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REFRIGERATION OF FRESH VEGETABLES - SOME PROBLEMS IN HANDLING, STORAGE AND TRANSPORTATION WITH SPECIAL REFERENCE TO DEVELOPING COUNTRIES[1]

by

Börje Emilsson

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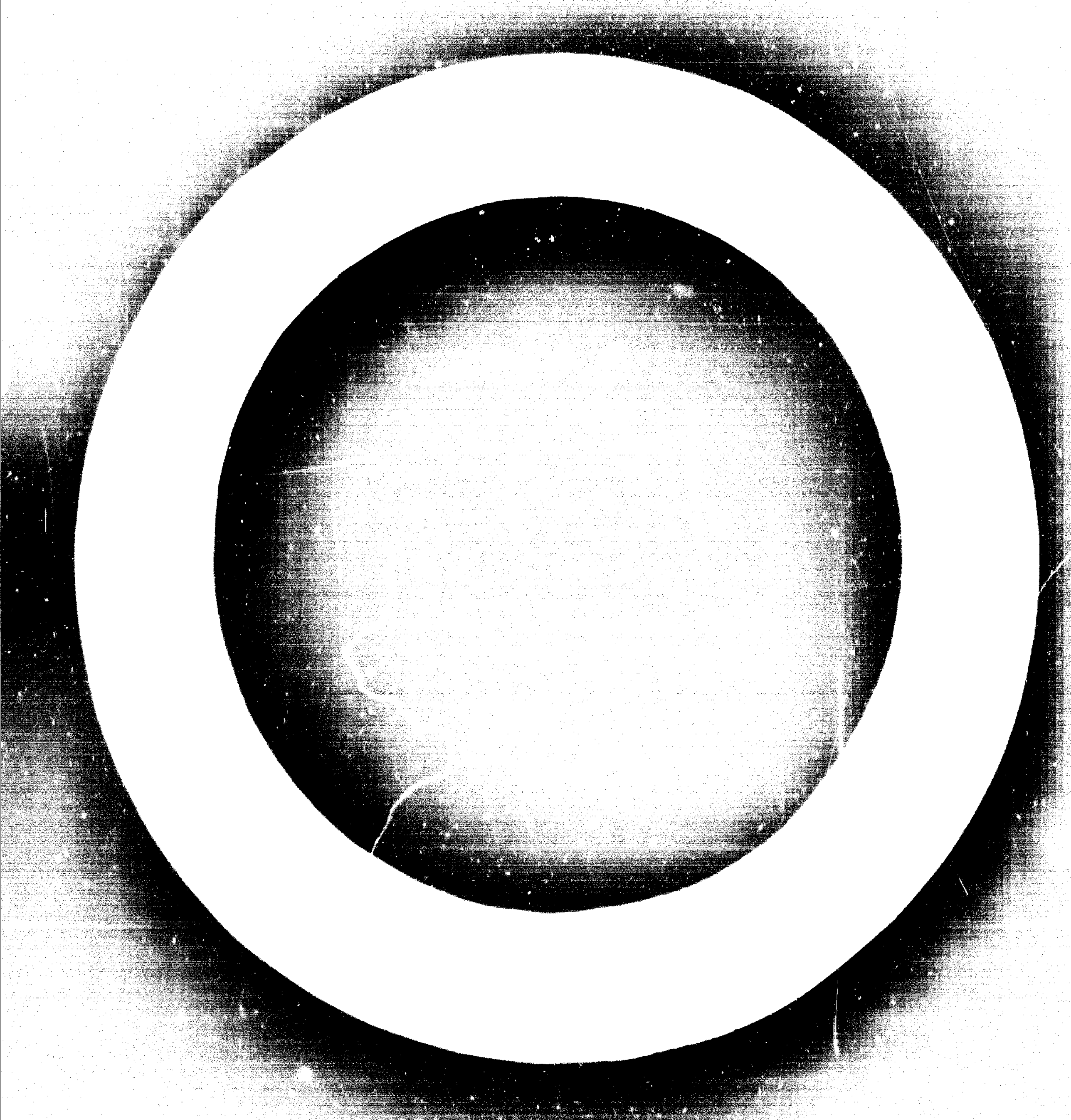

REFRIGERATION OF FRESH VEGETABLES - SOME PROBLEMS IN HAN[illegible] LING, STORAGE AND TRANSPORTATION WITH SPECIAL REFERENCE [illegible] DEVELOPING COUNTRIES.

by

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1. INTRODUCTION

In selecting the kinds of vegetables to be treated in this paper the follow[illegible] criteria have been applied

- it should be adapted to production in subtropical and/or tropical [illegible]
- it should be competitive on consumer's markets as a fresh vegetable [illegible] comparison to processed (canned, deepfrozen, dried etc.) produce
- it should be produced or marketed in considerable quantities over [illegible] areas of the world

On this basis the following vegetables have been chosen: artichokes, [illegible] carrots, celery, cucumbers, eggplants, lettuce, melons, onions, potatoes, radishes, sweet peppers, sweet potatoes and tomatoes. It is realized that selection [illegible] and quite open to discussion.

Among the vegetables selected two have an enormous importance for the [illegible] food supply. Number one is potatoes with an annual world production of [illegible] 300 million tons (mt.). Of these only about [illegible] are produced in deve[illegible] countries, which here are taken to include Central America, South Ameri[illegible] Middle East, Far East (excluding Japan and China) and Africa. Number [illegible] sweet potatoes (including yams), with a world production of about [illegible] annum. Of this quantity about [illegible] mt. fall on developing countries.

Far behind these leading vegetables follow tomatoes with an annual world [illegible]duction of about [illegible] (4.6 mt. in developing countries) and onions with [illegible] mt. (3 mt. in developing countries).

Some of the vegetables chosen e.g. artichokes, asparagus, eggplants, me[illegible] and radishes are - at least in large parts of the world - on the border to [illegible] items. One important reason to include them is that they appear to offer c[illegible]siderable potential in building up exports from developing to industrialized countries.

2. FUNDAMENTALS

2.1. Vegetable physiology

The storage physiology of fruits is discussed at some length in a recent paper by the present author (BÖRJE EMILSSON: Refrigeration of fresh fruits - problems in handling, storage and transportation with special reference to developing countries. Unido Expert Group Meeting Vienna February 1969; below for the sake of brevity referred to as FRUITS). Much of the information on fruit physiology given in section 2 of FRUITS applies to vegetables as well and it is recommended that it is read in conjunction with the study of the present paper. Here only some additional data will be provided on a few selected aspects of vegetable physiology.

Like fresh fruits fresh vegetables are alive and carry on within themselves processes characteristic of all living systems, the most important of which are those of respiration. As with fruits the respiration intensity varies very much between different kinds of produce. Among the vegetables discussed here, onions and potatoes have a low rate of respiration - and at the same time a very long storage life. Artichokes and asparagus, on the other hand, have a very high respiration intensity and also a very limited storage life. To illustrate the differences - at 0°C asparagus respires 10 - 20 times as fast as onions.

Most vegetables have a non climacteric pattern of respiration. After harvest the rate of respiration (and heat evolution) gradually declines as the produce ages in storage. Vegetables which are reproduction organs, e.g. potatoes, generally show increased respiration if sprouting is allowed to start during storage. One important exception to the common type of respiration in vegetables is the tomato, which shows a typical climacteric respiration pattern.

Ethylene has a significant effect on many vegetables. It induces ripening in tomatoes and melons just as in many kinds of fruits. In addition it may cause metabolic disturbances resulting in physiological injuries in e.g. carrots, cucumbers and lettuce. It is worth noting that ethylene may cause such disturbances also at temperatures at which it does not normally induce ripening, i.e. below 2° to 3°C (cf. FRUITS, section 2.4).

Vegetables are generally still more liable to lose water during storage than most fruits. For this reason measures to prevent water loss in storage have particular importance in vegetable storage.

