3rd Lecture: Physiology

Water loss and their physiological effects

Ripening: loss of water and respiration

Development – a series of biological processes from the onset of growth to the death of produce.

Growth – an increase in physical characteristics in the development of the product.

Ripening – a special stage in the development of the product in which all its characteristics were acquired during growth and development in order to reach an optimal harvesting state.

Loss of water of ripe fruits

Number one factor in the physiological decline of produce in prolonged storage

A nanostructural view of the cell wall disassembly process during fruit ripening and postharvest storage by atomic force microscopy

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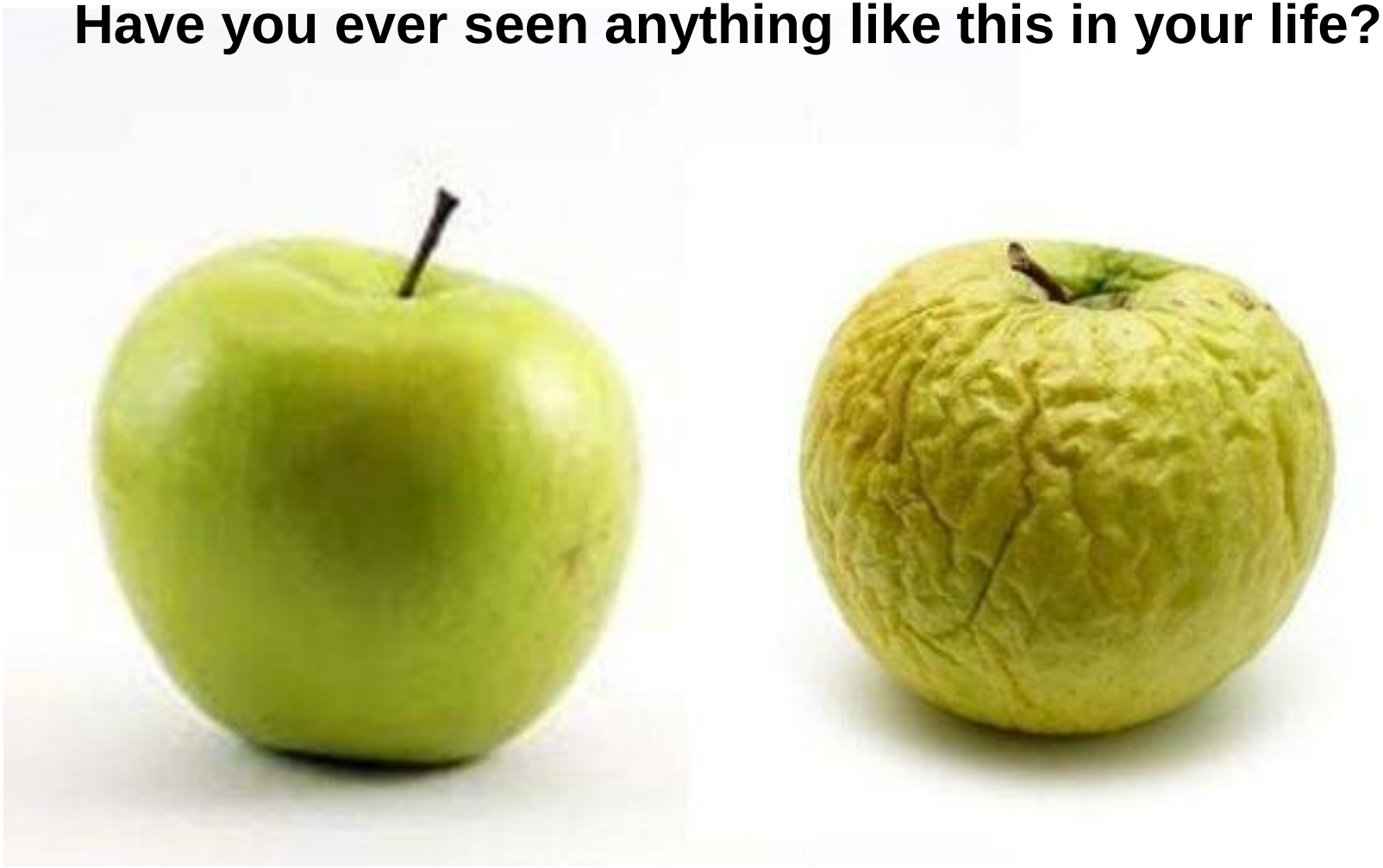
Have you ever seen anything like this in your life?



Water loss is

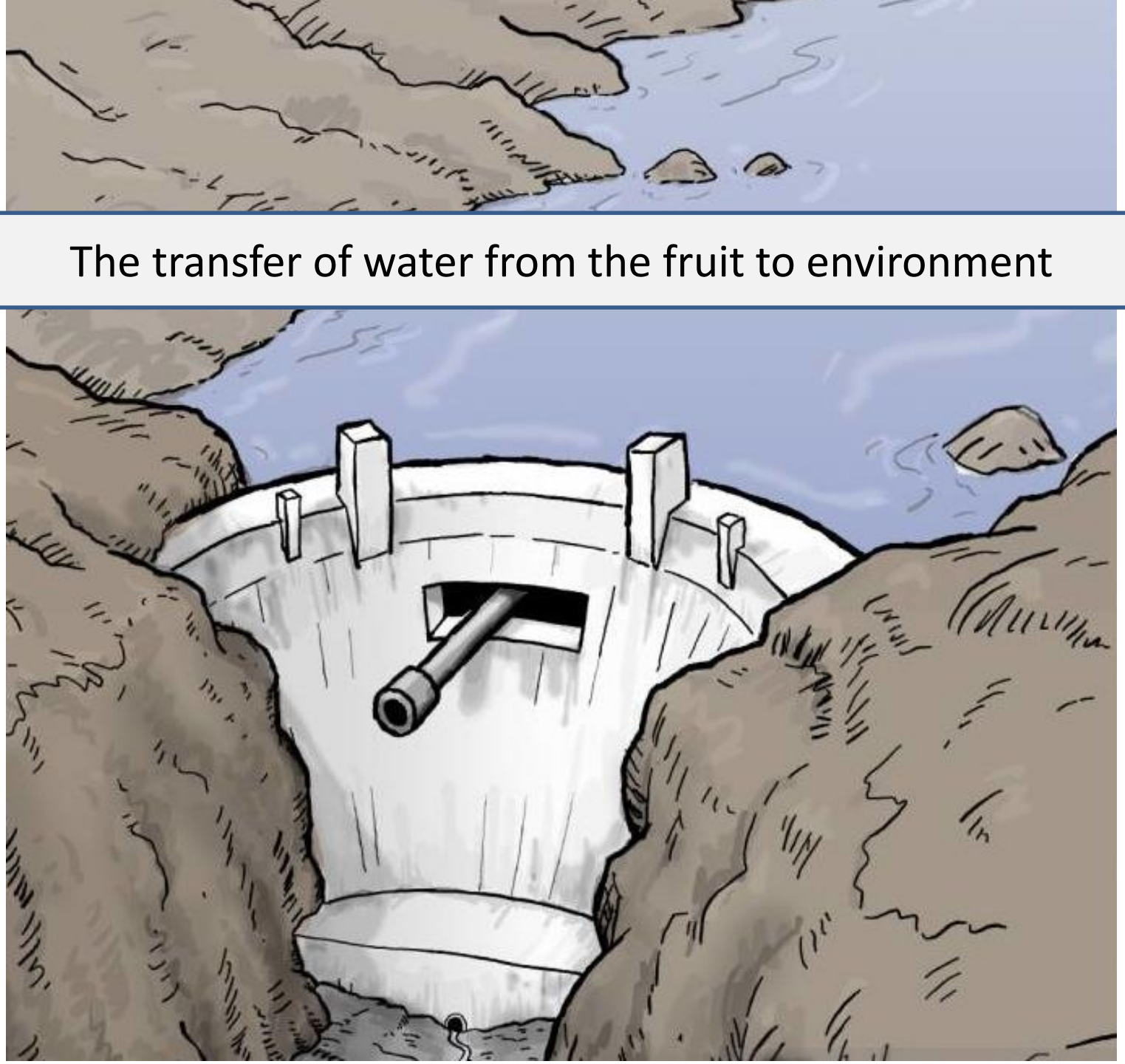
Number one factor in the physiological decline of produce in prolonged storage

