HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES

Minimally processed food

Prof. Dr. habil. agr. Dr.-Ing. Dr. Iryna Smetanska
iryna.smetanska@hswt.de

Fresh-Cut: diversity

HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES

Fresh-cut or minimally processed products = lightly processed, partially processed, fresh-processed, pre-prepared

Fresh-cut vegetables:

70%, shelf-life 10-14 days

- shredded lettuce, cabbage, spinach,
- “baby” carrots, onion
- cauliflower and broccoli florets,

30%

- sliced mushrooms, tomatoes and peppers,
- salad meals (contain meat, cheese, eggs)

Fresh-cut fruits:

shelf-life is much less than for vegetables

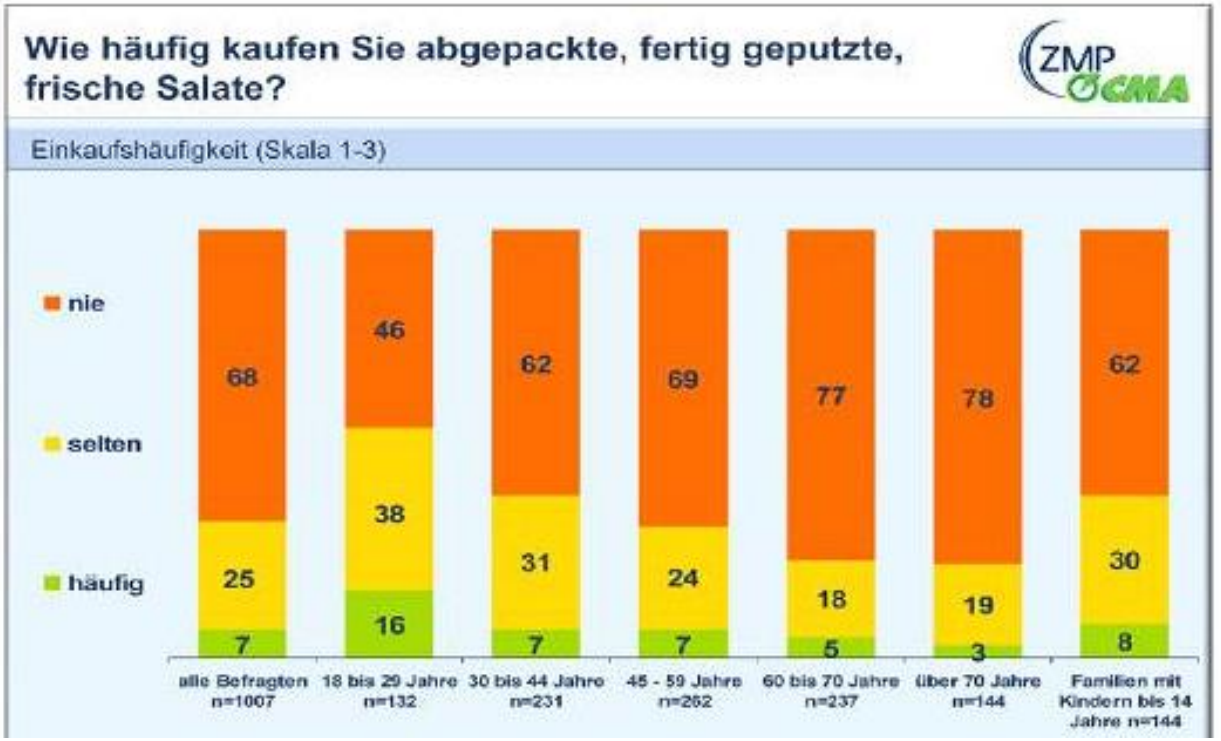
- peeled and cored pineapple,
- peeled citrus fruits and segments,
- slices of apple, peach, mango, melon,
- fruit salads.

- annual growth 10-15%
- 9-16 % of losses in the supermarkt

Fresh-Cut: consumption

HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES

How oft are you eating fresh cut salads?



Why do you prefer not to buy Fresh-Cut?

N = 937	%
Prefer to make by myself	22
Short storage time	21
Too expensive	8
Non-hygienic	5

Why do you prefer to buy Fresh-Cut?

N = 70	%
Practical, saving time	70
Taste	9
Diversity of components	4
cheap	4
Proper quantity	2

Criteria for marketing success:

HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES

fresh, convenient, ready-to-eat, safe

For consumers:

- external attributes (appearance and firmness, without defects, of optimum maturity and in fresh condition)
- eating experience (aroma, taste, texture)
- price
- product presentation
- ability to respond to current social food values (organic, fair trade, health options)
- satisfying the labeling requirements.

For food technologists:

Innovation: “Eat healthy, be happy”

extension of shelf-life

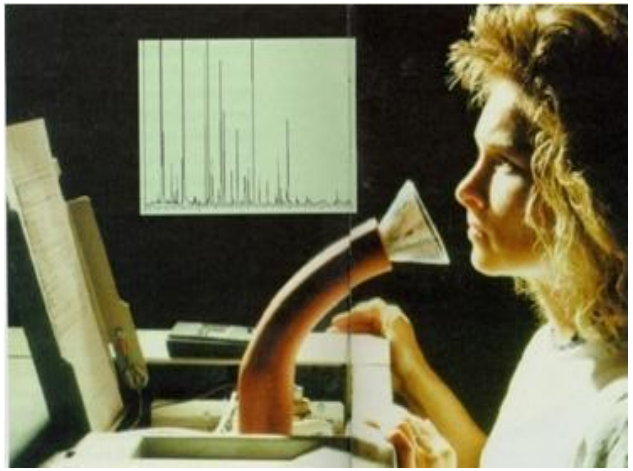
<u>safety</u>

What is fresh produce quality?

HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES

1. External = Appearance quality

Visual quality: size, shape, color, no defects or spoilage.
Defects: water soaking, tissue softening, color changes, package swelling.



2. Internal

aroma, taste and mouth-feel ► guarantee for repeat purchasing by consumers

Defects: off-odor or flavor development, fermentation.

3. Hidden

nutritional value and safety
recommendation of 5 servings per day

Food safety: Hazards

HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES

Safe food is free of physical and chemical hazards or dangerous microorganisms.
Poor safety ► business loss and poor image.

Hazards:

1. Physical

- **stones, glass, wood, hair, plastic, metals**

Pre- and postharvest

2. Chemical

- **natural substances (allergens, mycotoxins, alkaloids),**
- **chemicals (pesticides, water disinfectants),**
- **toxic elements (heavy metals).**

Pre- (fertilizers, growth regulators) and postharvest (waxes, detergents).

3. Biological

- **pathogenic MO ► cause infection or produce toxins**

Products that is perfect in appearance is not guaranteed to be microbiologically safe.

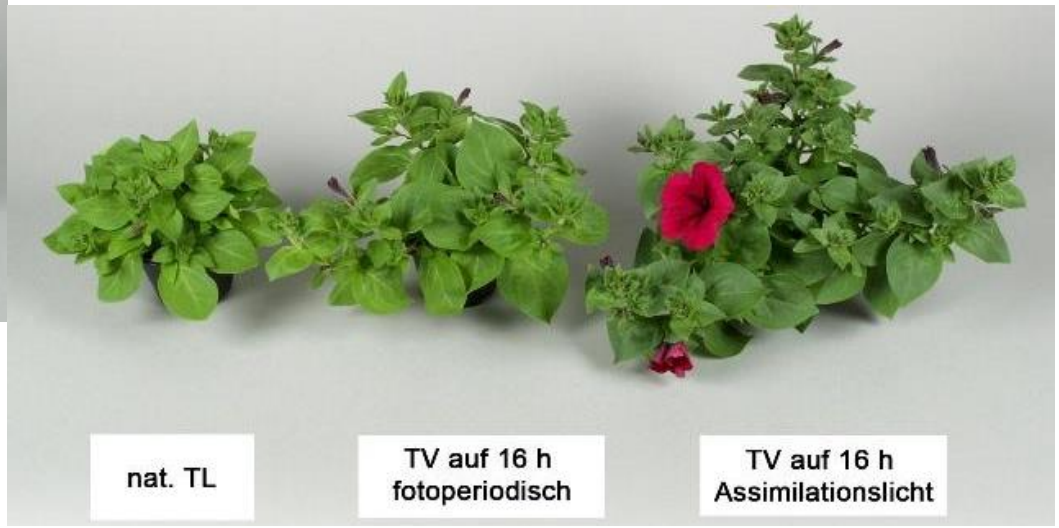
Pre- (soil, water, manure, air) and postharvest (poor worker hygiene, contaminated surfaces), storage (packages, transport).

Quality: pre-harvest factors

HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES

Cultivar: flavor, texture, post-harvest life, enzymatic browning.

Climatic factors:
- temperature (uptake of minerals)
- light intensity (level of ascorbic acid, texture, sunburn, fruit temperatures ► loss of firmness)
- rainfall (susceptibility to mechanical damage)



Quality: pre-harvest factors

HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES

Cultural practices:

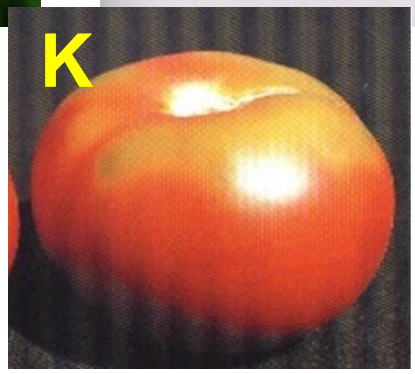
- fertilizers, pesticides and growth regulators (developing fruit, texture, appearance and taste).

Lack of calcium ► tissue softening

- too much or too little water (high rates of nitrogen ► susceptible to post-harvest diseases)

Manure and contaminated irrigation water ► pathogens onto crops (raw manure should never be applied to edible crops!).

Lack of nutrients



Quality: harvesting factors

HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES

Maturity determines quality!

Immature fruit:
- lack flavor, susceptible to disorders
- firm texture, contain proto-pectins

Fully mature fruit:
- optimal stage for harvest
- metabolic activity declines ► post-harvest changes slow ► storage life is improved
- develop desirable taste: starch to sugar conversion

Overripe fruits:
- are highly susceptible to damage during cutting

Many fruits are harvested at mature but unripe stage ► best eating quality.

Climacteric fruits (bananas, guavas) continue to ripen after harvest. These fruits can be ripened by exposure to ethylene.

Non-climacteric fruits (pineapples, oranges) must be harvested when mature (no further ripening and flavor development).

