Food Preservation Quarterly

Vol. 5, Nos. 1 and 2. March/June, 1945.

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Published by

DIVISION OF FOOD PRESERVATION
COMMONWEALTH COUNCIL FOR SCIENTIFIC
AND INDUSTRIAL RESEARCH.

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TIN IN CANNED FOODS.

ITS OCCURRENCE AND SIGNIFICANCE.

BY

H. A. McKenzie.

Few investigations have been made to determine the extent to which tin occurs naturally in foods. However, Bertrand and Ciurea, in an examination of beef, horse and mutton tissue, found from 0.5 to 4 parts of tin per million of fresh material except in the skin (6 to 9.5 p.p.m.), in the tongue (12 to 16.5 p.p.m.), and in the tongue mucous (18.6 to 26 p.p.m.). Misk found amounts varying from 5.9 parts per million in the brain to 137 parts per million in the liver and spleen The presence of tin has been demonstrated spectrographically in human blood and organs by Dutoit and Zbinden, in fish by Newell and McCollum, and in milk by Zbinden.

Since the large-scale use of tinplate containers for foods became widespread, attention has been focussed upon the contamination of such foods with tin. Hehnes in 1880 and Blyth in 1883 reported (in the Analyst) on the tin content of canned foods, but the first authoritative survey appears to have been published in 1908 by Buchanan and Schryver. This report gave figures for the tin content of certain meat and vegetables packed in plain cans, most of which had been stored for six or seven years. Goss later (1917) published figures for the distribution of tin in several types of canned fruits and vegetables.

Instances of considerable contamination of canned foods have been reported on many occasions. Dyer and Taylor (1931) found thirty-five samples of cheese to contain 43 to 786 parts of tin per million, and that seven of these had 314 to 786 p.p.m. Williams (1935) found thirteen out of sixty-nine samples of cheese to contain 286 to 958 parts of tin per million. Morgan and Rawlings have cited a number of cases of high tin content. For instance, the London public analyst in 1936 found 428 to 678 parts of tin per million in canned spinach, and 700 p.p.m. in canned apricots, and another analyst in 1935 found two samples of sild containing about 700 p.p.m.

It is of interest to note that if the tin were completely stripped from a No. 2½ can made from nominal 1.5 lb. tinplate, the theoretical tin content of the pack would be 1,200 p.p.m.

Adam and Horner in 1937 pointed out that figures like the above do not represent the amount of tin normally present in canned foods. Over ten years they determined tin in thirteen hundred samples. Fruits in plain cans, with the exception of rhubarb, rarely exceeded 100 to 150 p.p.m. Using methods of lacquering and storing of cans employed at that time, they found that, for periods up to two years, the tin content was rarely found to exceed 40 p.p.m. and generally was between 10 and 30 p.p.m. The effect of factors such as temperature, time of storage, type of lacquer, state of ripeness, and hydrogen-ion concentration was examined. This work has been generally supported by work carried out since, but occasionally high tin contents are still reported, and these are usually for plain cans where the product should have been packed in a lacquered can.

A survey of the tin contents of a series of canned foods marketed in Australia has been made by Lynch and Kefford (1939). Horner (1941) has examined the tin content of condensed milk.

Tin adversely affects the colour of foods containing anthocyanin pigments, such as cherries, berries, beetroot and plums. One effect is the formation of tin salts of the pigments which causes a bluish or brownish discolouration. During further storage the reducing systems within the can reduce the pigments to leuco (colourless) forms and eventually the product may be completely bleached. On the other hand, this reducing or bleaching action is important in maintaining the colour in other products, such as pears, pineapples and grapefruit. These products if packed in lacquered cans sometimes become brownish and unattractive during storage. In plain cans a bright, natural colour is usually maintained. The flavour of canned foods is sometimes affected by the tin present and this is particularly true of fruit juices. It has been found that the storage stability of fats is affected by the presence of tin.

Scott and Stewart have found that tin has a specific inhibiting action on the growth of *Clostridium botulinum*. In some foodstuffs inhibiting concentrations are built up in the first few days after canning, so that no growth occurs in inoculated cans. Whilst this effect is unlikely to enter significantly into the fixing of heat process times, it is important in interpreting the results of inoculated test packs in plain cans.

White and Unger and Bodlander were among the first workers on the pharmacology of tin salts. Animal tests have been carried out by Lehman, Salant, Rieger and Treuhardt, by Flinn and Inouye, and by Salant. Salant fed cats for long periods with tin as tartrate or chloride. With 10 mgs. daily per kilogram body weight for twenty-three days and 20 mgs. for three months he observed no harmful effects, but further feeding during two and a half months of from 30 to 50 mgs. per kilogramme daily caused loss of weight. Excretion was mainly through the intestine.

Schryver studied the effect of tin on the human organism by carrying out feeding tests on himself. He took 1 grain of tin, as sodium stannous tartrate, daily for a week, followed by 2 gr. the second week and 3 gr. the third week. There was no evidence of retention of tin during the first week, but about 2 gr. were retained during the third week with no ill effects.

It has been shown that tin combines with proteins becoming insoluble. Bigelow found that the longer food had been canned, the larger the amount of insoluble tin, and he considered that results for the toxicity of tin based on the use of soluble salts could not be used as a criterion of the toxicity of canned food containing tin in an insoluble form. Goss showed that with proteins of low tin content a small amount resisted peptic or tryptic digestion, this residue containing nearly all the tin. In the case of canned foods this interference would not appreciably affect the food value, but probably the tin protein complex would not be decomposed in the digestive process to exert toxic action. The possibility of complications owing to bacterial action in the stomach and intestines is realised. Schwartze and Clarke fed four men with canned pumpkin and asparagus for five days, during which time they received from 2 to 2.75 gms. (30 to 40 gr.). It was shown microchemically that tin was absent in twelve of sixteen urines and in no case was more than 0.4 mgs. impure tin oxide separated.

