INTERNATIONAL STANDARD ISO 3659

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Fruit and vegetables — Ripening after cold storage

Fruits et légumes — Maturation à l'issue de l'entreposage réfrigéré

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FOREWORD

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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.

International Standard ISO 3659 was developed by Technical Committee ISO/TC 34, *Agricultural food products,* and was circulated to the member bodies in October 1974.

It has been approved by the member bodies of the following countries :

Australia	Germany	Poland
Austria	Hungary	Romania
Chile	India	Spain
Czechoslovakia	Iran	Turkey
Egypt, Arab Rep. of	Ireland	Yugoslavia
France	Israel	

The member body of the following country expressed disapproval of the document on technical grounds :

New Zealand

Printed in Switzerland

Fruit and vegetables — Ripening after cold storage

0 INTRODUCTION

The techniques described in this International Standard are given for information only; each country, within the framework of its national regulations, may decree measures intended to forbid the use of certain procedures listed in this document.

In addition, the ripening techniques taken into account in this document only apply, either immediately after harvesting, or after a more or less long storage time, to products picked at a sufficient stage of physiological development. Supplementary ripening should in no case be applied to fruit or vegetables harvested ahead of time.

1 SCOPE AND FIELD OF APPLICATION

This International Standard describes methods the application of which enable good ripening conditions for fruit and vegetables[1] to be achieved following cold storage.

2 REFERENCE

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

3 AIM OF THE RIPENING FOLLOWING COLD STORAGE

Certain fruits are harvested and stored ripe (grapes, cherries, sweet chestnuts, raspberries, oranges, litchi) or at a stage close to full ripeness (apricots, strawberries, pineapples, peaches, plums). Others, on the other hand, are harvested and stored at a physiological stage very far from full ripeness (apples, pears, bananas).

The aim of the operation is therefore to improve the development of the fruit when this is insufficient and incomplete following cold storage, in order to obtain the optimum properties for consumption.

4 TEMPERATURE ZONES TO BE CONSIDERED

With regard to the fruit in the last category, when the behaviour of each species or variety in relation to the storage temperature is examined, it is apparent that there exist several temperature zones (or critical points) to be considered. Among these may be mentioned :

— an optimum cold storage temperature zone where the various phenomena characteristic of life are slowed down to the maximum without the appearance of physiological disorders;

— a ripening initiation temperature zone from and above which ripening begins to take place;

— a critical ripening temperature zone from and below which, when ripening does not normally take place, there appear physiological disorders.

When the optimum cold storage temperature and the ripening initiation temperature coincide, the fruits are ripe at the end of storage if the latter has been sufficiently long (for example apples kept at 4 °C). Ripening in this case is as often as not only necessary for fruit with insufficient colouring which may in this way acquire their ripe fruit colour (apples, lemons, mandarins, etc.).

On the other hand, when these two temperature zones are different, the fruits when taken from the cold room are not sufficiently developed and ripening following storage is then essential.

The treatments to be applied concern essentially either physical actions (temperature, humidity), or physical actions combined with chemical actions (ethylene, oxygen[2]). Their nature, duration and results depend on the species, the ecological history of the fruit, its physiological state at the end of cold storage, and the cold storage technique employed.

1) With regard to vegetables, this technique seems to be limited to tomatoes only.

2) These two substances are only indicated as examples.

5 INFLUENCE OF VARIOUS FACTORS ON RIPENING AFTER COLD STORAGE

5.1 Influence of the physiological state of the fruit

The physiological state of a fruit at the end of cold storage (or when harvested, if the ripening applies at this point) conditions the development of the fruit at the ripening temperature. Thus, for numerous fruits (apples, pears, peaches, lemons, etc.) too premature picking (insufficient development, excessive hardness) often does not allow correct ripening to be achieved.

Physiological diseases not apparent during cold storage may be revealed during ripening following such storage (internal browning of apples and pears, shrivelling, etc.).

5.2 Influence of the storage temperature

Numerous fruits which are subjected to too low a storage temperature or kept for too long a period at a temperature normally tolerated may undergo defective ripening when taken from the cold store; in addition, the period in the ripening room is also liable to aggravate the development of fungal, bacteriological and physiological deteriorations.

5.3 Influence of the relative humidity during cold storage

The development of the aroma during ripening may be insufficient when the relative humidity of the place of storage has been too high (pears, apples, etc.).

5.4 Influence of the quality of the fruit

Fruit intended for ripening after cold storage should be healthy (free from bruises, injuries and any visible attack of fungal origin and any visible onset of physiological deterioration which will appear during storage).

