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Apples — Cold storage

Pommes — Entreposage réfrigéré



Reference number
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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 1212 was prepared by Technical Committee ISO/TC 34, *Agricultural food products*, Subcommittee SC 14, *Fresh fruits and vegetables*.

This second edition cancels and replaces the first edition (ISO 1212:1976), which has been technically revised.

Annex A of this International Standard is for information only.

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Introduction

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

This International Standard does not apply unreservedly, therefore, to all varieties (cultivars) in all climates, and it will remain for each specialist to be the judge of any modifications to be made.

Subject to all restrictions arising from the fact that apples are living material, application of the guidance contained in this International Standard should enable much wastage in storage to be avoided and long-term storage to be achieved in most cases.

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Apples — Cold storage

1 Scope

This International Standard gives guidance on conditions for the successful cold storage of apples (*Malus communis* L.).

2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 2169:1981, *Fruits and vegetables — Physical conditions in cold stores — Definitions and measurement*.

3 Conditions for harvesting and storage

3.1 Harvesting

The principal criteria used to determine the optimal state of maturity for harvesting are as follows:

- a) ease of picking (the fruit is picked when it is easily separated from its spur; this is not, however, an objective criterion);
- b) total soluble solids content of the juice (TSS);

- c) the ground colour of the outer skin (period of change from green to yellow) which is judged with the aid of standard tables;
- d) the age of the fruit, expressed as the number of days from full bloom to harvest;
- e) firmness of the flesh;
- f) presence of starch in the flesh;
- g) fruit should be placed in storage immediately before or at the preclimacteric respiratory minimum for best storage performance.

These criteria are not universally valid; for a given cultivar 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 Characteristics for storage

Fruits put into storage should be of quality "Extra Class" or "Class I", the characteristics of which are defined in UN-ECE Standard No. FFV-01¹⁾ as follows.

Apples are classified into three classes as follows.

a) "Extra" class

Apples in this category should be of superior quality. In shape, size and colouring they should be typical of the variety and the stalk should be intact. They should have no defects with the exception of very slight alterations of the skin provided that these do not detract from the quality and the general appearance of the fruit and/or the contents of the package.

1) UN-ECE Standard No. FFV-01:1981, *Dessert and culinary apples and pears*.

b) Class I

Apples in this class should be of good quality. They should have the characteristics typical of the particular variety. However, the following may be allowed:

- 1) a slight defect in shape;
- 2) a slight defect in development;
- 3) a slight defect in colouring;
- 4) the stalk may be slightly damaged;
- 5) the flesh should be perfectly sound; skin defects not liable to impair the general appearance and keeping qualities are, however, allowed for each fruit within the following limits:
 - defects of elongated shape should not exceed 2 cm in length;
 - in the case of other defects, the total area affected should not exceed 1 cm², with the exception of speckles which should not extend over more than 0,25 cm² in area.

c) Class II

This class includes apples which do not qualify for inclusion in the higher classes but satisfy the minimum requirements specified above.

Defects in shape, development and colouring are allowed provided that the fruit retains its essential characteristics as regards quality, the keeping quality and presentation. The stalk may be missing, provided that the skin is not damaged.

The flesh shall be free from major defects. Skin defects are, however, allowed for each fruit, within the following limits:

- defects of elongated shape should not exceed 4 cm in length;
- in the case of other defects, the total area affected should not exceed 2,5 cm², with the exception of speckles which should not extend over more than 1 cm² in area.

NOTE 1 This class is not suitable for storage. Requirements are given for information only.

3.3 Precooling

Fruits should be cooled as quickly as possible after harvest. Apples are not injured by rapid cooling. Rapid removal of field heat and precooling of harvested apples are essential for long storage.

3.4 Packing

The fruit should be handled with care. The packages should allow the free circulation of air. Storage densities of 200 kg to 250 kg per cubic metre of usable space are considered as the maxima for apples.

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

4 Optimum storage conditions

For definition and measurement of the physical quantities affecting storage, see ISO 2169.

4.1 Temperature

The storage temperature of apples depends upon the variety. The optimum storage temperature is between – 1 °C and 0 °C. Cultivars which are not susceptible to chilling should be stored nearly at the freezing point. The highest freezing point for apples is about – 1,5 °C. Chill-sensitive cultivars should be stored between 2 °C and 4 °C.

Table 1 gives the recommended storage temperatures in air for different cultivars marketed internationally.