Many kinds of vegetables are highly liable to chilling injuries. The physiology of chilling is discussed in FRUITS section 2.6. In vegetables the increased susceptibility to microbial attacks sometimes induced by chilling is of particular importance. Kinds of vegetables liable to chilling injuries include cucumbers, eggplants, melons, sweet peppers, sweet potatoes and tomatoes.

As in fruits, attack of microorganisms - both fungi and bacteria - is probably the most important cause of loss in the storage of vegetables. The vegetables discussed in this paper have widely different problems of culture, field disease control, harvesting methods and handling practices. Therefore, each commodity must be considered separately with regard to the control of postharvest diseases. Some information on this subject as well as important references to the literature are given in section 3 of this paper for most of the vegetables included. A few general aspects will be briefly mentioned here. At harvest each commodity has a natural population of bacteria and fungus spores on its surface; these are a potential hazard to the keeping quality. Subsequent infection and disease development will depend on such factors as commodity vigour, natural resistance, extent of mechanical injury and of temperature, relative humidity and other conditions in storage. The basis for controlling most storage diseases is disease control during the preparation for and production of the crop. After harvest the necessary measures in general include careful handling practices and prompt and proper temperature and humidity control; in certain situations chemical treatment may also be recommended.

2.2. General precautions in cold storage

Most of the information given in FRUITS, section 3 is relevant to vegetables also and should be read in conjunction with this section. The optimum storage conditions for different kinds of vegetables are discussed in the next section of the present paper.

In the precooling of vegetables both hydrocooling and vacuum cooling have proved quite useful. Thus, hydrocooling is used for asparagus, celery, topped carrots and radishes. Vacuum cooling is of particular importance in the precooling of lettuce [illegible] also used for celery and radishes.

Some vegetables benefit from very high relative humidity in storage - 95 % or more. This applies [illegible] asparagus, carrots and lettuce. Onions, on the other hand, [illegible] generally [illegible] best under fairly dry conditions.

For vegetables [illegible] protective packaging is widely used to limit water losses. Plastic [illegible] of different kinds are used for wrapping of individual [illegible] (e.g. [illegible] cucumbers), consumer size packaging (e.g. radishes [illegible] (e.g. celery). The application of wax or wax emulsion [illegible] also proved beneficial for several kinds of vegetables [illegible] cucumbers, sweet peppers, mature green tomatoes, melons and [illegible]. Often the thickness of wax coating is critical. Too thin [illegible] may [illegible] little if any protection against moisture loss, whereas too heavy [illegible] increase decay and breakdown [illegible] waxing [illegible] more detailed information on waxing [illegible] in [illegible] (1958), HARTMAN & [illegible] (195[illegible]) and PLATE[illegible] (19[illegible]).

Some of the vegetables [illegible] in this paper, e.g. onions and potatoes, are sometimes [illegible] stored [illegible] attention must be paid to the air distribution in such stores [illegible] ensuring that the cooling air is evenly distributed through all parts of the [illegible], there may arise [illegible] with overheating [illegible] excessive losses through decay or sprouting.

It may sometimes be [illegible] to store different kinds of vegetables together or together with fruits. [illegible] this is only possible when the temperature and humidity requirements are the same for the kinds of commodity involved. [illegible] are [illegible] by ethylene and cross-transfer of odours. [illegible] temperature is above [illegible] ethylene may promote ripening in some [illegible], e.g. melons and tomatoes. Even at temperatures below [illegible] of inducing physiological disorders in e.g. carrots and [illegible]. [illegible] all these cases it is necessary to arrange mixed [illegible] than any chance of ethylene reaching spaces [illegible] produce [illegible] excluded. Several kinds of vegetables, especially celery, [illegible] liable to tainting. Dangerous in the generation of tainting are onions, carrots and potatoes and particularly [illegible] fruits. These circumstances must be taken into due consideration when arranging mixed storage.

2.2. Controlled atmosphere storage

The physiological background of controlled atmosphere storage as well as techniques available for CA-treatment are reviewed in FRUITS, section 4.1, to which reference should be made.

So far CA-storage has found very little application to vegetables on a commercial scale. Research on CA-treatment of many kinds of vegetables, however, is in progress in different parts of the world. Fairly promising results have been obtained in some instances.

2.3. Irradiation

The application of irradiation in the storage of fruits is discussed at some length in FRUITS, section 4.2. It is pointed out that the possible beneficial effects are control of storage diseases and delay of ripening.

With one note-worthy exception to be discussed below, not very much work has so far been carried out on the use of irradiation in vegetable storage. RANGPAR & SREENIVASAN (1966) report very briefly that the ripening of tomatoes could be delayed about 5 to 6 days by an irradiation dose of 20 - 25 krad. SOMMER & MAXIE (1966), also working with tomatoes, found that fruits irradiated in the preclimacteric state will either fail to ripen or ripen abnormally. When treated in the pink ripe or fully ripe stage with a dosage of 300 - 400 krad, however, tomatoes showed a beneficial extension of shelf life without undue harm to quality. Although not clearly stated by the authors, it appears that the extension be due to delayed incidence of storage rots.

Much interest in the application of irradiation in vegetable storage has been focused on the possibilities of controlling sprouting in potatoes and onions. Very low doses - 5 to 15 krad - may give a very efficient inhibition of sprout growth. At the same time, however, there are risks for undesirable side-effects. For further details reference should be made to section 3.09. and 3.10.

3. COLD STORAGE OF SELECTED KINDS OF VEGETABLES.

3.01. Artichokes

Artichokes (true artichokes, globe artichokes) are edible buds, made up of a cone of short, thickstemmed bracts. They should be harvested when they have reached their greatest size prior to the appearance of the floral parts.

The optimum storage temperature is -0.5° to 0°C with a relative humidity of 90 - 95 %. Information about the storage life varies: some sources state that it is only a few weeks, while U.S. DPT. AGRIC. (1968) maintains that artichokes should keep for at least 4 weeks in storage if initially uninjured buds are used and wilting is prevented.

Artichokes should be precooled to below 4°C soonest after harvesting.

Moisture loss and wilting may be retarded by packing the artichokes in perforated polyethylene liners.

Preliminary experiments by [illegible]LFRINIERI et. al. (1966) indicate that artichokes may benefit from CA-treatment (10 % O_2, 2 % CO_2).

No experience is available about long range transportation of artichokes by ship. There appears, however, to be fair possibilities for developing a technique adequate for this purpose.

3.02. Aubergine (eggplant)

Aubergines intended for storage should be harvested when they have a dark purple colour and before they turn brown or yellow, i.e. they should be picked when still somewhat immature ([illegible] 1936, cit. acc. WARDLAW 1937).

The optimum storage temperature of aubergines is 7° to 10°C. Below 7°C they are subject to chilling injuries. These may take the form of surface scald or internal browning. Aubergines that have been chilled are subject to decay by Alternaria when removed from storage.

Aubergines are not adapted to long storage. According to recent information from USA (U.S. DPT. AGRIC. 1968), they cannot be expected to keep satisfactorily even at optimum temperature for more than about a week and still retain good condition [illegible]. WARDLAW (1937), on the other hand, presents evidence indicating a somewhat longer storage life. Anyhow, trans-ocean transport by ship of aubergines hardly appears feasible with the technology presently known.

Aubergines are very liable to water loss and shrivelling during storage. Packaging in moisture retentive films may be helpful in this respect.

A review of storage diseases of aubergines is given by RAMSEY et. al. (1952)

3.03. Asparagus

Deterioration of asparagus in cold storage includes excessive wilting, elongation of the spears and opening up of the heads, rotting due to fungi or bacteria and general decline of quality. There is a definite increase in the amount of fibrous material, being most rapid immediately after harvesting. The formation of fibrous material is accelerated at high temperatures and to some extent arrested at low temperatures.

[illegible] other vegetable deteriorates so rapidly as asparagus at ordinary [illegible]ratures. Therefore, asparagus should be precooled immediately after [illegible] this is mostly done by hydrocooling.

[illegible]ratures of 0° to [illegible]°C are recommended and may give a storage life of [illegible] weeks, according to W[illegible]DLAW [illegible]937) even up to [illegible] weeks. According [illegible]PT. AGRIC. (1966) asparagus is liable to chilling injury of kept at [illegible] more than 10 days.