6 OPTIMUM CONDITIONS FOR CARRYING OUT RIPENING FOLLOWING COLD STORAGE

6.1 Ripening room

Ripening may be carried out in a cold room; however, it is preferable to be able to have specialized ripening rooms with suitable dimensions, the capacity of which allows better uniformity of the physical conditions (temperature, relative humidity, composition of the atmosphere) to be obtained.

The use of small rooms gives the advantage of being able to treat lots of fruit in a physiological state as similar as possible.

The ripening room may be constructed on the basis of ripening rooms for bananas (see figure 1), which include

— thermal insulation of the side walls and the ceiling;

— a system of ventilation allowing an air-circulation ratio[1] of 30 to 50 to be obtained to facilitate gas and heat exchanges;

— a device intended to regulate the relative humidity (humidifiers and hygrostats);

— a heating and refrigerating unit regulated by thermostats;

— a device allowing the gas mixture making up the atmosphere of the room to be replaced by fresh air;

(these appliances may be grouped in a single assembly which takes up little space and is easy to install)

— control equipment allowing the temperature and the relative humidity of the room to be read or recorded.

If the use of ethylene is envisaged, the room should be made as airtight as possible.

Figure 2 represents a rudimentary ripening room of the type which may be constructed in a shed or a cellar[2]. This room does not include either a refrigeration device or a device for renewal of the atmosphere. The latter operation is carried out roughly by means of a trap-door in the ceiling. The atmosphere in the room is rendered uniform by the use of a fan. In winter, it will be necessary to provide a heating device (hot-water, electric or gas) in order to obtain the necessary temperature (generally 15 to 22 °C).

6.2 Temperature

For most species of fruit, the optimum temperature zone lies between 15 and 22 °C. For plums and peaches, the optimum temperature is 13 °C.

The ripening phase is a phase of intense metabolic activity during which the fruit gives off large quantities of heat which have the effect of increasing the temperature of the room. If no refrigeration plant is available, the air should be renewed daily, at night or in the morning, so as to return the temperature to the selected value, or as close to it as possible.

Ripening of avocado pears at the end of the cooling period is carried out without special treatment by heating them to a temperature of at least 15 °C. The most preferred temperature is between 20 and 25 °C.

6.3 Relative humidity

Relative humidity should generally be maintained at a value of 90 to 95 % by means of sprays or, in the absence of these, by frequent waterings of the ground, unless otherwise specified.

6.4 Renewal of the atmosphere

Renewal of the atmosphere is necessary for at least 1 h per day to allow the evacuation of the gaseous products

1) For definition, see ISO 2169.

2) When these rooms are constructed in a shed, it is necessary to pay particular attention to the thermal insulation, with a view to allowing the temperature to be kept constant.

of the metabolism of the fruit. This operation is carried out by means of a device for renewing the atmosphere or, when this does not exist, by opening the door and the trap-door in the ceiling whilst keeping the fan running.

6.5 Method of storing

6.5.1 *Packages*

In order for ripening to occur in a uniform way, it is essential to facilitate to the maximum the circulation of air between and within the packets; to this end, the cardboard bands around the packages should be removed and, as far as possible, wooden battens placed between each case; or staggered stacking, for example, should be adopted.

It may be desirable with some fruits to sort and possibly grade them following ripening as not all fruit commence ripening as soon as they are exposed to ethylene and this can lead to packages containing fruit at different stages of the ripening process.

6.5.2 *Arrangement of the packages in the room*

The packets should be arranged on either side of the central corridor which is necessary for control and handling. Slats or duckboards should separate the first cases from the ground. When carrying out the stacking, small aisles should be provided between the piles of cases.

A space of 40 cm should be left between the top row and the ceiling.

6.6 Duration of treatment

The longer the period of previous storage, the shorter will be the time needed to arrive at the state of optimum ripeness.

This time varies according to the species.

Quality controls should be carried out regularly. It is necessary to keep a close watch for fungal deteriorations.

7 ADJUNCTS FOR RIPENING FOLLOWING COLD STORAGE

With the aim of accelerating the phenomenon of ripening, various processes to be used in addition to temperature control have been proposed.

These processes concern essentially the use of adjuncts such as ethylene and the use of oxygen-enriched atmospheres.

The use of adjuncts for ripening following cold storage remains, however, subject to acceptance in each country in conformity with the national regulations. Moreover, since such adjuncts will be in contact with foodstuffs they must be of appropriate purity.

