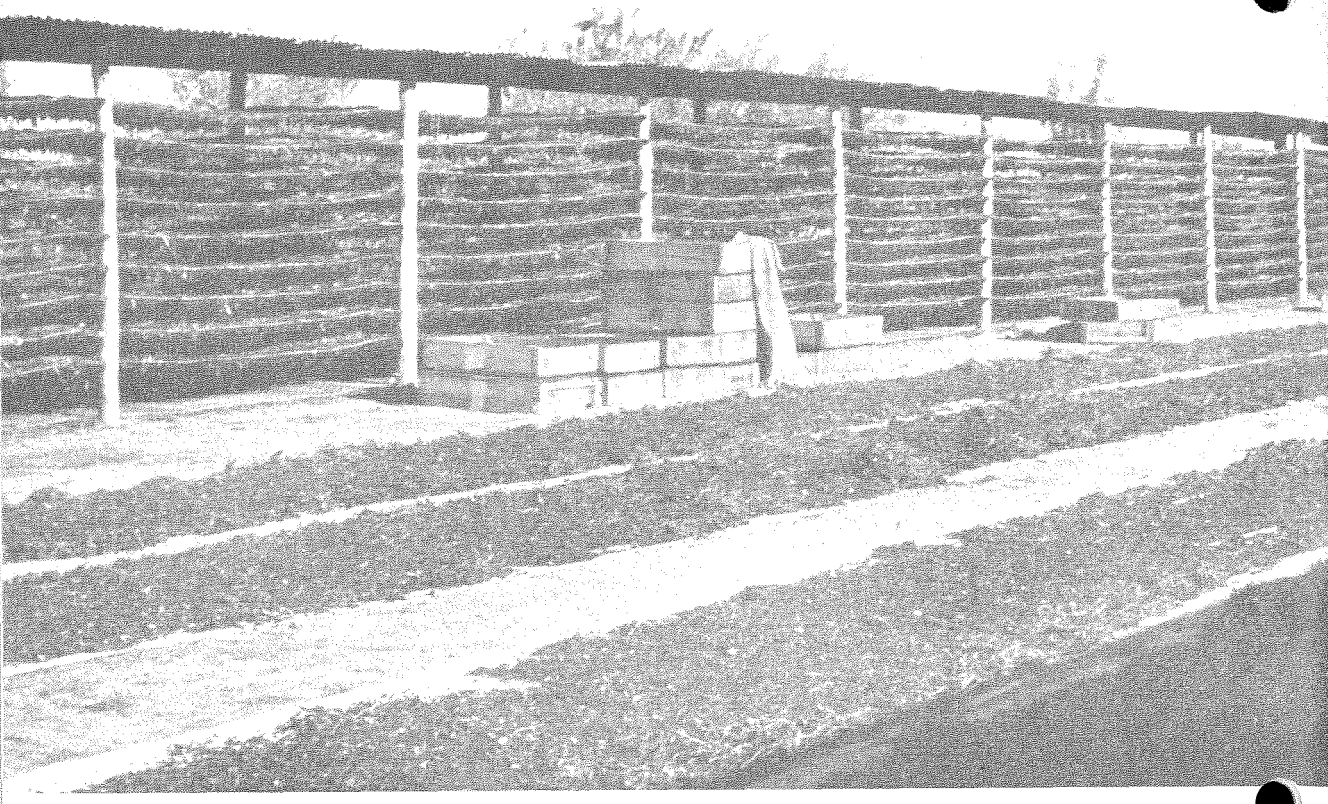
Mixed Dip

The fruit which was cold-dipped proved highly satisfactory on the market, but its slow rate of drying made it unpopular with growers until better seasons and prices brought them the money to build more drying racks. It was natural therefore that many minds turned to the possibility of combining the advantages of the hot and cold dips. Some potash and olive oil were added to the caustic soda dip, and the temperature was lowered. The staff of the Merbein Station investigated the factors involved and recommended to the industry a "mixed dip", which is still the most important dip in the cooler mid-Murray district. So far as is known, this "mixed dip" is peculiar to Australia.

Improvements in Emulsions

In 1934 a full-time Research Officer, Mr. E. C. Orton, was appointed to study fruit processing methods. From that time until his resignation in 1952, many changes were made in fruit processing methods as the result of his investigations. In a survey of fruit processing methods in 1935, it was noted that olive oils with a high free acid content were the most satisfactory in the cold dip. On the other hand, oils low in free acid produced an emulsion which soon "broke", releasing free oil which floated on top of the dip. This oil would adhere in patches to fruit dipped in the emulsion, and although the fruit so coated dried at the same rate as normally dipped fruit, it was darker, giving an unsatisfactory, piebald sample.

