DEBRECENI EGYETEM

# PRACTICAL EXERCISES FOR THE COURSE OF PROCESSING AND PRESERVATION OF HORTICULTURAL PRODUCTS

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*A Debreceni Egyetem fejlesztése a felsőfokú oktatás minőségének és hozzáférhetőségének együttes javítása érdekében*

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BEFEKTETÉS A JÖVŐBE

DEBRECENI EGYETEM

## Content

# Course 1: Quality of fruits and vegetables; chemical and physical parameters

The word “quality” comes from the Latin “qualitas”, which means attribute, property or basic nature of an object. However, nowadays it can be defined as the “degree of excellence or superiority” (Kader et al., 1985). Accepting this definition, it can be said that a product is of better quality when it is superior in one or several attributes that are objectively or subjectively valued.

Producing a quality product begins well before planting the seed. Soil selection and preparation, its fertility and irrigation potential, weed control and crop rotations, variety selection and other decisions have an influence on the quality of the product. In the same way, quality is affected by the climatic conditions during the growing period, as well as irrigation, fertilization, control of pests and diseases and other cultural practices. Harvest is the end of cultivation and the beginning of postharvest actions during which preparation for the market, distribution and sale take place. (http://www.fao.org/tempref/docrep/fao/008/y4893e/y4893e05.pdf)

**List the parts of plants we eat! Write some samples to each of them as well!**

- Fruit: tomatoes, cucumbers, eggplant, zucchini, squashes, peppers
- Flowers and buds: broccoli floret, cauliflower
- Pods: peas, beans
- Seeds: soy beans, wheat, rye, millet
- Leaves: lettuce, arugula, cabbage, parsley, basil, chives, dill, rosemary, beet greens, kale
- Stalks: broccoli stalk
- Bulbs: onions
- Tubers: potatoes
- Roots: radishes, carrots, beet root

**What do you know the nutrient composition of fruits and vegetables?**

Vegetables: their water content is around 80-90% (the highest is in lettuce, cabbage, tomato, the lowest is in corn, potato), their carbohydrate content varies between 5-15% (tomatoes are 5%, carrots are 10%, and potatoes are 18%), fat content is below 1%, protein content is between 1-5% (green peas are 5.4%, tomatoes are 0.8%)

Fruits: Carbohydrate content is higher than in vegetables, between 10-20% (lemon is 9.3%, apricot is 11%, grapes are 18%, banana is 22%, dates are 75%), sugar content is between 8-15% (lemons are 2.5%, apricots are 10%, bananas are 12%, grapes are 15%, dates are 66%), fat content is lower than in vegetables, under 1%, protein content is also lower than is vegetables below 2% (apples are 0.2%, oranges and peaches are 1%, avocados are 2%), and their mineral content in important.

**What carbohydrates can be find in fruits and vegetables?**

- Soluble carbohydrates (mono and disaccharides)
  - Glucose, fructose, saccharose (their ratios alter during ripening, characterize different fruit species
  - To set in the ratio: pruning/cutting or trimming of branches, vines
  - Concentration grows until harvesting, then decreases
  - Higher concentration in the skin and close to the skin (apple)
- Complex carbohydrates:
  - Pectin (dietary fiber), starch, cellulose

**Which organic acids can be find in fruits and vegetables?**

- Flavour components
- Substrate role: Ca-, Mg-, K-salts (free acids + Ca, Mg, K)
- Most frequent in apple: malic acid, citric acid
- Berries: citric acid, iso-citric acid
- Others: oxalate/oxalic acid, succinate acid
- Aim of storage: to preserve the acid content present at the moment a fruit is stored
- Duding deterioration their amount is decreasing.