The work of Lehman and Salant indicates that cats can tolerate 20 mgs. of tin per kilogramme without loss in weight or the appearance of toxic symptoms. Rough calculation shows the corresponding dose for man to be of the order of 5 grains daily. Thus it would appear that amounts of tin exceeding that likely to be derived from foods would have no ill effects and be largely unabsorbed from the intestine. However, there is some indication that with prolonged ingestion there may be some absorption and retention in the body. It is considered that doses considerably in excess of 5 grains would be required to produce symptoms of chronic poisoning.

These are stated to be metallic taste, vomiting, diarrhoea and pain in the stomach. Other symptoms said to have been observed sometimes are head pains, depression of the heart and difficulty with respiration. Kayser reported poisoning following the consumption of preserved eels found to contain 1,900 p.p.m. Luff and Metcalfe found symptoms of irritant poisoning in four men who ate canned cherries containing approximately 3,500 parts of tin per million and it was calculated that the dose was from 1.8 to 4.7 grains of tin. Gunther claimed that 2.3 grains of tin could cause symptoms of poisoning. Mann claimed that 2.7 grains of tin per oz. (6,400 p.p.m.) as tin oxalate from canned rhubarb caused griping pains and nausea.

The above provides some evidence that acute tin poisoning may be caused by amounts of tin which, under unusual circumstances may be present in canned foods. However, some or all of these earlier cases of poisoning reported may be bacterial in origin. Considering the very high consumption of canned foods very few cases have been reported particularly in recent years. There would seem to be less than a half-dozen cases of alleged chronic poisoning in the literature. There is a remote possibility that continued ingestion of tin may cause slight symptoms which would be difficult to diagnose correctly. Thus the toxicity of tin is not definitely established.

Buchanan, following Schryver's investigation, considered that there was no need to fear any ill-effects from consumption of amounts less than 285 parts per million (2 gr. per lb.). It is generally recognised that this limit is very reasonable. The English and Australian legal limit is 285 parts per million and the American figure (300 p.p.m.) is very similar. Present canning technology allows the tin content of most foods to be kept well below this figure. Therefore, at the present time the balance of evidence shows that no harm results from the consumption of minute amounts of tin in canned foods.

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*General review.

MICRO-ORGANISMS IN DEHYDRATED PRODUCTS.

By

W. J. Scott.

All dehydrated products contain living micro-organisms, often in substantial numbers. However, the water contents attained on manufacture are always sufficiently low to preclude the possibility of any growth by bacteria or fungi. The lower limits of water contents permitting mould growth are in equilibrium with relative humidities of 65-75 per cent., the corresponding levels for bacterial growth being from 90-95 per cent. Dehydrated products will have equilibrium humidities of 50 per cent. or less, most samples being within the range 10 to 30 per cent. When packed in suitable containers, therefore, there is no possibility of the storage life being limited by the growth of micro-organisms. Nevertheless, the microbial content of dried foods is not without significance for the following reasons. Firstly, the product should not contain organisms or their toxins which are likely to be harmful to man, and, secondly, the product should not contain organisms in numbers sufficient to lead to rapid spoilage during reconstitution at ordinary temperatures.

Some of the factors influencing the numbers and types of micro-organisms in the product are given below.

1. Condition of Raw Materials.

These should be of good condition and free from dangerous organisms or their toxins.

2. Conditions of Manufacture.

All treatments prior to the actual drying operations should ensure the maximum removal of soil-borne contamination where it exists. For vegetables in particular this means thorough washing with adequate quantities of clean water. Equipment should be maintained in a state of cleanliness which will add the least possible contamination to the product. Frequent washing and treatment with hot water will be necessary, and also attention to equipment to prevent accumulation of the product in any "pockets" in which micro-organisms might thrive. Contamination of the product by human contacts *is especially to be avoided as it is this type of contamination* which is likely to be the most dangerous. Wherever possible the washed product should be handled with suitable equipment, and not with bare hands. Facilities should be provided for all employees to wash their hands each time they enter the factory.

In addition to the elimination and exclusion of contamination it is important that no opportunity exists for significant growth of micro-organisms during *any* stage of the process. After pre-treatments by heat, the material should be spread in thin layers or on trays as soon as possible, where it may be held for periods of about two hours without risk of dangerous growth or toxin formation. Considerably longer delays may be dangerous unless the material is kept below 60° F.

For batch processes conditions should be such as will prevent growth of micro-organisms during the actual drying operation. In order to reduce risks of bacterial proliferation the products should rapidly attain a temperature of 125° F. or higher. Uneven or excessively slow drying might lead to serious contamination in portions of the material remaining moist for long periods. Where drying is instantaneous, as is spray drying, there will be some reduction of micro-organisms, the magnitude of the change depending on drying conditions, the types of organisms and the product.

3. Storage Conditions.

During storage there is a fairly steady reduction in numbers of micro-organisms at a rate which is a function of the temperature. At temperatures less than 50° F. changes occur slowly, but fairly rapid destruction occurs at temperatures above 85° F., at which temperatures substantial changes may occur within a few days. Estimates of the microbial contents of foodstuffs should therefore be made as soon as possible after manufacture, or, when delay is unavoidable, after storage at cool temperatures.

TOMATO VARIETIES FOR CANNING.

By

Victor M. Lewis.

INTRODUCTION.