This include:

- Water loss of the product during harvest and storage
- Weight loss of the product during the selling period
- External quality decline
- Internal quality decline (flexibility)
- Decline in the nutritional components

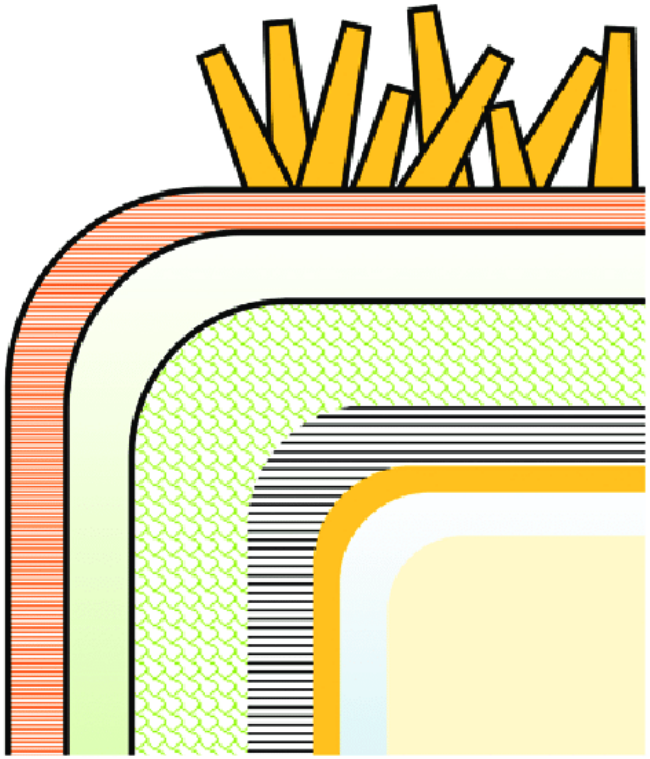
Small fruits have an increased surface area relative to their volume, so they tend to lose more weight

The transfer of water from the fruit to environment



The transfer of water from the fruit to the environment

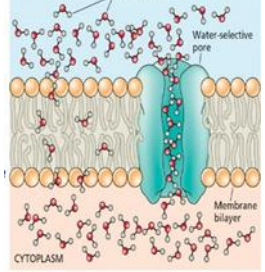
Main barriers to the passage of water from the fruit to the environment



1. The cuticle:
Consists of cutine and wax. There is lipophilic and hydrophilic barriers

2. Cell wall:
Passage through the cellulose mesh

3 .The cell membrane (plasma membrane, lipid phase).
Osmotic passage through the lipids and proteins in the membrane. Accelerated transition through aquaporins

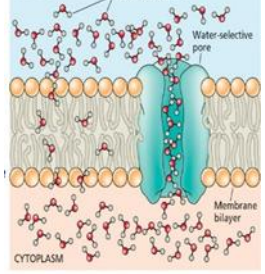


The passage of water from the fruit to the external environment is delayed by three main structural barriers:

In the cell membrane: the lipid layer of the cell membrane is a significant barrier to water transfer. Through the membrane there is also an accelerated and selective passage of water in the channels for water (Aquaporins) conduction. The rate at which water passes through the cell membrane depends on the structure of the channel, the number of channels located in the membrane and their control mechanism.

The cell wall is a mechanical barrier for water molecules determined by the size and density of pores found between cellular molecules. The cell wall plays a crucial role in maintaining the cell turgor and growth processes and development of the cell wall are related to the softening of the fruit.

The cutin layer surrounding the fruit is the last barrier the water needs to pass before it moves out of the fruit. The cutin layer consists mainly of long-chain fatty acids and other macromolecules. The wax layer above the cutin consists of different types of fats



The passage of water from the fruit through the cuticle to the external environment is affected by two way of water transition:

A. The lipophilic transition: The water molecules that are small and not charged can pass through the fat cuticle. The condensed waxes within the cutin layer determine the length of the transport that the water molecules undergo, and consequently the rate of exit into the atmosphere.

B. The hydrophilic passage: The passage of water through the cuticle is also carried out through hydrophilic components. Polar passages generated due to the hydrophilic components combined in the cutin layer.

Development

Ripening

Postharvest

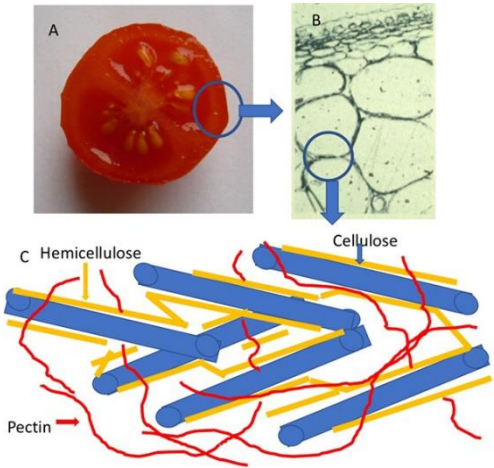
Slight XyG depolymerisation
Loosening of XyG-cellulose network
Major Pectin degradation:
- Demethylesterification
- Solubilization
- Depolymerisation
- Loss of Gal and Ara

Weakening of cell walls

Reduced intercellular adhesion

Loss of cell turgor

Fruit softening



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Factors that contribute to water loss