4.2 Relative humidity

The optimum relative humidity for storage of apples is between 90 % and 95 %. The high relative humidity is needed in long-term storage to control excessive fruit shrivel of cultivars (such as Golden Delicious) that are prone to shrivel.

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. Devices such as carbon filters and air washers to remove volatile organic products of metabolism are of doubtful value. Scrubbers do not maintain the necessary low level of volatiles (particularly ethylene).

Some ventilation should be provided. The circulation system should be designed to provide 0,25 m/s to 0,35 m/s airflow around the stacked containers. This

can be obtained with a circulation system which provides at least 7,5 air changes per hour based on the volume of the empty storage room.

5 Other methods of storage

5.1 Controlled-atmosphere storage

Recommended atmospheres are 1,5 % to 3 % oxygen and 1 % to 3 % carbon dioxide. Apple cultivars sensitive to chilling benefit the most from controlled-atmosphere storage.

General recommendations for levels of oxygen, carbon dioxide, storage temperatures and expected storage lives are given in table 2 for different cultivars.

These recommendations provide a range of gas composition, and experts in each country may specify specific levels of carbon dioxide and oxygen, and recommend temperatures for cultivars according to local requirements.

5.2 Storage in plastic packages

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

6 Storage life

Tables 1 and 2 give the expected storage life for different cultivars marketed internationally for storage in air or in a controlled atmosphere, respectively.

It is necessary in every case that the storage is not prolonged beyond the 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 also shows the susceptibility of varieties to such wastage.

Table 1 — Storage in air

Cultivar	Recommended temperature °C	Expected storage life months	Susceptibility to wastage during storage
Abbondanza	+2 to +4	4 to 6	Internal low-temperature browning
Belle de Boskoop	+3 to +4	5 to 6	Scald Internal low-temperature browning below + 3 °C
Blenheim Orange	+3 to +4	2 to 3	
Bramley's Seedling	+3 to +4	3 to 4	
Calville Blanc	+4	5	Bitter pit
Canada Reinette	+4	4 to 5 *)	Bitter pit
	+7	4	Internal low-temperature browning Browning due to ageing
Clochard's Reinette	+2	7 to 8	Insufficient colour at temperatures below + 5 °C
	+5	5 to 6	
Cox's Orange Pippin	+3 to +4	3	Bitter pit Internal low-temperature browning below + 3 °C
Golden Delicious	−1 to 0	7	Only for fruits coloured at harvesting Soft scald Lenticel rot
	+2 to +4	5	
Granny Smith	0	5 to 6	Scald Core browning

Cultivar	Recommended temperature °C	Expected storage life months	Susceptibility to wastage during storage
Jonathan	+2 for one month, +1 for the succeeding month and thereafter at 0	4 to 5	Internal low-temperature browning Jonathan spots Internal browning due to ageing
	+3 to +4	3	
Laxton's Superb	+3	3 to 4	
Mans Reinette	0 to +1	7	Late scald Lenticel rot
	+3 to +5	5 to 6	
McIntosh	0 to +1	4 to 5	Susceptible to senescent breakdown
Morgenduft = Imperatore	0 to +2	5 to 7	Scald Lenticel rot
Ontario	+4	5 to 6	Very susceptible to scald Internal browning at temperatures below + 2 °C
Red Delicious	0 to +2	6	Disagreeable flavour after 6 months' storage
Reine des Reinettes	+4	3	Susceptible to internal low-temperature browning below + 2 °C
Reinette Champagne	0 to +2	7 to 8	Spots
Richared	0	6	
Rose de Caldarò	+2	5 to 6	Internal low-temperature browning
Starking (Delicious Red)	0 to +2	5 to 6	
Stayman Winesap	0 to +2	4 to 5	Very susceptible to scald and disorders due to fungi
Sturmer Pippin	+2 to +3	6	Scald Internal browning
Winesap	0 to +2	5 to 6	Senescent breakdown
Winter Banana	+2 to +3	4 to 5	
*) The storage life of apples grown at altitude might be prolonged to 6 or 7 months.			