**Which volatile, aroma and flavour components can be find in fruits and vegetables?**

- Alcohols, esters, aldehydes, ketones, saturated and unsaturated hydrocarbons
- Ethylene: hormone accelerating ripening; produced by tissues; important role during storage
- Acetaldehyde: sign of deterioration, measured in the storage chamber

**Which harmful materials are produced by fruits and vegetables?**

- Cyanide-containing glycosides (mainly in seeds)
- Oxalic acid (in berries)
- Salicylic acid derivatives (in berries)
- Lectins (cherry and quince apple)
- Allergy: histamine (strawberry), pollens
- Agro technical chemicals: pesticides, insecticides (to keep the waiting time)

## Course 2: Maturation, physiology of maturation, methods determining the maturity stage

In some fruits, ripening is associated with a rapid increase in the rate of respiration and associated quality changes (flavour, colour, texture, etc.) known as the 'climacteric', which more or less coincides with eating ripeness. This represents the completion of maturation and is followed by senescence. Ripening is triggered by ethylene, which is then produced autocatalytically by the fruit. Climacteric fruit such as apples, tomatoes, bananas or mangoes can either be harvested at full ripeness for immediate consumption, or harvested before the climacteric for storage and transport before ripening (either through endogenous or exogenous ethylene). (J. G. Brennan (ed.) 2006. Food Processing Handbook)

**What is the difference between climacteric and non-climacteric fruits in their respiration rate?**

Non-climacteric: During cell division the respiration rate is quite large, but during the cell enlargement and ripening the respiration rate is continuously decreasing.

Climacteric: During cell division the respiration rate is quite large, but during the cell enlargement the respiration rate is continuously decreasing. During ripening the respiration rate is growing again, and in the senescence it is decreasing. See in the previous figure.

**What processes happen during growth and ripening in climacteric fruits?**

After the cell enlargement the amount of starch is decreasing but the amount of reducing sugars is increasing. The concentration of organic acids and proteins are also decreasing during cell enlargement and maturation. The structure of pulp is softening owing to the disintegration of starch and the forming of different sugars and pectin. It is because sugars and pectin are soluble but starch is non-soluble. The preferred taste of frits is due to the decreased organic acid and increased sugar concentration.

**Which physical and chemical changes happen during ripening?**

| Characteristic | Phenomenon | Reason |
|---|---|---|
| Colour | -Pigmentation | -Disintegration of chlorophyll<br>-Synthesis of carotenoids and anthocyanin |
| Tissue structure | -Softening | -Changing in structure of pectin<br>-Transformation of cell-wall forming components<br>-Hydrolysis of reserve materials |
| Flavour | -Carbohydrate composition<br>-Organic acids<br>-Aroma flavours | -Disintegration of starch to sugar<br>-Transformation of sugars<br>-Decrease of the amount of organic acids<br>-Synthesis of volatile materials<br>-Changes in the ingredients of volatile material |
| Energy | -Respiration intensity | -Character of ripening |
| Ethylene | -Ethylene production | -Character of ripening |

| | | |
|---|---|---|
| | -Ethylene sensitivity of tissues | -Increase with ripening |

**What are the quality standards for apple (minimum requirements and classifying parameters)?**

Minimum requirements: compulsory to all quality classes for human consumption:

- intact/uninjured,
- healthy (cannot be spoiled/deteriorated),
- clean, free from unknown materials,
- free from damage of pathogens and pests/parasites,
- free from unnatural surface moisture,
- free from strange smell/odour and/or taste/flavour.

The fruit should be carefully picked.

The apple has to be matured enough to be able to continue ripening and reach the demanded degree of maturity.

The state of the fruit has to be proper for transportation and cargo handling, and arrive to the place of use in expected state.

Classifying parameters:

- size: basis of classification
- shape: typical of variety [pl. Jonathan, Golden apples]
- Colour and distribution of the colour: primary colour (green to yellow), covering colour (covers min. 50 % of surface), colour depth (orange to red)
- skin: clean, intact, can be covered by wax (depends of variety)

**What are the objective measured parameters to standardise apple?**

- The firmness of apple (pulp): penetrometer (before/after picking), the softening values of apple varieties are different. Soft can be stored shorter, the harder the longer
- Composition: acid and sugar content
- Quality index = sugar content [g/l] + 10 × acid content [g/l]
- Higher acid containing apple has higher quality index but it can divide the consumers.
- For processing, both acid and sugar content should be high.
- During storage: acid content decreases, sugar content at first increases, then decreases.