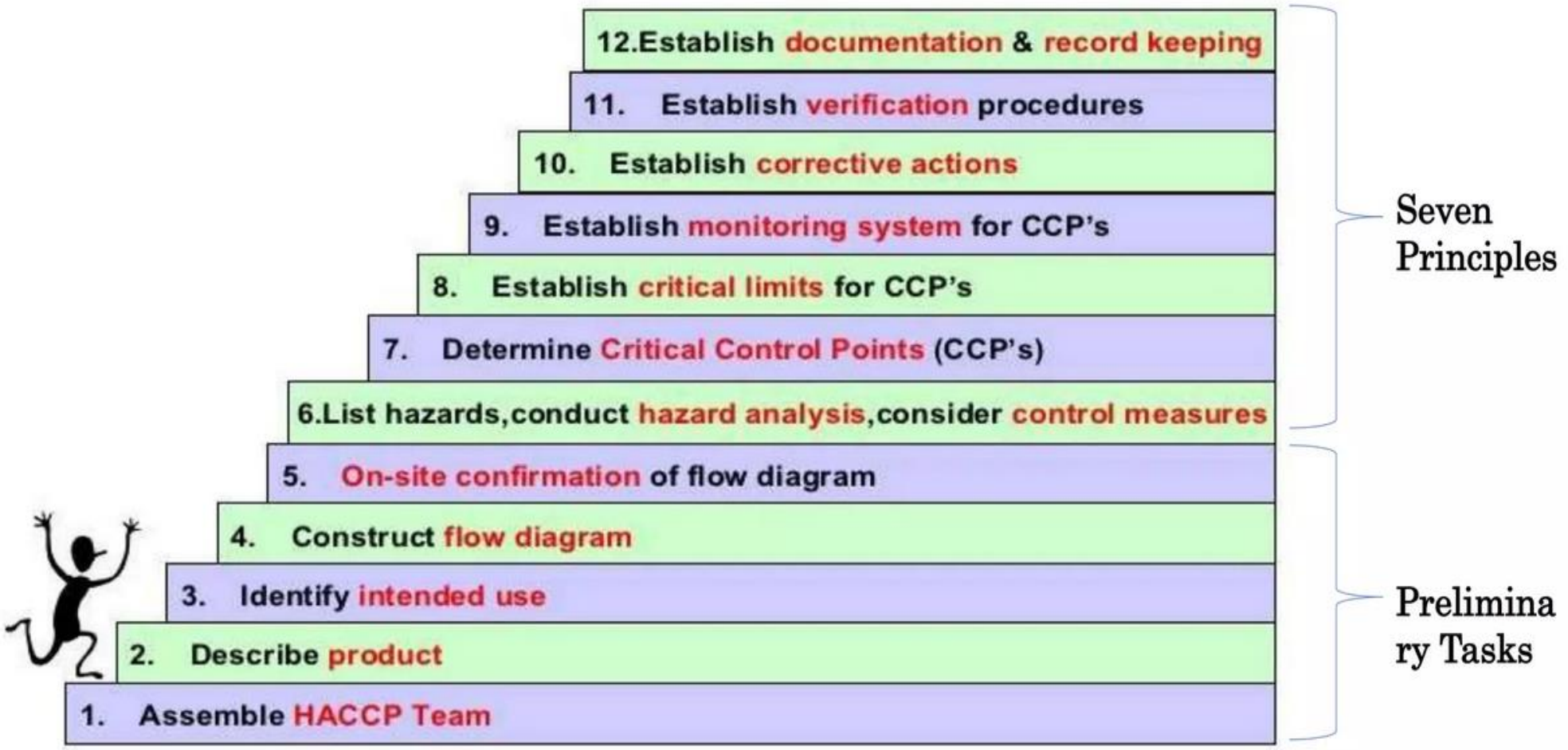
Commodities are not harvested at the correct stage of maturity are of lower quality and undergo rapid deterioration after harvest !

Immature

Overripe

Hazard analysis critical points: 12 codex steps

HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES



HACCP: Pre-2. Describe Product

HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES

PRODUCT/PRODUCT CATEGORY DESCRIPTION

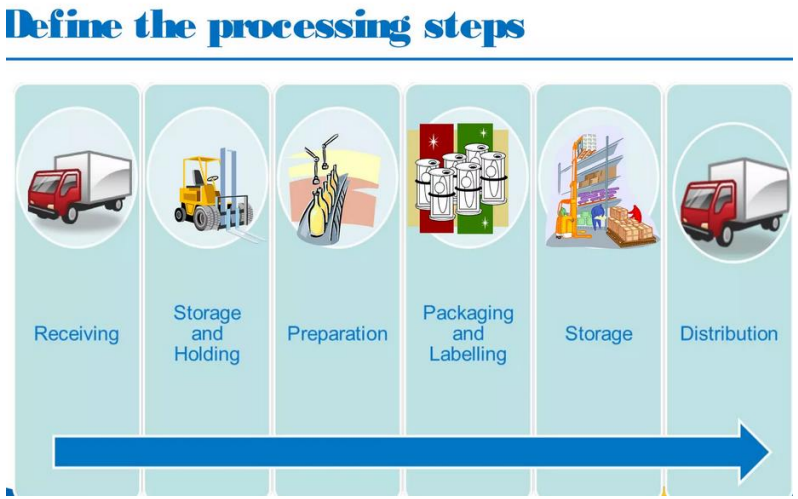
PURPOSE: To describe the product characteristics, storage and distribution factors as related to food safety.
HACCP STANDARD REFERENCE: ISO 22000: 7.3.3

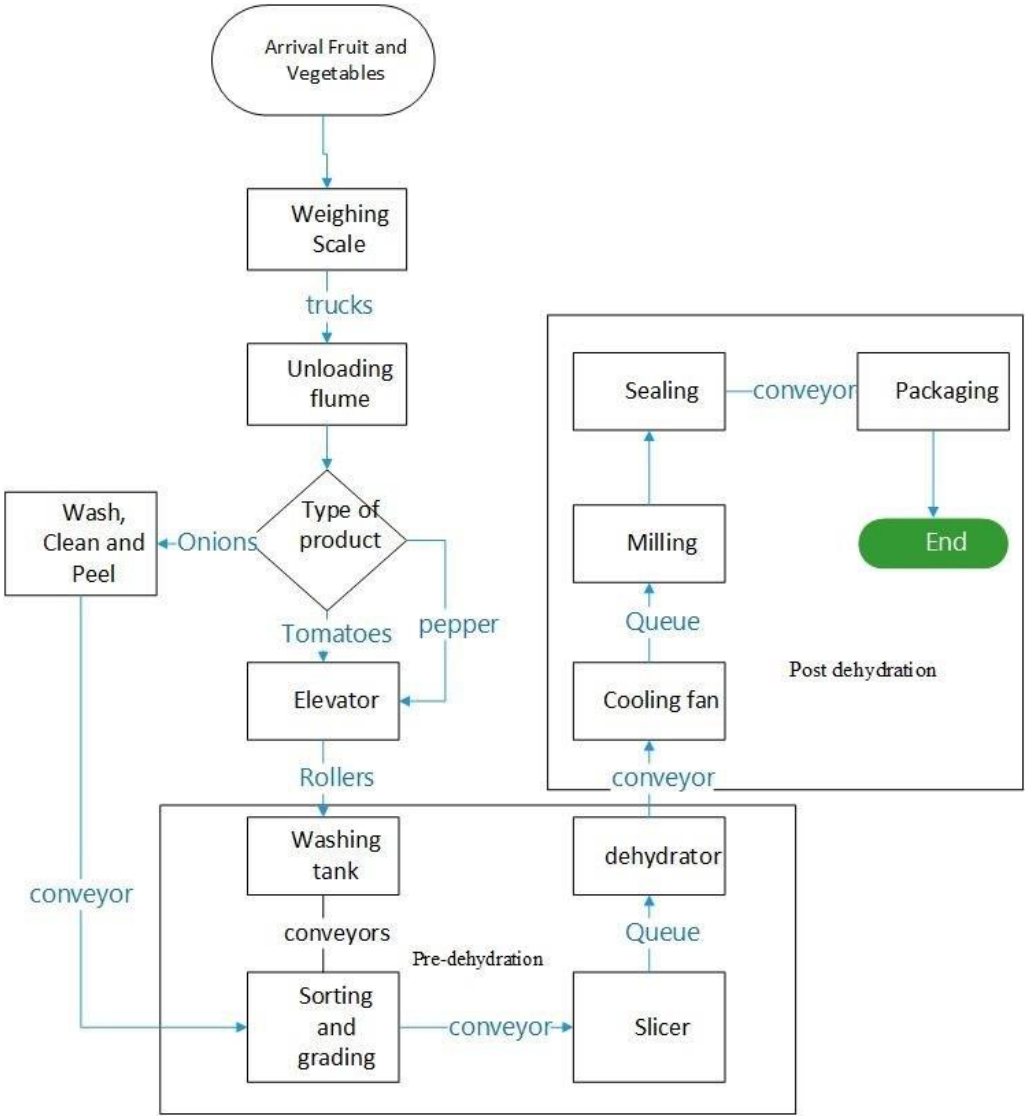
Product/Product Category (e.g. Name, type, size)	**Fresh cut salad : include tomatoes, cucumbers, lettuce, etc; paceged**
Process (e.g. Cold pack, hot fill, aseptic, freeze dried)	**Washing , cutting , Feeding and Indivudal Quick freezing ,Sorting, Packing & weighing, Stored**
Food Safety Characteristics (Physical,Chemical & Biological) See Biological CCPs Section in Standard for Control Mechanisms (e.g. pH, Aw, % salt, pasteurization, cooking, preservatives, refrigeration)	Per acetic acid washing for Sanitisation and to reduce Microbial Load. IQF will retards the growth of microorganisms
Intended Market (e.g. General public, age , adult, child, retail, food service, countries, regions, national)	For Industrial purpose
Consumer/Customer Use/Intended use (e.g. Ready to consume, heat and consume, mix and consume) Sensitive ingredient details Expected mis handling & Misuse	For Further process
Labeling/Label Instructions List Only Those Ingredients Containing Allergens, Sulfites (e.g. Preparation, storage needs, use by, best when used by)	Product Type: Batch No: Date of production: Bag/Box Number: Net weight: Allergen: NA
Packaging (e.g. Foil, plastic, glass, cup, can, hermetically sealed, gas permeable, tamper evident, modified atmosphere packaging)	Packed with LDPE white inner liner with HDPE Bag and sealed.
Normal Run Time* (Time between sanitation cycles) **Extended Run Time*** (Time and Date approved) *Optional if no Food Safety Implication	Continuous run for 16 hours.
Shelf Life (e.g. Days and temperature conditions)	12 Months for Bulk pack for further process. (Stored @-18 degree centigrade)
Storage & Distribution (e.g. Ambient, refrigerated, frozen, relative humidity, high altitude)	Storage @ -18 centigrade and during transportation between -15 to -18 degree cen.

3. Identify intended use
2. Describe product
1. Assemble HACCP Team

HACCP: Pre-4+5. Construct flow Diagram (+ On-site confirmation)

HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES





mmer

HACCP: 6. List hazards, conduct hazard analysis, consider control measures (Principle 1)

HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES

Hazards:

1. Physical
- stones, glass, wood, hair, plastic, metals

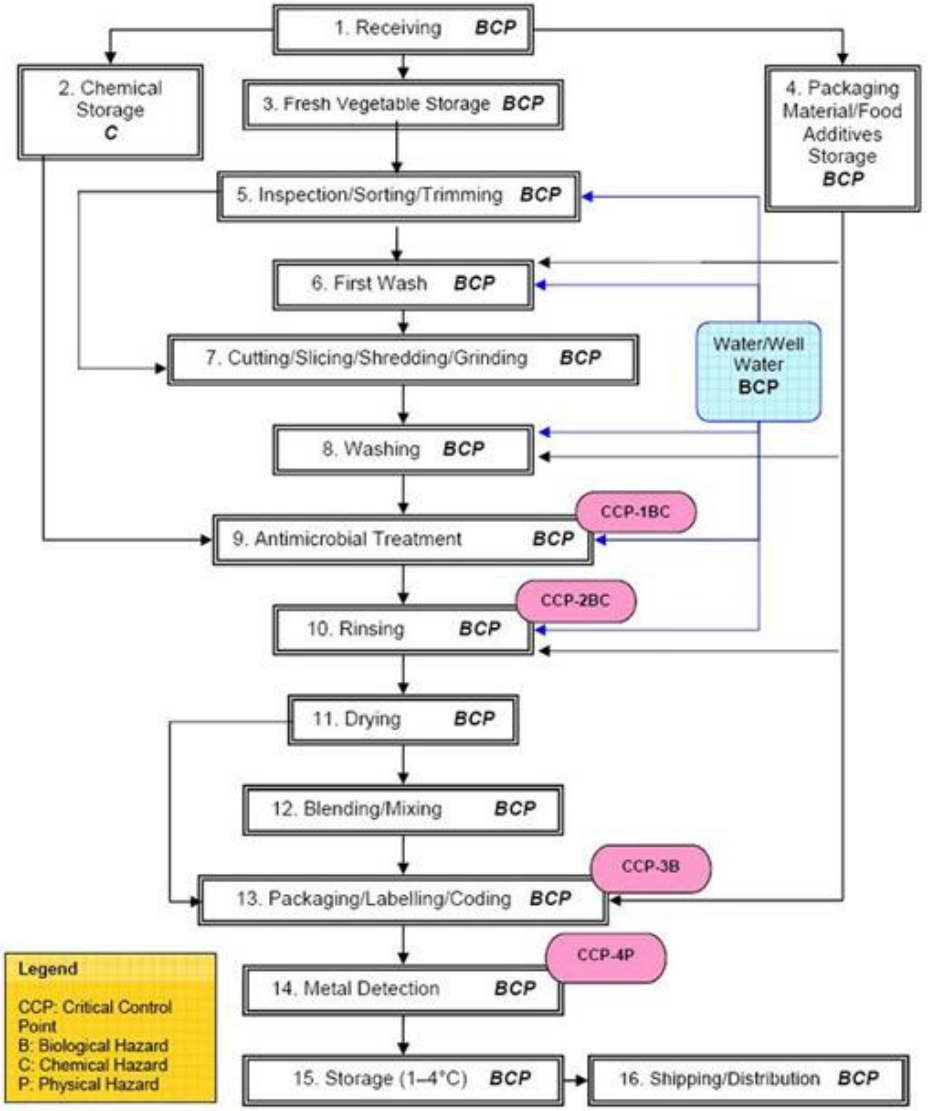
Pre- and postharvest

2. Chemical
- natural substances (allergens, mycotoxins, alkaloids),
- chemicals (pesticides, water disinfectants),
- toxic elements (heavy metals).

Pre- (fertilizers, growth regulators) and postharvest (waxes, detergents).

3. Biological
- pathogenic MO ► cause infection or produce toxins

Products that is perfect in appearance is not guaranteed to be microbiologically safe.
Pre- (soil, water, manure, air) and postharvest (poor worker hygiene, contaminated surfaces), storage (packages, transport).



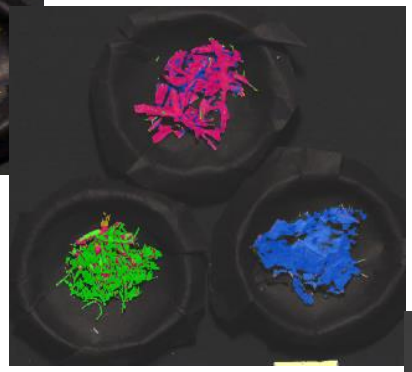
Establishing critical limits: Case Sorting

HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES

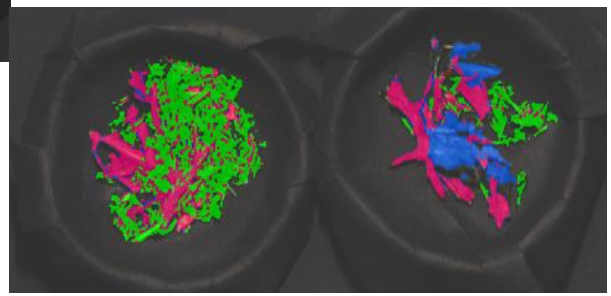
Weed detection in dried parsley using hyperspectral imaging

Hyperspectral Imaging Techniques (HSI)

Parsley cultivation (blooming groundsel)



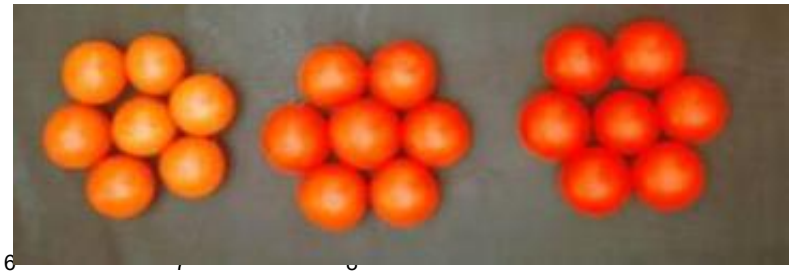
	1 backgro	2 lables	3 Thistle	4 Jacobs	5 Parsley	6 Parsely	Class error
1: backgro	0.998	0.000	0.001	0.000	0.001	0.000	0.002
2: lables	0.000	1.000	0.000	0.000	0.000	0.000	0.000
3: Thistle	0.030	0.000	0.970	0.000	0.000	0.000	0.030
4: Jacobs	0.000	0.000	0.103	0.873	0.016	0.009	0.127
5: Parsley	0.029	0.000	0.001	0.016	0.954	0.000	0.046
6: Parsely	0.015	0.000	0.000	0.103	0.000	0.882	0.118
Precision	0.98	1.00	0.90	0.98	0.96	0.90	0.054

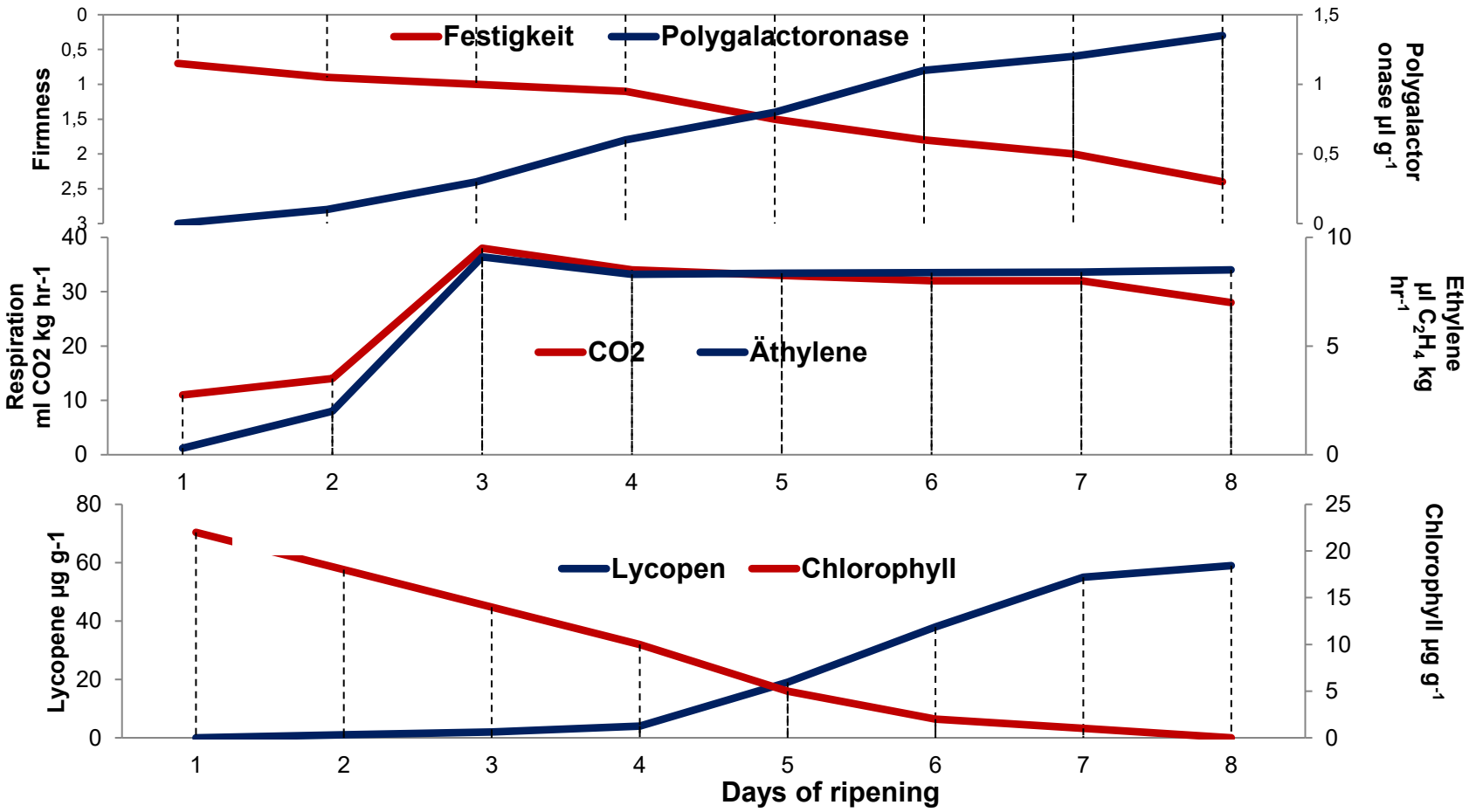


Analysed mixed herbs specimens. *perClass Mira* clearly indicates leaves from parsley (green), thistle (blue) and groundsel (pink)

Quality: physiological changes

HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES





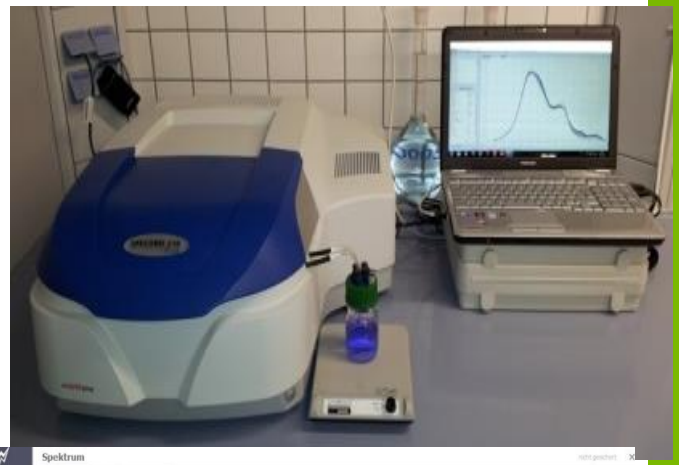
Quality: pre-harvest factors control measures

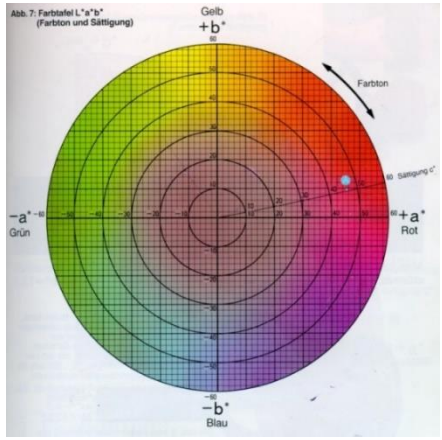
HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES

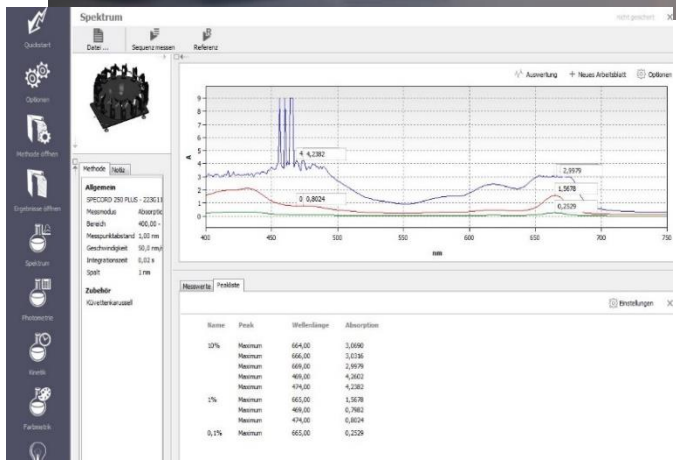
Cultivar (+): flavor, texture, post-harvest life, enzymatic browning.

