DEPARTMENT OF AGRICULTURE
DAIRY AND COLD STORAGE BRANCH
OTTAWA, CANADA

THE COLD STORAGE OF FOOD PRODUCTS

WITH SOME

NOTES ON INSULATION AND WAREHOUSE MANAGEMENT

BY

J. A. RUDDICK and JOSEPH BURGESS

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LETTER OF TRANSMITTAL.

OTTAWA, August 30, 1915.

To the Honourable
the Minister of Agriculture.

SIR,—I have the honour to submit for your approval the manuscript for a bulletin to be entitled "The Cold Storage of Food Products."

This bulletin is not proposed as a scientific treatment of cold storage problems, but rather as a popular discussion of the subject for the information of those who may have a commercial interest in it, and as a guide to inexperienced persons who have embarked in the cold storage business. It is not expected that the trained refrigerating engineer or the experienced cold storage manager will find much that is new or original in these pages, but there are a large number of the smaller establishments throughout the country in charge of men with no training or experience to guide them, and to whom such information should be helpful.

It is also believed that it would be a great advantage to those of the general public who make use of cold storage facilities, if they had a better understanding of the conditions which are necessary to secure the best results in the cold storage of food products, and it is hoped that the bulletin may be useful in this connection also.

In preparing the material for this publication, we have made some use, after revision and additions, of matter contained in previous bulletins, but now out of print.

I have received so much assistance and so many valuable suggestions from Mr. Joseph Burgess, Cold Storage Inspector, that I consider it only fair to acknowledge him as joint author.

I have the honour to recommend that this manuscript be published as Bulletin No. 44 of the Dairy and Cold Storage series.

I have the honour to be, sir,
Your obedient servant,

J. A. RUDDICK,
Dairy and Cold Storage Commissioner.

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THE COLD STORAGE OF FOOD PRODUCTS

WITH SOME NOTES ON INSULATION AND WAREHOUSE MANAGEMENT.

BY

J. A. Ruddick and Joseph Burgess

INTRODUCTION.

The cold storage industry has grown out of the practical experience of people living in northern climates who have observed the preservative effect of "cold" when perishable food prducts are exposed to it. Every person who makes use of a kitchen refrigerator, or places milk, butter, meats, fruit or vegetables in a cool cellar, puts into practice the principles which underlie the operation of the most up-to-date cold storage warehouse. The difference is one of degree as measured largely by the temperature employed in each case.

The thrifty householder who lays in a supply of butter, eggs, poultry, meats, etc., during the early part of the winter, when such things are in supply, and then keeps them in some unheated storeroom in a frozen condition or packed in snow for several months, has in view the same economic results as he would have if they were taken to a cold storage warehouse. There is this difference, however, that in the warehouse there is practically no change of temperature—no danger from thaws—and therefore, greater security in preservation.

The farmer who keeps apples, potatoes or any other vegetable in a "pit" during the winter, is taking advantage of the preservative effect of a low temperature when he covers them only sufficiently to prevent the frost from penetrating.

The fruit grower who stores his apples in a frost-proof warehouse, depends on the same means of preservation as the cold storage man does, namely a low temperature without frost. There is no difference in the effect, whether the temperature is reduced naturally or whether the same result is brought about by artificial means. The frost-proof apple storage is only a primitive cold storage warehouse dependent on weather conditions for efficiency. In the cold storage warehouses there is the advantage that the temperature can be absolutely controlled and the preservative effect of "cold" can be applied when it is most effective, namely during the warm weather or autumn, or immediately after the fruit is harvested and before cold weather sets in.

The cold storage industry benefits both the producer and the consumer by working to prevent alternate periods of glut and scarcity, accompanied by unprofitable prices at one time and exorbitant or prohibitive prices at the other extreme. The benefits derived from cold storage are well illustrated in its influence on the egg trade. There are other methods of preserving eggs, but of late years cold storage has supplanted, for commercial purposes, all other systems. If it were not for the cold storage facilities which are now available, the price of eggs would, for lack of a market, go so low during the laying period of spring and early summer that production would be seriously discouraged and the scarcity which would result during the season of non-supply would boost prices for all kinds of eggs to such an extent as to make them prohibitive for the majority of the people.

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The use of cold storage gives the producer a fair price for his eggs at all seasons, and the consumer can secure storage eggs in good condition during the fall and winter months at reasonable prices. No one would claim that cold storage eggs are equal to fresh laid, but the latter are not available in any quantity, and without the storage eggs, a large proportion of the people would be unable to secure sufficient eggs of any kind during the winter months, no matter what price might be paid for them. The same thing applies to butter, poultry, meat and fruit at certain seasons, but in a lesser degree.

PREJUDICE AGAINST COLD STORAGE AND COLD STORED FOODS.

That many people are prejudiced against any article which is said to have been in cold storage, can hardly be denied, and it must be admitted that they have sometimes had reason to be suspicious of cold storage goods. The average customer is not in a position to discriminate between defects which are actually due to long holding in cold storage and those which are the result of improper handling, or the lack of ordinary precautions in the storing of goods already out of condition. It is true that food products do not always come out of cold storage in good condition, for the reason that they are not always delivered to the cold storage in good condition. Merchants often neglect to take advantage of cold storage facilities until their produce is beginning to spoil. As a general rule articles of food are not kept long enough in cold storage to show serious deterioration if they have been in proper condition when placed therein.

Cold storage has been blamed for the inferior quality of much food which never saw the inside of a cold storage warehouse, but which would have been saved from deterioration if it had been so handled.

The cold storage industry has a sound economic basis, and, properly conducted, is of benefit to both producer and consumer. There are faults in the management of cold storage warehouses as in other kinds of business. It is a comparatively new industry and has been engaged in by men with no previous experience and very little knowledge of either the principles or practice of refrigeration. Lack of knowledge and experience has resulted in some badly constructed, poorly insulated and insufficiently refrigerated warehouses. These defects are gradually being remedied through the lessons taught by experience, and warehouses constructed during recent years are generally modern and up to date in every respect, while those in charge are showing more skill in the handling of all kinds of cold storage goods.