**How can you determine the optimal harvest time in case of apple?**

- Colour
- Abscission from tree
- Elapsed days from bloom
- Biological maturity
- Firmness of flesh/pulp

- Change in chemical composition
- Disintegration of starch → formation to sugar
- Intensity of respiration

## Course 3: Storage, storing methods, processes during storage

The aim of storing horticultural products is limiting respiration, transpiration and deterioration in order to save the after-ripening ability and the consumer quality. We can reach this with controlling temperature, humidity, motion of air and composition of air. In optimum case during after-ripening the best quality of products is forming. After the after-ripening over-ripening occurs which is a senescence process.

**What factors are affecting storing quality?**

- Cultivation factors: Variety, cultivation technology (soil cultivation, water and nutrient supply, plant protection)
- Harvest, transport and storing technology

**What factors are affecting the quality of apple storage?**

| Quality parameters | Cultivation | Harvest | Storage |
|---|---|---|---|
| - sugar | - light<br>- water supply<br>- nutrient supply<br>- temperature<br>- leaf/fruit ratio | - harvest time<br>- injuries<br>- immediate storage | - temperature<br>- relative humidity<br>- ethylene<br>- aroma components<br>- flavour materials<br>- $CO_2$<br>- $O_2$ |

**What are the storing parameters?**

- Temperature
- Humidity
- Composition of air
- Motion of air

**What is the difference between modified and controlled atmosphere storage?**

In the case of modified atmosphere storage, we try to approach the ideal value. In the case of controlled atmosphere storage, we set the exact value.

**What is the role of temperature?**

- Owing to cooling vital processes decrease.
- Metabolism processes decrease as well.
- Life of fruit (consumption time) lengthens.
- Different storing temperature to different species and varieties.
- Not properly selected temperature can cause softening and a decrease in nutrient contents.

**How does humidity affect to storage?**

- Equilibrium relative humidity is the ideal.
- If lower: Drying affect, mass loss, fading
- If higher: Water precipitates to surface, damages respiration and after-ripening, increases microbial activity

**What composition of storage atmosphere is good?**

- Respiration of fruits and vegetables wants to continue.
- Adequate $O_2$ / $CO_2$ ratio → metabolic processes of fruit are blocked
- Optimum $CO_2$ concentration is crucial → toxic effects, deterioration
- Under 4°C ethylene production does not occur.
- Transpiration is necessary, without it deterioration occurs.
- Volatile materials: Ethylene should be removed in order not to accelerate ripening.
- Unfamiliar volatile materials have to be filtered out from the environment because pulp can absorb and it will damage the taste.

**Why is the motion of air important during storing?**

- The same circumstances are in the whole storage chamber.
- Motion of air has drying effect.
- Forming gases have to be filtered out

**What are the effects of modified atmosphere?**

- $O_2$ – respiration intensity decrease
- $CO_2$ – inhibition of Krebbs-cycle, pH decrease, respiration increase or decrease
- Inhibit or stimulate the effect of ethylene
- Inhibition of cell-wall decomposing enzymes
- Decrease/increase of degree of chlorophyll decomposition
- After-ripening can be postponed
- Anaerobe circumstances: forming of ethanol and acetaldehyde

**What are the most important storing methods?**

- Stack/pile/heap storage (deposit outside)
- Normal storage: cellar
- Common (unrefrigerated) storage: Chambers with natural cooling air change
- Cold (refrigerated) storage: Unchanged/permanent atmosphere chambers (with mechanical cooling)
- Modified atmosphere storage
- Controlled atmosphere storage
- Ultra low oxygen storage (2% > $O_2$)

## Course 4: Deterioration processes of horticultural products

Deterioration means such changes in food products, to effects of which the consumer and biological values decrease or they become unsuitable for marketing and consumption. The aim of preservation is to prevent from deterioration processes and to protect the original good quality (flavour, firmness, composition).