Sixteen varieties of tomatoes from a trial at the Irrigation Research Station, Griffith, were canned at the Griffith Cannery. Before canning the fruit of each variety were divided into three stages of maturity, as follows:—

A series—mature, fully coloured fruit, slightly soft to the touch.

B series—mature, fully coloured fruit, but still quite firm.

C series—fruit still showing just a tinge of green on the shoulders.

A record of the colour of each series was obtained by spinning a sample of about twenty fruit on a disc and comparing the composite colour with the standard colours in Maerz and Paul's "Dictionary of Colour."

The varieties involved were:—

1. Bonnimar.
3. Grosse Lisse.
4. Indiana Baltimore.
5. Rutgers.
6. Pan American.
7. Pearson.
8. Pearson 29-17.
9. Pearson 32-5.
10. Pennheart.
11. Stemless Penn Orange.
12. Riverside.
14. Stokesdale.
15. Tatinter.
16. Tatura Dwarf Globe.
18. Washstate.
21. Bounty.

Examination of Canned Tomatoes.

Method of Point Scoring Used.

Each can tested was examined for drained weight, and texture, colour and flavour of the contents. A possible of 10 points was awarded to each of these considerations.

Drained Weight.—The drained weight was expressed as a percentage of the nett weight, and the following point score used:—

% drained wt.	Score.
55	
	1
57·5	
	2
60	
	3
62·5	
	4
65	
	5
67·5	
	6
70	
	7
72·5	
	8
75	
	9
77·5	
	10
80	

Texture.—The score for texture was based approximately on the percentage of whole tomatoes in the can, but consideration was also taken of the firmness of the fruit.

Colour.—The score used for colour was:—

Very good	9
Good	8
Good–Fair	7
Fair	6
Fair–Poor	5
Poor	4
Very poor	3

Flavour.—The flavour of the different samples of fruit was judged by a panel of five tasters. There was very marked divergence of opinion over individual samples, comments frequently ranging from good to poor. Agreement was far more pronounced with samples of poor, than with those of good or fair flavour. The score used was the same as that adopted for colour.

A Series.

In drained weight and texture the A series fruit scored badly. The average texture was poor to fair, the fruit being generally soft and the cans containing a large proportion of broken tomatoes. In colour, however, they were much better than either of the other series. Although the average score for flavour was slightly higher than that of the B series, there were a fair number of poor flavoured samples due no doubt to the inclusion of over-ripe fruit in the cans.

B Series.

In most respects these samples were intermediate between the A and C series. The texture was satisfactory, though not as good as that of the C series and the colour, with a few exceptions, was fair to good. The flavour on the average was slightly poorer than the A series, but was somewhat more uniform throughout the samples.

C Series.

The fruit in the C series had a good texture and gave high drained weight figures, but were poor in both colour and flavour.

Discussion of Stage of Maturity Results.

With the point score system adopted, where equal points are awarded for drained weight, texture, colour and flavour, there was very little difference in the average total scores for the three series. Emphasis should be placed, therefore, more on maintaining a satisfactory score in all four factors than obtaining a high score in one and a low one in another.

From the point of view of texture and drained weight, it would probably be unwise to can tomatoes which are more mature than those of the B series, while from the point of view of colour and flavour it would seem essential that the fruit be fully coloured. Care should be taken not to include overmature fruit in the cans as these lead to very noticeable off flavours.

Discussion of Individual Varieties.

Riverside.—A good canning variety, very good in texture with good colour and flavour.

Tatura Dwarf Globe.—A good canning variety, good texture, colour and flavour.

Tatinter.—A good canning variety, probably preferable to Tatura Dwarf Globe, owing to its firmer texture.

Rutgers.—Very good colour and flavour, but rather poor in texture.

Stokesdale.—Good colour and flavour and satisfactory texture.

Pearson.—Good texture, satisfactory colour and flavour.

Pearson 32-5.—Very similar to Pearson but slightly poorer in colour.

Pearson 29-17.—Inferior in texture to Pearson.

Washstate.—Good texture and flavour, but notably poor in colour.

Pennheart.—A small sample only of this variety was available, but it appeared to be good in colour, flavour and texture.

Grosse Lisse.—Satisfactory colour, flavour and texture.

Bonnimar.—Notably good flavour, and satisfactory colour and texture.

Stemless Penn-Orange.—Good texture and flavour, but colour probably unacceptable for canning.

Bounty.—Rather poor in texture, fair in colour and flavour.

Pan American.—Colour, flavour and texture fair only.

Indiana Baltimore.—Poor in texture and flavour.

Table of Summary of Results
on page 14.

Summary of Results.