THE FIELD FOR THE EXTENSION OF THE COLD STORAGE INDUSTRY IN CANADA.

The field for the expansion of the cold storage business, through the public cold storage warehouse, is not very extensive in Canada at the present moment. The larger centres have already been supplied, and the openings where a purely public cold storage business may be conducted successfully in distributing centres are not numerous. The erection of small warehouses in producing districts seem to afford the best opening for the extension of the industry at the present time.

There are many localities where small storage warehouses operated in connection with a produce business should prove of advantage not only to the owners, but to the producers in the district. The apple trade is susceptible of much improvement by the judicious use of cold storage facilities. It would be a comparatively simple matter to convert many of the present frost-proof apple warehouses, like those located at different points on Lake Ontario and in the Annapolis Valley in Nova Scotia, into

regular cold storage warehouses. It would be quite practicable in some places to establish a central refrigerating plant with pipe lines to carry the refrigerating medium to the individual warehouses. Only slight alterations in the insulation would be necessary, and such warehouses could be fully equipped with cold storage facilities at comparatively little cost.

The fishing industry and the trade in fish products probably offer as good a field for the extension of cold storage as any other line in Canada at present. The great distance from the sea at which a large number of the people of Canada must always reside, makes it impossible for them to procure sea food in fresh condition without the use of cold storage and refrigerated transportation. The cold storages already established in connection with the fishing industry of Nova Scotia and British Columbia within the last few years has resulted in a rapid development of both the export and the inland trade. The whole fishing industry could be greatly extended with the impetus that would be given to it by a more general application of refrigerated services.

THE REFRIGERATION OF DAIRY PRODUCTS.

(Condensed and adapted from a paper read before the American Society of Refrigerating Engineers, Chicago, October 18, 1909, by J. A. Ruddick.)

The refrigeration of dairy products may be divided under three heads, viz.: (1) the refrigeration of milk; (2) the refrigeration of butter; (3) the refrigeration of cheese.

THE REFRIGERATION OF MILK.

Housewives and dairymaids have, from time immemorial, employed a measure of refrigeration for milk by placing it in cool cellars, for the purpose of securing a maximum amount of cream or to keep it sweet as long as possible. It is only within recent years that actual refrigeration has been used in the preservation and handling of milk. Absoluetely pure milk, that is milk free from all germs of fermentation, will keep indefinitely at any temperature if protected from infection, but anyone familiar with conditions existing in dairies knows how impracticable it is to procure milk without more or less impurities finding entrance into it. If the multiplication of these germs which are thus introduced, is not checked in some manner, most profound changes soon take place in the milk.

Efforts are being made all over Christendom to obtain cleaner and more sanitary milk, and this is most essential, but the importance of cooling in that connection should be emphasized because it is the most efficient method of preserving milk in a sweet and wholesome condition, and one that has not been given the prominence which it deserves. The process of pasteurization, very often looked upon solely as a heating process, is really half of refrigeration, because the heating without immediate and rapid cooling would, in most cases, be worse than useless. Refrigeration will not remove impurities from the milk, but it does have the effect of checking the multiplication of bacteria. It is of the utmost importance that the cooling of milk should be proceeded with as quickly as possible after it is drawn from the cow. Milk which is cooled immediately, say to 60° F., will keep longer and be in better condition than if it is allowed to remain at a temperature of 70 to 80 degrees for several hours and then cooled to 40. The refrigerating engineer who is called upon to design a milk-cooling plant, or the dairyman who desires to provide some means of cooling milk, should arrange for quick cooling with as little exposure to the air as possible.

For practical purposes, a temperature of 40° F. is low enough for the preservation of milk, but even then its preservation can only be a matter of days under ordinary commercial conditions.

REFRIGERATION OF BUTTER.

Refrigeration is probably more useful to the butter trade than it is to the trade pertaining to any other food product. It is also highly essential in the practice of the art. The principal butter-making countries of the world are in the northern hemisphere, and the periods of production are more or less intermittent, owing to the fact that the summer season is more favourable for production than the winter months are. It follows, therefore, that there is a large surplus of production over consumption at certain periods of the year, and this surplus must be held in reserve to supply the shortage at other periods. Before the days of refrigeration, the consumption of butter during the off-season was very much curtailed, owing to the fact that it was difficult to secure supplies in good condition. With cold storage available for carrying the surplus product during the summer months, consumers can now obtain their requirements in practically as good condition during the winter as at any other time of the year. This has resulted in an enormous increase in the consumption of butter all over the world, because it is spread thicker when the quality is good, and the business of dairying has grown and developed to an extent which would not have been possible without the aid thus rendered by refrigeration.

Butter is an unstable product. It is at its best when freshly made, and its fine quality will last only a few days at ordinary temperatures in the summer months. As the temperature is reduced, the changes which take place in the butter to bring about rancidity and other undesirable flavours proceed more slowly, so that the "age" of butter is determined by the temperature at which it is held rather than by the number of days or weeks that may have elapsed since it was made. At one time it was thought to be undesirable to keep butter below the freezing point of water under any circumstances, but gradually, in the light of experience, the storage temperature of butter has been reduced, until at the present time it is the practice in some places to hold it as low as zero F. or even lower.

Experiments and investigations have shown that butter eventually changes perceptibly under any storage temperature, no matter how low, and that the effect of storing at different temperatures is only a matter of degree and not of absolute stoppage of all change in any case.

As far as we have been able to learn from recorded experiments and observation, slightly better results have always been obtained at the lowest temperature employed. In view of this fact, one can hardly say what is the best temperature, having regard only to the best possible preservation. There is so little gain, however, when the temperature is reduced below zero F. that the point of diminishing return may be fixed between zero and 10° F. That is for long storage. When butter is to be stored for short periods under four or five weeks, it does not appear to be necessary to store it below 20° F. A lower temperature means unnecessary expense, because the butter should be well preserved for that period at 20° F.