[illegible]commended that the butts of asparagus be placed on wet moss or other [illegible]sorbent material during transit or storage to prevent loss of moisture [illegible]aintain freshness of the spears. The use of moisture retentive packaging [illegible] has also been advocated.

[illegible] indications that asparagus may benefit from CA-treatment. Thus, [illegible] et al. (1936) found that asparagus exposed to early treatment with [illegible]oxide (i.e. during cooling) showed improved appearance, keeping [illegible] flavour over untreated control lots. Storage of all-green asparagus [illegible]phere containing 5 - 10 % CO_2 retards soft rot development (LIPTON [illegible]

[illegible] of storage diseases of asparagus and their control is given by SMITH [illegible]966). Bacterial soft rot (caused by Erwinia carotovora), which may [illegible] either the tip or butt of the asparagus, is the principal decay. It may [illegible]trolled by careful handling to avoid injuries, by right [illegible] of bruised [illegible] rapid precooling and optimum storage temperature.

[illegible] fresh asparagus is not cold stored for longer periods. It appears un-[illegible] whether its economical storage life is sufficiently long to allow long [illegible] transportation by other means than by air.

[illegible]arrots

[illegible] storage carrots are harvested when mature and after leaves have [illegible] slightly browned appearance. During harvest carrots are topped to [illegible] the crown or [illegible] of the root. Careful handling during and after harvest [illegible] bruising, cutting and breakage will help insure successful storage. [illegible] damaged carrots should be removed as they are particularly sus-[illegible]e to some storage diseases.

[illegible] may be stored in bulk, in crates or in pallet boxes. Generally the [illegible] mentioned methods are preferable. Good air circulation is important [illegible] uniform temperatures. It also aids in preventing condensation.

[illegible]imum storage temperature for carrots is 0°C. It is desirable that the [illegible] precooled to this temperature soonest after harvesting.

[illegible]s lose moisture readily and wilting results. Therefore, humidity in [illegible] should be kept high, but condensation or dripping on the carrots must [illegible]carefully avoided as this may lead to decay. In a recent study VAN DEN [illegible] & LENTZ (1966) found decay, weight loss and changes in quality to be [illegible] when the relative humidity was maintained at or near saturation (98 - 100 %) than at 90 - 95 %.

[illegible]ts are well adapted to long storage. Under optimum conditions most [illegible]ties may be held 4 to 5 months.

Ethylene may induce abnormal metabolism in carrots, causing bitterness. Therefore due precautions must be taken to prevent ethylene contamination of the storage air. It has been reported that the bitterness may be removed by holding carrots at room temperature for a few days after removal from storage.

Carrots are attacked by a number of storage diseases, the most important of which are grey mold rot (*Botrytis cinerea*) and watery soft rot (*Sclerotinia sclerotiorum*). Control methods include careful handling, prompt cooling and optimum storage conditions. A prestorage dip treatment of 0.1 % sodium-o-phenylphenate solution has been found beneficial in reducing storage decay. For a detailed discussion of storage diseases in carrots see SMITH et. al. (1966).

The information given above applies to mature carrots. Immature carrots have a shorter storage life. They may keep for 4 to 6 weeks at 0°C, especially if topped, hydrocooled and packaged in polyethylene bags.

3.05 Celery

The optimum storage temperature for celery is 0°C. This is fairly close to the freezing point of celery, which is around -1°C and care must be taken that the temperature does not fall too low. Freezing injury is marked by a general loosening of the epidermis, evident on twisting an injured stem.

Relative humidity should be kept at a high level (90 to 95 %) in order to prevent wilting. The use of perforated polyethylene film crate or carton liners provides an effective method to minimize moisture loss. However, the use of film liners is not widespread commercially, perhaps because of interference with precooling. Use of the jacket system (cf. [illegible], section 2. 4.) has proven successful for celery storage in Canadian tests.

Celery should be precooled soon after harvesting. Methods used are refrigerated forced air cooling, hydrocooling or vacuum cooling. Hydrocooling is stated to be the most common method and the temperature of the produce should be brought down to as near 0°C as possible. Vacuumcooling is widely used for celery packed in cartons for long distance shipment.

In storage of celery it is essential that good air circulation is maintained around crates or cartons. Otherwise there is danger of local overheating due to heat of respiration.

Some growth takes place in celery while in storage; the central stalks lengthen considerably. In most varieties also some blanching of the stalks occurs during storage.

Especially under unsuitable storage conditions celery is subject to attacks of watery soft rot and other storage diseases. Watery soft rot originates in the field and is caused by a fungus (*Sclerotinia sp.*) that is able to develop to some extent even at 0°C. For further information on storage diseases of celery reference should be made to SMITH et. al. (1966).

Celery should keep well for 2 to 3 months if stored under optimum conditions. Transocean transport by ship is easily feasible.

…6. Cucumbers

…mbers should be harvested at frequent intervals to prevent them from …ming too large or overripe. They are very subject to mechanical injuries …to fungal and bacterial rotting. Care in handling is therefore of great …ortance. It has been observed (PLATENIUS et. al. 1934) that small fruits … considerably more susceptible to disease injury than larger ones. In some …ances, mature, …lly grown cucumbers kept more than three times as long … immature ones of the same picking.

…has been found that the keeping quality of cucumbers varies considerably …ween varieties, from season to season and locality to locality. This may …lain why differences in opinion have arisen as to the optimal storage con…tions.

…t authors agree that cucumbers are liable to chilling if kept at tempera…es below 10°C or even 12.5°C. Symptoms of chilling are moisture saturated …s developing just below the surface. A few days later the whole area may …come soft. In dry air the moisture saturated areas will become soft and this …ptom is referred to as pitting. Another important symptom of chilling is …elerated yellowing. Chilled cucumbers show increased susceptibility to …ay.

…degree of chilling injury depends on the temperature and length of the …rage period. Injury may or may not be apparent at the time of removal … storage. The length of time the cucumbers are retained after they have … removed from storage, exerts a strong influence upon symptom develop…n.

…LAND (1966) reports that the sensitivity of cucumbers to chilling may … considerably. He studied the influence of variety, conditioning and delayed …ling. The term conditioning refers to keeping the fruits for some time at a …perature just above the chilling range, while delayed cooling is the applica… of temperatures well above the chilling range. The results obtained indi… that all these factors can influence storage life at chilling temperatures. …s studies A…LAND found some interesting evidence of a correlation …ween respiration intensity, level of ethylene production and sensitivity to …ling.

… recommendations as to the optimum storage temperature for cucumbers …erally vary between 7° to 12°C with an emphasis on 10°C (INT. INST. …RIGERATION 1967; U.S. DPT. AGRIC. 1968). The storage life in this …perature range is stated to be 1 to 2 weeks. However, sometimes the use … temperatures lower than 7°C has been advocated. There are also reports …ting that a longer storage life may be obtained (cf. WARDLAW 1937).

…mbers are very susceptible to shriveling and therefore the humidity in … should be kept high - preferably 90 - 95 %. Wax is often applied to …e water loss and improve appearance. A recommended practice is to … a paraffin-carnauba emulsion containing approximately 7 % solids …AKER & DAVIS 1952). Wrapping in moisture retentive film may be very …ficial and has in recent years come into extended use in several countries.

…llowing of cucumbers is accelerated by ethylene. Therefore, all possibilities …thylene influence on the fruits must be carefully excluded in storage and …sportation. Modified atmospheres, particularly 5 % O_2 and 5 % CO_2, will …tard yellowing (…PELAND 1961).

The storage life of cucumbers is a little too short to allow safe transocean transportation by ship. It may be possible, however, to develop an improved technology creating better keeping properties. This might perhaps include CA-treatment.

3.07. [illegible]

Of the many different kinds of lettuce, only the iceberg variety of the head lettuce type is adapted to long time storage. Therefore, the discussion here will be confined to iceberg lettuce.

