
INTERNATIONAL STANDARD



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Apples — Guide to cold storage

Pommes — Guide pour l'entreposage par réfrigération

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FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO Member Bodies). The work of developing International Standards is carried out through ISO Technical Committees. Every Member Body interested in a subject for which a Technical Committee has been set up has the right to be represented on that Committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

Draft International Standards adopted by the Technical Committees are circulated to the Member Bodies for approval before their acceptance as International Standards by the ISO Council.

Prior to 1972, the results of the work of the Technical Committees were published as ISO Recommendations; these documents are now in the process of being transformed into International Standards. As part of this process, Technical Committee ISO/TC 34 has reviewed ISO Recommendation R 1212 and found it technically suitable for transformation. International Standard ISO 1212 therefore replaces ISO Recommendation R 1212-1970 to which it is technically identical.

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ISO Recommendation R 1212 was approved by the Member Bodies of the following countries :

Australia	Greece	Paraguay
Brazil	Hungary	Poland
Bulgaria	India	Portugal
Chile	Iran	Romania
Colombia	Italy	South Africa, Rep. of
Czechoslovakia	Korea, Rep. of	United Kingdom
France	Netherlands	Turkey
Germany	New Zealand	U.S.S.R.

No Member Body expressed disapproval of the Recommendation.

The Member Body of the following country disapproved the transformation of ISO/R 1212 into an International Standard :

Poland

Apples – Guide to cold storage

1 SCOPE AND FIELD OF APPLICATION

This International Standard describes methods for obtaining conditions for the successful cold storage of apples.

The limits of application of this guide are given in the annex.

2 REFERENCE

ISO 2169, *Fruits and vegetables – Physical conditions in cold stores – Definitions and measurement.*

3 CONDITIONS OF HARVESTING AND PUTTING INTO STORE

3.1 Harvesting

The principal criteria used to determine the optimal state of ripeness for harvesting are as follows¹⁾:

- the ease of picking (the fruit is picked when it is easily separated from its spur; this is not, however, an objective criterion);
- the colour (period of change from green to yellow), which is judged with the aid of standard tables;
- the age of the fruit, expressed as the number of days that have elapsed since full flowering.

These criteria are not universally valid; for a given variety they vary from one region to another and it is for the grower to decide on his own criteria for picking, on the basis of experience.

3.2 Quality characteristics for storage

Fruit put into cold storage should be sound, free from bruises or obvious physiological disorders, and free from any visible sign of fungal or bacterial attack. It should be clean and free from traces of water in the liquid state.

3.3 Various treatments before storage

The practice of pre-ripening should be forbidden, as it is the source of much wastage in storage.

3.4 Putting into store

The fruit should be put into the cold immediately after harvesting.

3.5 Method of storage

The packages should be of such a kind, and so arranged in the cold store, as to permit free circulation of air. As an indication, storage densities of 200 to 250 kg per cubic metre of usable space, for apples in cases, are considered as maxima that should not be exceeded.

The use of box pallets makes possible an increase of 10 to 20 % in storage density.

4 OPTIMUM STORAGE CONDITIONS²⁾

4.1 Temperature

Most varieties of European origin keep in the neighbourhood of + 4 °C; a lower temperature is harmful. Apples of American origin, on the other hand, keep well at 0 °C. There are exceptions: for example the Jonathan variety at 0 °C is sometimes affected by the internal browning which is characteristic of low-temperature disorders.

Table 1 gives the recommended temperatures for different varieties entering into international trade. In controlled-atmosphere storage, the storage temperature is sometimes higher, as shown in table 2.

4.2 Relative humidity

The optimum relative humidity for storage of apples is 90 %.

4.3 Air circulation

There should be a uniform distribution of air within the cold store, the rate of mixing being sufficient to keep the spatial differences in temperature and humidity within reasonable limits. Such devices as carbon filters and air washers, to remove volatile organic products of metabolism, are of doubtful value since such gases have no significant physiological effects at the recommended temperature of storage.

1) Tests for the hardness of the flesh, and for the presence of starch, can also be used.

2) For definitions and measurement of the physical quantities affecting storage, see ISO 2169.

If the apples are being stored in air, and the cold store is sufficiently gas-tight for carbon dioxide to accumulate, some means of ventilation should be provided.