VARIETY.	A SERIES					B SERIES					C SERIES					WEIGHTED TOTAL $\frac{(2A + 4B + C) \times 100}{280}$
	Texture	D. Weight	Colour	Flavour	TOTAL	Texture	D. Weight	Colour	Flavour	TOTAL	Texture	D. Weight	Colour	Flavour	TOTAL	
1. Bonnimar ...	4·5	4	8	7	23·5	6	3	6	7	22·0	5	5	4	5	19·0	54
3. Grosse Lisse	4	4	7	5·5	20·5	6·5	4	8	6·5	25·0	8	4	4	4	20·0	57
4. Ind. Balt. ...	4	4	8	5·5	21·5	4·5	1	7	5·5	18·0	7	3	4	4	18·0	47
5. Rutgers ...	6·5	4	8	6	24·5	4	2	7·5	6	19·5	8	8	6	5·5	27·5 *	55
6. P. American	3	2	8	6·5	19·5	5·5	4	6	6	21·5	4	3	4	6	17·0	50
7. Pearson ...	6	3	7	6·5	22·5	7	4	6·5	5·5	23·0	6	4	6	5	21·0	56
8. P. 29-17 ...	4·5	1	7·5	6	19·0	6·5	2	7	6	21·5	8	5	4	4	21·0	51
9. P. 32-5 ...	4	2	8	6·5	20·5	7·5	6	5·5	5	24·0	8	4	4	4	20·0	56
10. Pennheart ...	4·5	2	8	7·5	22·0	7	5	6	7	25·0	6	4	4	6	20·0	58
11. St. Penn. Or.	5	1	...	7·5	13·5 *	7·5	4	...	6·5	18·0 *	9	4	...	7·5	20·5 *	...
12. Riverside ...	6	3	8	7	24·0	7·5	4	6·5	6	24·0	9	8	4	5·5	26·5	60
14. Stokesdale ...	6	4	8	6·5	24·5	6·5	3	6	6	21·5	9	8	4	5	26·0	57
15. Tatinter ...	6	5	7	5·5	23·5	7·5	6	6	6	25·5	...	...	...	...	...	62
16. Tat. Dw. Gl.	6	5	8	5·5	24·5	6·5	4	7·5	6	24·0	8	10	6	4·5	28·5	61
18. Washstate ...	8	5	6	5·5	24·5	6·5	5	4	6	21·5	8	8	3	4	23·0	55
21. Bounty ...	4·5	1	8	6	19·5	6·5	1	6·5	6·5	20·5	6	5	4	5·5	20·5	50
Means ...	5·1	3·1	7·3	6·3	21·8	6·1	3·7	6·4	6·1	22·3	7·3	5·7	4·4	4·7	22·1	

* Scores for colour omitted.

NOTES ON THE DEHYDRATION OF APRICOTS, PEACHES AND PEARS.

By

S. A. Trout and E. G. Hall*.

INTRODUCTION.

Tree fruits have been preserved successfully by drying and the process has usually been carried out by individual growers in Australia over a period of many years. During the war the production of evaporated apples has been greatly increased in Tasmania, where there is available a large surplus of apples formerly exported overseas and to the mainland States. The production figures for dried tree fruits in Australia are shown in the following table:—

	Average Production (tons).	
	1936–37 to 1940–41 *	1943–44.
Apples	535	3,500 (approx.)
Apricots	1,611	1,871†
Figs	61	...
Peaches	488	479†
Pears	304	437†
Plums	53	...
Prunes...	2,579	3,187† (good season)
Nectarines	46	24†

* *Production* Bulletin 36, page 30. Australian Commonwealth Bureau Census and Statistics, 1944.

† Report of New South Wales Dried Fruit Board.

There has been no appreciable increase, however, in the production of other dried tree fruits during the war in spite of increased demand by the Services and the public; the production of dried fruits other than apples has remained constant at about 5,000 tons, with prunes comprising about half of this quantity. Under war-time conditions of strong demand and higher prices for fresh and canned fruit there has been no inducement to dry good quality fruit.

Even before the war the drying of peaches, pears and apricots was confined frequently to lower quality fruit unsuitable for the fresh market or for cannery use. Thus these dried fruits have come to be regarded as low-priced, low-quality substitutes for the canned article and their drying has remained relatively undeveloped and unimportant.

However, investigational work commenced in America and developed further both overseas and in our laboratories has shown that, by the use of new methods of artificial dehydration, stone fruits can be dried to give a product superior to the usual sun-dried article. The methods give some promise of producing fruit which may be able successfully to compete on a price-quality basis with canned fruit. It is believed that by a proper co-ordination of

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canning and dehydration greater quantities of peaches, pears and apricots could be processed with more profit to the grower and more satisfaction to the consumer.

Sun Drying.

Peaches, pears and apricots are usually dried by exposure to the sun in the inland growing areas where the conditions are hot and dry. Pre-treatment of the fruit varies, but usually consists of washing, cutting, pitting, trimming, traying and sulphuring for various periods with fumes of burning sulphur. The trays are then spread in the sun and the time of drying may vary from a few days to a few weeks according to the variety of the fruit and the weather conditions. In the event of rainy weather the trays have to be stacked and covered, and if conditions remain unfavourable the drying has to be completed in a dehydrator (if available), otherwise the fruit will be lost. The drying yard is usually located near the preparation shed and in general 1 acre of yard is required to dry the crop from 20 acres of orchard. The sun-dried product is generally of good colour and translucent in appearance, but often contains a considerable amount of dirt from the drying yard. Insect infestation may develop during the later stages of sun drying, necessitating fumigation before packing for storage.

By modern standards for food handling, sun-dried fruit is unsatisfactory, being often dirty, sometimes unattractive in appearance and variable in quality. The product can be considerably improved by hot water washing and drying in a dehydrator, with resulphuring if necessary.

Dehydration.

Artificial drying or dehydration in which temperature, air flow and humidity are controlled in a heated drying tunnel results in a more uniform, hygienic and higher quality product and one with a higher vitamin content than corresponding sun-dried fruit. Because of rapid drying relatively few drying trays are needed, there is a saving in labour, weather hazards become of no importance and fruit can be dried successfully in any climate.

However, on the negative side successful dehydration requires greater uniformity of raw material and more careful control than sun drying. It could be comparatively costly especially if the dehydration plant is used only during a short fruit season, but by combining the dehydration of stone fruits, pears, apples and, if possible, vegetables later in the year, it should be possible to keep operating costs within reasonable limits.

In America, where the commercial dehydration of stone fruits is becoming well established, it is accepted that dehydration will gradually replace sun drying by reason of the superiority of the dehydrated product.

Colour Differences Between Sun Dried and Dehydrated Fruit.