The optimum storage temperature for iceberg lettuce is as close to its freezing point as possible without risks for actual freezing. The recommended temperature is 0°C and as lettuce is easily damaged by freezing it is imperative that all parts of the storage room be kept above the highest freezing point of the produce (-0.2°C). The rate of respiration of lettuce is increased greatly with increase in storage temperature throughout the temperature range from 0°C to 25°C, which results in a shortened storage life at the higher temperatures. Thus, lettuce will keep about twice as long at 0°C as at [illegible].

High relative humidity in the store is essential for keeping the lettuce fresh. A relative humidity of 90 - [illegible] % is recommended. [illegible] storage [illegible] packed in [illegible] individual head wraps [illegible] as cartons [illegible] packing, [illegible] that favour decay. Films [illegible] and perforated polyvinyl [illegible] Among [illegible] advantage [illegible] facilities [illegible] important [illegible] berg lettuce [illegible] and PARSONS [illegible].

Rapid precooling [illegible] harvest is essential for [illegible] optimum storage [illegible] precooling [illegible] expensive [illegible] vacuum cooling [illegible] today [illegible] lettuce [illegible] from [illegible] and [illegible] is vacuum cooled.

The use of vacuum cooling has made [illegible] important changes in shipping and packaging methods. [illegible] have been superseded [illegible] fiberboard boxes.

For vacuum cooling, lettuce [illegible] placed in [illegible] from which the air is exhausted [illegible] the lettuce [illegible] leaves [illegible] to evacuate the [illegible] barometric condensers and [illegible] commercial vacuum [illegible] lettuce, but some can hold two [illegible] temperatures [illegible] 4 [illegible] be expected to lose approximately [illegible] 6°C [illegible] ice [illegible] information on vacuum cooling see [illegible] (1961, 1962).

The main causes of deterioration of lettuce in storage are microbial decay (bacterial soft rot and Botrytis rot), russet spotting and pink rib. Bacterial soft rot can be quite well controlled by maintaining consistently low temperatures. Botrytis will grow even at temperatures around 0°C, although the growth is rather slow. Since most of the field infections are on the outer leaves of lettuce, trimming off a few extra leaves may give some control. Russet spotting is a physiological disorder. It is associated with temperatures around 4° to 5°C, overmaturity at harvest and minute quantities of ethylene in the holding atmosphere. Accordingly due precautions must be taken to ensure that storage spaces for lettuce are completely uncontaminated by ethylene.

In recent years considerable research has been carried out in USA to determine the possible benefits of CA treatment of Iceberg lettuce. The present conclusion appears to be that if optimum temperature conditions are maintained continuously there is little advantage in controlled atmospheres. However, if temperatures are somewhat above the optimum, reducing oxygen concentration to 1% or a little lower decreases the rate of [illegible] lettuce [illegible] susceptible to russet spotting [illegible]

[illegible] storage life for successful marketing.

[illegible]

[illegible] is very polymorphic. It has been [illegible] but there are so many [illegible]

[illegible]

[illegible] considered [illegible]

[illegible] although the flesh may soften and [illegible] extent.

The optimum maturity at harvest depends to some extent on the demands on length of storage life.

Various criteria of picking maturity are discussed at length by WITHAM [illegible] DAVIS (1962). Determinations of the soluble solids content (e.g. by a hand refractometer) may provide useful guidance. For cantaloupes and some other types of melons a light abscission [illegible] develops at the point where the fruit is attached to the stem as the fruit approaches maturity. When this crack completely encircles the stem, the melon is at the "full slip" stage and contains the maximum amount of sugar. [illegible] can be harvested at the "full slip stage" for local markets but must be harvested earlier if they are to be transported to distant markets.

Changes in netting and skin colour are other external signs of maturity. [illegible] as the major sign of maturity. [illegible] changes from green or grey to brown or yellow. [illegible] change, in relation to other ripening processes [illegible].

The [illegible] period and ready [illegible] ripening [illegible] harvest [illegible] experience is required [illegible].

[illegible] cooling. [illegible]

When [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] Onions

[illegible] discussion here refers only to the common onion (Allium cepa L.).

[illegible] of refrigeration is essential for some varieties of onions; others can [illegible] in common storage for long periods provided the climatic conditions [illegible] not unfavourable. However, even for onions with excellent keeping [illegible] cold storage may offer practical and economical advantages, e.g. [illegible] tropical conditions or when very long storage is intended.

[illegible] studies have been made in many countries to determine the keeping [illegible] of various onion cultivars. These range from very poor to very good. [illegible] principal onion cultivars of USA have been investigated by MAGRUDER [illegible] who found White Creole, Red Creole and Australian Brown to [illegible] best keeping ones. Other varieties known to have excellent storage [illegible] are Giza No. 6 (Egypt), Pukekohe Longkeeper (New Zealand) and [illegible] Hungary).

[illegible] store well, an onion should mature normally. The neck should be [illegible] sealed by dried and shrunken leaves. "Bottle neck" onions have [illegible] keeping properties.

[illegible] onions are placed in storage the tops are usually removed, and fre- [illegible] the roots. Removal of the [illegible], especially if they are not dry, [illegible] surfaces, where [illegible] organisms can easily enter. Such [illegible] should be carefully dried without delay. This drying procedure [illegible] essential for successful storage.

[illegible] relative humidity is low and rains seldom occur during the [illegible] Southwestern USA, [illegible] (Egypt), curing is easily and [illegible]. Even under [illegible] very dry conditions, however, [illegible] It is recommended [illegible] to circulate [illegible] per hour for each m^3 of [illegible] good skin colour without [illegible], the circulating air [illegible] temperature of 24° to 27° and at least [illegible] relative humidity. [illegible] above [illegible] humidities above [illegible] produce good [illegible] air circulation is imperfect. [illegible] temperature becomes too low during [illegible], the bulbs may not [illegible] good skin colour. There are no standards for determining when [illegible] is cured, but it appears to be [illegible] process is complete [illegible] neck is tight and several paper- [illegible] enough to rustle. Experience shows that onions have lost [illegible] when this condition is reached. After curing is com- [illegible] temperature of the onions must be lowered as quickly as possible.

[illegible] factors influence the storage life of onions. Under all storage conditions, [illegible] continually lose water and dry matter, but the more serious losses [illegible] from storage [illegible] and from sprouting and rotting.

[illegible] optimum storage temperature for onions is 0°C. At this temperature they [illegible] dormant and reasonably free from decay for extended periods.

[illegible] are damaged by freezing, which may occur at temperatures below -1°C. [illegible] considerable variation between individual onions in their reaction to [illegible] temperature. Some bulbs in a lot may freeze quickly when they reach a [illegible] temperature of -1°C and show severe injury upon thawing. Others may not [illegible] they are frozen they may thaw out without injury. Onions affected with freezing injury show watersoaked, grayish-yellow fleshy scales when cut. In slight freezing the outer fleshy scales alone are affected, but when the bulbs are exposed to low temperatures for a prolonged period the inner scales may also become watersoaked and discoloured. Onions only slightly frozen may recover with little perceptible injury if allowed to thaw slowly - preferably at a temperature around 5°C - and without handling.

Humidity has a decisive influence on the storage result. High humidity, especially when free water accumulates on the onions, can be disastrous. In a saturated atmosphere diseases spread rapidly, and a decaying bulb may easily infect all of those surrounding it. High humidities favour rooting but have little influence on sprouting. On the other hand, water losses during storage increase with increasing vapour pressure deficit of the surrounding air. Generally a comparatively low relative humidity - 60 to 70 % - is recommended for onion storage. However, humidities as high as 85 % in combination with forced air circulation may give satisfactory results.

Condensation occurring on removal from cold storage may favour decay. Warming onions gradually should avoid this difficulty.

The most important microbial storage diseases of onions are bacterial soft rot (Erwinia carotovora) and grey mold neck rot (Botrytis spp.). Bacterial soft rot is controlled by careful handling and curing, low temperature and low humidity in storage. The control of Botrytis neck rot depends largely on weather favourable to the maturing of the tops at the end of the growing period and on adequately curing the neck tissues after harvest. The storage temperature should be kept at 0°C and the relative humidity at 60 - 70 %. However, even the low temperature of 0°C will not completely [illegible] the development of the rot if the onions had active infections at [illegible].