The possibility of employing a mechanically prepared emulsion containing a minimum of stabilizer and a high oil content was investigated. Oils other than the traditional olive oil were tried. Paraffin oil with added stabilizers gave good results, but maize oil gave poor results. Peanut, cottonseed, and soya bean oil, if properly emulsified, gave



Sun-drying sultanas. The sultanas drying on the racks will be transferred to the Sisalkraft and hessian sheets in the foreground and thence to sweatboxes, for transport to the packing house.

results similar to those obtained with emulsified olive oil. By 1937, several proprietary emulsions were on the market with the beneficial result that the dried fruits were more uniform in quality. In at least one of these products, which was made on a cooperative basis by the packing houses which contributed funds to the Merbein Station for these investigations, the emulsifier used was triethanolamine.

When war came in 1939 substitutes were found for the ingredients of the dip—cottonseed oil in place of olive oil, and vine ash in place of commercial potash. Oleic acid could be replaced by linoleic or stearic acid. But no satisfactory substitute apart from caustic potash was found for potassium carbonate, although many were tried. Sodium carbonate gave a solid deposit on the skin of the berry, and a number of substances aimed at increasing the osmotic pressure were investigated—sodium acetate, molasses, sodium metasilicate, and others. It was concluded that if supplies of potassium carbonate or hydroxide became unavailable, sultanas would have to be dipped in heated caustic soda dips.

By the time the war ended it was reported that promising results had been obtained with the use of new sulphonated oil preparations derived from neatsfoot oil. In the cold dip, these preparations gave improved wetting and faster drying. Over the next few years, from the leads given by the Merbein Station, various commercial firms developed the dipping oils in use at the present time. These contain oleates derived from animal fats as the major constituents. The Merbein Station examines the performance of the brands available to growers each year—at present there are four, and all give similar drying rates and quality of dried fruit.

Green Tinge

Some parcels of Australian cold-dipped sultanas show a "green tinge" after arrival on the U.K. market. This fruit does not find a ready sale, and the Merbein Station

has examined the problem. Treatment on the drying green to remove the green tinge consists of sprinkling water on the fruit spread on the hessians while it is hot, rolling up in the hessians while damp for an hour or two, and again exposing in thin layers to the sun. If the tinge persists, the treatment should be repeated next day. A moderate amount of the green tinge is accepted by packing houses, as all fruit darkens on storage. It is generally agreed that the persistent green tinge which causes difficulties with buyers results from the more immature fruit, so the control of the problem rests largely in the hands of the growers.

Sulphite Dip

The "mixed dip" evolved by the Station in the late 1920's has not changed in formula over the years, and is still recommended and used. One variation, however, has developed. This is the "sulphite dip". When rain falls during the drying season, partially dried fruit may become mouldy or ferment on the drying racks. Mr. Orton suggested adding a sulphite to the mixed dip to prevent this damage. Not only did it reduce damage; on good fruit it gave a superior colour. Addition of sodium sulphite to the mixed dip is now recommended for the mid-Murray districts where the drying season is shorter and less reliable. The recommendation continues to stand despite the disadvantage that some fruit treated in the sulphite dip "sugars" on storage, developing granules of sugar crystals.

OTHER INVESTIGATIONS

In the last three or four years, the actual drying process has been studied more fully. The action of the dip material is to change the cuticle of the berry chemically so that it becomes more permeable to water. Drying occurs in three stages. In the first stage, the grape retains its regular ellipsoidal shape by an elastic contraction of the skin. This actually thickens the cuticle and reduces its permeability. In the second stage the skin commences to wrinkle in the range of 20–50 per cent. loss in original weight. In the third stage the drying rate decreases markedly, beginning when 95 per cent. of the total loss of weight has occurred. The drying rate is controlled by diffusion of water through the waxy cuticle. A rise in temperature increases the drying rate because vapour pressure of water and permeability of the cuticle increase with rising temperature.

Although the most spectacular and popular story is the development of the cold dip, the Merbein Station has assisted the dried fruits industry in a number of other ways. Calibration tables have been prepared for the electrical moisture meter used by packing houses to test fruit for moisture content on reception from growers. Similar tables were also prepared for dried apples and prunes. Control of insect pests in dried fruits has been studied and dosages of ethyl formate, the standard insecticide now in use in the industry, have been worked out. Toxic grease bands encircling stacks of fruit in storage in the packing houses have been used to trap migrating larvae of the dried fruit moth and other injurious insects.