7.1 Use of ethylene

Ethylene is sometimes used to induce the start of ripening (principally for bananas and tomatoes). In most cases it is applied to fruits which have already begun to ripen, in order to accelerate this process.

The rate of development of the biochemical phenomena of ripening increases in the presence of ethylene. There is activation of the respiration with an increased production of carbon dioxide, which has a retarding effect. It is therefore necessary to provide for elimination of carbon dioxide by renewing the atmosphere of the rooms to avoid obtaining carbon dioxide contents which are too high. When no device for renewing the atmosphere exists, opening the trap-doors in the ceiling and the door must suffice. The concentration of ethylene to be reached in the atmosphere of the room should be 1 to 2 parts per 1 000. A proportion five times higher is not harmful but provides no advantage.

Several applications of gas are required if leaks from the ripening room occur. This is equally so when the practice of opening a door or an air vent for short periods to prevent the accumulation of carbon dioxide is adopted.

The lower limit of flammability of ethylene-air mixtures is 2,75 % (*V/V*). In order to guard against risks of explosion, it is preferable to use a nitrogen-ethylene mixture with a content of 5,5 % (*V/V*) ethylene, which is not explosive. The ethylene or the nitrogen-ethylene mixture is delivered in compressed gas cylinders, which should be placed outside the rooms in a ventilated corridor.

The quantities of gas injected should be controlled carefully by a flow meter, and circulation of the atmosphere is essential to achieve good conditions of uniformity.

Ethylene is used at a concentration of 0,1 to 0,4 parts per 1 000 to improve the colouring of plums.

The ripening of tomatoes with the use of ethylene has been recommended. The best results are obtained with tomatoes which are "turning". The ethylene is used at a concentration of 0,25 to 0,5 parts per 1 000. The treatment is stopped when the fruit is pink; the turning of the colouring, initiated by the ethylene, is completed on its own in the absence of the gas.

In numerous cases (for example, pears) three or four applications of the treatment are often sufficient to obtain the desired result.

In other cases, the treatment should be repeated until ripeness is achieved.

On certain species, ethylene is only effective when it is applied immediately or very shortly after harvesting (before the climacteric phase); consequently its application is of no importance.

7.2 Use of atmospheres enriched by oxygen

The importance of oxygen-enriched atmospheres varies with the age of the fruit.

- For recently harvested fruit the application of ethylene at 1 part per 1 000 in the air at 20 °C is more effective than oxygen enrichment whatever the concentration of oxygen.

- For certain fruit taken from refrigerated stores, the importance of ethylene decreases in relation to the storage time. Thus, at the end of storage (over 5 months) only oxygen enrichment with at least 50 % (*V/V*) oxygen allows the yellow coloration of these fruits to be obtained in the shortest time.