Translucent scales is an important physiological disorder and occurs on onions grown in widely separated areas. It is [illegible] characterized by the grayish watersoaked appearance of a part or all of one or more fleshy scales giving them a translucent appearance. All fleshy scales may be affected in severe cases. Seriously affected scales frequently develop a [illegible] to brown colour as viewed in cross section. Translucent scales was previously thought to occur to some extent in the field, but is now believed to develop only after harvest. Onions that show little or none of the disorder when removed from storage may show an appreciable amount of translucent scales in the market. The cause of the disorder is not known. Evidence so far available indicates that for best control, onions should be stored promptly after they are cured, and cooled quickly and held at 0°C and 60 to 70 % relative humidity.

For a detailed discussion of storage and market diseases in onions reference should be made to SMITH et. al. ([illegible]).

In recent years several chemicals have been tried to prevent or delay sprouting and rooting in stored onions. Of these maleic hydrazide (MH) has been found the most effective ([illegible] 1955, [illegible] 1961, ISENBERG & ANG 1963). MH should be applied in the field when onions are nearly mature and tops are beginning to fall. MH is beneficial not only on those cultivars that have a short storage life, but is also beneficial in extending the shelf life of good storage types after they have been removed from prolonged cold storage.

Radiation at low doses - about 8000 - 10000 rads - is also effective in the control of sprouting of onions. However, decay is not controlled by this low dosage. Irradiation may cause discolouration of the internal growing points. ([illegible] & SAWYER 1959).

[illegible] optimum conditions globe onions can be held in storage for 6 to 8 months, [illegible] sprout inhibiting treatment even longer. Some types have a considerab[illegible] storage life. Long distance transportation of onions [illegible] no par[illegible] difficulties provided the recommendations for optimum storage condi[illegible] observed.

[illegible] Potatoes

[illegible] the world's potato crop is stored without the application of artificial [illegible]. Under certain conditions, e.g. tropical climate, very extended [illegible] and special demands on quality, it is, however [illegible] economical pro[illegible] and sometimes even a necessity to store potatoes under refrigeration.

[illegible] of efficient storage of potatoes are to avoid undesirable chemical [illegible] and to minimize losses by water loss and by respiration, by sprout [illegible], by frost or high temperature injury and by diseases. The storage [illegible] of the potato is highly complicated and the [illegible] on the subject [illegible]. Here only the most important aspects can be briefly discussed.

[illegible] most important chemical changes in stored potato tubers [illegible] carbo[illegible] metabolism. In the tubers occur perpetual conversions of starch into [illegible] of one form of sugar into another, and of sugar into starch. These [illegible] conversions reach a state of balance at levels of the different substances [illegible] determined in the first place by the storage conditions, particularly [illegible] temperature, but also by other factors such as maturity of tubers, variety [illegible] previous storage history.

[illegible] storage below 6° to 7°C there occurs a gradual accumulation of sugars [illegible] potato. Both sucrose and reducing sugars increase [illegible] necessarily [illegible] proportions at different temperatures. The maximum values are [illegible] after 6 - 8 weeks storage and may be [illegible] times higher in potatoes [illegible]°C as compared to tubers stored at 10°C.

[illegible] which have become sweet at a low temperature may be desweetened [illegible] storage for about two weeks at a higher temperature, say 15° to 20°C. The [illegible] change involved in this process is the re-formation of starch from the [illegible].

In addition to the increase in sugar content caused by exposure to low tempera[illegible], the concentration of sugar exhibits an upward trend after prolonged [illegible] at higher temperatures. This appears to be a symptom of senescence. [illegible] of sweetening starts earlier, and is more rapid, the [illegible] temperature. It has been suggested that [illegible] sweetening is large[illegible] by the sprout growth. However, this relation is a [illegible] than a causal connection, as sweetening occurs to an even greater extent [illegible] sprouting is suppressed either chemically or by irradiation.

The rate of respiration of potato tubers depends to a great extent on the storage [illegible]. Over the range 5° to 25°C the respiration rate increases about [illegible] for every 10°C rise in the temperature. This relation will, however, [illegible] generally only obtain for a short period after the tubers have been placed [illegible] the various temperatures. During prolonged storage at different tempera[illegible] it is obscured by variations in other factors, such as the concentration [illegible] sugar, which affect the rate of respiration. As a result of this, respiration [illegible] may well be as rapid as at 20°C.

There is a seasonal rhytm in the respiration evident even if the temperature is kept at a constant level during the entire storage period. Generally respiration is at a maximum during the two months following harvest; then it decreases to a lower constant level for some months and starts to increase again after 6 to 8 months of storage.

Respiration causes weight loss in storage. However, under normal conditions it does not account for more about one tenth of the total physiological weight loss, the predominant part of which is water loss.

<u>Water is lost</u> from potato tubers by evaporation. The rate of loss from any particular sample of potatoes is proportional to the water vapour pressure deficit of the surrounding air. The loss under any given deficit is restricted by the periderm, which is comparatively impermeable to water vapour. Freshly harvested tubers lose water at a greater rate than later in the storage season. This is probably due to breaks in the periderm caused by the harvesting operations, which heal during storage. There may also be changes in the periderm during storage which render it less permeable to water vapour.

The low rate of evaporation which is established after the [illegible] is maintained until [illegible] growth [illegible] there [illegible] due to the fact that the [illegible] much more permeable to water vapour than is the periderm [illegible] demonstrated a [illegible] growth and the [illegible] In their experiments the [illegible] /mm Hg vapour pressure deficit [illegible] /week [illegible] every [illegible] weight of sprouts [illegible] Hg V. P. D.)

When sprouting commences, [illegible] processes in the [illegible] vated. As demonstrated [illegible] ceeds. Therefore, the control of sprouting has a decisive influence on the storage result.

The sprouting [illegible] of the potato is highly complex. [illegible] generally are in a deep [illegible] under [illegible] for sprouting [illegible] after several [illegible] begin to sprout even when stored [illegible] low temperatures [illegible]

The most important [illegible] the period of dormancy [illegible] of potato and the temperature of storage. There [illegible] normally [illegible] effect [illegible] different varieties [illegible] often [illegible] crop variety [illegible] the rate of [illegible]

Temperature [illegible] period [illegible] storage [illegible] water loss [illegible]

[illegible] by storage at a higher temperature (say 10°C) could result in a shorter [illegible] period than continuous storage at the higher temperature.

[illegible] data available indicate that the influence of the climatic conditions [illegible] growth of the tubers on the length of the dormant period is limited [illegible] evidence has been found, though, that tubers grown under short [illegible] conditions may sprout earlier than those grown under long days.

[illegible] points of from -1° to -2 [illegible] have been recorded for potato tubers, [illegible] of freezing injury vary with the severity of exposure. Tubers which [illegible] been only slightly damaged may exhibit a blue-black discontinuous ring [illegible] region. More severe injury leads to a blue-black necrotic net- [illegible] the pith in addition to necrosis in the vascular tissue. In the final [illegible] of freezing injury the whole [illegible] when thawed becomes wet and soft. If [illegible] are [illegible] they may be cooled to [illegible] below their actual freez- [illegible] as under- [illegible] evidence indicates that tubers may be [illegible] cooled to [illegible] depending on variety and other factors) for 1 to 3 hours [illegible]

[illegible] temperatures which are not low enough to freeze the [illegible] has been described as low temperature breakdown. [illegible] blotches in the flesh of the tuber [illegible]

[illegible] This [illegible] of the [illegible]

[illegible]

[illegible] water, respiration [illegible] and [illegible] in the [illegible]

[illegible] and RAMSEY [illegible] give [illegible] references.

After this brief review of the storage physiology of the potato the optimum storage conditions should be discussed. In doing this it must first be stressed that the quality of the potatoes, when put into storage, has a decisive and often overriding influence on the storage result. To produce potatoes, which will store well, it is necessary to give careful attention to their cultivation, to the efficient control of diseases in the field and to gentle handling in all phases of operation.