**What deterioration can occur in the case of food products?**

- Origin: Physical, chemical, (micro)biological. One caused or several caused.
- Outward form: Visible, invisible
- Intensity: Slow, medium, fast

**What deterioration processes do you know according to their origin?**

- Physical (physical-chemical): Mechanical effect, injury, fading, transpiration
- (Bio)chemical: Oxidation, respiration, protopectin - pectin transformation, enzymatic processes (enzymatic oxidation of acids and mixture of cell content)
- Microbiological: Caused by biological processes deriving from microbe activity

**What is the difference between enzymatic and non-enzymatic processes?**

- Non-enzymatic processes: can be reduced by changing the external factors → reversible
- Enzymatic processes: can be inactivated by eliminating enzyme activity → irreversible

**Which factors are affecting multiplication of micro-organisms?**

Time, nutrient content of the medium, water activity, temperature, pH, oxygen content

**Why is water activity important?**

$a_w = P/P_0 = RH/100$

$P$ → water vapour pressure in food

$P_0$ → water vapour pressure of pure water

$a_w$ → water activity

$RH$ → relative humidity

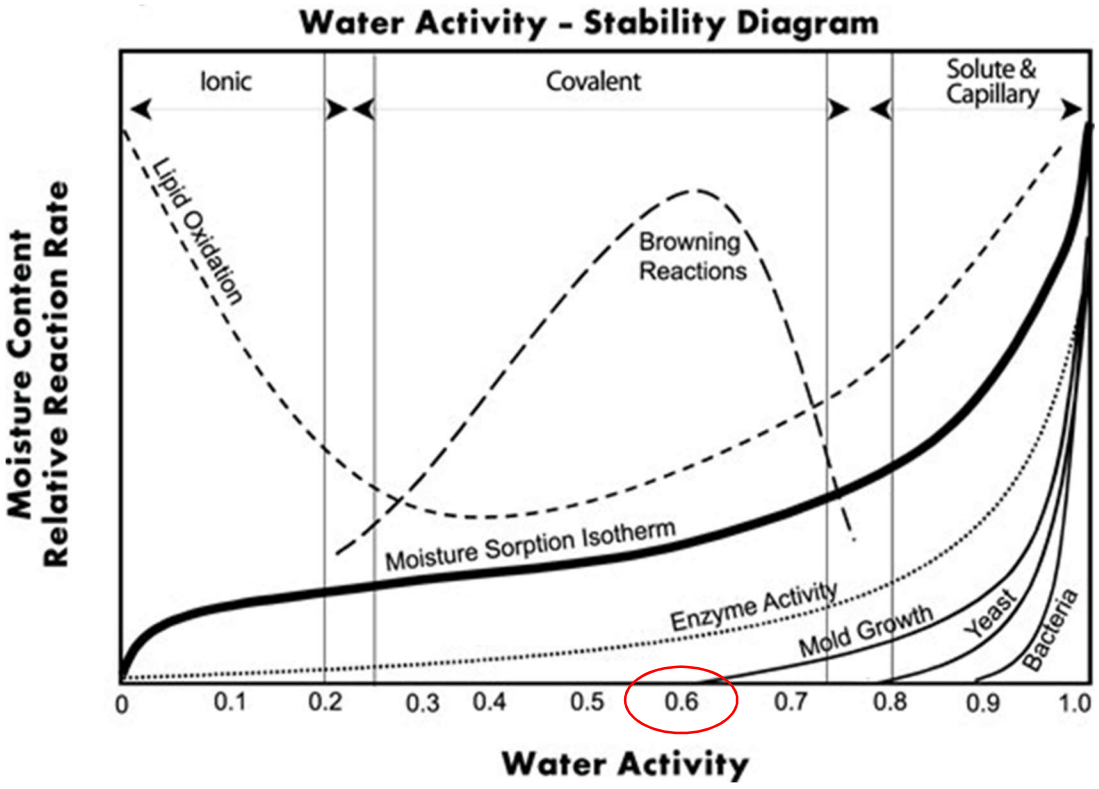
Water activity can be between 0 and 1. Lowest level of microbe multiplication: 0.6. For example, the water activity of an apple is around 1. It means that an apple is very damageable.