The engineer or cold storage manager, in determining the temperature at which butter is to be stored with an eye to economy and good results, must consider two things: first, how old the butter is and at what temperature it has been held previous to being offered for storage, and secondly, how long it is to be stored before it will go into consumption. A point worth noting in the storage of butter is that heavily salted butter does not keep as well in cold storage as butter which is lightly salted.

One of the troubles of butter storage is the development of mould on the parchment lining of packages, also on the surface of the butter and even throughout its mass. Mould is a low form of plant life. It is not a spontaneous growth, but comes only from seed. The spores (seeds) of mould are very common in the form of dust almost everywhere. The conditions which develop them are dampness, suitable food and a favourable temperature with a rather wide range, all of which conditions are present in a butter package. The trouble can generally be traced to the creamery

where, by careless handling, either the parchment paper or the packages have been infected. Packages made from unseasoned wood are sometimes responsible for the growth of the mould. The salts of unseasoned wood appear to furnish suitable food for mould growth. Conditions in the cold storage warehouse may favour the development of the mould. Thorough disinfection of butter rooms at least once a year is imperative if the rooms are to be kept sweet and free from mustiness. We have had good results from washing all interior surfaces of cold storage rooms with a solution of one part of bi-chloride of mercury to 1,000 parts of water and, of course, every one is aware of the beneficial effect of a periodical coating of whitewash. Great care must be exercised in the use of bi-chloride of mercury on account of its highly poisonous nature.

THE REFRIGERATION OF CHEESE.

When we place butter, meats, fish and similar products in cold storage, we measure the efficiency of the storage and the success of the undertaking by the extent to which the goods have been preserved without change from their original condition. Produce of this kind, is, or should be, at its best when first placed under refrigeration.

The refrigeration of cheese intelligently conducted is an entirely different problem, for, unlike most other products for which cold storage is employed, it continues to improve in quality for many months. A Canadian or Cheddar cheese will vary in point of time when it reaches its best quality in storage. We have kept them nearly three years with continual improvement in quality, showing a rich, meaty texture with a mild though distinctly "cheesy" flavour.

The highest type of Cheddar cheese—that which is produced in Great Britain—is seldom placed in cold storage, but is cured and stored at a temperature of 60 to 65 degrees, and it is at that temperature that the most desirable flavour is developed. In Canada the weather conditions are different to those of the United Kingdom, and the temperature which prevails during the summer months in ordinary cheese curing rooms and warehouses in this country is too high for good results, as it often rises to 85 or 90 degrees. If cheese is exposed to these high temperatures for a few days only immediately after it is made, certain ferments are encouraged and developed which, if not checked later by comparatively low temperatures, will eventually produce results that are detrimental to the quality of the cheese.

The role of refrigeration in cheese storage is therefore to control, rather than to check, those fermentative changes which in most other products mean decay or at least deterioration.

It is obvious that the temperature at which cheese should be held in cold storage will depend upon whether such cheese have been cool-cured or have been exposed to unduly high temperatures. Strictly cool-cured cheese of good quality need not be stored at temperatures under 55 or 60 degrees. At that temperature the desirable flavours will develop and the texture of the cheese will continue to improve for many months.

On the other hand, if cheese has been exposed to high temperatures, the ripening processes will have proceeded further, as well as those undesirable changes already mentioned, and in order to check these injurious ferments, a comparatively low storage temperature is necessary, say 36 to 40 degrees, according to the condition of the cheese. A Cheddar cheese will never develop its highst quality at these low temperatures. The flavour will be lacking in that peculiar, rich "cheesy" quality from which it derives its highest value. It is a case, however, of choosing the lesser of two evils.

The shrinkage in the weight of cheese in storage is an important item in the cost of carrying it. The shrinkage may be almost entirely prevented if the cheese are coated with paraffin wax when they are ten days or two weeks old. It will pay to paraffin any cheese which are to be stored for one month or more.

The practice of "paraffining" also prevents the growth of mould on the surface of the cheese, which may be troublesome if excessive.

REFRIGERATION IN RELATION TO FRUIT GROWING IN CANADA.

The possibilities of cold storage as an aid to the fruit growing industry in Canada is a question in which interest is growing to a considerable extent, but as yet fruit growers may be considered backward in securing cold storage facilities close to their orchards. This is, no doubt, partly due to the fact that the many first-class frost-proof warehouses throughout Canada are giving fair satisfaction, and growers are cautious about incurring the extra expense entailed in the remodelling and in the operation of mechanically cooled warehouses.

There is no question but that cold storage facilities are a necessity in carrying on and developing the fruit industry along certain lines, but it is also true that cold storage is not a remedy for every defect, nor would it prevent the early decay of much of the fruit which is marketed. There are certain things cold storage will not do, and it is just as well that we should have at the beginning a clear understanding of its limitations as well as its possibilities. Reference has frequently been made to the large quantities of apples wasted every year in Canadian orchards, especially when there is a heavy crop, and it has been urged that if cold storage were available all this enormous loss would be avoided. This view of the matter is entirely erroneous. In the first place, it is not possible to preserve by cold storage the scabby, bruised and wormy windfalls, of which unfortunately too large a percentage of the average crop consists, and in the second place it would not pay to employ cold storage to save them even if it were possible. The proper destination for such inferior fruit is the evaporator or the cider mill. The losses arising from diseased fruit, or from mechanical injuries received in picking and packing, far exceed any losses which may result from a lack of cold storage facilities, especially for late or winter varieties. We do not say that to minimize the importance of cold storage, but rather to emphasize the other thing. We will never derive full benefit from cold storage until we first learn to handle our fruit carefully, so as to avoid bruises and other injuries.