Accepted trade standards for colour and texture in dried stone fruits are based on the sun dried article, and dehydrated fruit in terms of these standards will usually be inferior to the best sun-dried fruit, but better than the average. However, on the basis of colour and texture after cooking, the dehydrated product will compare more favourably with canned fruit than will the sun dried.

Sun-dried apricots have an attractive deep colour and a glossy, translucent appearance, whereas the dehydrated fruit is usually paler and somewhat dull and opaque. It has been shown experimentally that exposure of the freshly-sulphured fruit to sunlight or to artificially-produced ultra violet light for a short period before drying will satisfactorily deepen the colour. However, blanching before sulphuring so improves the colour that such treatments become unnecessary.

The Importance of Blanching Before Dehydration.

Experiments in America and at this laboratory, which have been confirmed by commercial experience, have shown that blanching the cut fruit in live steam at a temperature of 200-212°F. before sulphuring will enable the production of a dehydrated article superior to the sun dried in texture, reconstitution and palatability. The colour of apricots may not be as deep as the sun dried, but the colour of blanched dehydrated peaches will be very much deeper. The colour of blanched dehydrated pears resembles the sun-dried product. Blanching inactivates by heat certain enzymes responsible for the browning of cut fruits and, by partially breaking down the structure of the fruit tissues, reduces considerably the drying time. In the cases of apricots the absorption and retention of sulphur dioxide is increased by blanching, thus enabling a great reduction in sulphuring time. Blanched fruit reconstitutes quicker than unblanched.

Method of Blanching.

The trays of freshly-cut fruit are steamed in a batch-type cabinet blancher or else in a continuous tunnel blancher until the fruit has a semi-cooked and translucent appearance. This can be best judged by cutting a few fruits, and if all except a small area in the centre of the fruit has a cooked appearance, blanching will be satisfactory. If blanching is continued beyond this stage the fruit will bleed during sulphuring and slab during drying. Such slabbed fruit reconstitutes badly and should be graded out from first quality packs.

After drying, properly blanched fruit will be translucent in appearance and of an attractive uniform colour, whereas under-blanched fruit will be more or less opaque and uneven in colour.

The period of blanching will naturally vary with the temperature, the type, maturity and size of the fruit. The blanching time will decrease with increasing maturity, and small fruits require a shorter time than large fruit. Thus to ensure uniform results the fruit should be graded for size before preparation commences. However, if the fruit is sliced, grading for size is unnecessary and a more uniform product is obtained.

The approximate blanching times at 212°F. for halves of average size and canning-ripe maturity are as follow:—apricots, 2-3 minutes; pears and peaches, 8-10 minutes.

Maturity of Fruit.

Selection of good quality fruit of uniform maturity and at the *canning ripe* stage is essential for dehydration, as inferior fruit increases the costs of preparation and yields a product of poor colour, flavour and texture. Under-ripe fruit should not be used, as blanching fixes the greenish colour of such fruit, giving the dried product an unattractive greyish-green appearance. Soft ripe fruit should not be used, as it will break down during blanching and sulphuring with excessive bleeding.

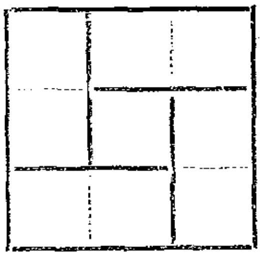
Sulphuring.

Blanched fruit only requires sulphuring for a short period, usually of 1 to 2 hours' duration, and approximately 8 pounds of sulphur are required for one ton of prepared fruit. Blanching increases the sulphur dioxide retention by apricots, but not by peaches and pears. However, even with unblanched fruit a short sulphuring is sufficient for dehydration, because the loss of sulphur dioxide during the rapid dehydration is very much less than during the slow sun drying.

In large-scale experiments carried out this season both freestone and cling-stone peaches sulphured for 1½ hours at 8 lb. per ton, and then dehydrated, had bags usually used for hard vegetables, and known as "Chapman" sacks, are generally unsatisfactory as storage containers because of the difficulty of providing ventilation. Open mesh *onion* bags are more satisfactory and are to be preferred when the use of bags is unavoidable. Such bags can be used successfully for hard vegetables.

Stacking of Bags.

Where large quantities of hard vegetables are to be stored in bags, the bags should be stacked in pillars formed by laying pairs of bags crosswise up to a height of not more than six bags. The bottom bags should be laid on a false floor of slats on 2 x 4 inch bearers and the individual stacks or pillars should be separated by an air space of 3 to 4 inches. Another good way to stack bagged produce, which has the additional advantage of providing vertical ventilating shafts, is shown in the accompanying sketch, which illustrates two alternate layers in a stack. With this method it is not usually necessary to leave a space between each individual stack or pillar.



Handling from Cool Storage.

If produce is taken straight from cool storage to atmospheric conditions during warm or damp weather, there is frequently a considerable condensation on the cool surface of the material. Such "sweating" is very undesirable and should be avoided wherever possible; it is more marked the higher the atmospheric humidity. Unless such wet produce dries out quickly it is very liable to rotting and breakdown. Sweating can be avoided by allowing the produce to warm up gradually by holding at an intermediate temperature of 45-50°F. for one to three days. If this is not practicable, the packages should be ventilated as thoroughly as possible on removal from cool storage and the vegetables disposed of without delay. Sweating will not be harmful if the vegetables are to be processed within twenty-four hours of removal from cool storage.

Inspect Frequently.

During storage the vegetables should be carefully inspected at frequent intervals and removed at the first appearance of undue deterioration such as decay, sprouting or shrivelling. It never pays to keep deteriorated produce in storage or to store produce initially of inferior quality or damaged in any way.