Immediately after harvest potatoes should be cured by holding them at comparatively high temperature and high relative humidity for about 10 to 14 days. During this period cuts and bruises are healed by the formation of wound periderm and the skin is strengthened by further suberization. Although wound periderm formation is most rapid at temperatures around 20°C, it is recommended to use a curing temperature in the range 10° to 15°C as decay is less likely to [illegible] late [illegible] other [illegible] damages or frost injuries are present, however, [illegible] the storage [illegible] to 10°C [illegible] desira[illegible] also [illegible] of the potatoes and reduce [illegible] way. However, [illegible] harvested, [illegible] potatoes with [illegible] delicate skin [illegible] immediately [illegible] temperatures [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] more readily achieved the lower the temperature of the air, because of the [illegible] relationship between the water holding capacity of air and its tempera- [illegible]

[illegible] up the storage requirements for table potatoes - temperature for short [illegible] storage 10°C and for prolonged storage 4° to 7°C, the lower temperature [illegible] used if uncontrolled sprout growth or rotting due to disease are likely to [illegible] sources of loss. Storage at low temperatures should generally be pre- [illegible] by [illegible] weeks or more of curing at 10°C or above. Humidity should be held [illegible] high as possible, bearing in mind the dangers of condensation. Unless the [illegible] humidified to a water V. P. D. not exceeding 0.5 mm Hg air circulation [illegible] be restricted to the minimum which avoids overheating and too great a [illegible] temperature scatter. The potatoes must on no account be wet as result of con- [illegible] or other factors. Light must be excluded to prevent greening.

[illegible] potato processing industry (chips, french fries, dehydrated potato products) [illegible] respects puts special demands on the storage conditions for its raw- [illegible]. Thus, especially for chips the content of reducing sugars must be [illegible] very low level. For potatoes destined for processing into chips a [illegible] temperature of 10°C is recommended, often in combination with sprout [illegible] below). If reducing sugars do accumulate potatoes may be [illegible] by exposure to 10° - 20°C for a week or [illegible]. This proce- [illegible] is expensive and sometimes not effective for reasons not as [illegible] understood. For further information on the storage of potatoes for [illegible] reference should be made to TALBURT & SMITH (1967).

[illegible] respects the storage requirements for seed potatoes are the same as [illegible] the avoidance of disease and excessive shrinkage. [illegible] additional considerations, however, must be taken into account [illegible] seed potatoes. These concern the ways [illegible] often characteristic [illegible] variety [illegible] storage conditions may influence the subse- [illegible] behaviour and yield of the seed. The problem of choosing the optimum [illegible] for seed potatoes is highly complicated, the choice being [illegible] number of factors including, in addition to variety growing [illegible] intended utilization of the harvest etc. It cannot be discussed here; [illegible] information see BURTON (1966), who gives a number of additional [illegible]

[illegible] 2 to 3 months' storage sprouting can be expected in potatoes stored at [illegible] above 5°C. With increasing sprouting storage losses, particular- [illegible] increase steeply. This has promoted the development of [illegible], which are today used commercially to an important [illegible] the world. [illegible] of these, maleic hydrazide, is applied [illegible] the potato foliage. Plants must be actively growing in order that [illegible] translocated from the foliage to the tuber. This is one [illegible] maleic hydrazide as the [illegible] of the crop must be [illegible] stage. Isopropyl N-chlorophenyl carbamate (CIPC) [illegible] the most widely used [illegible] United States. [illegible] in the sprout inhibition field, inhibi- [illegible] complete with no sprouts developing under ideal application [illegible] applied as a water dip, as a dust or preferably as an [illegible]. Treatment [illegible] formation and should not be [illegible]. In the United Kingdom the use of nonanol has been [illegible] applied directly to the stored potatoes by evaporating [illegible] system of the store. For further information [illegible] reference should be made to BURTON (1966) [illegible] (1967).

Irradiation may be considered as an alternative to chemical sprout inhibition. Commercial control of sprouting can be attained with most varieties at dosages between 8000 and 10000 rad. Detrimental effects may occur, e.g. increased rotting, increased incidence of after cooking darkening and inhibition of wound periderm formation, but are generally not serious at the very low dosages recommended. At least at present it appears doubtful, whether irradiation may compete economically with chemical treatments.

The technology of potato storage without the use of artificial refrigeration is highly variable and must be adapted to local conditions. It will not be discussed here; a vast literature is available.

Much of the information necessary in considering refrigerated storage of potatoes has already been given above. This applies e.g. to desirable holding temperatures, the minimum safe temperature and the desirable air humidity. Only a few additional points should be discussed here. On the grounds of maintaining a high humidity in the refrigerating air, and also of avoiding some of the potatoes being at too low a temperature it is preferable to use a refrigerating plant with a large area heat exchanger. This should deliver air almost continuously through the tubers, at a temperature not lower than 1°C below the potato temperature. Alternatively a system may be adopted whereby much colder air is fed into the humid recirculated air [illegible]. The question of desirable rate of air circulation has been the subject of much controversy. It is discussed at length by BURTON (1966), who concludes that in bulk storage an air circulation rate of 30 - 40 m³ per ton and hour will give an acceptable scatter of temperature within the stack. Much higher figures than this are quoted in the literature but may lead to excessive losses through evaporation.

In refrigerated houses potatoes may be stored in bulk, in bags or in pallet boxes. The latter method may reduce pressure bruises and internal black spot.

Under optimum storage conditions potatoes of good quality will keep for very long periods - 8 months or even longer. Long transportation offers no serious difficulties provided adequate facilities are available.

3.11. Radishes

Only spring radishes are considered here. Bunched radishes have a relatively short storage life because of the perishability of the tops. They can be held at 0°C and a relative humidity of 90 - 95 % for 1 to 2 weeks.

Topped radishes are more interesting from the storage point of view. They are generally packed in plastic bags, which prolongs the storage life considerably. Rapid precooling is [illegible], hydrocooling being the preferable method. Black spot is reduced by washing radishes in chlorinated water. Topped and prepacked radishes can usually be held [illegible] weeks at 0°C. For such radishes transoceanic transport by ship may be feasible.

3.12. Sweet peppers

Sweet peppers are liable to chilling injury at temperatures below 7°C. At temperatures of 0° to 2°C they usually develop pitting in a few days. Peppers held at low temperature long enough to cause serious chilling injury generally also develop numerous lesions of alternaria rot. *Alternaria* causes mould and decay at the calyx. Temperatures below 4 - 7°C also predispose peppers to attacks of Botrytis. For further information on storage diseases reference should be made to [illegible] (LEACH [illegible], 1966).

[illegible] temperatures above 10°C ripening proceeds rapidly. Attacks of bacterial [illegible] are also stimulated in this temperature range.

[illegible] general recommendation for the cold storage of sweet peppers is to use [illegible] storage temperature of 7° to 10°C (U.S. DEPT. AGRIC. 1968, INT. INST. REFRIGERATION 1967). According to these sources peppers could not be [illegible] longer than 2 to 3 weeks even under the most favourable conditions. However, in spite of the evidence regarding chilling damages referred to above, [illegible] authors (cf. WARDLAW 1937) recommend storage at 0°C and indicate [illegible] this temperature may give the longest storage life - up to 6 or 7 weeks. [illegible] opposite extreme PUSHKA & SRIVASTAVA (1963) report from studies [illegible] 11° to 13°C to be the optimum storage temperature.

[illegible] storage life of sweet peppers may be prolonged with about a week by pre-[illegible] in moisture-retentive films, e.g. polythylene. Beneficial effects [illegible] also be obtained by waxing. Not only is shrinkage reduced but also shafing [illegible]. Only a thin coating should be applied (for details see HARTMAN & [illegible] 1955).

[illegible] sweet peppers are not ideally adapted to long time storage, it appears [illegible] research to develop methods allowing transocean ship transportation [illegible] commodity.