To reduce water activity, we have to increase the osmotic potential of the solution. For this purpose, we have two possibilities:

- To decrease water content
- To increase concentration of dissolved materials

**What is the relation between water activity and deterioration?**

The water activity of dried foods is around 0.2. The water activity of concentrated foods is around 0.6 (see on figure). Lowest level of microbe multiplication: 0.6.




(http://aqualab.decagon.com.br/educacao/measurement-of-water-activity-for-product-quality/)

**List food preservation methods!**

Food preservation methods according to the **origin of deterioration processes:**

- Macro biological deterioration:
  - Rodents, birds, insects (packaging, alarming systems, respect storage rules)
- Physical deterioration:
  - To inhibit the changing of moisture content (climatisation of storage chamber, packaging)
  - To preserve consistency (emulsifying, dispersing, gelling materials)
  - Protection against transport damage
- Chemical deterioration:
  - To inhibit enzyme activity
  - To inhibit auto-oxidation (antioxidants)
- Microbiological deterioration:
  - To exclude microbes (packaging)
  - To eliminate microbes (filtration)
  - To inhibit the activity and multiplication of microbes (cooling, freezing, drying, microbe inhibitors, etc.)

- To kill microbes (heat treatment, radiation)

Food preservation methods according to the **effects:**

- Physical methods
  - Heat treatment,
  - Heat extraction,
  - Reduction of water content
  - microfiltration
  - others (radiation, gasification with inert gases)
- Physical-chemical methods
  - Salting
  - Marinating
  - Smoking
  - Adding sugar
- Chemical methods
  - To add chemicals to food, which inhibit or kill agents responsible for deterioration (preservatives, acetic acid, benzoic acid)
  - To provide low-oxygen state
  - Carbonic acid and CO2 preservation
- Biological methods
  - Natural acidification: material produced by a microbe inhibits the multiplication of another deteriorating microbe (lactic acid fermentation)
  - Artificial acidification: salt-acetic acid, alcoholic or lactic acid containing liquid is used with the combination of heat treatment

# Course 5: General operations and preparation methods of fruit and vegetable processing

At the time of harvest, most foods are likely to contain contaminants, to have components which are inedible or to have variable physical characteristics (for example shape, size or colour). It is therefore necessary to perform one or more of the unit operations of cleaning, sorting, grading or peeling to ensure that foods with a uniformly high quality are prepared for subsequent processing. It is not possible to produce high quality processed foods from substandard raw materials and these mechanical separation procedures, which are applied near the beginning of a process, are a highly cost-effective method of improving the quality of the raw material. (P. Fellows 2000. Food Processing Technology)

**What are the most important steps of processing horticultural products?**

1. Raw material preparation
   1.1. Pre-cleaning, cleaning
   1.2. Sorting
   1.3. Grading
   1.4. Peeling
   1.5. Pricking (cutting)
   1.6. Chopping
   1.7. Blanching
   1.8. Improving the texture
2. Main process
3. Finishing operations
   3.1. Fixing/stabilizing the colour
   3.2. Sealing/tinning/canning
   3.3. Heat-treatment

**What is the difference between sorting and grading?**

They are similar processes. During sorting we decide whether the raw material is suitable or not suitable for processing. During grading we work with the suitable part and we grade according to other special quality standards.

**What are the viewpoints of sorting?**

- Colour, mass, profile, and size
- Removing the damaged parts
- Deteriorated, damaged by insects or other animals, unhealthy, mechanically damaged pieces
- Removing the immature or over matured pieces
- Removing the deformed pieces
- Removing the undesirable colour pieces

**List some sorters and graders!**

Sorting table, roller sorter, sorting belts, drum sorter, drum grader, disk sorter / grader, rod sorter, colour sorter

**What are the requirements concerning washing and water for washing?**

Washing:

- Effective but considerate
- Does not cause dry material lost
- To reduce microbe number
- Principle of counter flow, economical water consumption
- After washing rinsing is important

Water:

- Drinking water quality
- Safe from toxic materials
- Microbiological state
- Fe-, Mn-ion concentration < 0,3 mg/l
- Water hardness: proper hardness (25 GH°) to avoid precipitation or dissolving