It should be remembered that the storage periods given below only apply under good conditions and with good vegetables. Often, in actual practice, vegetables will have to be removed from storage after shorter periods, hence the warning that they should be inspected frequently. It is foolish to place a consignment in storage, and expect it to keep for four months and then fail to carry out an inspection until it has been in store for four months (or more). Unless frequent inspections are made during storage avoidable losses will occur.

The requirements for successful storage of the vegetables of importance for processing are outlined below.

Potatoes.

Cool Storage.—Potatoes are best stored at a temperature of 42-45°F. with a relative humidity of 90 per cent. At lower temperatures the potatoes develop sugar and, besides becoming too sweet, are then liable to scorch during drying. At high temperatures sprouting becomes troublesome and shrivelling is increased. Potatoes should be held at a temperature of about 60°F. with a fairly high humidity for the first ten to fourteen days. This initial "curing" results in less rotting and less shrivelling. Under these conditions potatoes should keep satisfactorily in cold storage for periods up to six months. The bags should be stacked in the storage room on a false floor and spaced so as to allow good circulation of air through the stack.

Common Storage.—Potatoes can be successfully stored in sheds through the winter months in cool districts if certain precautions are taken to keep the shed temperature as low as possible and to provide ventilation. The storage shed should be in the coolest spot available, such as on a southern hillside, and should be sheltered from the sun. The buildings must have ventilating doors low down in the walls and high up in the roof. These would be closed on all except cold days and would be opened at night to take full advantage of the cool night air which will circulate through the shed and cool the potatoes. If best results are to be obtained the shed should be insulated to reduce heating during the day. The insulation should be waterproofed on the *inside*. A cheap and satisfactory insulating is obtained by fastening wire netting 6 to 12 inches out from the walls and tightly packing the space with straw. To prevent condensate drip the ceiling should be insulated more than the walls. The potatoes should be stacked on a false floor and should be kept six inches clear of the walls. They may be stored in bulk in bins instead of in bags if the bins are built clear of the walls and if vertical ventilating shafts are placed in the middle of the bin from the floor up. These shafts are build by nailing eighteen-inch lengths of two-inch boards spaced one inch apart to four-by-two inch studs.

Pitting or Clamp Storage.—Although extensively practised overseas where the winters are more severe, clamp storage is of limited use in Australia because it is difficult to keep the temperature of the potatoes low enough and it is difficult to ventilate them properly. Sprouting and rotting are often serious troubles, especially if the clamps are not properly constructed. However, clamping may be useful as a cheap method of storage during the winter months in the coldest parts of the country. Actually the storage is rarely underground because of difficulties of ventilation and drainage; therefore the process is not strictly pitting and should be referred to as clamp storage.

A dry, well-drained spot should be selected on sloping ground. Two poles are placed on the surface, parallel and four feet apart. Straw or brush is placed on the ground between them and the potatoes piled in on the straw to make a conical heap or, if large quantities are being stored, the potatoes should be heaped in a well-ridged row. The potatoes are then thickly thatched with straight straw, wheat or rye straw being much better than oat or barley straw; reeds can also be used. The thatching is then covered with beaten-down sods of earth, the sodding being done from the bottom up to within nine inches of the top, which should be covered with a straw ridge. The provision of additional ventilation by the use of piping coming through the top is desirable to reduce the risks due to excess moisture. Finally a drain nine inches wide and nine inches deep is cut around the clamp. Potatoes must be well dried before clamping, as excess moisture causes excessive rotting. If weather permits it is as well to leave the potatoes with only the straw covering for a fortnight or so to remove some of the moisture. Potatoes in clamps should keep satisfactory for three to four months; that is, until the spring in cool highland areas.

General.—Potatoes should be stored in the dark, as light causes a greening of the skin, and even partial exposure to light may cause a yellowing of the flesh. They should not be lifted until fully mature and should be thoroughly dry before being placed in storage.

Freshly-dug potatoes can be held satisfactorily for several weeks at ordinary shed temperatures even in warmer areas provided that the stack is well ventilated. If it is noticed that the potatoes are shrivelling too much they may be sprinkled with water as required, but this precaution would only be necessary in warm, dry weather.

Certain varieties may be unsatisfactory for processing if they are cold-stored for long periods. This applies particularly to the Brownell variety for dehydration.

Carrots and Parsnips.

Cool Storage.—Carrots and parsnips are best stored at a temperature of 32-34°F. with a humidity of 90-95 per cent. Under these conditions they will keep for four to five months. The roots should be carefully harvested as the skin of the carrot particularly is tender and easily injured. The tops should be cut off close. For cool storage the roots should be washed in clean, running water, dried and placed in crates or boxes. Owing to the difficulty of providing adequate ventilation there is too much sweating in bags. If plenty of clean water is not available, carrots and parsnips are better not washed unless they have been dug from heavy soil and are very dirty.

Common Storage.—If unwashed and handled carefully, carrots and parsnips can be common stored for two to three months without undue loss in the manner described for potatoes. If shrivelling is noticeable the bags should be sprayed occasionally with water and covered with damp bags. However, if the roots are too damp, or sweat due to inadequate ventilation, rotting may be serious.

General.—Wherever possible, only carrots from new ground should be stored. Watery Soft Rot caused by the fungus *Sclerotinia sclerotiorum* has been found to be responsible for much of the rotting of stored carrots. This disease originates in the field. Where carrots have been grown on the same ground for some time the roots will be considerably infected with this fungus which will cause considerable rotting if the roots are subsequently stored or if they are transported long distances with insufficient ventilation.

Short varieties of carrots, such as Chantenay, keep better than long varieties, principally because shrinkage is less. Under warm, dry conditions the rate of shrivelling of carrots and parsnips can be very rapid.