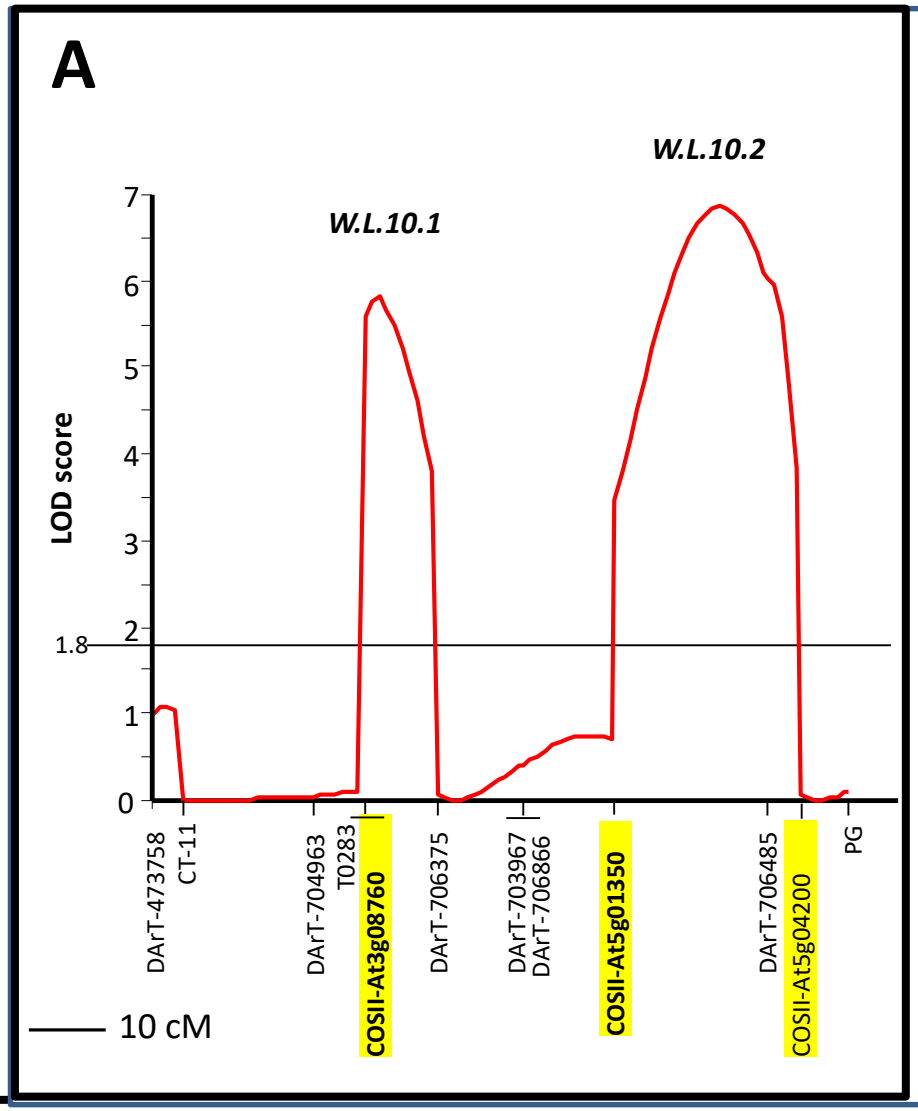
- **Genetic factors**:
  Cultivars
- **Environmental factors**:
  Temperature,
  Relative humidity
- **Anatomical factors**:
  Stomata
  Surface area (leaf vs. fruit)
  Wounds
  Harvesting conditions
  Ripening stage

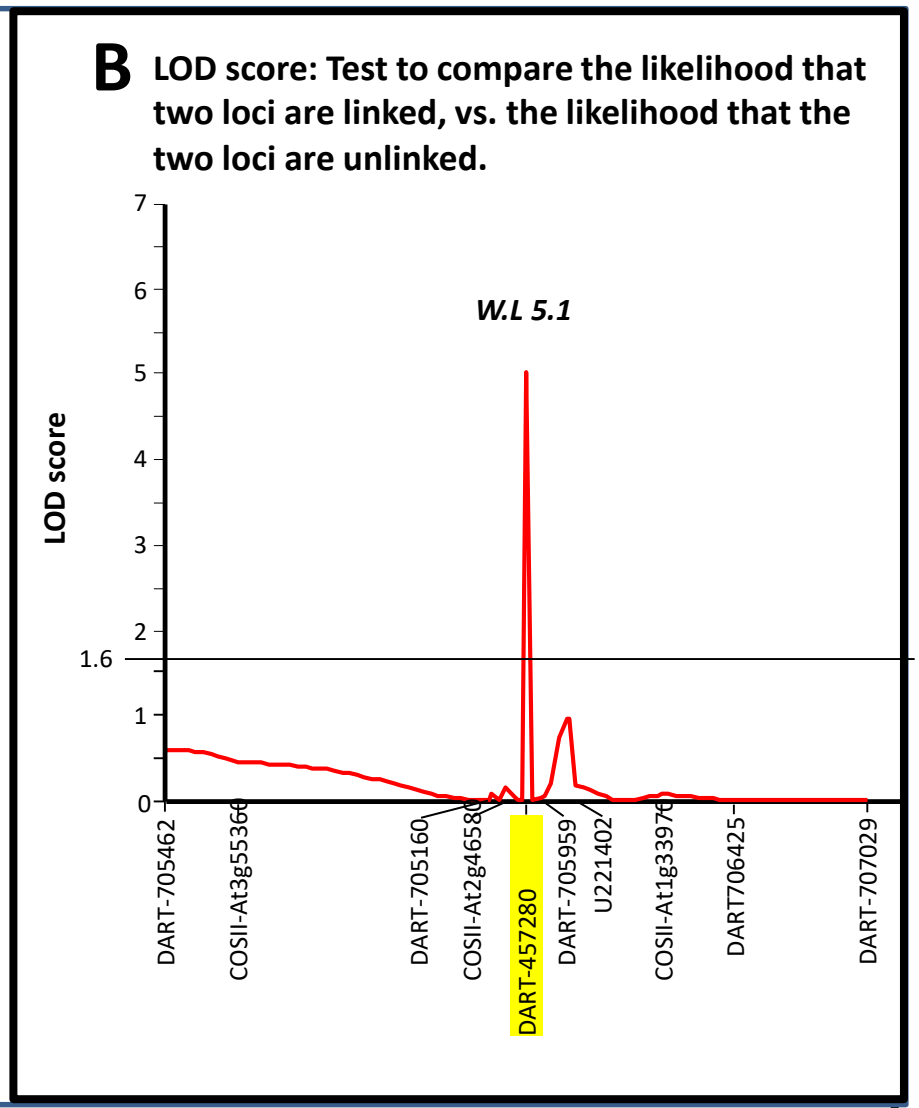
Genetic factors

Effect of storage at 20 C during 5 days on the rate of water loss by different pepper varieties

Level	Loss of water from mg/cm2	Origin	Cultivar
High	a 3.13	Hungary	Csokro
High	b 2.74	Czechoslovakia	PCR
Medium	c 0.97	Turkey	Turkey
Medium	c 0.83	Canada	Pimento perfecto
Medium	d0.66	USA	Early bell 400
Medium	e 0.55	USA	California wonder
Low	f 0.44	France	Doux d'Espagna
Low	f 0.40	Holland	Golden Crest
Low	gı 0.38	Holland	AC2196
Low	g 0.32	Spain	Dulce italiano

Identify QTLs that control the loss of water in pepper fruit in the BC2 population (backcrossed populations)





R^2 :	0.1	0.13	0.1	0.08

Near-isogenic lines to the sequence area of chromosome 10

High Loss of water

PI 1154 (Capsicum *annuum*)

X

low loss of water

USDA -162 (*C. chinense*)

PI 1154 X F1

PI 1154 X BC1

PI 1154 X

BC2

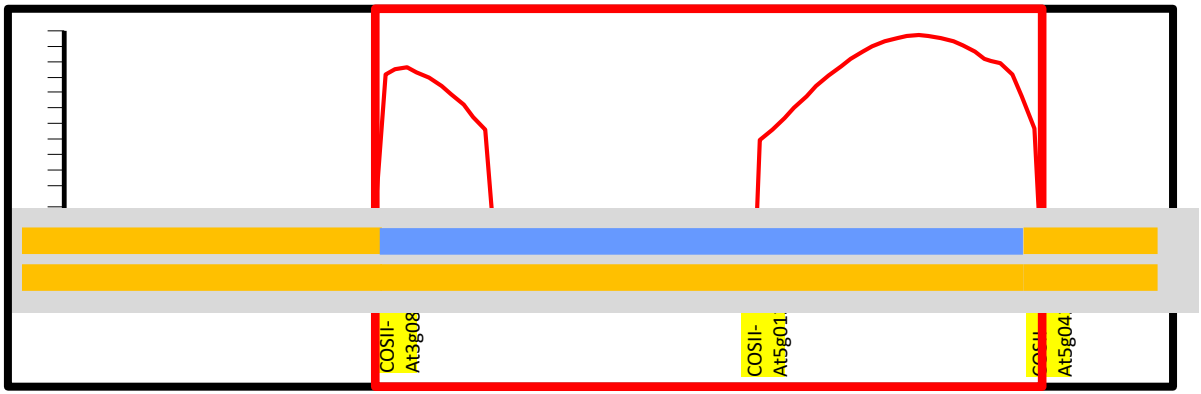
BC3

BC2F2

BC3F2

BC3F3

Contributing QTL



High loss of water

Low loss of water

Recurrent-NIL

Donor-NIL

Water loss from the fruit is partially determined before ripening

Percentage of difference between near-isogenic lines	Average lines with high water loss value (Recurrent-NILs)	Average lines with low water loss value (Donor-NILs)	
46	40.03 **	21.63	Loss of water from red fruit (mg/cm2)
43	33.39 *	19.15	Loss of water from green fruit (mg/cm2)