Refrigeration can be made to serve the fruit industry of Canada in the following different ways:—

1. In the more general use of iced cars for the transportation of fruit in warm weather.
2. In the chilling or pre-cooling of early apples and tender fruit before shipment in iced cars.
3. In the cold storage of apples intended for long keeping, and by extending the season for choice varieties.

USE OF ICED CARS.

The use of the iced cars for the carriage of fruit is increasing year by year, and fruit growers are learning that the question of temperature in transit is of quite as much importance as the length of time occupied in carrying the fruit from one place to another. As an illustration it may be permissible to refer to the experience of this Department in the shipment of peaches from St. Catharines and other Niagara points to Montreal, for export to Great Britain, in 1910, the details of which are to be found in bulletin No. 27 of the Dairy and Cold Storage Series. It was found that better results were obtained when the fruit was despatched to Montreal in iced freight cars than when it was sent by express without ice, although it took one day longer to go by freight. The same thing will apply in the shipment of any fruit. The manner in which the packages are stowed in an iced car is of the greatest importance in securing the best results. The full benefit of the ice is lost unless there is pro-

vision for a free circulation of air from the ice bunkers and among the packages. Refrigerator cars are very often loaded so that there is little or no circulation of air, and in such a car the temperature will be uneven and much higher than it should be. This is one thing about which a great deal has yet to be learned by the average fruit shipper in this country. There is rather a common impression that the ice adds moisture to the air in a car, but that is not necessarily so, and if there is a good air circulation under and between the packages the air will be drier than it would be if there was no ice in the car at all. The moisture from the fruit is carried by the circulating air to the ice bunker and deposited on the cold surface of the ice.

PRE-COOLING OF EARLY APPLES AND TENDER FRUITS BEFORE SHIPMENT.

Peaches, plums and other soft fruits are not susceptible of being preserved for any length of time in cold storage. The best that can be done is to keep them in a firm condition for transportation and marketing at reasonable distances. The refrigerator car is useful as far as it goes, but it is inefficient when depended on for prompt cooling. The proportion of ice to the contents of a full car is necessarily very small, and when a car is filled with warm fruit it takes too long to reduce the temperature. This is all the more noticeable if the car itself has not been chilled before the fruit is loaded. An average temperature of 40 degrees may be considered about the possible minimum temperature in a refrigerator car using ice only in warm weather, but it seldom goes below 44 or 46 unless the heat is removed from the fruit before it is loaded. If the fruit is warm when loaded into the car, it will take from two or three days to bring the temperature down and the car will have to be kept well iced in the meantime. All this time the ripening process is proceeding rapidly.

It is obvious that if any plan can be devised whereby the chilling of the fruit can be accomplished in a few hours instead of taking days, the fruit will carry much farther and in better condition. There is this further advantage, that fruit which is to be promptly cooled after picking can be safely allowed to remain longer on the tree and thus reach a fuller development of its quality.

Until very recently the pre-cooling of fruit or other produce was confined almost entirely to the Pacific Coast in the United States. The conditions under which this practice has been developed, especially in California, find no exact parallel in Canada, but there are a few districts such as the Niagara peninsula where we think the work may be carried out successfully. There are two methods of pre-cooling, known respectively as "Car Cooling" and "Warehouse Cooling." The warehouse plan has some outstanding features which make it very suitable in districts where small plants will not only serve the purpose of pre-cooling, but also provide refrigerated storage space for 10 to 20 cars of fruit. A strong feature of the warehouse system is that it requires considerably less refrigeration to do the same amount of work than the car cooling system does. This is due partly to the poor insulation in the average refrigerator car and the fact that it is difficult to make airtight connections between the cooling plant and the openings into the cars. The lack of any reserve of cooling power is also a disadvantage in the car cooling system, making it necessary to provide a large refrigerating capacity if the work is to be done expeditiously.

THE CAR COOLING SYSTEM.

In car cooling the loaded cars are run into a shed adjoining the building which contains the refrigerating machinery, and by means of adjustable ducts, a stream of cold air is forced through the cars. The intake is usually attached to a side door, and the return to each hatch at the top of the car. Thus the air is circulated between the chamber containing the expansion or cold coils and the car containing the fruit. The thorough cooling of a car of fruit is equal to three or four tons of ice meltage, according to the quantity of fruit and the amount of heat which it contains when

put in the car. This represents the saving in ice to be credited to pre-cooling; but, of course, the saving of ice is not the most important thing. The cooling of a car may be completed with a well equipped and properly designed plant in about 4 or 5 hours, and the number of cars that may be cooled at one time depends on the size of the plant.

Experienced engineers say that there should be about 12 tons of refrigeration for each car to be cooled. That is to say, if it is desirable to cool 10 cars at one time it will be necessary to have machinery with a capacity of about 120 tons of refrigeration in 24 hours. There are a number of rather complicated engineering questions involved in the construction and operation of a car cooling plant, and it is advisable that the highest expert advice should be secured before anything of the kind is undertaken.

WAREHOUSE COOLING.

A pre-cooling and experimental fruit warehouse was erected by the Dominion Government at Grimsby, Ontario, during 1914. This warehouse, which was built and equipped according to the design of the senior author, is intended to afford facilities for carrying on experiments in the cold storage of different varieties of fruit and also in demonstrating the value of pre-cooling for long-distance shipment.

There are 4 pre-cooling rooms on the main floor, each having a capacity for cooling one carload of fruit per 24 hours. In addition to the pre-cooling and experimental chambers, there is storage space for 12 to 15 cars of fruit. A large number of trucks are provided, and these are loaded with the fruit from the growers' drays and then wheeled into the pre-cooling rooms to remain there without unloading until the fruit is to be loaded into the cars. The truck is then wheeled direct into the car.

It is believed that a warehouse of this type equipped either with the gravity brine system, or with mechanical refrigeration, will best serve the needs of localities where a sufficient quantity of fruit is shipped to warrant the cost.