[illegible] Sweet potatoes

[illegible] sweet potatoes are stored in non refrigerated ware houses. The [illegible] of refrigeration, however, is advisable in all cases when ventila-[illegible] not maintain low enough temperatures.

[illegible] requirements for successful storage of sweet potatoes include sanitary [illegible] houses, avoidance of low temperature injury prior to harvesting and [illegible] storage, careful handling, exclusion of diseased roots, thorough curing [illegible] and observation of correct conditions of temperature and [illegible] (WARDLAW 1937).

[illegible] of sweet potatoes is delicate and easily broken. Wounds in the skin [illegible] organisms. Therefore great care should be exercised [illegible] harvesting and handling operations to keep wounding and bruising at a [illegible].

[illegible] most of the important varieties of sweet potato can be stored success-[illegible] some are consistently less subject to shrinkage and decay than others.

[illegible] potatoes are usually stored in slatted crates or [illegible] baskets. Palletiza-[illegible] crates and use of pallet boxes facilitates handling ([illegible] & [illegible]HMAN [illegible]).

[illegible] entering on a prolonged period of cold storage, [illegible] important that all [illegible] wounds should be adequately protected [illegible] development of wound cork. A preliminary curing [illegible] provide the [illegible] conditions [illegible] formation, is therefore essential [illegible] proceeds most rapidly [illegible] relative humidity of [illegible] begins [illegible] two days [illegible] temperatures [illegible] should not be delayed more than two days after harvesting.

After curing the temperature should be reduced to 13° - 15°C. The relative humidity should remain at 85 - 90 % during storage. Most varieties will keep satisfactory for 4 to 6 months under these conditions. Weight loss of 2 - 6 % can be expected during curing and about 2 % per month during subsequent storage (MINGES & MORRIS 1953).

Sweet potatoes are subject to chilling if exposed to temperatures below 13°C. Slight injury, indicated by the appearance of internal discolouration, has been observed after an exposure of 10 days at 0°C and after 29 days at 4.4°C. In addition to internal discolouration symptoms of chilling include increased susceptibility to decay, internal breakdown and off-flavours when cooked.

Storage temperatures above 15°C stimulate development of sprouting and may cause internal breakdown.

Several microorganisms are responsible for production of diseases of sweet potatoes [illegible] in the field and during subsequent storage, others are only [illegible] pathogenic in storage. In attempting to control wastage in storage attention must be given to the [illegible] of [illegible] infected material, to [illegible] during harvesting and handling operations and to providing suitable storage conditions. [illegible] potatoes may be [illegible] ed with [illegible] marketing (KUSHMAN [illegible] al. [illegible]).

There appears to be no [illegible] in [illegible] shipment of sweet potatoes provided proper storage conditions of temperature and humidity can be maintained.

3.14. Tomatoes

There is a great number of commercial varieties of tomatoes [illegible] of varieties in size, shape, colour and [illegible]. In [illegible] ters [illegible] are to be found in the [illegible] of different countries. [illegible] important to note [illegible] been [illegible] between different varieties grown under the same conditions [illegible] response to storage temperatures (WARDLAW [illegible]).

The demand for tomatoes [illegible] the year [illegible] transport of this [illegible] commodity [illegible] common [illegible]. The conditions under which the crop is grown and harvested are many and varied. This also applies to transport and [illegible].

According to [illegible] involved, tomatoes may be harvested [illegible] green [illegible] ly coloured [illegible] green [illegible] rences in colour [illegible] a well standardised [illegible] desired maturity.

The harvesting of [illegible] green [illegible] must be [illegible] ripen [illegible] slowly and [illegible] flavour [illegible].

It is generally [illegible] that tomatoes [illegible] the vine are [illegible] in flavour to those picked [illegible] ripened [illegible] storage. [illegible] superiority of locally [illegible] when [illegible], to those picked green and transported long distances.

[illegible] are delicate and must be handled very carefully at all stages from [illegible] to packing. Attention to packing shed sanitation and the immediate [illegible] of all diseased, cracked or bruised fruits are important in the [illegible] of wastage.

[illegible] tropically grown tomatoes intended for export WARDLAW & McGUIRE [illegible] that the time between harvesting and coming to the temperature storage should be as brief as possible. [illegible] not only depreciation as a [illegible] and ripening at high temperatures, but fungal pathogens make [illegible].

[illegible] & McGUIRE (1932) have also studied the question of the effect of [illegible] cold packs to tropical temperatures during transfer from a precooling [illegible] the ship's holds. They found that exposure for 4 hours at 27° - 30°C [illegible]

[illegible]

and in autumn. It was found that, whereas [illegible] grown from [illegible] performed earlier, results that English tomatoes are subject to chilling injury below 10°C (BAIN [illegible] 1957), the summer grown fruit showed considerable tolerance of low temperatures. Thus at storage at [illegible] there was no wastage after 30 days and on removal to [illegible]°C the tomatoes ripened slowly. No explanation was found [illegible] summer grown fruit should tolerate low temperatures better than autumn grown fruit.

On the basis of their results discussed above, WARDLAW & McGUIRE (1933) recommend that mature green tomatoes grown in Trinidad be stored at [illegible]°C. At this temperature a storage life of 30 days or more may be expected, with a further storage life at [illegible] 21°C of 12 to 14 days with low wastage [illegible] REFRIGERATION [illegible] quotes a recommendation from [illegible] to 2 [illegible]°C which is expected to give a storage life of 6 weeks. On the other hand most investigators working in other parts of the world [illegible] the optimum storage [illegible] As to the storage life at this temperature [illegible] up to 4 [illegible] weeks [illegible]

[illegible]

[illegible] the physiological disorders befalling tomatoes in storage chilling is [illegible] most important one. Some symptoms of chilling injury have already been [illegible] but it appears warranted to give a fuller account of this subject. [illegible], chilling injury cannot be detected immediately upon removal from [illegible] temperature. It does not become apparent until the tomatoes have been in [illegible] temperature for 2 or 3 days. At that time tomatoes that have been [illegible] chilled have a dull, lifeless [illegible] appearance and feel rubbery to [illegible] touch. The internal symptoms are a watery, but not mushy, appearance of [illegible] tissues and a slightly fermented odour. Alternaria rot in a pattern around [illegible] scar and in the form of numerous small lesions over the surface [illegible] accompanies chilling injury. TOMKINS (1965) has made an interesting [illegible] of the relation between true physiological injury and secondary micro- [illegible] infections in chilling of tomatoes.

[illegible] tomato is subject to a great number of microbial storage diseases. Of [illegible] importance among these are alternaria rot (*Alternaria tenuis*), bacterial [illegible] (*Erwinia carotovora*), [illegible] rot (*Fusarium* spp.), grey mold rot [illegible] and Phoma rot (*Phoma destructiva*). Control measures vary [illegible] measures in the field, gentle handling and proper storage [illegible]. TOMKINS (1963) obtained promising results in control of storage [illegible] tomatoes by the use of wraps impregnated with [illegible] acetate. [illegible] were effective even at [illegible]. The tomatoes [illegible] storage [illegible].

[illegible] of storage diseases of tomatoes and their control reference [illegible] made to LAMBERT et al. (196[illegible]).

[illegible] of extensive research the storage physiology of the tomato [illegible] storage conditions is [illegible] by the [illegible] there appears [illegible] allowing more extended storage with [illegible] more extended transportation than [illegible]

[illegible] become least sensi- [illegible]

[illegible] establish the possible beneficial effects of CA-treatment

[illegible] possible benefit [illegible] temperature" storage technique [illegible] temperature for storage of green [illegible] to ripen [illegible] as slowly as possible and [illegible] temperature [illegible] to 0°C for the fully ripe tomatoes. A com- [illegible] wraps appears worthy of consideration.

[illegible] transport by ship in the [illegible] of the world is hardly [illegible]. As indicated, means might be found in the future to [illegible]

[illegible]

[illegible] marketing high quality watermelons is the correct determina- [illegible] methods have been suggested for determining the best [illegible] these are reviewed by WHITAKER & DAVIS (1962). According [illegible] field test for judging maturity is a change [illegible] especially [illegible] the part of the melon that is in contact with the ground - the so called "ground spot". At maturity, the background colour of the rind on this part of the melon changes from greenish white to pale yellow. It is stressed that considerable experience is necessary to harvest watermelons successfully.