P≤0.05 = *

P≤0.001 = **

Genetics

The composition of the wax in the cuticle is related to the loss of water from the th… …ogen lines

	'USDA 162' Mean +SE	'PI 115… M…	…162 / …154
Water Loss after 5 days (mg/cm^2)	52.4 ± 0.1		0.4
Fatty Acids	3…	… ± 14.1	0.6
Terpenoids/Sterols		409.3 ± 10	0.1
Alkanols	…1.8	42.4 ± 1.3	0.4
A…	1.1 ± 0.2	3.6 ± 0.04	0.3
…	215.4 ± 14.1	632.4 ± 16.1	0.3
…16 dioic	3.4 ± 0.9	11.4 ± 0.3	0.3
18-OH 18:0	260.9 ±16.4	50.8 ± 27.3	5.1
9,18di-OH	6.3 ± 0.7	19.9 ± 0.7	0.3
epoxyω-OH	21.1 ± 2.2	94.5 ± 5.2	0.2
18:1 epoxy	6.6 ± 0.5	19.6 ± 5.3	0.3
Total cutin (mg/cm^2)	764.3 ± 55.3	1196.7 ± 1.8	0.6

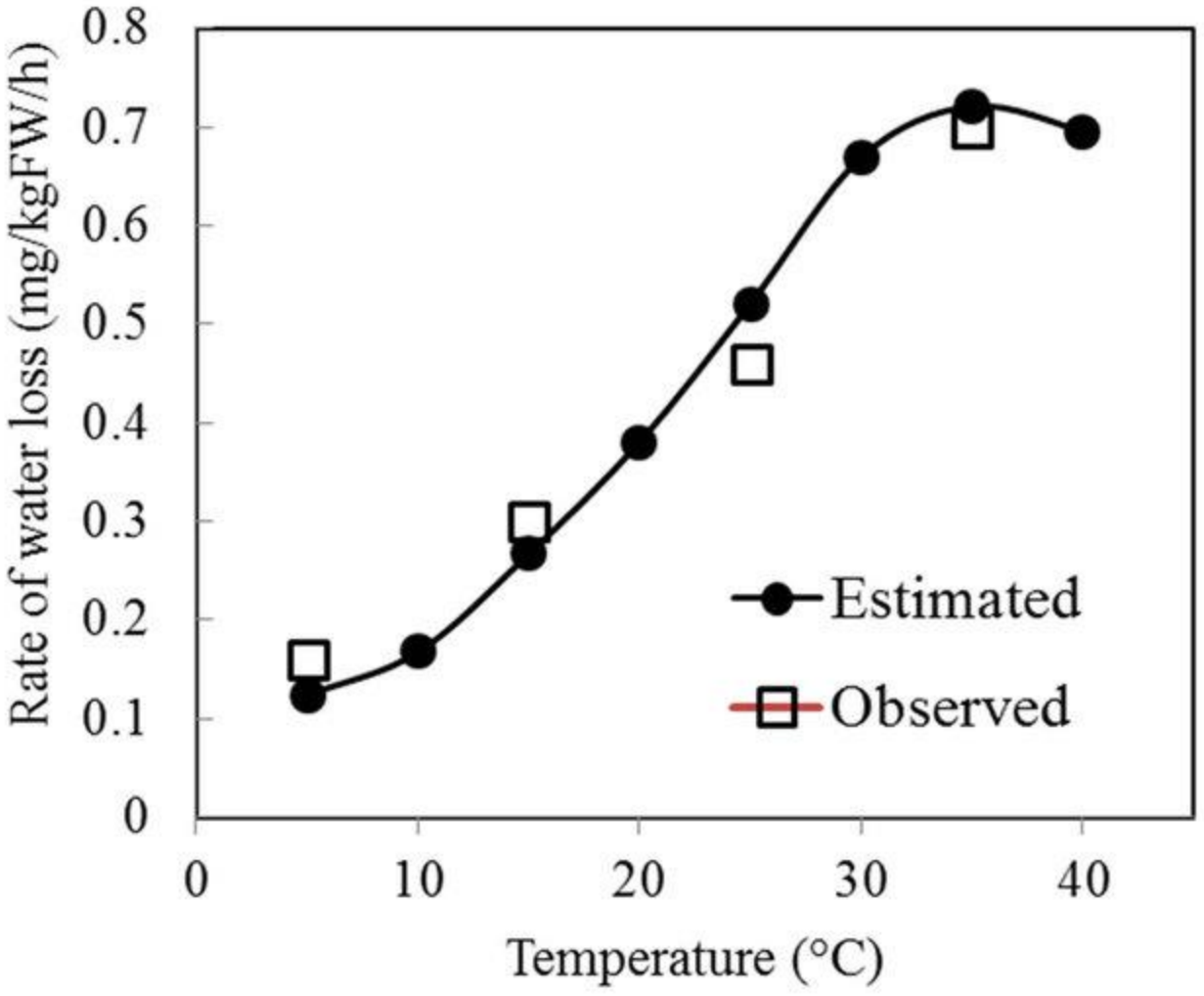
There is a positive correlation between the amount of wax and cutin in the fruit and the decrease in water loss.