Climatic factors (-):

- temperature (uptake of minerals)
- light intensity (level of ascorbic acid, texture, sunburn, fruit temperatures ► loss of firmness)
- rainfall (susceptibility to mechanical damage)







Advantages, disadvantages, and requirements of fresh-cut vegetable products prepared at different locations.

Location of processing	Characteristics and requirements
Source of production	Raw product processed fresh when it is of the highest quality Processed product requires a minimum of 14 days post-processing shelf-life; Good temperature management critical Economy of scale Avoid long distance transport of unusable product Vacuum and gas-flushing common; Differentially permeable films
Regional	Raw product processed when of good quality, typically 3 to 7 days after harvest Reduced need to maximize shelf life; about 7 days post-processing life required; Good temperature management vital Several deliveries weekly to end users Can better respond to short-term demands Vacuum and gas-flushing common; Differentially permeable films
Local	Raw product quality may vary greatly, since processed 7 to 14 days after harvest Relatively short post-processing life required or expected Good temperature management required, but is often deficient Small quantities processed and delivered More labor intensive; discard large amounts of unusable product Simpler and less costly packaging; less use of vacuum or gas-flushing techniques

Quality: post-harvest changes

HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES

(loss of weight, quality, nutritional value, etc.)

1. **Physiological**

- **respiration**
- **ethylene**
- **transpiration**
- **texture**

2. **Biochemical**

- **appearance, taste**
- **color (discoloration, browning), flavor**
- **composition (nutritional quality – vitamins, organic acids)**

3. **Microbiological changes**

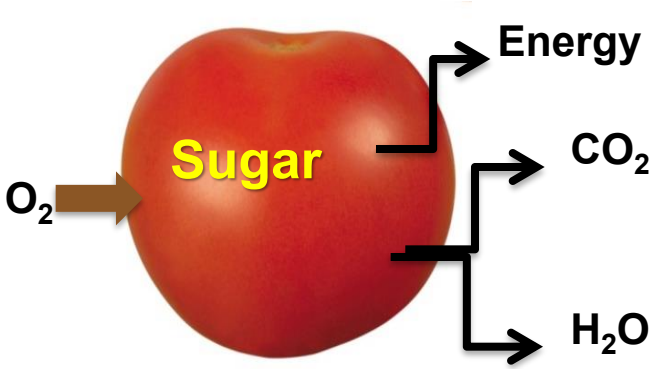
Approaches:

- **better understanding of physiology**
- **development of methods and techniques for storage and processing**

Post-harvest: Respiration

HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES

Respiration is primarily a function of postharvest quality loss ► causes progression of ripening, water loss, enzymatic discoloration.



Stored organic molecules (carbohydrates, proteins, fats) are broken down into end products ►

- **loss of nutritional value**
- **loss of flavor (especially sweetness)**
- **loss of dry weight.**

The rate of deterioration is proportional to the respiration rate

Commodities classified according to respiration rate

Class	mg CO_2/ kg hr, 5^0C	Commodities
Low	5-10	garlic, onion
Moderate	10-20	cucumber, pepper, tomato, radish
High	20-40	lettuce
Very high	40-60	green onion, watercress
Extremely high	>60	peas, spinach

Fresh-Cut: Respiration

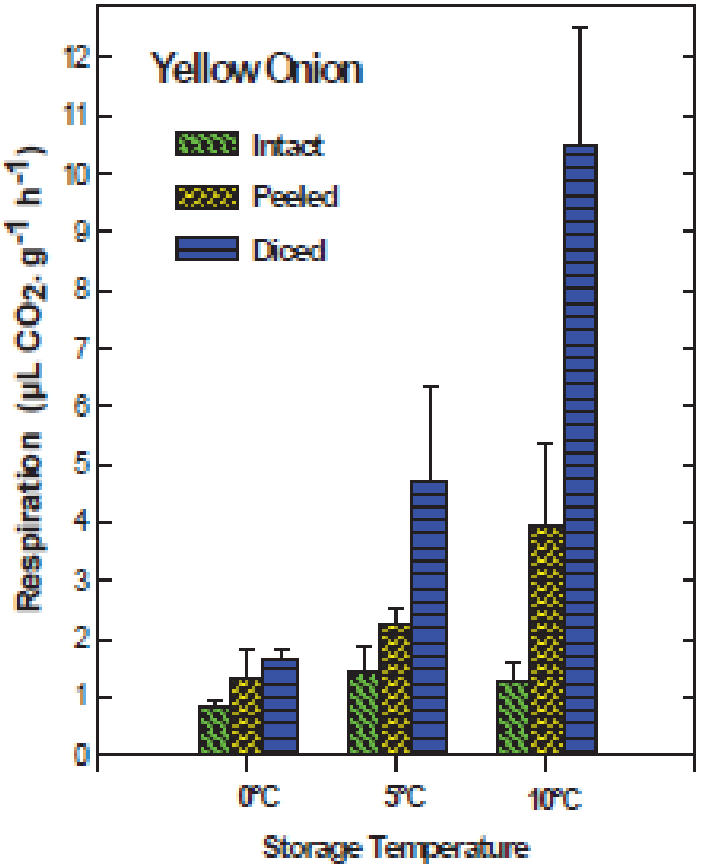
HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES

Respiration ► causes progression of water loss, enzymatic discoloration.

Stored organic molecules (carbohydrates, proteins, fats) are broken down into end products ►
- **loss of nutritional value**
- **loss of flavor (especially sweetness)**
- **loss of dry weight.**

Factors influencing respiration:

- **atmospheric composition (CO2 : O2)**
- **temperature (▼during storage)**
- **ethylene level**
- **damaging**



Respiration rates of onion, depending of processing

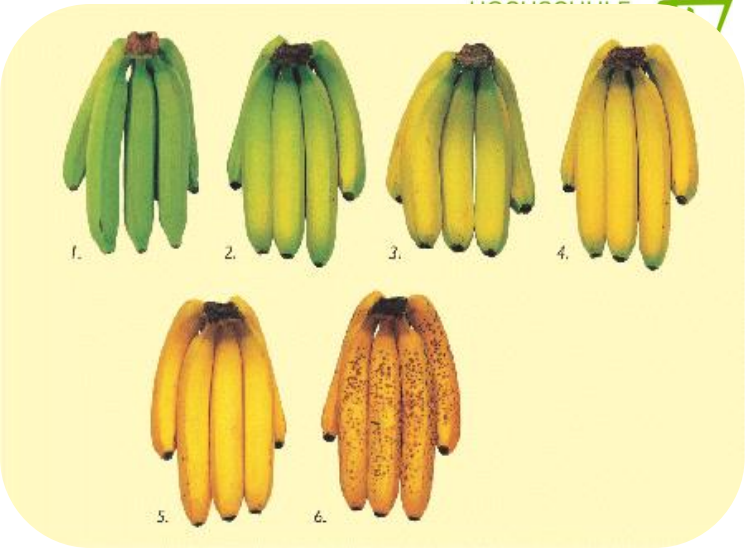
Cantwell et al., 2009

Ethylene

-plant hormone, regulates development, senescence, abscission

-is important factor in ripening

-might cause softening, undesired color changes (wilting and yellowing), lead to off-flavor development.



There is no consistent relationship between the C_2H_4 production capacity of a commodity and its perishability; however, exposure of most commodities to C_2H_4 accelerates senescence.

Ethylene: intensity of production

Level	µmol C_2H_4/kg hr	Comodity
very low	0.1	leafy and root vegetables
low	1-1.0	cucumber, pepper
middle	1.0-10.0	tomato
high	10.0-100.0	apricot
very high	100	cherimoya

Climacteric and non-climacteric commodities

HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES

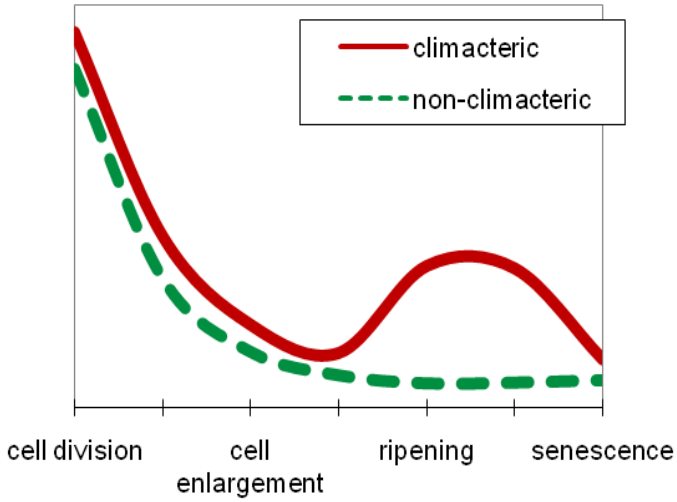
climacteric

post-harvest ripening

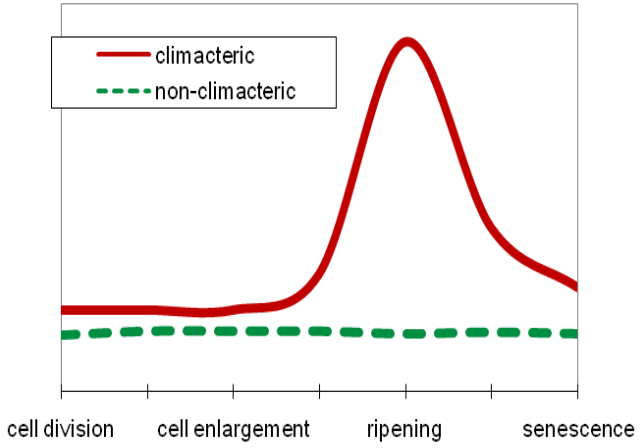
- **increase in respiration level**
- **biochemical changes (destruction of cell wall pectin, starch hydrolysis) synthesis of ethylene**