THE COLD STORAGE OF APPLES INTENDED FOR LONG KEEPING.

It is one thing to keep apples merely from rotting, and another thing to preserve them in that crisp, juicy condition which adds so much to their value and encourages large consumption. Some varieties may be preserved in ordinary storage quite as long as it is desirable to keep them, but most of the standard varieties could be delivered to market in better condition and with less loss from decay if they were promptly cold stored after picking. This point should be emphasized as it is of the highest importance that there should be as little delay as possible. A delay of one week between picking and storing will shorten the life of the apple, even if it is afterwards kept in cold storage. This applies particularly to the early or quick ripening varieties. Any apple which had become soft is too ripe for successful cold storage treatment. Any decay in the form of rots, especially the ordinary brown or soft rot, will be arrested very little, if arrested at all. The Northern Spy may be cited in this connection. Well developed specimens of this variety with sound skins, stored promptly after picking, will keep exceedingly well, but at the same time, this variety is also very susceptible to rots if the skin is broken or injured in any way, and for this reason it frequently does not keep well in cold storage.

Apples which are well matured on the trees, but still firm, will keep better and longer than if picked at any earlier stage. Well matured apples show less tendency to scald. This is very marked in the case of the Rhode Island Greening. In tests which the Department made in 1909-10 with apples of this variety, those that were picked rather early scalded badly in cold storage, while others from the same tree picked three weeks later were almost free of this rather serious defect. If the Green-

ing has reached the stage when it shows a faint blush, there is not apt to be much scalding. A good colour seems to be a great protection against scalding in all varieties. It is generally held that late varieties of apples grown in those localities where the season is longest and where they reach the greatest maturity on the trees, are the ones which will give the best results in cold storage. There are usually complaints about the poor keeping of apples in the winters following warm autumns, and yet the crop in such a season possesses the very qualities which would give good results in cold storage, providing the apples are picked and stored at the proper time.

RE-PACKING OF BARRELLED APPLES UNNECESSARY IF HELD IN COLD STORAGE.

The re-packing of barrelled apples, which is now so generally practised in the frost-proof warehouses in Ontario and Nova Scotia, could probably be dispensed with if the apples were sent promptly to cold storage after careful packing in the first place. In 1909 the Dairy and Cold Storage Branch made some trial shipments to test this matter. A carload of Spies and Baldwins was divided, one lot of each variety being put in a frost proof warehouse and the other sent to cold storage, at St. John, N.B. The first lot was re-packed, but the cold storage lot was shipped without re-packing. Both lots were sold together in Glasgow in the month of March. After paying the cold storage rates, it was found that the cold storage lot netted from 10 to 70 cents per barrel more than the others.

There were both No. 1 and No. 2 apples in these lots, and it is interesting to note that the No. 1 apples gave the greatest gain in cold storage. Full particulars of these trial shipments will be found in Bulletin No. 24 of the Dairy and Cold Storage Series. It may be of interest to add that one box of Spies from the cold storage lot was held for 18 months. The quality was well preserved and the apples stood up well after being removed to ordinary room temperature. This box of apples was held for the first six months at 32 degrees, and after that at 30. The latter is undoubtedly the best temperature; but, of course, it is very near the danger line, and great care has to be taken at such an extremely low temperature to prevent some part of the storage room from reaching the freezing point of the apples.

THE SEASON FOR CHOICE VARIETIES MAY BE EXTENDED.

The matter of extending the season for certain varieties is important, but it is well to consider carefully, before attempting to carry apples much past their regular season, as to what the probabilities are of finding a profitable market for them. It would not be advisable to carry some varieties into the season for others of superior quality, but choice dessert apples like the Fameuse and McIntosh Red for instance, will always find a market if in good condition. The Gravenstein is another fall apple which responds to cold storage treatment, and is much improved in carrying quality by prompt cooling after picking. The season for the Rhode Island Greening has been extended in New York State by at least two months by means of cold storage. The King is another variety which does well in cold storage, especially if it is well coloured and stored promptly.

STORAGE OF PEARS AND SMALL FRUITS.

With respect to other fruits, the pear is probably the one which gives best results in cold storage. Some varieties may be carried for several months in perfectly satisfactory condition. Many pear growers in the Hudson River Valley store a large part of their crops and market them in New York for the Christmas trade.

We are of the opinion that the season for special varieties of grapes might easily be extended very considerably with proper management, but the data relating to grapes in cold storage is very scanty.

WRAPPERS AND COLD STORAGE.

The life of fruit is prolonged by the use of paper wrappers. The wrapper helps to prevent the bruises which may result from the handling and pressure of tight packing, and it also prevents the spread of mould spores or other germs of decay from one fruit to another. The wrapper offers the further advantage that it prevents, to some extent, the collection of moisture on the surface of the fruit when it is changed from a low temperature to a comparatively high one.

THE COLD STORAGE OF EGGS.

Cold storage has, during recent years, almost entirely superseded other methods for the preservation of eggs in large quantities. The knowledge gained by experience and the improved equipment of cold storage warehouses has combined to eliminate certain imperfections which were at one time thought to be inseparable from this method of preservation. These defects are now properly attributed to bad management of the egg rooms, or to the fact that the eggs were too old when placed in store. The age of an egg in respect to condition is determined as much by the temperature to which it has been exposed as it is by the number of days that may have elapsed since it was laid. Eggs for long keeping in cold storage should be gathered as soon as they are laid. Only clean eggs should be accepted and they should be placed in cold storage as quickly as possible. The eggs produced during the months of April, May and the early part of June are the most suitable for cold storage purposes. Candling is advisable unless one is absolutely sure the eggs are new laid. When the weather becomes warm, the eggs deteriorate so quickly that it is difficult to secure them in good condition, and in no case should they be stored without candling. If they are kept in cold storage any length of time, they should be re-candled before placing them on the market.