4.4 Storage life

Table 1 gives the expected storage life for different varieties entering into international trade, under the storage conditions mentioned above.

It is necessary in every case that the storage is not prolonged beyond limits compatible with the maintenance of good quality.

It is also essential to draw samples of the fruit periodically so as to detect immediately the appearance of wastage during storage. Table 1 shows the susceptibility of these varieties to such wastage.

5 ADJUNCTS AND OTHER METHODS OF KEEPING

5.1 Controlled-atmosphere storage

The following gas mixtures are most frequently recommended¹⁾ :

1) carbon dioxide	5 %
oxygen	2 %
nitrogen	93 %

2) carbon dioxide	10 %
oxygen	10 %
nitrogen	80 %

3) carbon dioxide	0 %
oxygen	3 %
nitrogen	97 %

4) carbon dioxide	5 to 8 %
oxygen	12 to 15 %
nitrogen	difference to 100 %

These compositions are given by way of illustration, and it will be for the experts in each country to give any necessary advice on any other kinds of composition, according to the particular requirements of each variety, as regards the content of carbon dioxide or of oxygen in the atmosphere, or on account of particular local conditions.

Table 2 summarizes, for certain varieties, the gas mixtures which have given the best results, and also the recommended temperature and the expected storage life.

5.2 Storage in plastics packages

The use of certain types of plastics films known to be suitable for contact with food products permits losses in mass during storage to be reduced considerably. Interesting results have been obtained in this way by lining boxes of apples with plastics film or by covering a certain quantity of cases with a plastics tarpaulin.

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1) The following similar compositions have also been recommended :

— In Australia :	carbon dioxide	2 to 3 %
	oxygen	2 to 3 %
	nitrogen	94 to 96 %
— In New Zealand :	carbon dioxide	2 %
	oxygen	3 %
	nitrogen	95 %

TABLE 1 – Storage in air

Variety	Recommended temperature °C	Expected storage life months	Susceptibility to wastage during storage
Reine des Reinettes	+ 4	3	– susceptible to internal low-temperature browning below + 2 °C
Cox's Orange Pippin	+ 3 to + 4	3	– bitter pit – internal low-temperature browning below + 3 °C
Belle de Boskoop	+ 3 to + 4	5 to 6	– scald – internal low-temperature browning below to + 3 °C
Jonathan	+ 2 for one month + 1 for the succeeding month and there- after at 0	4 to 5	– internal low-temperature browning – Jonathan spots – internal browning due to ageing
	+ 3 to + 4	3	
Canada Reinette	+ 4	4 to 5*	– bitter pit – internal low-temperature browning – browning due to ageing
	+ 7	4	
Richared	0	6	
Clochard's Reinette	+ 2	7 to 8	– insufficient colour at temperatures below + 5 °C
	+ 5	5 to 6	
Golden Delicious	– 1 to 0	7	– only for fruits coloured at harvesting
	+ 2 to + 4	5	– soft scald – lenticel rot
Mans Reinette	0 to + 1	5 to 6	– late scald – lenticel rot
	+ 3 to + 5	5 to 6	
Stayman Winesap	0 to + 2	4 to 5	– very susceptible to scald and disorders due to fungi
Winesap	0 to + 2	5 to 6	
Red Delicious	0 to + 2	6	– disagreeable flavour after 6 months' storage
Starking (Delicious Red)	0 to + 2	5 to 6	
Winter Banana	+ 2 to + 3	4 to 5	
Calville Blanc	+ 4	5	– bitter pit
Ontario	+ 4	5 to 6	– very susceptible to scald – internal browning at temperatures below + 2 °C
Blenheim Orange	+ 3 to + 4	2 to 3	
Bramley's Seedling	+ 3 to + 4	3 to 4	
Laxton's Superb	+ 3	3 to 4	
Mac Intosh	0 to + 1	4 to 5	– susceptible to internal browning limited to small spots in the seed cavities
Morgenduft = Imperatore	0 to + 2	5 to 7	– scald – lenticel rot
Abbondaza	+ 2 to + 4	4 to 6	– internal low-temperature browning
Rosa di Caldaro	+ 2	5 to 6	– internal low-temperature browning

* The storage life of apples grown at altitude might be prolonged to 6 or 7 months.