non-climacteric

Without changing of ripening in post-harvest



respiration

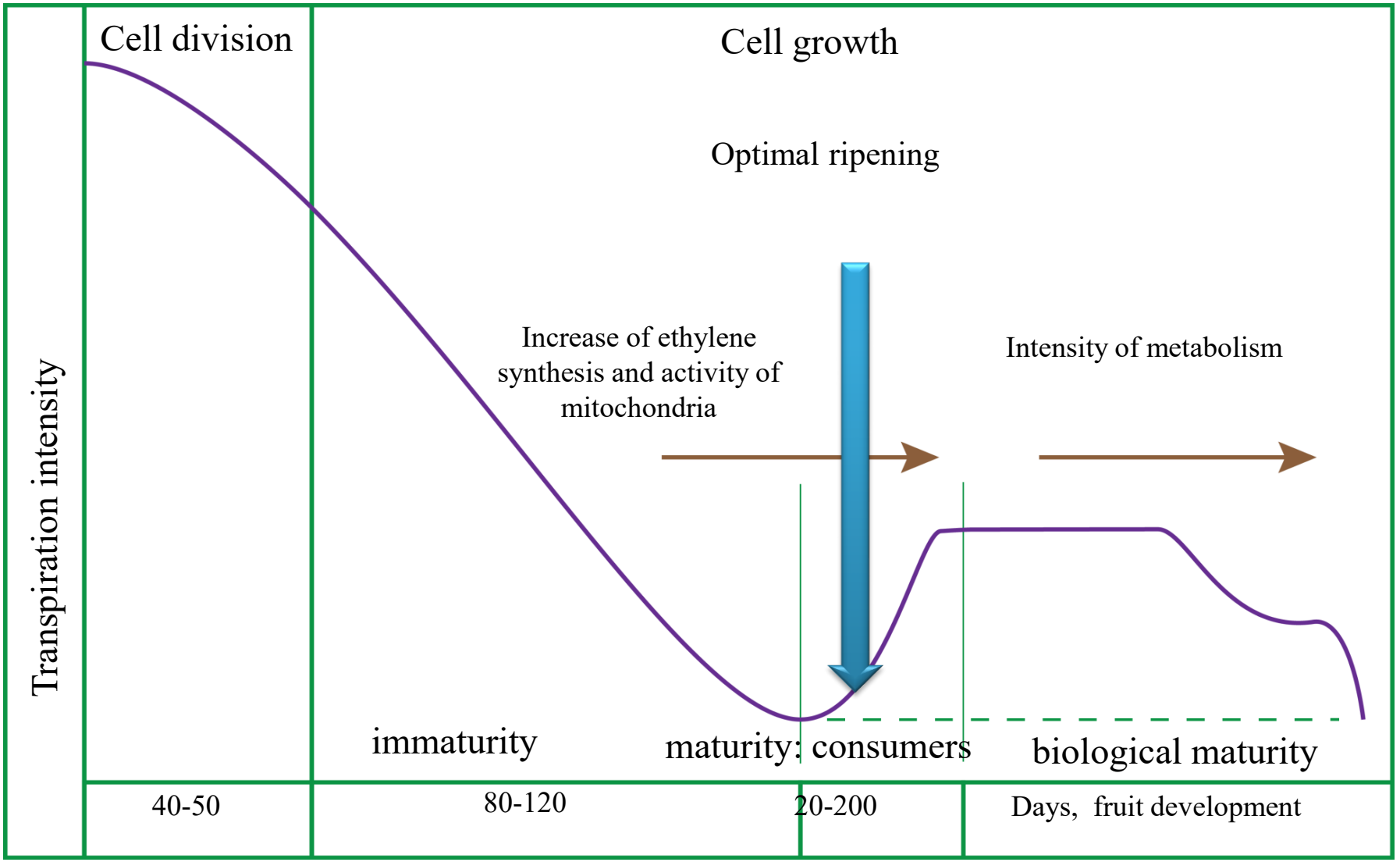


ethylene-production

Climacteric fruits should not be stored with non-climacteric

Climacteric commodities: ripening

HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES



Transpiration

HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES

Plant tissue - 65-95% water.
Growing plants - constant flow of water (transpiration stream).

Water deficiency cause plants to wilt.

Water loss at which commodities become unmarketable

Commodity	Max permissible loss (%)
Onion	10
Cabbage	7-10
Pepper	7
Leek	7
Cucumber	5
Carrot	4
Lettuce	3-5

Fresh-Cut: Cutting: water loss

HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES

Cutting-injury depends on:

-plant tissue (root or leaf)
-cutting technique

1. mechanical

natural cuticle (barrier) is removed ► severe tissue disruption:
-▲ ethylen diffusion
-▲ respiration,
-▲ water loss: 5-10 fold by carrot, 10-100 fold by spinach, cucumber
- ▲ microbial decay

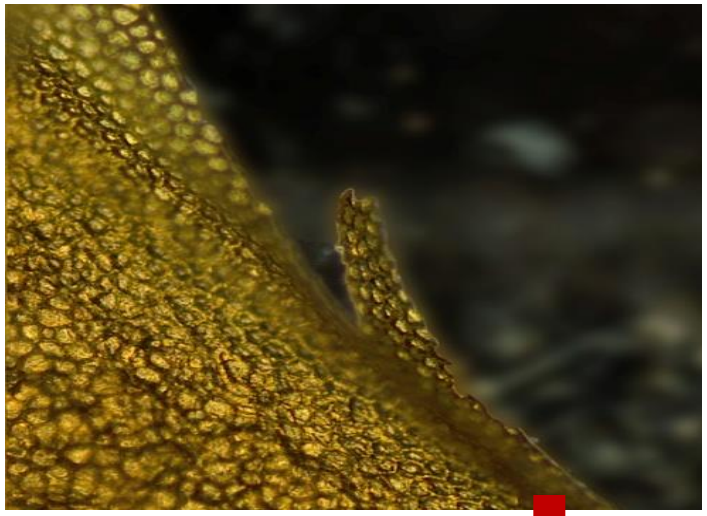
2. chemical

-softening enzymes (pectinesterase)
-browning enzymes (polyphenoloxidase)

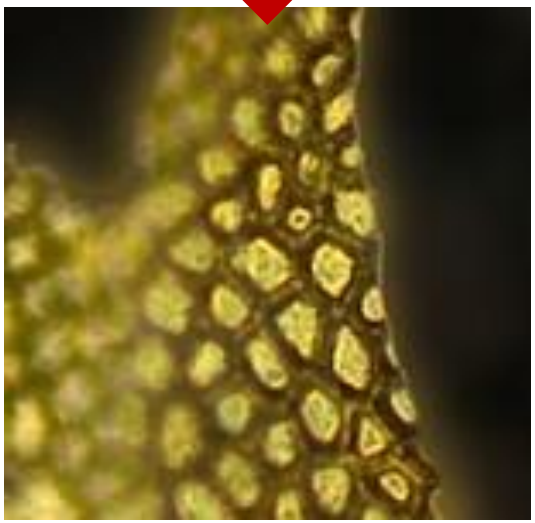
Result: ▼ shelf-life via browning, off-color, softening, decay.

Fresh-Cut: Cutting: water loss

HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES



Tomato cut with sharp knife



Tomato cut with blunt (not sharp) knife

Smetanska, 2013, non published

Fresh-Cut: Cutting: water loss

HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES

Prevention:

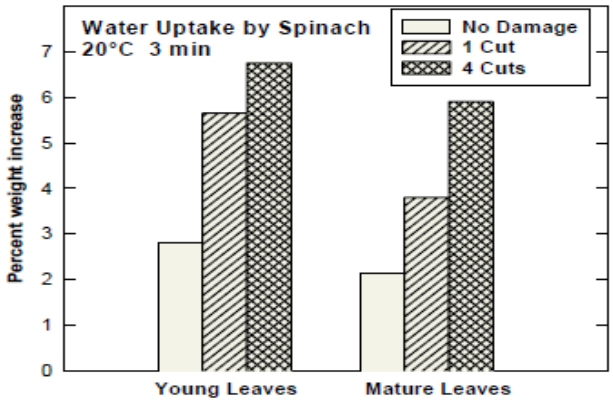
- **high-speed cutting, knife sharpness**

- **storage – RH 99%, CA**

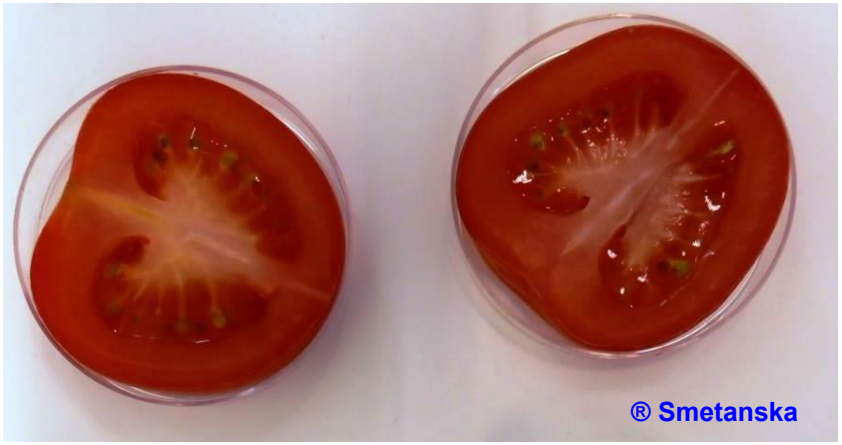
- **treatment with 0,5% $CaCl_2$: cross-links between free C-groups of pectin – strengthening of cell walls; + stabilize cell wall - may leave bitter off-favor**

Fresh-Cut: Cutting: water loss

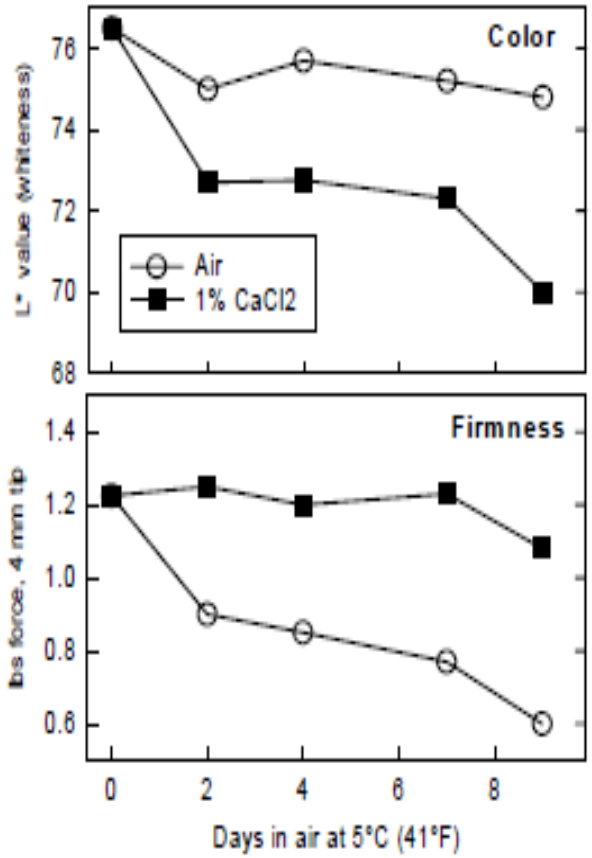
HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES



Water uptake by young and mature spinach leaves in relation to the number of cut surfaces, Cantwell, unpublished



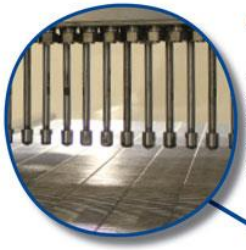
Fresh-cut: day 1 and day 4 at 5˚C: water-soaked area in tomato slices



Effect of 1 % CaCl2 dip on color and firmness of pear slices, Gorny et al.1998

Prevention of water loss by cutting

HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES

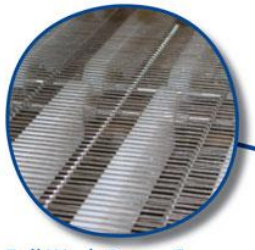


Adjustable Jet Array

Jetmax Plus provides operators with flexiblity to configure for a full range of cutting widths for multiple orifices at 12.5mm spacings, or 3-4 orifices at desired spacings from 12.5 - 500mm. A vertical adjustment feature also allows the jet array to be raised and lowered to accommodate product thicknesses from 5mm to 200mm.

Choice Of Modular Conveyor Belt

The Jetmax Plus Conveyor system is available with a range of belt options which can be customised to suit each application. Standard belt types include Uniflex interlocking stainless steel wire belts or white acetal modular belts with paddles for product stabilisation.



Full Wash Down Conveyor

The Jetmax system is specifically designed with daily clean up in mind. Valuable features including a crevice-free design, slide out drip trays, and removable access panels all make daily cleaning operations faster and more effective.

KMT Jetline High Pressure Pump

KMT's Jetline pump is ideally suited for food applications. The Jetline is based around the Streamline V slow stroke intensifier which has a continuous output capacity of 55,000 psi. The Jetline is standard with stainless steel componentry for the entire high pressure system.