**List some cleaner and washer!**

Dry cleaner, air separator, horizontal selector, flotation washer, drum washer, spray washer, scrub washer

**Why is peeling needed?**

Peeling is used in the processing of many fruits and vegetables to remove unwanted or inedible material, and to improve the appearance of the final product. The main consideration is to minimise costs by removing as little of the underlying food as possible and reducing energy, labour and material costs to a minimum. The peeled surface should be clean and undamaged. There are five main methods of peeling (P. Fellows 2000. Food Processing Technology):

1. flash steam peeling
2. knife peeling
3. abrasion peeling
4. caustic peeling
5. flame peeling.

**What are the aims and methods of size reduction?**

Aims can be:

- Final size is between 2 levels (e.g. spices)
- To reach certain shape, size (e.g. shopped fruits and vegetables)
- To increase specific surface (to intensify certain processes and chemical reactions), e.g. fruit juice extraction, larger evaporating surface

- To lyse the cells (e.g. crushing tomato or fruits)

Methods: crushing, grinding, chopping, cutting, slicing

## Course 6: Preservation by heat extraction, process of freezing, freezing methods, frozen products

Chilling is the unit operation in which the temperature of a food is reduced to between -1ºC and 8ºC. It is used to reduce the rate of biochemical and microbiological changes, and hence to extend the shelf life of fresh and processed foods. It causes minimal changes to sensory characteristics and nutritional properties of foods and, as a result, chilled foods are perceived by consumers as being convenient, easy to prepare, high quality and 'healthy', 'natural' and 'fresh'.

Freezing is the unit operation in which the temperature of a food is reduced below its freezing point and a proportion of the water undergoes a change in state to form ice crystals. The immobilisation of water to ice and the resulting concentration of dissolved solutes in unfrozen water lower the water activity (aw) of the food. Preservation is achieved by a combination of low temperatures, reduced water activity and, in some foods, pre-treatment by blanching. There are only small changes to nutritional or sensory qualities of foods when correct freezing and storage procedures are followed. (P. Fellows 2000. Food Processing Technology)

**What are the methods of heat extraction?**

- Cooling, pre-cooling
- Cold storage
- Freezing
- Frozen storage
- Combined methods:
    - Freeze-drying (lyophilization): dried products
    - Freeze concentration (cryoconcentration): concentrates

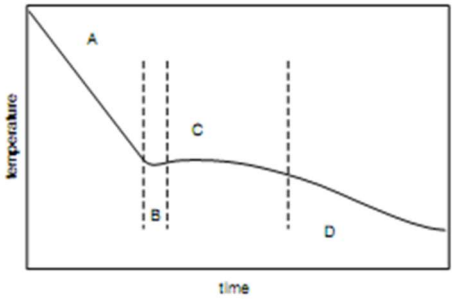
**What are the effects of freezing on microbes?**

During freezing solutions become more concentrated (concentration influences the freezing point). Enzymes are inactivated, proteins are denaturated, the operation of DNA and RNA are changed, the cell structure is also changed.

Chilling shock: freezing cause osmotic pressure difference. Ice crystals injures microbe celles mechanically (slow freezing). Melting causes osmotic pressure difference.

**What are the steps of freezing process?**

1. Cooling to the freezing point (removal of sensible heat above freezing point). → A
2. Freezing (removal of latent heat). → B and C
3. Further cooling to the desired subfreezing temperature (removal of sensible heat of frozen food below freezing point. → D




(http://stellarfoodforthought.net/process-freezing-101-4-variables-food-processors-must-understand/)

**What refrigerants do you know?**

Air (convective): Composition, Temperature, Humidity, Dew point temperature, Current of air, Mechanical and microbiological purity