TABLE 1 (concluded)

Variety	Recommended temperature °C	Expected storage life months	Susceptibility to wastage during storage
Renetta Champagne	0 to + 2	7 to 8	— spots
Granny Smith	0	5	— scald — core browning
Sturmer Pippin	+ 2 to + 3	6	— scald — internal browning

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 TABLE 2 – Controlled-atmosphere storage
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Variety	Recommended temperature °C	Recommended mixtures		Expected storage life months
		Carbon dioxide %	Oxygen %	
Bramley's Seedling	+ 3 to + 4	8 to 10	11 to 13	6 to 8
Cox's Orange Pippin	+ 3 to + 4	5	2,5	4 to 5
Golden Delicious	0	10	10	7 to 8
		5	2	
		2	3	
Jonathan	+ 3	0	3	6
	+ 3,5	9	12	
		7	13	
	+ 4	6	15	
Starking (Delicious Red)	0	5	3	6 to 8
	+ 3	0 to 3	3	
Laxton's Superb	+ 4,5	10	2,5	6 to 7
		6	14	
Mac Intosh	+ 3,5	5	3	
		7	14	
Winston	+ 2 to + 3	7	13	8 to 9
Belle de Boskoop	+ 4	5	2	6 to 8
Richared	0	5	2	6 to 8
		10	10	6 to 7
Stayman Winesap	0	5	2	6 to 8
Winesap	0	5	2	6 to 8
Sturmer Pippin	+ 2 to + 3	2	3	8
		5	3	
		5	5	
		7	7	
Rome Beauty	0	2	3	7

ANNEX

LIMITS OF APPLICATION – ECOLOGICAL EFFECTS AND DEFECTS ARISING DURING STORAGE

A.1 LIMITS OF APPLICATION

This International Standard provides guidance of a very general nature only. Because of the variability of the fruit according to the time and place of cultivation, local circumstances may make it necessary to specify other conditions of harvesting or other physical conditions in the store.

These recommendations do not apply unreservedly, therefore, to all varieties in all climates, and each specialist will himself decide on any modifications to be made.

Moreover, this International Standard does not take into account the role played by horticultural factors, and wastage during storage is not dealt with. The importance of these two subjects has not been forgotten, but the influential factors (i.e. ecological or agrotechnical factors) are not very well understood; moreover, the origin of many of the most frequent physiological disorders of apples is still uncertain, as are often the appropriate means of combating them. It has therefore seemed difficult to prepare International Standards on these two points.

Nevertheless it has seemed useful to give, in this annex and for purposes of record, a few recommendations which appear sufficiently well founded in the present state of knowledge.

Subject to all possible restrictions arising from the fact that fruits are living material and may vary considerably, the application of the recommendations contained in this International Standard and this annex should enable much wastage in cold storage to be avoided and storage for a satisfactory period to be generally achieved.

A.2 INFLUENCE OF ECOLOGICAL FACTORS

The generally unfavourable influence of certain ecological and agrotechnical factors is now better known.

Under these conditions, and since it is also necessary to supply the market from the first weeks after harvesting, it is desirable not to put into cold storage at all (or only for a short period) fruit of which the unfavourable ecological background is liable to make good keeping a matter of delicate balance. This applies especially to

- fruit of large size;
- fruit from young trees;
- fruit from trees which are lightly loaded or closely pruned;

- fruit from trees which have been too heavily manured or treated with unbalanced fertilizer, particularly if the nitrogen content is too high;
- fruit harvested during a rainy period.

It should also be pointed out that after a cold, damp summer, keeping is delicately balanced and, finally, that irrigation should be carried out with care and that any excess is detrimental to keeping.

A.3 DEFECTS ARISING DURING STORAGE

Generally distinction is made between damage of cryptogamic origin and damage of physiological origin.

A.3.1 Cryptogamic damage

Disorders originating from micro-organisms (whether parasites entering through wounds or latent parasites) are very numerous.

There are hardly any means of combating these, other than preventive measures concerned with

- care in all handling operations;
- sorting of sound from unsound fruit immediately before putting them into the cold store;
- preliminary disinfection of the cold store and packages;
- frequent disinfection of sorting rooms;
- systematic removal of sources of contamination in the orchard (cankers, rotten fruit, etc.);
- use of packages impregnated with antiseptics, if not prohibited.