Quality Components

Standard with IP66 electrics. Jetmax only incorporates components from leading manufacturers including SEW to deliver a system which will deliver years of dependable service.

http://www.hydroprocess.fr/en/chefcut-en/

https://www.performancewaterjet.com.au/jetmax-food-cutting-machineHigh-speed cutting

Fresh-Cut: Transpiration

HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES

Prevention of water loss:

- ▲relative humidity

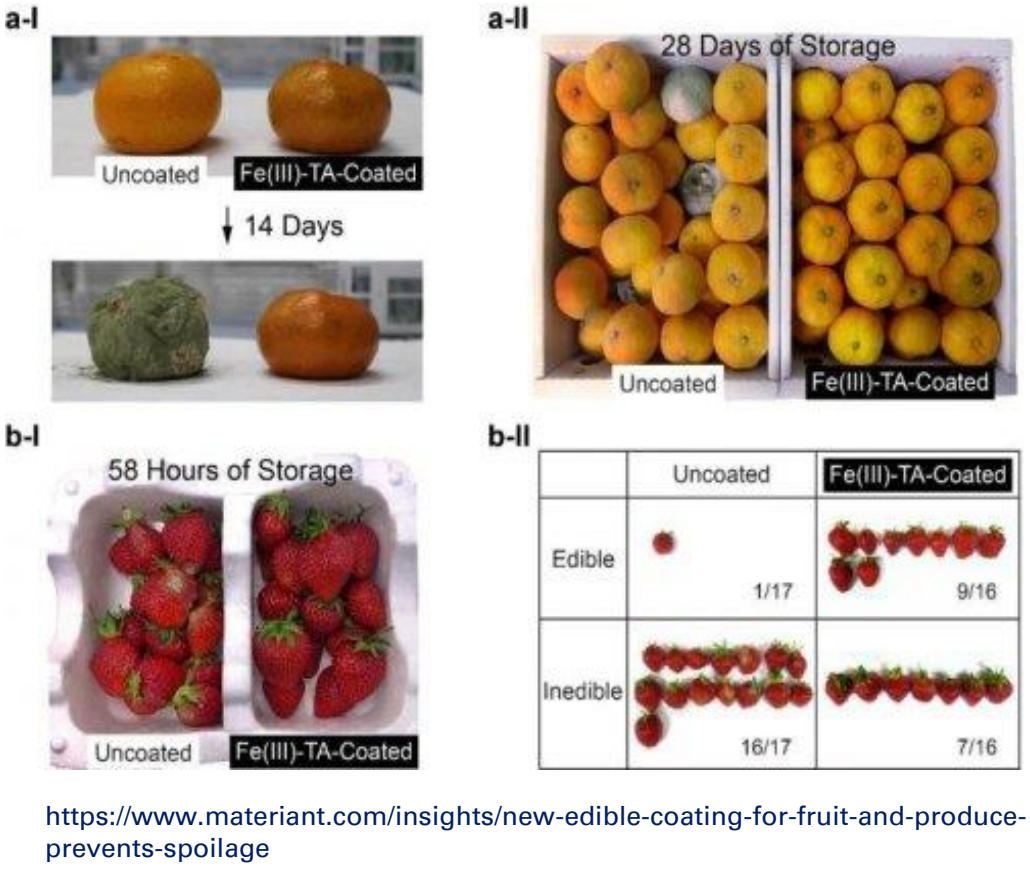
Solution: moist atmosphere, RH 90-95%

- ▼air movement

Solution: packaging materials allowing controlled air flow

- ▼ surface area of product
- ▼ mechanical damage.

Product	T, ^{0}C	RH, %	Storage, days
Cucumbers	10-13	95	10-14
Tomatos	13-21	90-95	7-21
Beans	4-10	40-50	180-300



https://www.materiant.com/insights/new-edible-coating-for-fruit-and-produce-prevents-spoilage

Dipping – $CaCl_2$ (+ firmness, - bitter off flavors)

Edible coatings – with e.g. sucrose esters ► micro-modified atmosphere around products.

Transpiration: coatings

HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES

Edible coatings

Avocado

Granny Smith Apples (ex Südafrika)

NatureSeal AS1
dipped P+4

Control P+4

Cantaloupe Melons

Banana

NatureSeal

Post-harvest: Temperature

HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES

- for each ▲of 10^{0}C above optimum, the rate of deterioration ▲ by 2-3 folds
- influences the effect of ethylene, respiration, transpiration and pathogen growth
- has different influences on chilling-sensitive and non-chilling sensitive commodities.

Vegetables according to sensitivity to chilling injury

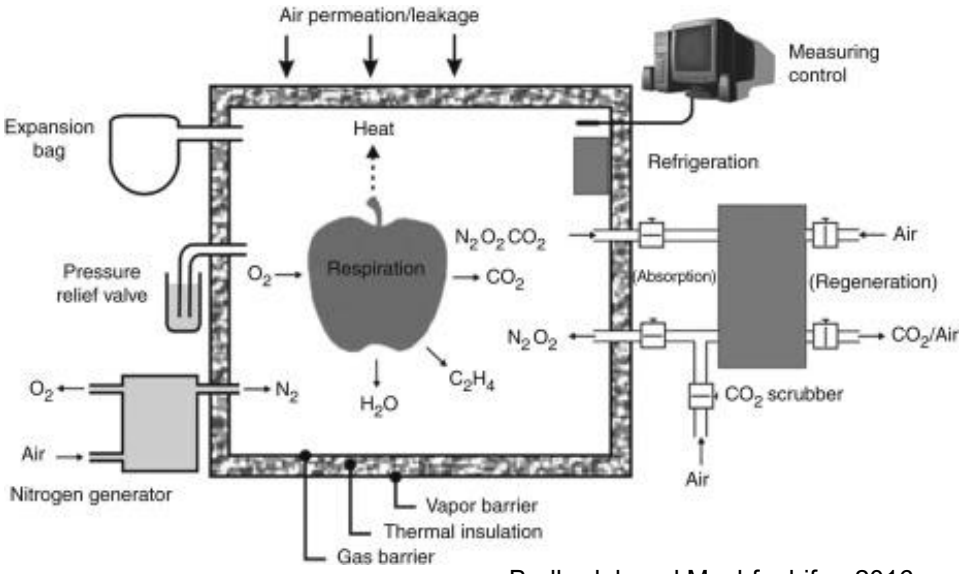
NON-CHILLING SENSITIVE COMMODITIES	T (^{0}C)	CHILLING SENSITIVE COMMODITIES
High temperature injury	40	High temperature injury
Optimum ripening temperature	25	Optimum ripening temperature
	10	Ideal for transit and storage
Ideal for transit and storage	5	Chilling injury
	0	Freezing injury
Freezing injury	-5	
Cabbage, carrot, onion, radish		Cucumber, pepper, tomatoes

Chilling sensitive vegetables loose:
aroma, texture, vitamins,
color (brown),
appearance (glass-surface)

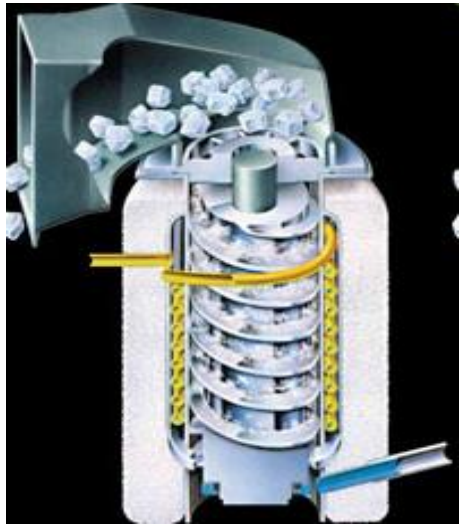
Storage techniques

Cold storage rooms

https://www.dutchtecsource.de/champignon+verarbeitungstechnik/k%C3%BChler



Bodbodak and Moshfeghifar, 2016



http://www.elektro-ralfs.de/haupt/kaelte/eiscrusher2.jpg

HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES

Factors Influencing Cold Storage Efficiency:

1. Temperature:
vary depending on the produce / product

2. Humidity:
above 90% for most fruits and vegetables

3. Ventilation:
to ensure even cooling and to prevent ethylene gas

4. Ethylene Sensitivity:
ethylene-sensitive fruits and vegetables should be stored separately from ethylene-producing

5. Chilling Injury:
prone to chilling injury fruits and vegetables

Discoloration

HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES

Degradation of pigments

1.Chlorophyll
Yellowing, lost of green color

2. Carotenoids
Bleaching of yellow or red color

3. Anthocyanins
Changing of blue or red color to grey

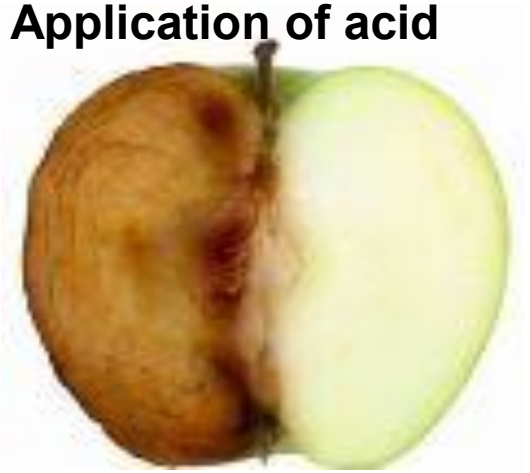
Enzymatic browning

1.Polyphenoloxydase
phenolic oxidation

2. white bloom (carrot)
– abrasion, irregular surface, lignification

Application of intensive light

Application of acid



Smetanska, 2017, unpublished

Discoloration: browning

HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES

Browning:

1. **Enzymatic – discoloration through oxidation of phenolics through polyphenoloxydase**
2. **Non-enzymatic - pre-harvest (cultivars, soil, fertilizers, climate, harvesting) and post-harvest (light)**

Controlling of browning:

1. **Chemical methods**

sulfites, inactivation of enzyme with citric acid (pH opt 7), but it can influence taste

2. **Physical methods**

Temperature : low temperature (↓ enzymatic activity, ↓metabolic rates)

Oxygen availability (↓O2, ↑ CO2 → ↑anaerobic respiration →off-favor, MO): MAP, edible coating

Smetanska, 2017, unpublished

Color changes: whitening

HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES

White blush

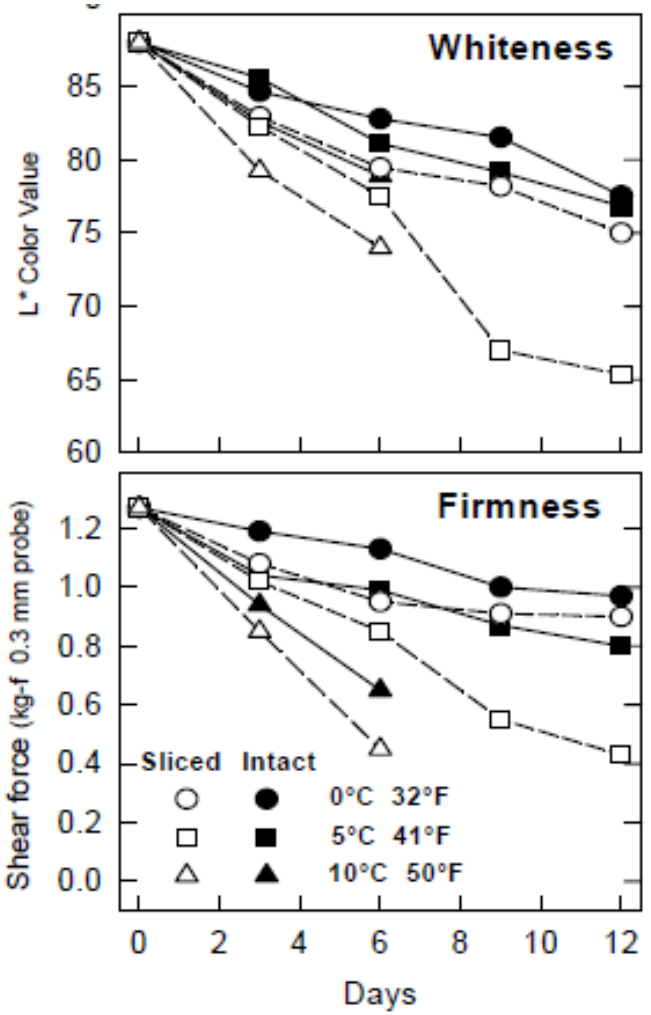
Abrasion of surface , irregular surface, lignification