- Solutions: fluidized bed freezers, belt freezers

Liquid media (convective): Salt solutions, $CO_2$, $N_2$

- Solution: cryogenic freezers

Contact freezing

- Solution: package freezer

**What phases of freezing are in foods?**

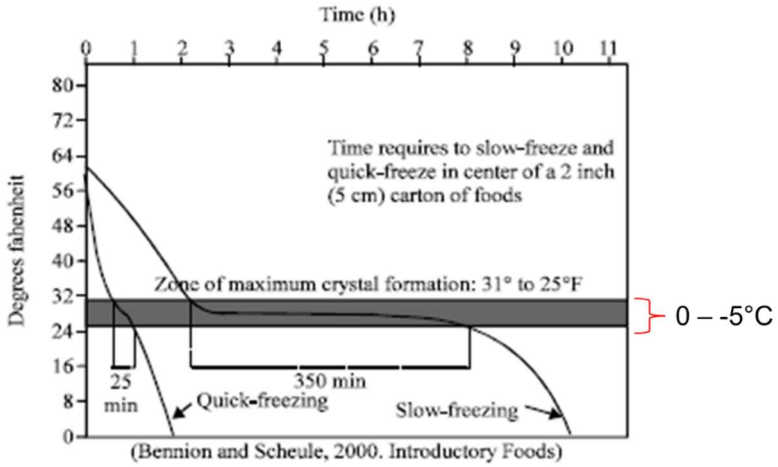
- < 0°C (0%) → beginning of freezing
- 0 – -25°C → biologically free water freezes
- -25°C (60%) → limit of biological reversibility
- -25°C (92%) → biologically bound water, limit of colloid reversibility
- -60°C (100%) → total frozen

% = It shows what percentage of water is frozen

**How are the ice crystals forming during slow- and quick-freezing?**

Slow-freezing → macro size ice crystals

Quick-freezing → micro size ice crystals




**What are the characteristics of quick- and slow freezing?**

- Quick-freezing
  - Velocity of freezing is larger than diffusion
  - Ice crystals in cells (intracellular freezing)
  - Micro crystal structure
- Slow-freezing
  - Increased diffusion processes caused by osmotic potential
  - Ice nucleation in intercellular space
  - Macro crystal structure (extracellular)
  - Mechanical pressure to cells
  - More effective against microbes

## Course 7: Preservation by water extraction, process of drying, drying methods, dried products

Dehydration (or drying) is defined as 'the application of heat under controlled conditions to remove the majority of the water normally present in a food by evaporation' or in the case of freeze drying by sublimation. The main purpose of dehydration is to extend the shelf life of foods by a reduction in water activity. This inhibits microbial growth and enzyme activity, but the processing temperature is usually insufficient to cause their inactivation. Therefore, any increase in moisture content during storage will result in rapid spoilage. The reduction in weight and bulk of food reduces transport and storage costs. Drying causes deterioration of both the eating quality and the nutritional value of the food. The design and operation of dehydration equipment aim to minimise these changes by selection of appropriate drying conditions for individual foods. (P. Fellows 2000. Food Processing Technology)

Method: decreasing water activity until about 0.2.

**What are the most important operations of water extraction?**

| Physical bases of water extraction | Operation | Resulting dry material content (%) | Products |
|---|---|---|---|
| **Evaporation (thermal way)** | Concentration<br>Drying | 60–80<br>92–98 | Concentrated fruits and vegetables<br>Vegetable and fruit powders, dried products |
| **Diffusion** | Revers osmosis | 20–35 | Concentrated products and aroma concentrations |
| **Crystallization** | Cryoconcentration | 32–50 | Concentrated fruit juices |
| **Sublimation** | Freeze-drying (lyophilization) | 92–99 | Fruit powders, tomato concentrates, orange concentrates |
| **Concentration in high-frequency field (12–15 MHz)** | – | 52–76 | Valuable fruit concentrates (not widespread in the industry yet) |

**What parameters are influencing the successfulness of drying?**

- Size of surface (specific surface)
- Thickness of stratum
- Sensitivity of the material
- Relative air humidity (mas to be under the equilibrium)

**What is the motion of liquid inside of the drying product?**

- Diffusion: in homogenous and solid material
- Capillary flow: in granular and porous materials

- Flow caused by shrinking and pressure difference
- Flow caused by gravitation
- Flow caused by evaporation and condensation

**What do you know about constant rate period?**

- Depending on:
  - Heat and material transmission factors
  - Surface size
  - Difference between moisture content and temperature in drying air and dried material
  - External factors!
- Drying rate per unit area is constant as long as the following conditions are satisfied:
  - The wet surface is water-saturated (i.e. behaves like the surface of pure water)
  - The air temperature, humidity and velocity are kept constant
  - Heat is transferred to the wet surface only by convection from the drying air

**What do you know about falling rate period?**

- After critical moisture content
- Two phases:
  - When moisture does not cover totally the surface (approaches the equilibrium moisture content)
  - When internal water transport controls the process
- Internal factors!