Eggs which are allowed to lie around a country store for a week or more exposed to heat and injurious odours, are not suitable for cold storage.

The cases and fillers, it is needless to say, should be new and made of odourless material. Many eggs are tainted by musty fillers, or fillers which become musty in store.

Any person who uses secondhand cases or old fillers is liable to meet with very much disappointment and financial loss. Care should be taken to see that any material which is used as a cushion for the bottom and top layer of eggs, should be thoroughly dry and free from any signs of mould or "mustiness." For that reason, new excelsior is probably the best material to use for that purpose.

One of the defects of cold storage eggs in the past has been a tendency to develop mustiness of flavour, due to the growth of mould or "fungus" on the shell. Two conditions which promote the growth of mould are moisture and too high a temperature. It follows, therefore, that the lower the storage temperature is, and the drier the air in the room is kept, the less will be the trouble from mould, other things being equal. But there is a practical limit to the reduction of the humidity, and if carried too far, it will cause excessive shrinkage in the eggs. It is now generally recommended that 78 to 83 per cent of relative humidity is about right at a temperature

of 29 to 30 degrees. The humidity may be controlled, to some extent, by keeping calcium chloride in trays suspended in the air currents, as the affinity of this salt for water is very great. Some authorities claim that calcium chloride has a germicidal effect also, and that the air of the room passing over surfaces wetted with calcium chloride brine is more or less disinfected.

A sling psychrometer should be provided for determining the relative humidity. This consists of two accurate thermometers firmly fixed to a frame, which is attached to a handle with a swivel so that it can be whirled in the air. The bulb of one thermometer, which should project about one inch below the frame, is covered with a piece of muslin, and before whirling, this bulb is moistened with water at as nearly as possible the same temperature as the storage room. After whirling for about half a minute, the readings should be quickly taken. The evaporation of moisture from the muslin covered bulb reduces the temperature as shown on that thermometer, and the drier the room is, the more rapid will be the evaporation; hence, the greater the difference in the readings of the two thermometers. Other forms of the wet and dry bulb thermometer are provided with devices for keeping the muslin constantly wet. These last named instruments should be fanned vigorously for half a minute before taking the reading. A table for calculating the relative humidity from the difference in the two readings will be found on page 18.

A considerable change of opinion has taken place in regard to the minimum temperature for egg storage during recent years. At one time, 40 degrees was considered to be low enough, but the temperature has been gradually reduced, until now the most experienced egg men hold the temperature as low as possible without freezing the eggs. The critical temperature for perfectly fresh eggs is about 27 to 28 degrees, but 29 to 30 is as low as it is practicable to keep the temperature in egg rooms. Very perfect equipment and exceedingly good insulation are required to maintain a uniform temperature of 29 to 30 degrees without having some part of the room too cold. The indirect or air circulation system is generally popular for the equipment of egg storage rooms, and it is needless to argue that if the insulation is very efficient a smaller amount of refrigeration will be required to maintain the temperature of the room at the desired point, and there will be less difference between the average temperature of the rooms and that of the air at the point where the circulation enters.

It is an advantage also to have the inlets for cold air well distributed, so as to reduce the flow of air at any given point.

In piling the egg cases in a storage room, it is necessary to put dunnage between the different tiers so as to make provision for a free circulation of air among the cases. When eggs are kept at 29 or 30 degrees, it does not seem to be necessary to turn the cases from time to time, as it is when the temperature is higher. The low temperature stiffens the white of the egg to such an extent that the yolk is prevented from floating and becoming attached to the shell. In connection with this point, it is also advised that the eggs should be placed in the fillers with the point down, because it is obvious that the yolk in rising will not come in contact with the shell as quickly with the big end up as it would if the point were up.

Difficulty is usually experienced in removing eggs from low temperatures into the ordinary atmosphere without injury, especially in climates where the relative humidity is high. The cold egg collects moisture from the air. One plan of avoiding the condensation of moisture is to remove the eggs by successive stages through rooms, each of a higher temperature than the preceding one, until the outside temperature is approached. Another plan for handling small quantities of eggs is to bring

them into a moderate temperature room a few hours before they are to be taken away from the warehouse, and there they should be covered with a tarpaulin or canvas to prevent the circulation of air in and around them while they are being warmed to the temperature of the air in the room.

Too much care cannot be given to egg storage rooms to have them thoroughly disinfected every year. As soon as they become empty they should be thoroughly dried by ventilation and heating, if necessary, and then given two coats of whitewash. For the purpose of thorough disinfection, a scrubbing of the interior surfaces with a solution of 1 part bi-chloride mercury (corrosive sublimate) to 1,000 parts of water, before whitewashing, will thoroughly destroy all spores of mould or other germs.

TABLE OF RELATIVE HUMIDITY PER CENT.

	Difference between Dry and Wet Thermometers.												
Dry Thermometers.	0·5	1·0	1·5	2·0	2·5	3·0	3·5	4·0	4·5	5·0	5·5	6·0	Dry Thermometers.
27	94	88	82	76	70	64	59	53	47	42	36	30	27
28	94	88	82	76	71	65	60	54	49	43	38	33	28
29	94	89	83	77	72	66	61	56	50	45	40	35	29
30	94	89	84	78	73	67	62	57	52	47	41	36	30
31	95	89	84	79	74	68	63	58	53	48	43	38	31
32	95	90	84	79	74	69	64	59	54	50	45	40	32
33	95	90	85	80	75	70	65	60	56	51	47	42	33
34	95	91	86	81	75	72	67	62	57	53	48	44	34
35	95	91	86	82	76	73	69	65	59	54	50	45	35
36	96	91	86	82	77	73	70	66	61	56	51	47	36
37	96	91	87	82	78	74	70	66	62	57	52	48	37
38	96	92	87	83	79	75	71	67	63	58	54	50	38
39	96	92	88	83	79	75	72	68	63	59	55	52	39
40	96	92	88	84	80	76	72	68	64	60	56	53	40
41	96	92	88	84	80	76	72	69	65	61	57	54	41
42	96	92	88	84	81	77	73	69	65	62	58	55	42
43	96	92	88	85	81	77	74	70	66	63	59	56	43
44	96	92	88	85	81	78	74	70	67	63	60	57	44
45	96	92	89	85	82	78	75	71	67	64	61	58	45
46	96	93	89	85	82	79	75	72	68	65	61	58	46
47	96	93	89	86	83	79	76	72	69	66	62	59	47
48	96	93	89	86	83	79	76	73	69	66	63	60	48
49	97	93	90	86	83	80	76	73	70	67	63	60	49

Example.—If the dry bulb gives a reading of 30 degrees and the wet bulb shows a difference of two degrees lower, the figures in the column under two degrees and opposite 30 is 78, which represents the relative humidity.