Importance of the Relative Humidity

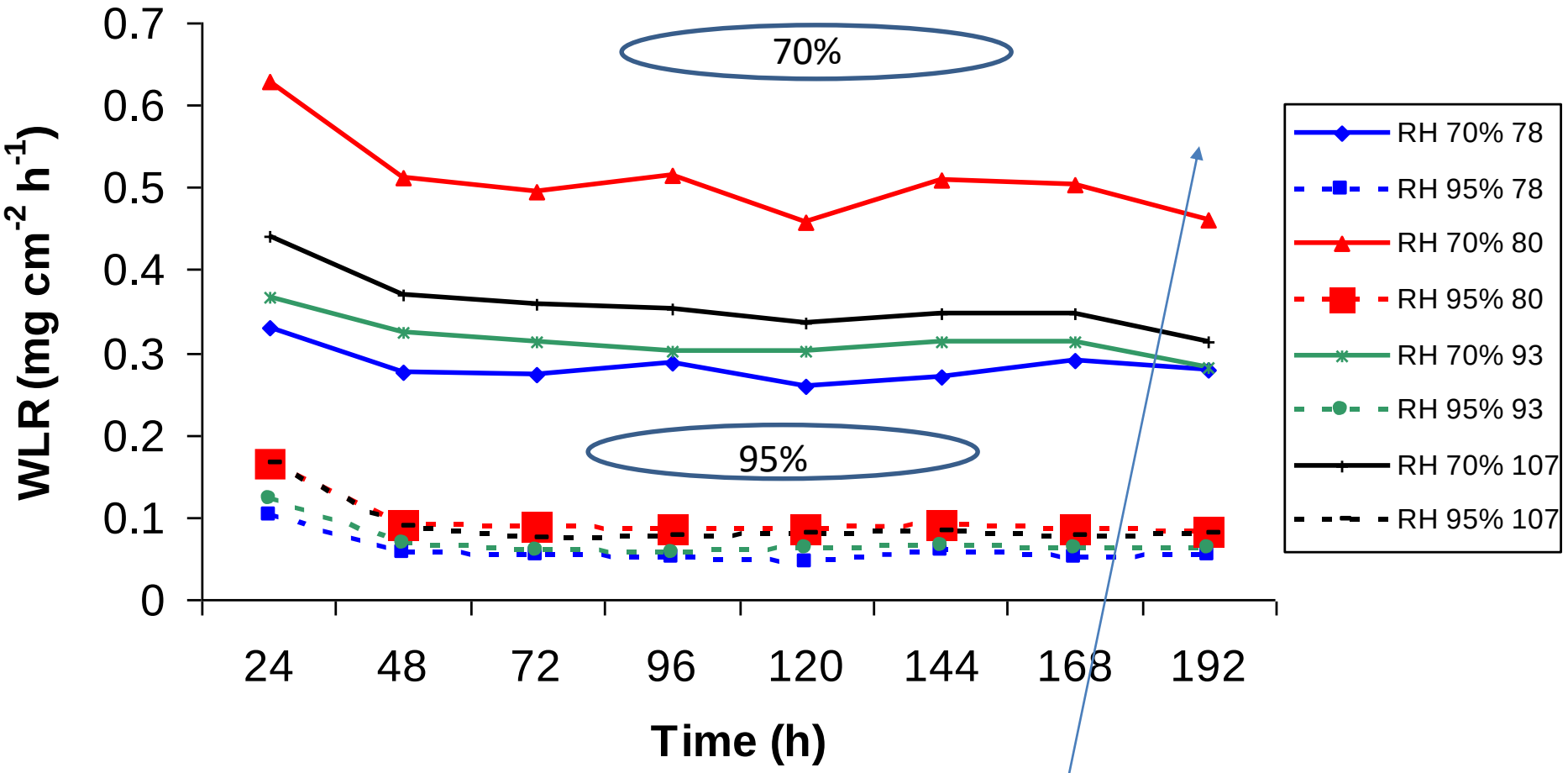
Water loss (%)	The induced factor
1	Increase of respiration and ethylene production
1	Enhanced senescence
2	Increase of chilling injury
3	Effect of cell membranes
4	Reduction of vitamins and aroma
5	Reduction of color and softening
6	Texture changes

The relation between water loss and respiration of fruit

Effect of temperature on water loss from cherry tomatoes



Rate of water loss on four parent lines, stored at 12 degrees C, with humidity of 70 and 95%

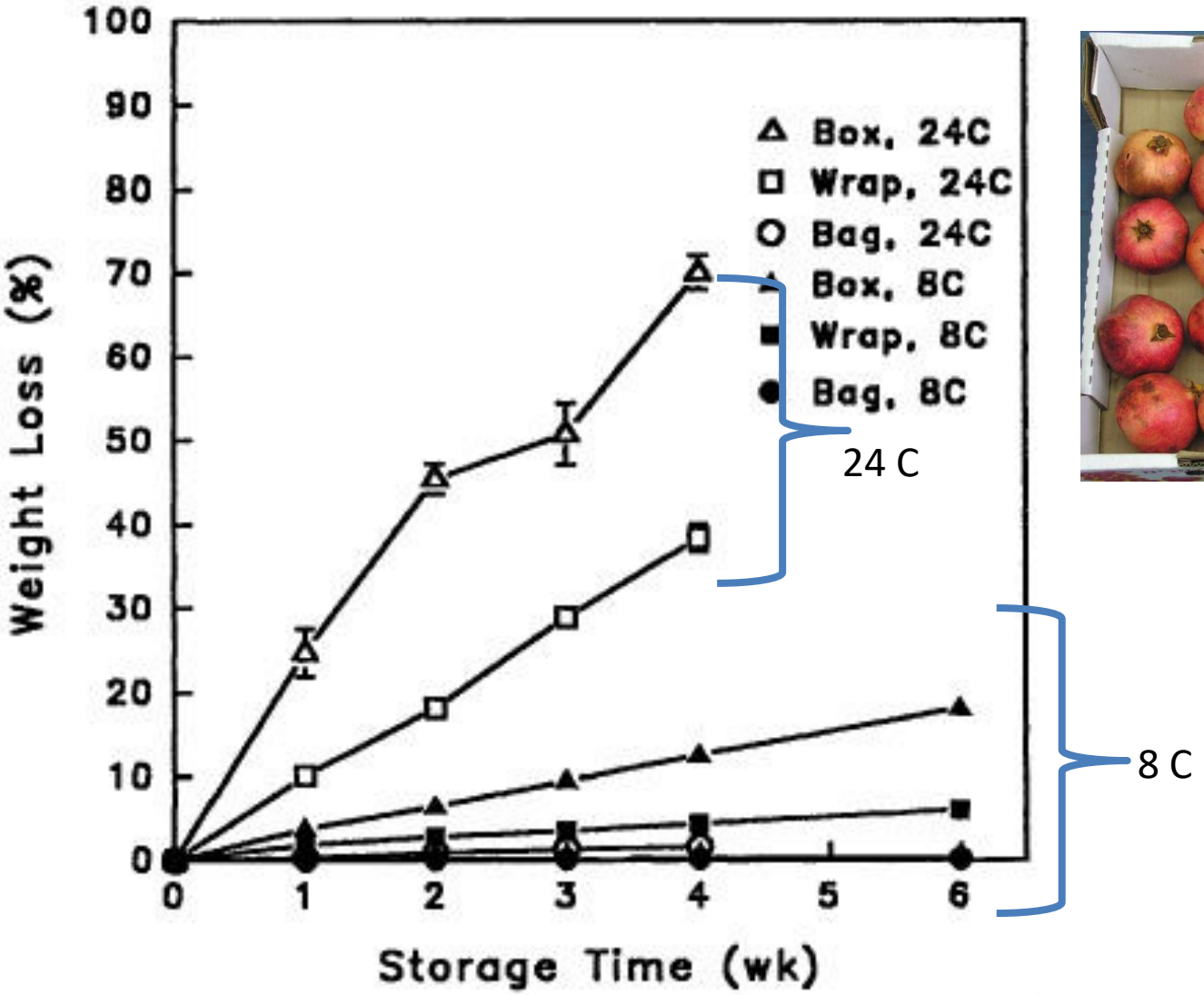


High water loss – 80-ı 107

Low water loss – 93-ı 78

Humidity during storage

Effect of temperature and plastic wrapping on weight loss



Water losses in pomegranate stored with and without plastic wrapping (increase humidity) at 8 and 24 C