Mould Damage

Considerable loss of fruit from mould damage on drying racks may occur if the drying season is wet. If, however, the rack is enclosed with the Sisalkraft commonly used on drying greens, and sulphur is burnt in the enclosure, the sulphur dioxide produced is an effective mouldicide. This treatment also improves the colour of the fruit. The Station has taken a leading part in the preliminary investigations into rack dehydration, the purpose of which is to devise portable equipment to artificially dry the fruit already on the rack when wet weather strikes. A Californian authority has expressed the view that in the long run, tunnel dehydration is preferable to sun-drying or rack dehydration, mainly from the viewpoint of contamination of the fruit with dust. In 1957 the Station installed a small tunnel dehydrator so that this aspect of fruit drying could be studied.

Tree Fruits

A number of investigations have been carried out on tree fruits. In the late 1920's the drying of apricots was studied at the request of the Departments of Agriculture of New South Wales, Victoria, and South Australia. It was shown that the desired amount of sulphur dioxide could be added to the freshly cut halves of the fruit by using small covers or "sulphur hoods" to treat the fruit as soon as possible after pitting,

and by arranging for continuous slow production of sulphur fumes during the whole period of sulphuring.

From 1939 to 1945 the Station undertook a number of studies related to the war effort. In one investigation, dried apricots packed in steel drums were left in the sun at Merbein for a period and compared with the same fruit packed and stored in other ways. It was concluded that, for best results under service conditions, the fruit should be packed as dry as possible and stored within a tinplate container in a wooden box. In the dehydration of peeled and sliced pears and peaches, it was found that the fruit could be immersed for up to five minutes in a sulphite solution to replace the traditional sulphuring with fumes of burning sulphur. The amount of sulphur dioxide retained in the fruit depended on the pH of the dip.

NEWS FROM THE DIVISION OF FOOD PRESERVATION AND TRANSPORT

GAS CHROMATOGRAPHY

As part of an investigation of the nature of the disorder superficial scald, which affects apples in cold storage, the Division's Biochemistry Section has for some years been studying the volatiles given off by apples. The technique of gas chromatography is being used to separate volatile hydrocarbons, which cannot be separated readily by other means. The Section is also studying the natural oil in the skin of apples in relation to their storage behaviour, and expects to use gas chromatography for separating and identifying constituents of the oil.

The mixture of volatiles is injected into a moving gas which enters a column composed of a solid adsorbent, or a non-volatile liquid on an inert support. The components of the mixture move through the column at different rates and on emergence give separate signals on a detector. The detector being used at Homebush is based on differences in thermal conductivity between the carrier gas and organic vapours.

Gas chromatography can also be used for separating and identifying the constituents of flavours, and for studying the changes in flavour which occur during processing and storage.

PERSONAL

DR. GABRIEL HAMOIR, Agrégé, Laboratoire de biologie générale, Université de Liège, Belgium, spent three months as a guest worker in the Division's Physico-Chemical Unit at Sydney University from early in June 1958. Dr. Hamoir is a leading authority on the proteins of fish muscle, and the Laboratory at Liège, of which he is Director, is one of the leading centres in the world for biochemical and biophysical research on muscle proteins. In Australia Dr. Hamoir is working on the isolation of myosin from the muscle of local species of fish.

DR. R. N. ROBERTSON, Assistant Chief of the Division and leader of its Plant Physiology Unit, has accepted an invitation to become Visiting Professor of Horticultural Science at the University of California, Los Angeles, U.S.A., for nine months beginning in September 1958. Professor J. B. Biale, the occupant of the chair, who will be going on a mission for the Food and Agriculture Organization of the United Nations, is an authority on post-harvest physiology, and his department has made notable contributions to the physiology of ripening in fruits, a field in which Dr. Robertson and his co-workers have a keen interest.

Mr. J. SHIPTON, Senior Research Officer, has rejoined the Division to take charge of investigations on the freezing of fruit and vegetables. For a number of years Mr. Shipton was a member of a team carrying out research at Homebush on the dehydration of fruit and vegetables, but in July 1951 he was seconded to the Commonwealth Department of Commerce and Agriculture (now Department of Trade) as Chief Food Technologist in its Defence Food Section.