RELATIVE HUMIDITY FOR A GIVEN TEMPERATURE IN EGG ROOMS.

There is not much data recorded on this subject.

Madison Cooper suggested the following relation between temperature and relative humidity:—

Temperature.	Relative Humidity per cent.	Temperature.	Relative Humidity per cent.
28	85	35	68
29	83	36	66
30	80	37	64
31	79	38	61
32	75	39	59
33	74	40	56
34	70		

If it is desirable to increase the humidity, sprinkle water on the floor wherever possible, or hang damp cotton in front of the openings of the cold air duct. To reduce the humidity, place trays of broken or pulverized chloride of calcium in different parts of the room. Catch basins, sloping to one end, should be placed beneath the trays to carry off the drip. The humidity is higher at the ceiling than at the floor, and if the trays are placed near the ceiling the results will be more satisfactory and the trays will be out of the way. The best style of a chloride of calcium container is one made like a wire basket, about 2 feet wide and any length necessary. A galvanized iron pan 2 inches wider than the container should be placed about 6 or 8 inches below it to carry off the drip.

THE COLD STORAGE OF FURS AND WOOLLENS.

All goods subject to attack by moths are absolutely protected from such injury if kept in a temperature under 40 degrees. In large centres of population, a profitable trade is being developed in the storage of this class of goods, which includes fur in all forms, woollen clothing, blankets, carpets, rugs, drapery, etc. The cold storage of furs also prevents the deterioration which follows their exposure to a hot, dry atmosphere. The softness, therefore the durability, of the skin, and the glossiness of the fur are preserved by low temperatures.

No attention is necessary during the period of storage, but the warehouseman in his own interest should make a careful inspection when the goods are received, and note on the receipt any defect or injury which may be apparent at that time. All goods should be well shaken and brushed before being placed in storage, and all traces of "moth balls" or other evil smelling substances carefully removed in order to avoid risk of injury or taint of food products in the same warehouse. A special room should be set aside for this class of custom, if the quantity of goods received will warrant it.

INSULATION.

Insulation.—Refrigerating engineers have during the last few years practically discarded the empty space—the so-called dead air space—once extensively used for insulating purposes. Theoretically, a dead air space is a poor conductor of heat, but the ordinary air space is not a dead air space. As one side of the space becomes warmer than the other, the air immediately in contact with it becomes lighter on account of the increase in temperature and at once ascends, while colder air from the other side takes its place. Thus we have a circulation of air within the space and heat is carried from one side to the other by convection.

In the insulation of wooden walls, the best practice at the present time provides for an outer and inner shell, as nearly as practicable impervious to air and dampness, with a space between to be filled with some non-conducting material. The width of the space will depend on the filling to be used and the temperature to be maintained in the storage room.

For a cold storage constructed of wood, there is no better material for filling spaces than planing mill shavings. Where available at all they are cheap; they are elastic and do not settle readily; but most important of all, they can be obtained in a very dry condition and they do not absorb moisture readily after being placed in position. One foot of shavings, if protected from dampness, provide sufficient insulation for ordinary purposes. There may be some difficulty in obtaining a sufficient supply of shavings in places remote from manufacturing centres, but many of the large sash and door factories now pack shavings in bales, weighing about 75 pounds each, for convenience in shipping. The weight of shavings required to fill a given space will depend somewhat on the kind of wood from which they are made, and also to some extent on how tightly they are packed, but a fair average is from 7 to 9 pounds per cubic foot of space. They should be packed sufficiently to prevent subsequent settling.

Sawdust vs. Shavings.—Because it costs little or nothing and is readily available in most country districts, there has been a tendency to use sawdust for filling spaces in the walls of small cold storage buildings. It is, however, far from being a satisfactory material for this purpose. In the first place, as sawdust is cut from green timber, it is always more or less damp and is, therefore, not a good insulating material. The dampness not only conducts heat, but it encourages the growth of mould and rot, first in the sawdust itself, and then in the walls of the building. As a result of the mould, the air in the storage room becomes musty and thus injurious to the quality of the foods stored therein. If it is found impossible to procure shavings, sawdust is probably the next best cheap material, if it is well dried before being used.

Insulation must be dry.—One of the problems in cold storage construction is to provide against moisture being absorbed by the materials composing the insulation. Moisture or dampness may come from the outside air or from the goods in storage. It must be understood that dampness, as referred to in this connection, does not imply the presence of water in the ordinary sense, but simply the presence of moitsure as we find it, say, in green lumber as compared with dry or well seasoned lumber.

In a wooden wall filled with shavings, it is the shavings which must be protected from dampness. This can be done by using damp-proof paper between the two courses of sheathing or boarding, both on the outside and the inside of the walls.