Effect of moisture on pomegranate quality in prolonged storage

95%

80%

65%

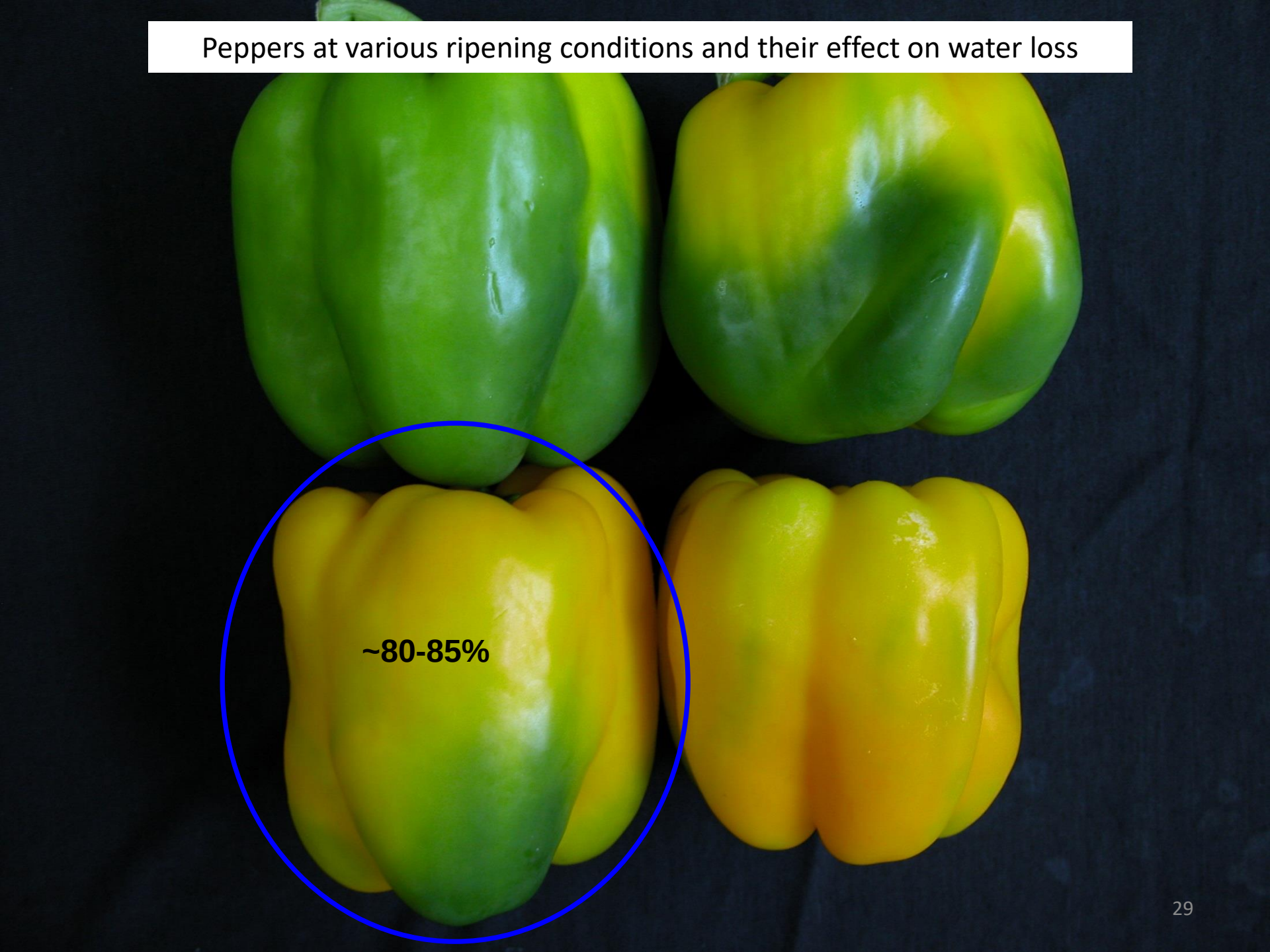

Foggers
DAMKA
DAMKA
DAMKA
DAMKA
DAMKA
DAMKA

Effect of moisture during storage on the daily percentage of weight loss

		Percent of weigh loss			
Product	Temperature	RH 95%	RH 90%	RH 85%	RH 80%
Apples	0 C	0.011	0.022	0.033	0.044
Chinese cabbage	0 C	1.610	3.220	4.840	6.420
cabbage	0 C	0.058	0.116	0.175	0.233
Carrot	0 C	0.315	0.630	0.945	1.260
Grapes	0 C	0.036	0.064	0.096	0.128
Peaches	0 C	0.150	0.300	0.45	0.600
Pears	0 C	0.018	0.036	0.054	0.072
Potato without curing	6 C	0.070	0.141	0.211	0.282
Potato with curing	6 C	0.021	0.042	0.063	0.084
Tomato	C 8	0.060	0.119	0.180	0.240

Effect of ripening on weight loss

Peppers at various ripening conditions and their effect on water loss

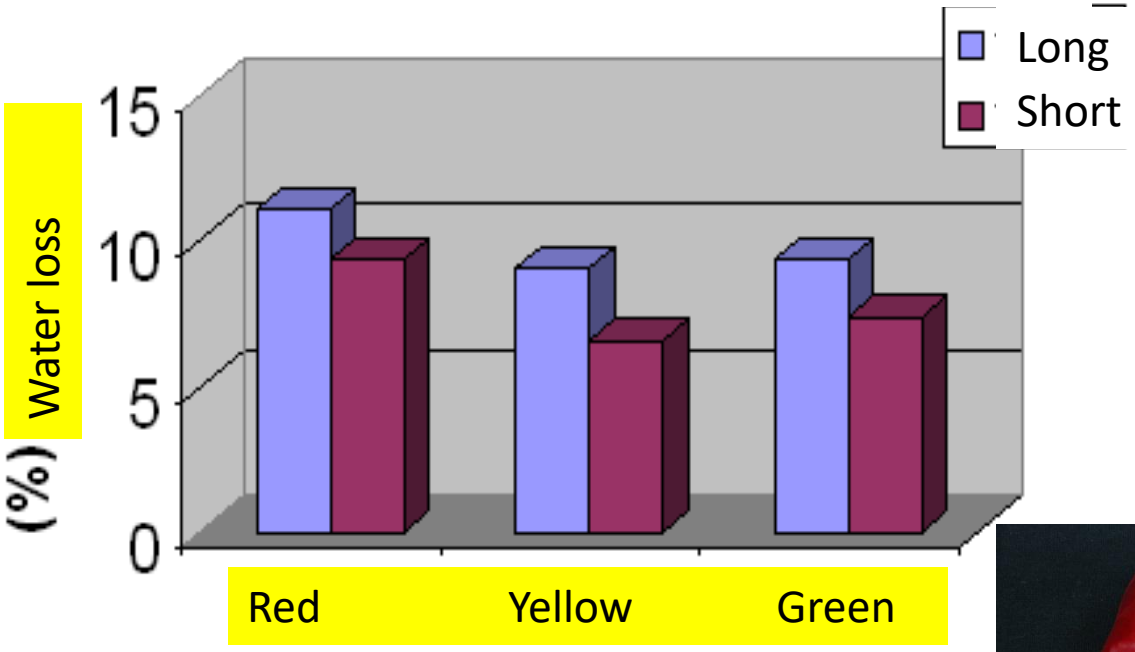


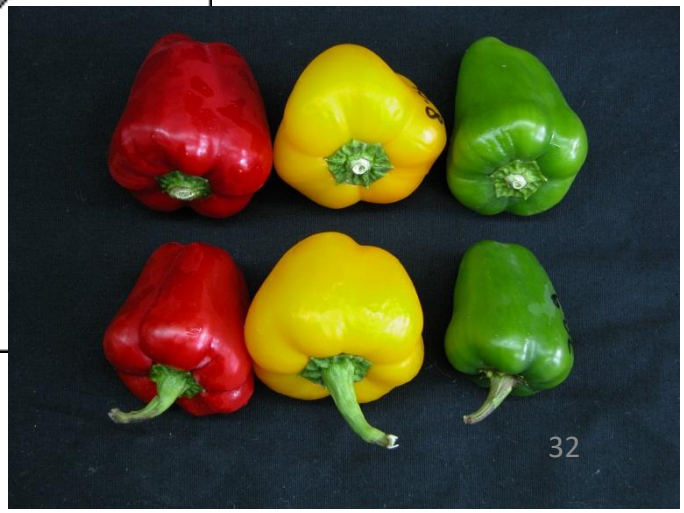
Rate of water loss from fruit harvested in various ripening conditions (red strain 7158)