Watermelons are not adapted to long storage. At low temperatures they are subject to various forms of chilling injury, while at high temperatures decay limits the storage life. A storage temperature of 4° to 10°C may be regarded as a good compromise. In this range watermelons should keep for 2 - 3 weeks. However, a report from the U.S.S.R. ([illegible] 1958) indicates that suitable varieties can be kept up to 3 months at 3° to 4°C.

Watermelons lose red colour at low temperatures, even at 10°C, while at 21°C colour is intensified. They decay less at 0°C than at 4°C but tend to become pitted and get an objectionable flavour after 1 week at 0°C.

Flavour of watermelons may be improved by holding them for 7 days at room temperatures.

Attempts to organize long range transport and marketing of watermelons will obviously meet with considerable difficulties.

[illegible]NCLUDING REMARKS

[illegible] Packing

[illegible] in packing of fresh fruits are reviewed in FRUITS, section 6. Much [illegible] general information given there applies to vegetables also but a few [illegible] aspects will be considered here.

[illegible] traditional packages for most vegetables are bags [illegible] wooden cases. De-[illegible] on package performance are, however, increasing due to a number of factors such as longer shipping distances, new methods of selling and of trans-[illegible] and higher requirements on produce quality. The use of cartons offers [illegible] possibilities for packaging improvement for a number of vegetables. [illegible] of importance in this connection that the introduction of vacuum cooling has made possible the use of cartons for produce traditionally precooled with [illegible] e.g. lettuce.

[illegible]troduction of tray-pack or cell-[illegible] cartons has more or less revolu[illegible] the packing of apples and pears. [illegible] well wo[illegible] study the [illegible]bilities of applying such types of [illegible] also to some [illegible] of vegetables, [illegible] first place tomatoes, possibly also [illegible] peppers and others.

[illegible] of moisture retentive wrappers [illegible] beneficial - in some cases [illegible] for many vegetables [illegible] example [illegible] in [illegible]-film, which [illegible] early, [illegible] by the retail trade to be [illegible]

[illegible] vegetables, e.g. potatoes and [illegible] bulk bins [illegible] alternative to traditional methods of [illegible]. Thus, bulk bins holding [illegible] for storage and delivery [illegible] well [illegible]

[illegible] Transport

[illegible] of fresh fruits by land, [illegible] FRUITS, [illegible] The information given there [illegible] to vegetables [illegible]

[illegible] of the vegetables treated in this [illegible] to offer [illegible] cargo. Presently substantial [illegible] from USA to Europe. Also [illegible] peppers and tomatoes may under certain [illegible]

[illegible] of vegetables discussed here [illegible] and sweet potatoes [illegible] very long storage life [illegible] without [illegible] of refrigeration [illegible]. This practice [illegible] for [illegible] probably be replaced by [illegible] under controlled temperature [illegible]

[illegible] Marketing

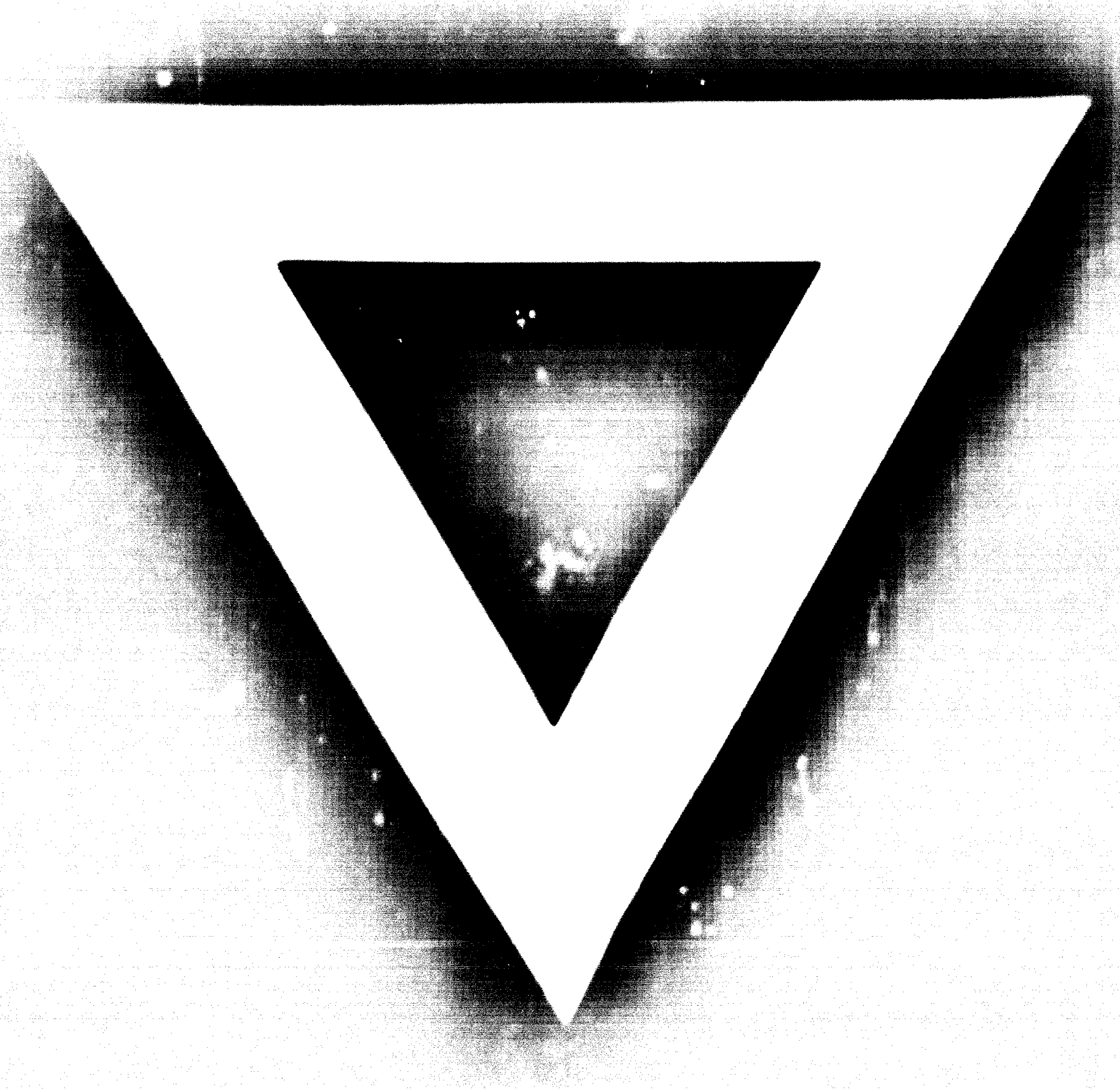
[illegible] in marketing of fresh fruits are [illegible] in FRUITS, section [illegible] is studied in [illegible] with the present paper [illegible] information given in FRUITS is relevant to vegetables also.

[illegible] with fruits standardized and improved [illegible] in any [illegible] for developing the marketing of fresh vegetables. [illegible] extremely important and full considera[illegible] of breeding new varieties better adapted to mechanized production and with quality characteristics entirely corresponding to the demands of the [illegible] markets.

The establishment of official rules for planting [illegible], grading, quality standards, packing etc. is an important and indispensable tool for developing the vegetable industry as well as the fruit industry. Such rules must be [illegible] on local [illegible] and experience [illegible] export is considered, [illegible] then must be given to the demands of interested export [illegible].

Adequate transport facilities between production areas and markets are indispensable for the [illegible], expansion and [illegible] of the vegetable industry. A further [illegible] generally is the establishment of packing stations, [illegible] ally located and [illegible] adequate equipment for [illegible], storage, grading, packing etc.

There [illegible] storage [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] for the [illegible] industrial [illegible]



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