Brick or concrete walls absorb moisture readily, and unless they are given some special waterproofing treatment, the insulating quality of such a wall is rather low. The outside surfaces of brick walls may be painted with some effect, but where shavings are to be used inside of brick or concrete, the inner surface may be coated with pitch, paraffin wax, or some of the patented coatings on the market. Coating walls with either pitch or paraffin in cold or even cool weather without special apparatus is a rather difficult operation, on account of the tendency of both substances to harden very quickly. In using pitch, care must be taken not to get coal tar, or any mixture of coal tar, which would be ruinous on account of its odour. Pitch is odourless when it hardens. If the inside surfaces of brick or concrete walls cannot be properly waterproofed, the next best plan is to put 1-inch furring strips on the wall, then one course of matched lumber, which will form the inside surfact of the space to be filled. It will be all the better if the sheathing is covered with damp-proof paper.

Spruce lumber to be used.—Only spruce lumber should be used for the inside finish of refrigerators, ice boxes, or for the ice chamber.

SPECIAL INSULATING MATERIALS.

No attempt will be made to deal herein with the various prepared insulating materials such as cork board, slag wool, flax fibre, etc. These materials are put on the market as proprietary articles, and those who control them are always ready to give full particulars as to their use and cost. Cork board and flax fibre (Lith) have been extensively used of late years in the insulation of the larger cold storage warehouses, and especially in cases where the structural part of the building has been of concrete or brick.

PROBLEMS OF MANAGEMENT.

There is probably no other line of business which will show the effect of poor equipment, bad management or insanitary conditions like the cold storage business. The goods stored are of such a perishable nature that the whole equipment must be kept up to a very high state of efficiency in order to secure results which are at all satisfactory, and the manager of a cold storage warehouse is often confronted with problems which will tax his knowledge and ability to the limit. Some of these problems are (1) the question of humidity in high temperature rooms, (2) placing the different kinds of produce in the warehouse, so that none are injured through unfavourable temperatures or from odours arising from other produce, and (3) keeping the warehouse clean and sweet smelling.

The proper humidity to be maintained for the different kinds of produce is a question which has not yet been gone into very thoroughly and the data on the subject is not very extensive. However, we think every cold storage manager should know the relative humidity in his high temperature rooms, as there is no doubt it is an important factor in keeping different kinds of vegetables, fruit and eggs in the very best condition, and we would suggest that a record of the relative humidity be kept for reference.

(See reference to sling psychrometer on page 17, and table for calculating the relative humidity from the difference in the readings on page 18.)

In placing the many kinds of produce which are now delivered to cold storages, we would emphasize the importance of storing all high flavoured goods, or goods susceptible to other flavours, in separate rooms as far as possible. Under this head we would place such goods as butter, eggs, fish and onions. Apples, evaporated fruits, etc., may be stored with like commodities, or with enclosed goods where flavours are not likely to penetrate.

Butter is sometimes stored with lamb, beef quarters, poultry, etc., and there does not appear to be any objection to this practice if the freezing is done in separate rooms.

Eggs absorb odours readily, and in no case should they be stored with other produce. Fish and onions, on account of their high odour, should be stored separately from other produce. Cold storage goods have been very much injured in the past through carelessness or inattention to these details.

Racks or hangers of some description should be provided for game, poultry, fowl, etc. It is bad practice to store such goods in heaps on the floor. It is also advisable to have floor racks, so that meat, fish and other commodities will not come into contact with the floor. This is especially true if there is much difference in the temperature of the rooms underneath. The racks should be made of good strong material and in sections so that they can be taken out and cleaned when necessary.

COLD STORAGE TEMPERATURES FOR DIFFERENT ARTICLES.

—	—	Degree Fah.
Apples	Long storage	31 to 32
Apples	Short storage	35
Apples, evaporated		28
Butter	Long storage	0 to 10
Butter	Short storage	20
Cabbage		32
Carrots		33
Celery		32 to 33
Cheese, cool cured		55 to 60
Cheese, ordinary cured		36 to 40
Eggs		29 to 30
Furs		30 to 40
Fish, to freeze		-15 to 0
Fish, frozen for storage		12 to 14
Game, to freeze		5 to 0
Game, frozen	Long storage	10
Game	Short storage	28
Lard		38 to 40
Lemons		38
Meats, to freeze		0 to 10
Meats	Long storage	12 to 15
Meats	30 days	30
Meats	A few days	35
Milk		38 to 40
Onions		32
Oranges		34 to 35
Parsnips		33
Potatoes		34
Poultry, to freeze		- 5 to 0
Poultry, frozen	Long storage	10
Poultry	Short storage	28
Pork	Short storage	30

SANITATION.

Different warehouses vary greatly in cleanliness and in the purity of the air in the rooms. The nature and extent of the business has something to do with this problem, but it is a matter of management more than anything else. Some warehouses where all kinds of goods are stored are kept in ideal condition, and one feels that articles of food coming out of these places are worth a premium over those which have been stored in other places which have not been so well managed.

In most warehouses there is a season of the year when business is slack, and this opportunity should be used for a general cleaning up. There is nothing that sweetens a cold storage warehouse like whitewash, and we would strongly recommend that every part of the building should have at least two coats per year.

The following formula for making whitewash is taken from Cooper's Practical Cold Storage.

HOW TO PREPARE WHITEWASH.

Slake half a bushel of lime with hot water, stirring continuously while slaking, strain it and add one peck of salt dissolved in warm water. The proper consistency for whitewash is a thin paste, and water will have to be added to secure this consistency after mixing the dissolved salt with the whitewash.

To each 12-quart pail of whitewash composed as above, add a good fair handful of Portland cement and a teaspoonful of ultramarine blue. The cement and blue should be added only as the whitewash is being used and should be thoroughly stirred into the whitewash; otherwise, when applied it will be streaked.

If there are any pipes or other equipment in the rooms to be whitewashed that will rust, do not use salt in the mixture around the piping.

Don't put on too thick a coat—just enough to cover the surface in good shape —then allow from 1 to 3 days for drying. If you dry the whitewash out too quickly it will flake or brush off very easily; on the other hand, a very slow drying will allow the water to soak into the wood and may cause unpleasant odours.

Whitewash containing Portland cement must be used without delay.