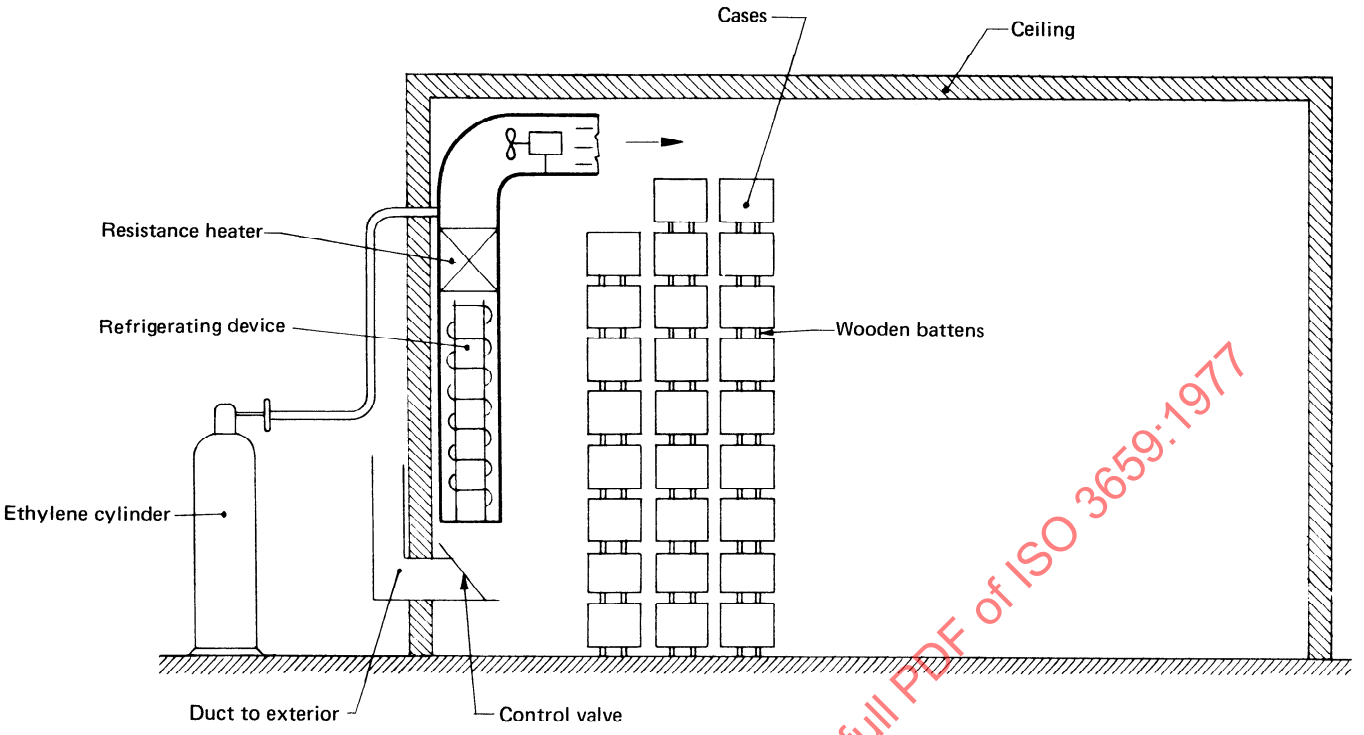

FIGURE 1 – **Diagram of ripening room**

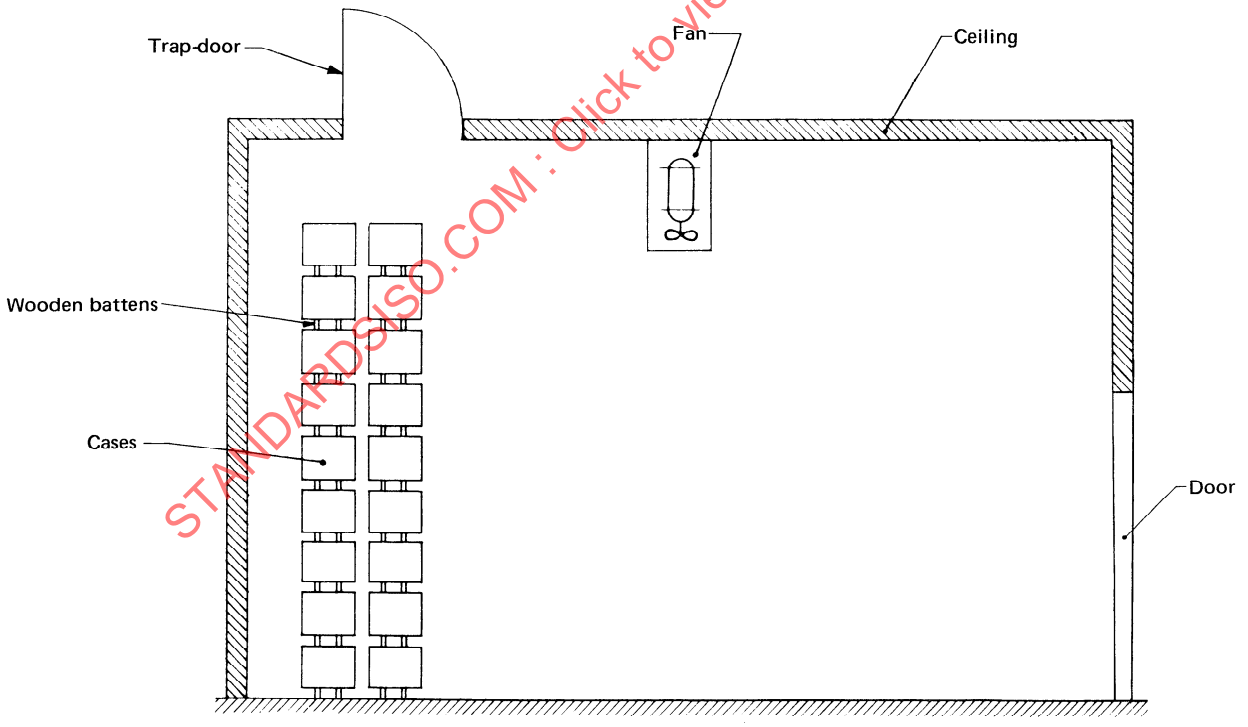

FIGURE 2 – **Diagram of rudimentary ripening room**