Prevention:

– inactivation of lignfication enzymes with citric acid (pH opt 7), but it can influence taste

- *application of edible coatings:* sodium caseinate or stearic acid

Smetanska, 2017



Color and firmness changes of intact and sliced mushrooms (Tuncell and Cantwell)

Color changes: whitening

HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES

Smetanska, 2017

Physiological changes: green color

Chlorophylls

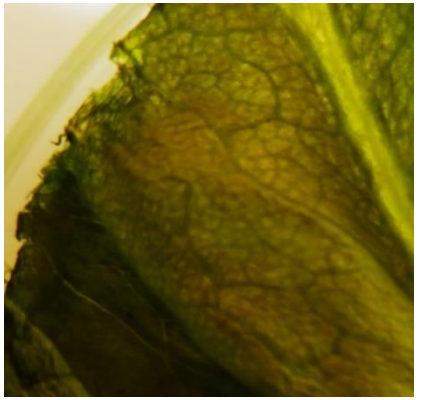
HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES

-organic complexes with Mg^{2+}-Ion
- not resistant against pH and heating
- Yellowing or degreening
- Reason: release of acids and enzymes

Preventing of destruction:

chemical: sulfites, CaCl2

physical: low temperature and light, MAP (▼respiration)



Changing of color under exposure of UV, Smetanska, 2017, non published

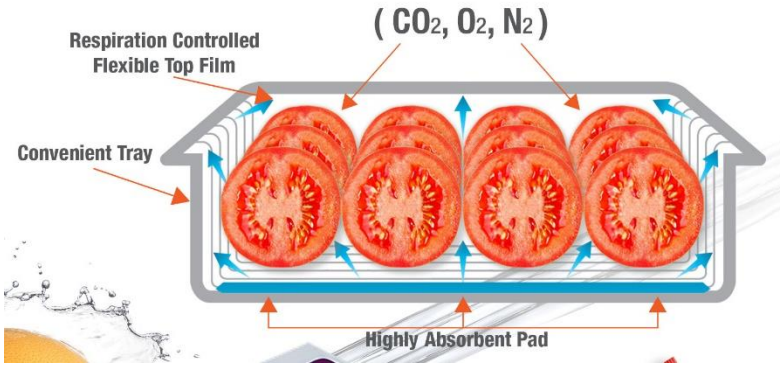
Controlled and modified atmosphere

HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES

Atmosphere - 21% O_2 and 0.03% CO_2

CA

- ▼ O_2 (1-5%) and ▲ CO_2 (1-5%)
- ▼ respiration and MO

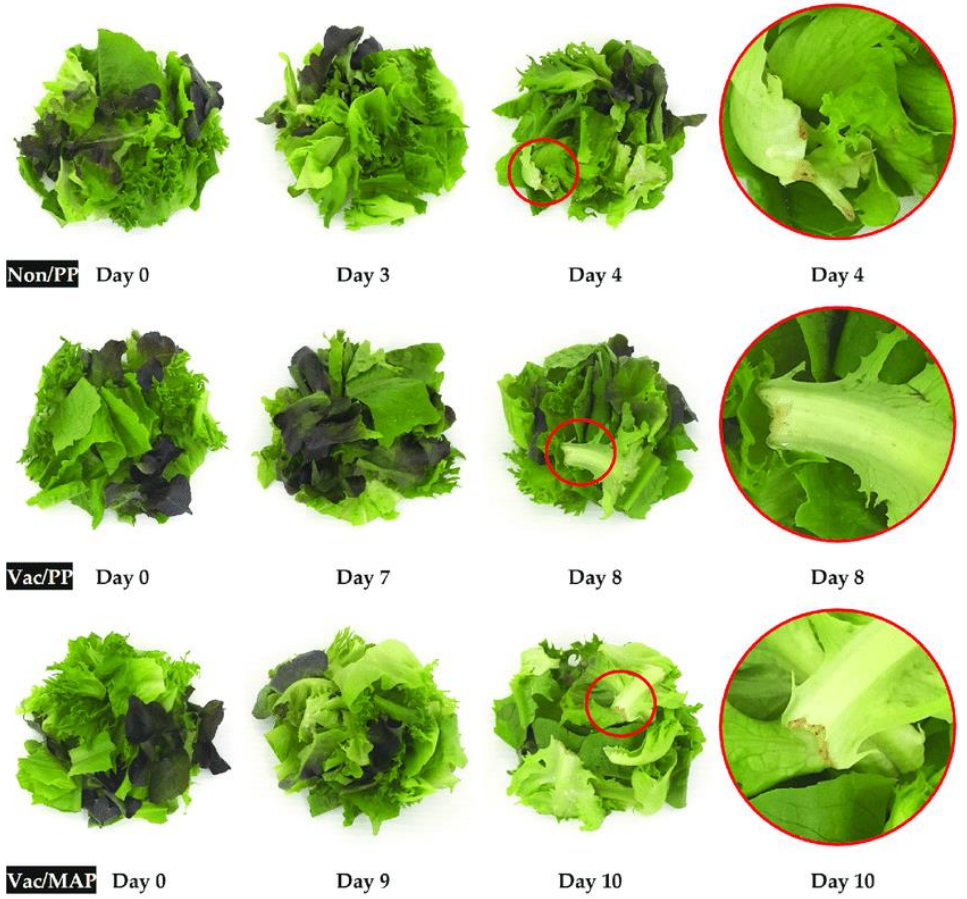


http://zultec.com/wp-content/uploads/2018/12/5-MAP-Modified-Atmosphere-Packaging.jpg

MAP (Modified Atmosphere Packaging)

- with natural gases and suitable packaging materials

1. Respiration Control
2. Gas Composition
3. Moisture Management



Wanakamol, Warissara & Kongwong, Pratsanee & Chuamuangphan, Chaipichit & Bundhurat, Damorn & Boonyakiat, Danai & Poonlarp, Pichaya. (2022). Hurdle Approach for Control of Enzymatic Browning and Extension of Shelf Life of Fresh-Cut Leafy Vegetables Using Vacuum Precooling and Modified Atmosphere Packaging: Commercial Application. Horticulturae. 8. 745. 10.3390/horticulturae8080745.

Modified atmosphere

HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES

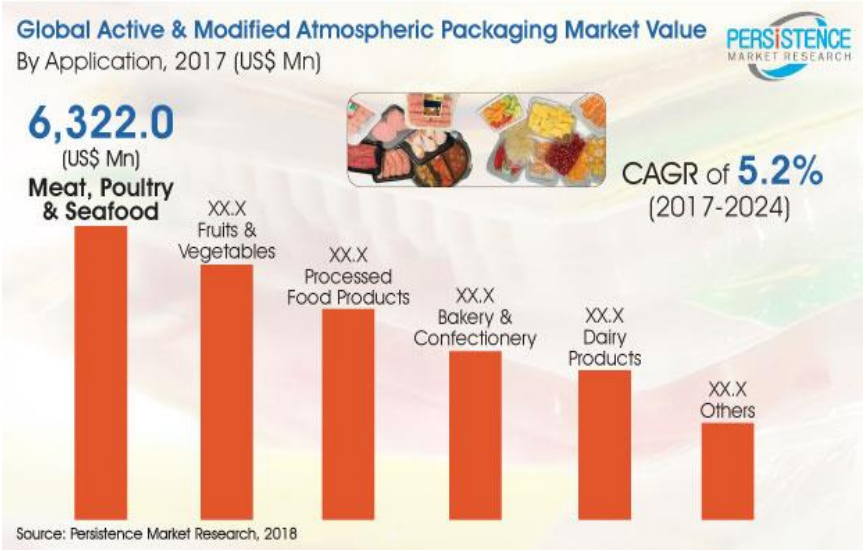
MAP-Gases

▲ CO_2
- suppress MO growth through decreasing pH

▲ N_2
- substitutes O_2 (prevents oxidation)
- inert, low solubility in water (prevents physical damages of packaging)

▼ O_2
- suppress growth of aerobic MO and prevents oxidation.

▲ NO
- Prevents chilling injuri



http://zultec.com/wp-content/uploads/2018/12/5-MAP-Modified-Atmosphere-Packaging.jpg

Modified atmosphere

HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES

ohne MAP

starke rotbraune Färbung

mit MAP

frisches Aussehen

mit Siegelfolie PE coex; Gas 1, Gas 2

ohne MAP

Gurken stark verschleimt
z. T. aufgelöst

mit MAP

Gurken glasig

mit Siegelfolie PE coex; Gas 1, Gas 2

ohne MAP

Farbe verblasst,
trocken

mit MAP

kräftige Farbe,
noch knackig

mit Siegelfolie PLA MP; Gas 2

ohne MAP

starke Gärung, Äpfel zum Teil verfärbt
Hefewachstum optisch erkennbar,
insbesondere bei der Wassermelone
(weiße Flecken)

mit MAP

Siegelfolie PP mit Gas 3

optisch noch
einwandfrei

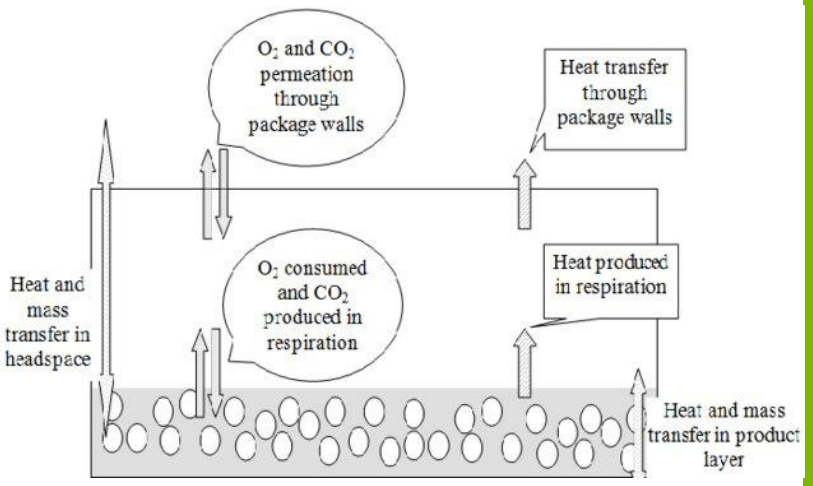
K2 Ingenieur-& Handels GmbH

Modified atmosphere: packaging

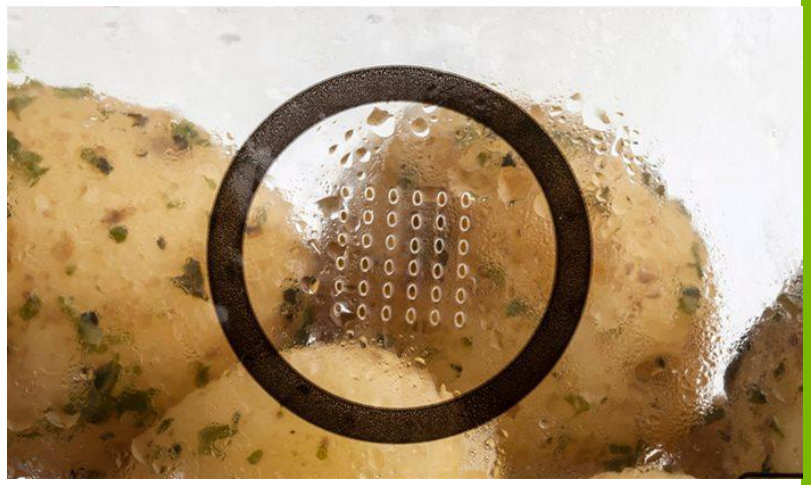
HOCHSCHULE WEIHENSTEPHAN-TRIESDORF UNIVERSITY OF APPLIED SCIENCES

Table 6. Effect of small holes on atmospheres in bags of commercial products stored at 0° or 10°C (32 or 50°F). Holes were made in the bags with a hot 25 gauge needle (Peiser and Cantwell, unpublished).