Table 2 — Controlled-atmosphere storage

Cultivar	Recommended temperature °C	Recommended mixture		Expected storage life months
		Carbon dioxide %	Oxygen %	
Belle de Boskoop	+4	5	2	6 to 8
Cox's Orange Pippin	+3 to +4	5	2,5	4 to 5
Golden Delicious	−1 to 0	1 to 3	2 to 3	7 to 8
Granny Smith	+0,6	0 to 1	1,5 to 3	5 to 6
Jonathan	0 to +2	3 to 5	2,5 to 3	6
McIntosh	+3,5	2 to 5	3	6 to 8
Richared	0	5	2	6 to 8
Rome Beauty	−1 to 0	0 to 1	1,5 to 3	7
Starking (Delicious Red)	0	5	3	6 to 8
	+3	0 to 3	3	
Stayman Winesap	−1 to 0	2 to 5	2 to 3	6 to 8
Sturmer Pippin	+2 to +3	2 to 5	3 to 4	8
Winesap	0	1 to 2	2 to 3	6 to 8
Winston	+2 to +3	7	13	8 to 9
Yellow Newton	+3,3 to +4,4	7 to 8	2 to 3	6 to 8

Annex A

(informative)

Role of the grower and wastage during storage

A.1 Role of the grower (Influence of ecology and method of cultivation)

The general unfavourable influence of certain ecological and agrotechnical factors is now better understood. Therefore, and since it is also necessary to supply the market from the first weeks after harvesting, it may be desirable not to store, or to store for only a short time, fruit which because of poor cultural conditions may not store well.

This applies especially to

- large size fruit;
- fruit from young trees;
- fruit from trees which are lightly loaded or severely pruned;
- fruit from trees which have been too heavily manured or treated with unbalanced fertilizer, particularly if the nitrogen content is high;
- fruit harvested during a rainy period.

It should also be noted that after a cold, damp summer, fruit may not store well, keeping is delicately balanced, and irrigation should be carried out with care since excess may reduce storage life.

A.2 Wastage in storage

In general, distinction is made between damage of cryptogamic origin and damage of physiological origin.

A.2.1 Post-harvest diseases

Disorders originating from microorganisms (parasites entering through wounds or latent parasites) are numerous.

Losses from post-harvest diseases can be reduced by

- 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.2.2 Physiological disorders

Table A.1 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 spot, withering, brown heart and internal browning in the form of small spots between the seed cavities.

Table A.1 — Storage of apples — Physiological disorders

Designation and description of disorder	Horticultural factors (ecology, date of harvesting) and factors relating to conditions in cold store provoking or revealing the disorder	Remedies, preventive measures	Cultivars
Freezing — glassy appearance of flesh and epidermis; general softening	Lowering of temperature below the freezing point	Prevent lowering of temperature	
Internal low-temperature browning: — the flesh acquires a brown colour, and finally the epidermis goes brown	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)	Raise storage temperature for susceptible varieties	Ontario Belle de Boskoop Cox's Orange Pippin Reine des Reinettes Jonathan Canada Reinette Sturmer Pippin
Internal browning due to ageing (senescent breakdown): — the flesh becomes brown, more or less dark; it is dry and mealy	Late harvest Delay in placing in cold store Large fruit and fruit from poor crops Glassiness during harvesting Too long duration of storage	Storage should not be continued when risks of internal browning are considerable	Jonathan Canada Reinette
Storage scald: — browning of epidermis, in bad cases over whole area	Premature harvesting Large fruit Insufficient changing of the atmosphere Relative humidity is too high	Thorough and frequent ventilation of cold store Use of controlled atmosphere (use of chemical products or of oiled paper may also be useful)	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	Mineral imbalance in soil and tree Large fruit and fruit from lightly loaded trees Premature harvesting	Spraying of orchard with calcium nitrate or calcium chloride (red varieties). First treatment: 2 weeks after fall of petals (0,5 % solution), then every 2 weeks	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 core zone; when the deficiency is acute, the fruit is markedly distorted	Lack of boron	Application of borax to the orchard (30 kg per hectare) or spraying with sodium pentaborate in preflowering stage and at setting of young fruit (0,02 % solution)	Canada Reinette Belle de Boskoop Granny Smith Jonathan Sturmer Pippin McIntosh

Designation and description of disorder	Horticultural factors (ecology, date of harvesting) and factors relating to conditions in cold store provoking or revealing the disorder	Remedies, preventive measures	Cultivars
Water core: — translucent appearance of the flesh, starting at medium depth, continuing towards the periphery and then towards the heart	Hot period accompanied by heavy rains or irrigation	Suspend cold storage Do not continue storage too long	Golden Delicious Stayman Winesap Mans Reinette Jonathan
Soft scald: — light chestnut depressed spots forming a nearly continuous band round the fruit	Excess of nitrogen Influence of cold and damp weather Delay in placing in cold store Keeping at too low a temperature	Use a higher storage temperature	Golden Delicious Jonathan Winter Banana

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