Ripening stage	Water loss (mg/cm2 per h)
Mature ripe	0.51c
Red color 40-50%	0.53bc
Red color 75-80%	0.56b
Red color 95-100%	0.65a

Different stem length

Effect of the full of cut stem on water loss





Impact of harvesting time on water loss in mint

6:30

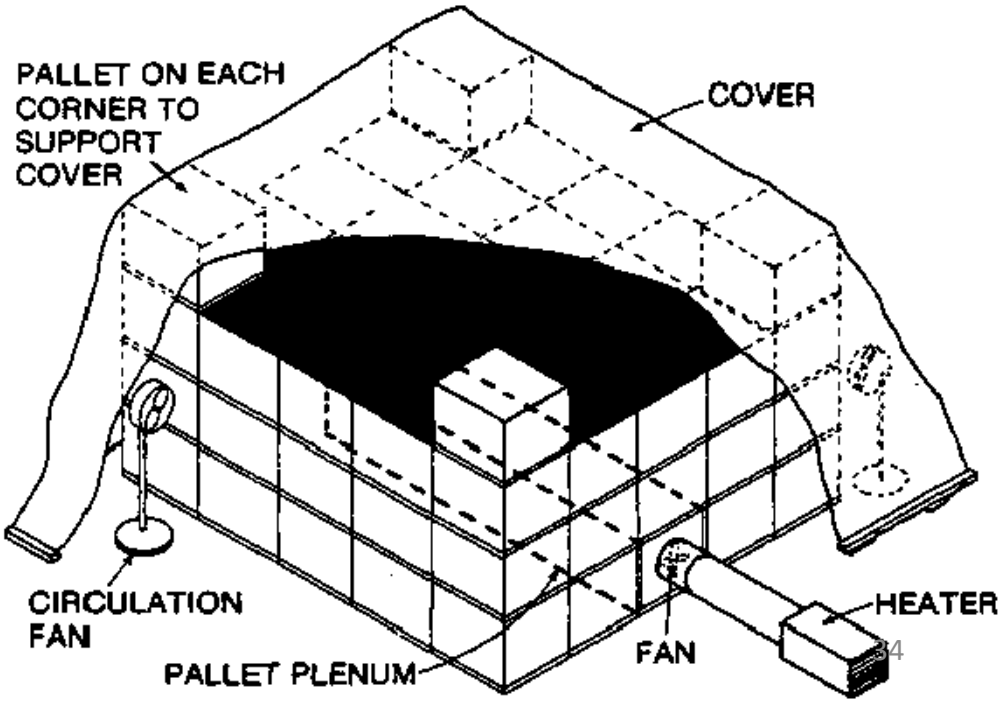
10:30

13:00

Level of the photosynthetic metabolites: higher sugar content after morning hours

Curing

Potato: 12-14 C for 5 days at 95% RH
Sweet potato : 32 C for 5 days in 95% humidity



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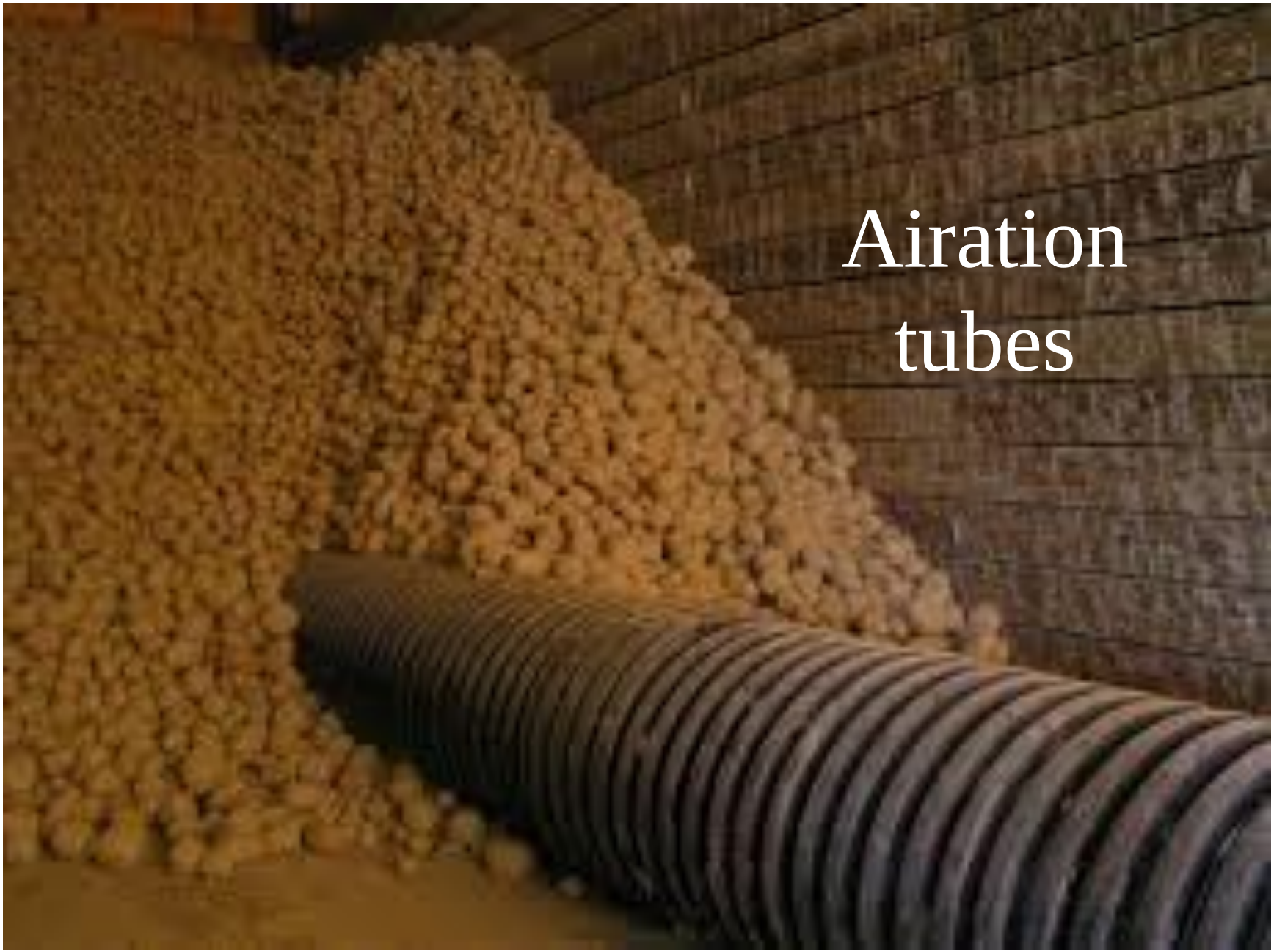
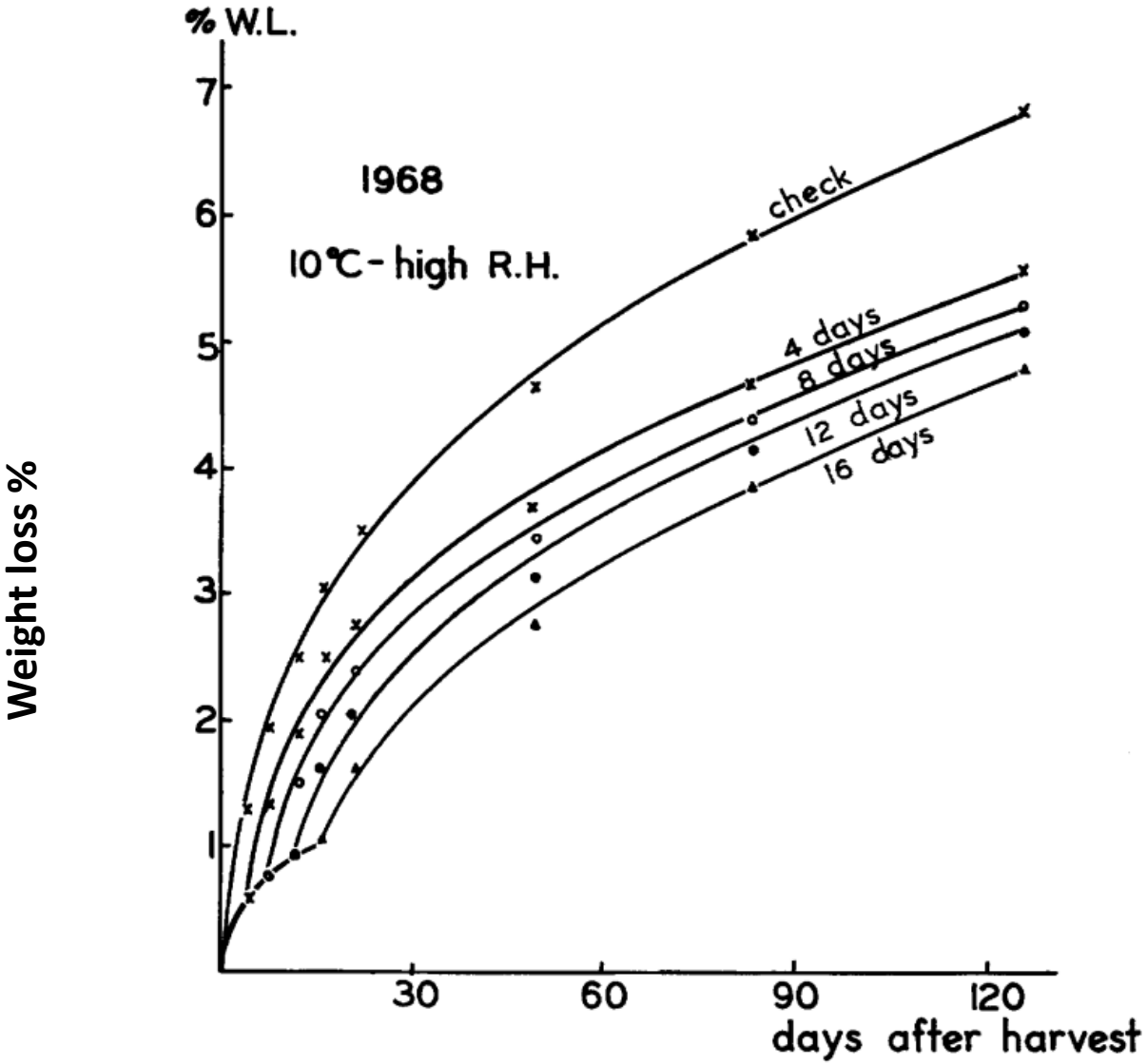
Kenyan farmers