		Day 3		Day 5	
Product		O_2 %	CO_2 %	O_2 %	CO_2 %
Coleslaw, retail bag	Control 0°C	1.36	3.7	1.07	3.8
	Control 10°C	0.22	5.5	0.28	5.1
	1 hole 10°C	3.07	7.0	4.97	6.7
	4 holes 10°C	10.73	4.3	15.70	3.9
Garden Salad, food service bag	Control 0°C	0.69	9.2	0.17	8.8
	Control 10°C	0.06	12.1	0.02	11.7
	1 hole 10°C	1.46	10.0	1.03	9.7
	4 holes 10°C	4.80	8.0	10.57	7.8
Garden salad with romaine, retail bag	Control 0°C	0.03	10.6	0.03	10.6
	Control 10°C	0.01	12.8	0.01	13.0
	1 hole 10°C	3.97	10.6	4.80	10.0
	4 holes 10°C	6.60	5.2	14.97	5.0



Barrios, Sofia & Lema, Patricia & Marra, Francesco. (2013). Modelling passive modified atmosphere packaging of strawberries: Numerical analysis and model validation. International Food Research Journal. 21. 506-515.



Conclusions

HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES

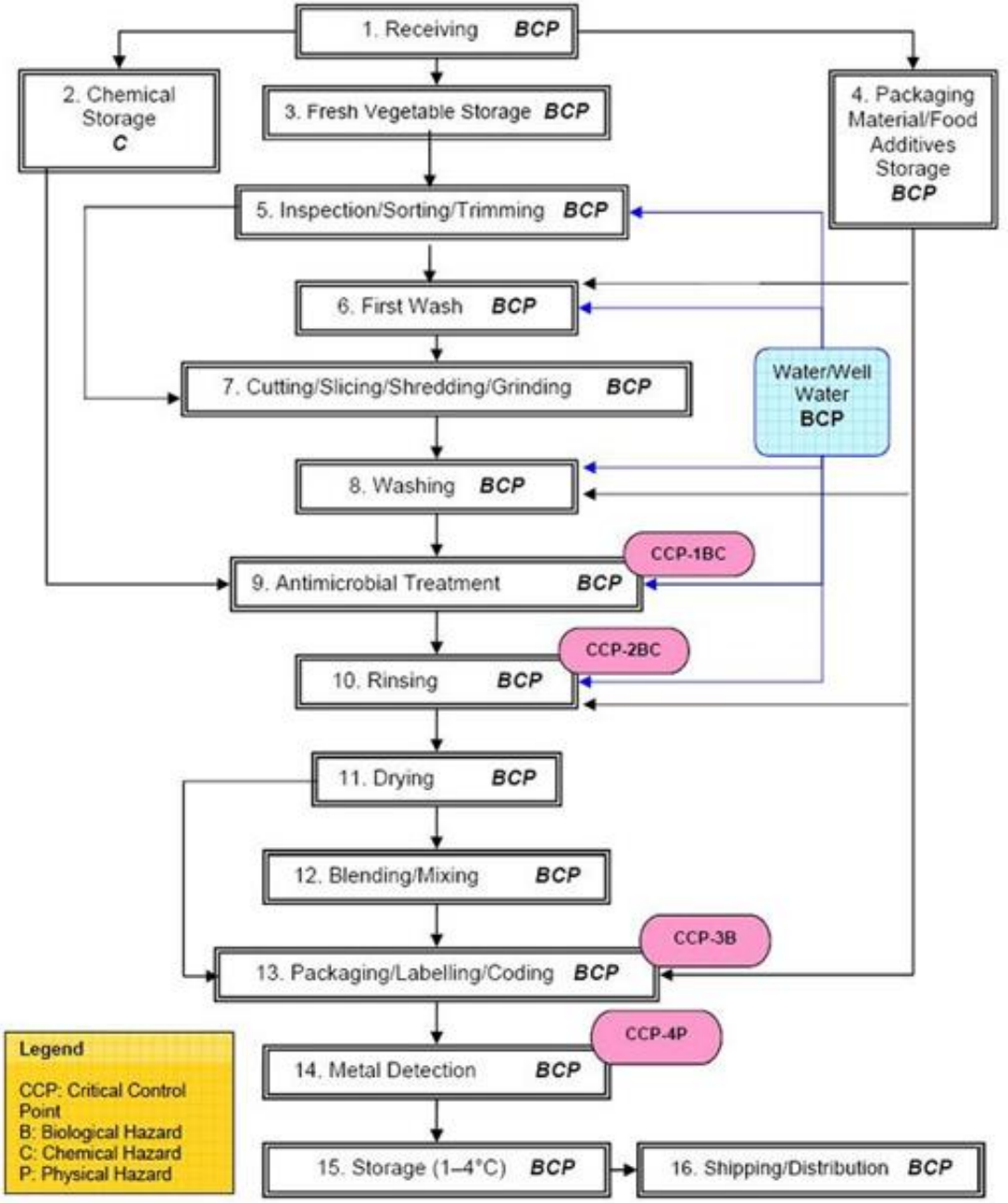
Qualitative and quantitative losses of fresh-cut :

Fresh fruits and vegetables are extremely perishable and have a relatively short shelf live.

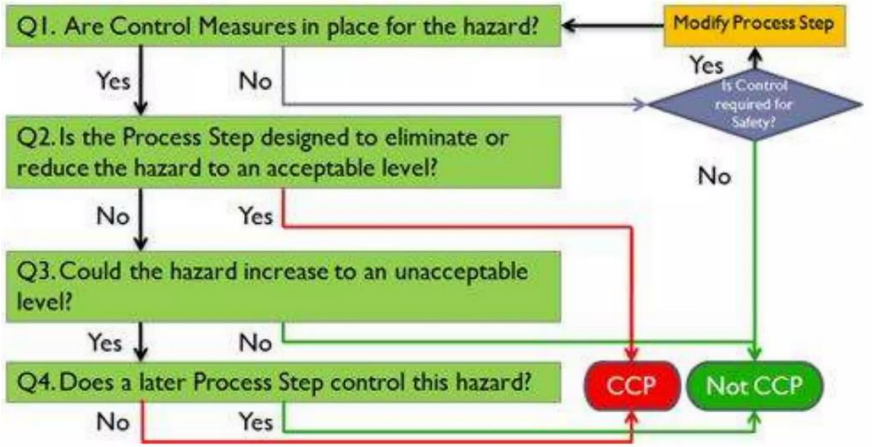
Post-harvest changes include:
•Biochemical - carbohydrates, organic acids, pigments, vitamins, volatiles
•Physiological –respiration and transpiration
•Biological and microbiological – damage caused by insects, fungi and bacteria

For extending shelf life of fresh-cut products the consideration of the following parameters are necessary :

- **appropriate selection of variety**
- **reducing water loss by maintaining optimal relative humidity,**
- **reducing respiration by lowering temperature,**
- **slow respiration by maintaining optimal gaseous environment,**
- **reducing decontamination.**



Identifying Hazards



CCP = Critical Control Point(s)

HACCP: Establish documentation and record keeping

HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES

Risk Assessment for Foreign body contamination, Plastic, Glass and Wood

Location		Assessment Date		Last assessment Date	
Hazards identified	Risk assessment to consider foreign body contamination including Plastic, Wood and Glass on site	*Calculate Hazard Rating – Frequency (Sv + Prb)*			Rating
		Frequency	Severity	Probability	
			3	2	6
Control Measures					
	Control to reduce or eliminate risk				
1	Glass register and weekly glass audit				
2	Weekly Hygiene audit checks general house keeping for and foreign bodies. If there is a repeat issue it will be marked Red. This audit is bonus related and is discussed at the weekly management meeting				
3	Broken pallets are removed to outside the compactor area and dumped into a skip.				
4	All damaged crates are removed to the waste area and returned.				
5	Glass breakage procedure are followed and completed if there is a breakage.				
6	All staff receive Hygiene and Food safety training				
7	Jewellery policy enforced and monitored via the Hygiene audit				
Low risk.					

What is Needed ?

HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES

Approved Suppliers

Staff Training

Operational Control

Personnel

- Trained for their job
- Understand food safety

Equipment

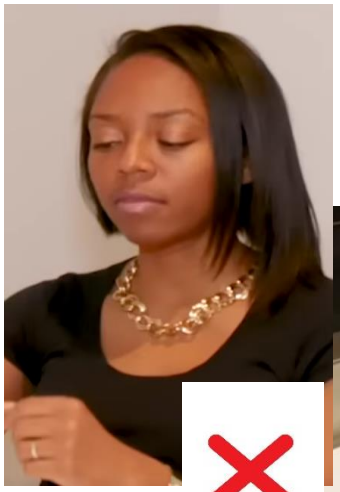
- Design and installation
- Maintenance and Calibration

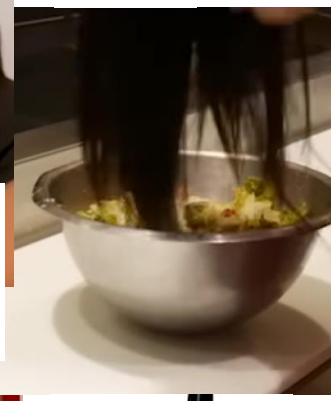
The HACCP team should be multidisciplinary in nature. It includes supply chain department, production, engineering, electrical, quality all departments to have a better ideas.

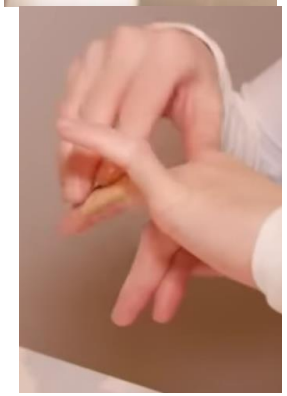
Personal Hygiene

HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES

Uniform
Nails
Hair
Bruises
Diseases







Factors	Extending of shelf-life
cultivation	appropriate selection of variety pre-harvest cultural practices harvest maturity
sanitation	reduction of contaminations without changing of color, taste, odor; decontamination of water with UV, O_3
cutting	precise, depending on plant tissue
packaging	reducing respiration: optimal gaseous environment – CA, MAP, ethylene absorbents, packaging materials
coating	edible coatings (pectin, alginate, starch, Ca), protecting MO
storage	Temperature Humidity

Minimally processed food: Fresh Cut

HOCHSCHULE WEIHENSTEPHAN-TRIESDORF UNIVERSITY OF APPLIED SCIENCES

Re- utilization of industrial wastes

Criteria	Impor-tance, %	Products											
		Pet food		Vegetable juice		Feed		Aqua-culture		Fruit juice		Insects	
Innovation	5	8	0,4	6	0,3	2	0,1	6	0,3	2	0,1	10	0,5
Costs for production	15	6	0,9	5	0,75	10	1,5	8	1,2	5	0,75	1	0,15
Investment costs	20	4	0,8	3	0,6	8	1,6	8	1,6	3	0,6	1	0,2
Image	15	7	1,05	9	1,3	1	0,15	2	0,3	8	1,2	8	1,2
Success	25	8	2	8	2	3	0,75	1	0,25	2	0,5	1	0,25
Win	20	8	1,6	6	1,2	1	0,2	1	0,2	2	0,4	1	0,2
Sum of criteria (max. 10 Pkt.)	100		6,75		6,2		4,3		3,85		3,55		2,5
Placement			1		2		3		4		5		6

IDP Food Management: Michels, Smetanska, 2018

Thank you for your attention!

HOCHSCHULE
WEIHENSTEPHAN-TRIESDORF
UNIVERSITY OF APPLIED SCIENCES