The use of fungicidal aerosols has been recommended. Certain countries have, however, prohibited these.

A.3.2 Physiological damage

Table 3 classifies the most important data relating to the most frequent disorders.

The data are very general and may not apply to particular local conditions.

Specialists can amplify this table by investigations, in particular, of Jonathan spots, withering, brown heart, and internal browning in the form of small spots between the seed cavities.

TABLE 3 — Storage of apples — Physiological disorders

Designation and description of the disorder	Horticultural factors (ecology, date of harvesting) and factors relating to conditions in cold store provoking or revealing the disorder	Remedies, preventive measures	Susceptible varieties
Frost Glassy appearance of the flesh and epidermis, general softening	<ul style="list-style-type: none"> Lowering of temperature below the freezing point 	<ul style="list-style-type: none"> Prevent the lowering of temperature 	
Internal low-temperature browning The flesh acquires a brown colour, and finally the epidermis becomes brown	<ul style="list-style-type: none"> Excess of nitrogenous fertilizer Large fruit and fruit from poor harvest Long duration of storage at critical temperature (apples at 0 °C instead of + 4 °C) 	<ul style="list-style-type: none"> Raise the storage temperature for susceptible varieties 	<ul style="list-style-type: none"> Ontario Belle de Boskoop Cox's Orange Pippin Reine des Reinettes Jonathan Canada Reinette Sturmer Pippin
Internal browning due to ageing The flesh becomes brown, more or less dark; it is dry and mealy	<ul style="list-style-type: none"> Late harvest Delay in placing in the cold store Large fruit and fruit from poor crops Glassiness during harvesting Too long duration of storage 	<ul style="list-style-type: none"> Storage should not be continued when the risks of internal browning are considerable 	<ul style="list-style-type: none"> Jonathan Canada Reinette
Scald Browning of epidermis, in bad cases over the whole area	<ul style="list-style-type: none"> Premature harvesting Large fruit Insufficient changing of the atmosphere 	<ul style="list-style-type: none"> Thorough and frequent ventilation of the cold store Use of controlled atmosphere (use of chemical products or of oiled paper may also be mentioned) 	<ul style="list-style-type: none"> Ontario Stayman Winesap Mans Reinette Richared Belle de Boskoop Starking (Delicious Red) Granny Smith Sturmer Pippin
Bitter pit Small depressed spots of irregular shape, dark green in colour changing to brown	<ul style="list-style-type: none"> Mineral imbalance in the soil and the tree Large fruit and fruit from lightly loaded trees Premature harvesting 	<ul style="list-style-type: none"> Spraying of orchard with calcium nitrate or calcium chloride (red varieties) First treatment : two weeks after fall of petals (0,5 % solution), then every fortnight 	<ul style="list-style-type: none"> Cox's Orange Pippin Canada Reinette Calville
Internal cork Small brown spots below epidermis. Small brown spot may occur anywhere in the flesh and in the core zone. When the deficiency is acute the fruit is markedly distorted	<ul style="list-style-type: none"> Lack of boron 	<ul style="list-style-type: none"> Application of borax to the orchard (30 kg per hectare) or spraying by sodium pentaborate in the preflowering stage and at the setting of young fruit (0,02 % solution) 	<ul style="list-style-type: none"> Canada Reinette Belle de Boskoop Granny Smith Jonathan Sturmer Pippin Mac Intosh
Water core Translucent appearance of the flesh, starting at medium depth, continues towards the periphery and then towards the heart	<ul style="list-style-type: none"> Hot period accompanied by heavy rains or irrigation 	<ul style="list-style-type: none"> Suspend the cold storage Do not continue storage too long 	<ul style="list-style-type: none"> Delicious Stayman Winesap Mans Reinette Jonathan
Soft scald Light chestnut depressed spots forming a nearly continuous band round the fruit	<ul style="list-style-type: none"> Excess of nitrogen Influence of cold and damp weather Delay in placing in the cold store Keeping at too low a temperature 	<ul style="list-style-type: none"> Use a higher storage temperature 	<ul style="list-style-type: none"> Golden Delicious Jonathan Winter Banana