Curing in Europe


Storage England

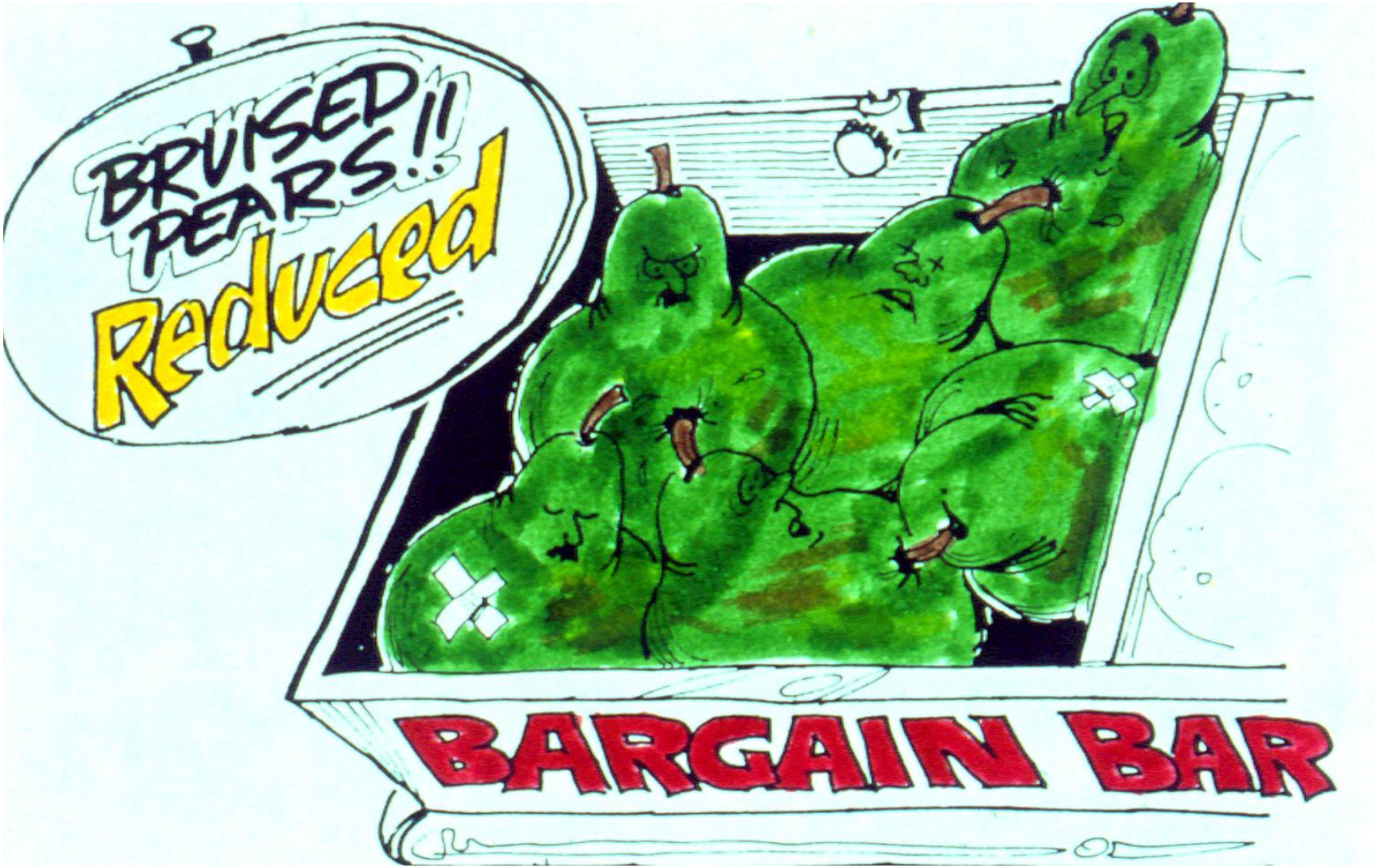

Airation
tubes

Effect of curing period at 10 C for 4-16 days on weight loss of potatoes stored at 5 C



Schipper 1971 Amer. Potato.J.

Stem end bruises and their effect on water loss



Summary

Ways to reduce the rate of water loss (summary)

- Low temperatures
- Harvesting correctly and in optimal ripening mode
- Storage at high humidity (90% to 95%) (Except for dry onions and garlic – 70%)
- Prevention of wounding by curing,
- Waxing
- Use of edible coatings
- Packaging

Importance of the Relative Humidity in secondary induced process

Water loss (%)	The induced factor
1	Increase of respiration and ethylene production
1	Enhanced senescence
2	Increase of chilling injury
3	Effect of cell membranes
4	Reduction of vitamins and aroma
5	Reduction of color and softening
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