Carrots particularly require good ventilation during storage as they give off moisture and carbon dioxide in considerable quantities.

Freshly-cut carrots and parsnips can be held satisfactorily for two or three weeks at ordinary shed temperatures, even in warmer areas, provided that the stack is well ventilated and that, when necessary, precautions are taken to reduce shrivelling.

Cabbages.

Cool Storage.—Cabbages are best stored at a temperature of 32°F. and a relative humidity of 90-95 per cent. If humidity control is available the humidity should be kept at about 75 per cent. for the first few days to allow rapid drying out of the outer leaves, which then act as a better protection for the head. Under these conditions, if carefully handled, late varieties should keep for about three months, whereas earlier varieties will keep for only four to six weeks.

Common Storage.—Late varieties of cabbage can be common-stored without excessive loss for several weeks during the winter months in the colder areas.

General.—Cabbages for storage should be carefully selected and carefully handled. Only sound, mature, firm heads should be used; they should be cut so as to leave an inch or so of stalk after trimming off loose outer leaves. However, several good wrapper leaves should be left to protect the head. On removal from storage the heads should be trimmed again to remove loose and damaged leaves. Good ventilation during storage is essential, and, to achieve this, the cabbages should be in crates or in small slatted bins; they should not be stored in bags which do not allow sufficient ventilation. Condensation of moisture on the heads must be prevented in order to avoid serious rotting and rapid yellowing of the leaves, which is serious if there is any "sweating" during storage.

Onions.

Cool Storage.—The best conditions for the storage of onions are a temperature of 32°F. and a relative humidity of 70-75 per cent. A relatively low humidity is necessary to prevent undue root growth and decay. Therefore, onions should not be stored with other produce. Under these conditions sprouting is checked and root growth retarded. The Australian Brown and Brown Globe varieties will keep for six to seven months and the mid-season varieties, such as Brown Spanish, Hunter River Brown and Hunter River White, should keep well for four months, while the early varieties are not suitable for cool storage for more than two months.

Common Storage.—Late brown onions will keep for four to five months in common storage in the cooler districts during the winter and early spring months, and the mid-season varieties should keep for two to three months, provided that the onions are properly handled and provided that the storage shed is dry and well ventilated.

General.—Onions for storage should be well matured, that is, they should not be pulled until the tops become brown and fall over. For storage to be successful, onions must be "cured" after harvesting to dry out thoroughly the outer scales of the bulb. A satisfactory procedure is to dry off the onions for three or four days in windrows in the field and then top them, leaving about an inch of stalk. The final curing is then carried out in slatted crates under cover so that air circulates freely through the onions. This will require a period of about three to four weeks. After curing, the onions should be well sorted and any thick-necked, double or injured specimens removed for immediate marketing.

Onions for storage should be packed in crates, boxes or in open mesh bags, which must be stacked so as to provide very good air circulation. Best results are obtained when the onions are stored in an insulated storage shed and when full advantage is taken of the cool night air to keep the temperature of the onions as low as possible. The principal trouble in common storage is sprouting, which is kept in check at low temperatures and develops most rapidly at 60°F. Unless the storage atmosphere is kept dry root growth will also be serious, and unless the onions are well cured and sorted before storage rotting may cause considerable losses.

Silver Beet.

Silver beet is very perishable and can only be held satisfactorily in cool storage. It should be stored at 32° F. and a relative humidity of 90-95 per cent., under which conditions it should keep fairly well for two weeks if quite fresh when placed in store. Silver beet should be stored in crates and requires very good ventilation to avoid "sweating" during storage.

Beetroot.

The best storage conditions for beetroot are a temperature of 32°F. and a relative humidity of 95 per cent. Beetroot tends to shrivel badly, therefore the humidity must be kept as high as possible. Under these conditions good roots will keep for three to four months. They can be common stored for a few weeks in the colder districts, but will not hold in good condition for more than a week or two under warmer conditions, mainly because of excessive shrivelling.

Before going into storage beetroot should be topped by twisting off the tops two or three inches above the crown and well sorted to remove all diseased or injured specimens. They should be handled very carefully and stored in slatted crates or boxes; bags are unsatisfactory and storage in large bulk should be avoided.

Swede Turnips

Cool Storage.—Swede turnips store well and will keep for five to six months at a temperature of 32°F. and a humidity of 90-95 per cent.

Common Storage.—Swedes should keep for three months in common storage during the winter and early spring in cooler areas, and under common storage can be satisfactorily handled in the same manner as potatoes.

General.—Harvesting should be done carefully; the tops should be cut closely, but trimming should be reduced to a minimum. All diseased or damaged roots should be graded-out before storage. Although they may be stored in bags, better results are obtained by the use of crates or boxes. Wilting during storage may be kept in check by occasionally applying a fine spraying of water. Sprouting is kept in check in cool storage, but in common storage sprouting and wilting are the principal troubles. If the storage temperature is much more than 45°F. the development of sprouting and wilting will reduce the storage life to about two months.

Under warmer conditions, such as in Sydney during the winter, swedes will hold satisfactorily for about six weeks provided that they are stored in a cool, well-ventilated spot and that steps are taken to reduce wilting.

Peas and Green Beans.

These perishable vegetables are similar in their storage requirements. Holding without refrigeration is possible for a day or two, but even then there is a serious loss of quality, especially sugar from peas, which is particularly undesirable for processing. If peas or beans must be held more than a day after picking they should be placed in cool storage. They should be stored at 32°F. with a relative humidity of 90-95 per cent. Under these conditions they will keep well for one to three weeks. For best results they must be young and tender, sound and dry and stored in well-ventilated boxes or crates; the tropical fruit case is a very satisfactory container provided that they are firmly but not tightly filled. These vegetables are liable to sweat in storage, therefore the use of bags is not desirable. Diseased material should not be stored.

Green Corn (Sweet Corn).

Green corn is very perishable and should be processed within a few hours of harvesting. Even if the cobs are held at ordinary temperatures until the next day, there will be a serious loss of quality. It can be held at 32°F. with a relative humidity of 85-95 per cent. for only one week with safety and should be stored in well-ventilated crates.

Tomatoes.

In order to obtain maximum colour and flavour tomatoes for processing are usually not picked until they are coloured and firm ripe. If they have to be transported a considerable distance they must be picked less coloured in order to avoid damage in transit, but it must be remembered that the more coloured they are when picked the better will be the quality when ripe. For longest storage tomatoes should be picked when "mature green" and stored at 55°F. with a relative humidity of 85 per cent. The "mature green" stage is reached when the green skin shows a whitish tinge and a pink colour starts to show in the flesh; if picked less mature they will not ripen properly. Under these conditions they will keep for three to six weeks, depending on the quality of the fruit, the season of the year and probably on the variety. Limited experience indicates that autumn-grown tomatoes store better than those maturing earlier in the season. Coloured fruit is best held at 45°F., at which temperature it should keep for two weeks. Ripe fruit may be held for a few days at 32°F., but should be processed within a few hours of removal.

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This article has been prepared from unpublished data from general observations, from information supplied by colleagues and from certain published material. The latter includes the following:—

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The Council's Scientific Liaison and Information Bureau has prepared a bibliography on vegetable storage and copies may be obtained on application to the Council's Head Office.

VEGETABLE DEHYDRATION.

We have received recently from the *United States Tariff Commission* a report No. 5 of their *War Changes in Industry Series* dealing with *Dehydrated Vegetables*, issued in September, 1944. The following abstract is taken from its summary on pages 1-3:—

"During the present war expansion in the dehydrated-vegetable industry, one of the so-called "war babies," has been at a phenomenal rate, production having increased by nearly 4,000 per cent. When the war ends, however, conditions responsible for most of this expansion will no longer exist and a rapid decline will be inevitable. This report traces the development of the industry from its beginning to the present time and attempts to answer a number of questions concerning its ability to survive in peacetime.

From its beginning the dehydration of vegetables has been primarily a war measure; its history in the United States goes back to the Civil War, when soldiers' rations contained small quantities of dried vegetables. Dehydrated vegetables reappeared, each time on a larger scale, in the Alaskan gold rush, the Spanish-American War, and the Boer War. It was during World War 1, however, that the saving in storage and transportation made possible by dehydration was firstly realised. The greatest progress was achieved in Germany; there 60 per cent. of the army's vegetable ration consisted of dehydrated vegetables. The United States also became interested in dehydrated vegetables, but they never constituted an important part of the food supplies of its armed forces during the First World War, and only about nine million pounds were shipped overseas.

By the end of the First World War, however, the dehydrated-vegetable industry in the United States had reached a greater development than ever before; about thirty plants, having a capacity of twelve million pounds annually, were then in operation. But all the plants were working on army contracts, and when these were cancelled the industry was not able to survive except in a very small way. Consumer response to dehydrated vegetables was poor, partly because there had been no civilian consumption during the war and partly because the products were not put out in sufficiently attractive form. Furthermore, the companies engaged on war contracts did not have sufficient resources to tide them over a period of depression or to carry on an expensive campaign of advertising and research. Later on the industry made some recovery. By 1940 a number of firms were in operation, specialising principally in dehydrated soups and in powdered vegetables for use as condiments; in Germany the industry had a similar experience during the period between the two wars.

World War II brought the realisation that supply and shipping problems would be vastly greater than in World War I, and that, in addition, there would be a shortage of tin for containers for canned foods. Consequently there was an immediate expansion of the dehydrated-vegetables industry. Since the last war considerable progress had been made in methods of drying, packaging and storage. So far as manufacturing facilities were concerned, however, practically an entirely new industry had to be created.

Revival of dehydration of vegetables has taken place in Axis-controlled Europe, especially in Germany, where the output probably exceeds that of the United States.

Little post-war demand for dehydrated vegetables for the military establishment or of feeding the liberated countries need be expected. As after the last war, the future of the industry will depend principally on the domestic civilian market. The situation, however, will be so different that the prediction that future experience will be similar to past experience is hardly justified. Technical methods and the quality of the product will be far superior to those after the last war, and there will be a well-established market for dehydrated soups and powdered vegetables resting upon a pre-war foundation. Prices of dehydrated soups in the retail markets already compare favourably with the canned. The trade is unanimous in predicting a great future for this particular phase of the dehydrated-vegetable industry. Despite the rise of the frozen-food industry as a new competitor in the field, some of the most experienced processors nevertheless go so far as to predict a great future for dehydrated vegetables in general, possibly as great as that for canned and frozen vegetables. They believe, however, that the road ahead will be long and hard, calling for costly advertising campaigns and further improvement and diversification of the product. Most of the present manufacturers and distributors of dehydrated vegetables believe that very soon after the war is over 90 per cent. of the processors who have been depending upon war contracts alone will be forced out of business.

Dismantling of the plants and disposition of the equipment are not considered insurmountable problems. In view of the probability that there will be a shortage of all kinds of equipment after the war, and as the dehydration of a large number of other products besides vegetables requires dehydrating machinery, it is expected that no unusual difficulties will be encountered in disposing of such machinery or of the preparatory equipment —which is the same as that used in the canning and quick-freezing plants."