**List some drying equipment!**

Atmospheric dryers, vacuum dryers, solar dryer, tray dryer, tunnel dryer, conveyor dryer, drum dryer, spray dryer, fluid-bed dryer, freeze dryer

## Course 8: Concentrated products, thermal and non-thermal processes

Evaporation, or concentration by boiling, is the partial removal of water from liquid foods by boiling off water vapour. It increases the solids content of a food and hence preserves it by a reduction in water activity. Evaporation is used to pre-concentrate foods (for example fruit juice, milk and coffee) prior to drying, freezing or sterilisation and hence to reduce their weight and volume. This saves energy in subsequent operations and reduces storage, transport and distribution costs. There is also greater convenience for the consumer (for example fruit drinks for dilution, concentrated soups, tomato or garlic pastes, sugar) or for the manufacturer (for example liquid pectin, fruit concentrates for use in ice cream or baked goods). Changes to food quality that result from the relatively severe heat treatment are minimised by the design and operation of the equipment. (P. Fellows 2000. Food Processing Technology)

Method: decreasing water activity until about 0.7.

**What possibilities do you know for concentration?**

- Evaporation (thermal way)
  - Evaporating water
  - Atmospheric pressure / vacuum
- Cryoconcentration
  - Crystallization and separation of water
- Osmoanabiosis, osmotic dehydration
  - Increasing osmotic potential
- Membrane methods
  - Filtrating water

**What physical and chemical processes occur during concentration?**

- Evaporation of volatile materials
  - Free alcohols, esters, free acids, carbonyl compounds
- Sugar decomposition
- Non-enzymatic browning
  - Fructose → HMF (pH<3)
  - Maillard-reaction (pH>3,5)
- Caramelization
- Decomposition of colour agents
  - Anthocyanids, chlorophyll
- Decomposition of vitamins
  - Vitamin-C, thiamine

**Why is important the boiling point of water?**

Boiling point of water depends on the pressure and the concentration of solution. If the pressure is decreased, the boiling point is also decreasing. If the concentration is increased, the boiling point is also increasing.

**List some evaporators!**

Pan evaporator, boiler, vacuum evaporator, plate evaporator, film evaporator, multiple-effect evaporator,

**What is membrane filtration?**

Membrane is a selective permeability film.

It lets certain components of multi-component mixtures through (permeate) and keeps others back (retenate).

Types:

- Membrane filtration: the driving force is pressure difference, physical permeability, pore size.
- Material transport membrane processes: the driving force is steam pressure, concentration difference, temperature difference, chemical permeability.

## Course 9: Preservation by heat treatment, heat-treating methods, heat-treated products

Heat treatment is one of the most important methods used in food processing, not only because of the desirable effects on eating quality, but also because of the preservative effect on foods by the destruction of enzymes, micro-organisms, insects and parasites. (P. Fellows 2000. Food Processing Technology)

Depending on their intensity, thermal preservation processes are classified into two categories:

Pasteurization: heat processing at relatively mild temperature (70–100°C). Pasteurization destroys vegetative cells of microorganisms but has almost no effect on spores.

Sterilization: heat processing at high temperature (above 100°C) with the objective of destroying all forms of microorganisms, including spores.

Sterilization alone provides long-term preservation of foods, on the condition that recontamination is prevented by proper packaging. Pasteurization, on the other hand, provides only short-term stability or requires additional preserving factors (hurdles) such as refrigeration or low pH for long-term effectiveness. (Zeki Berk 2009. Food Process Engineering and Technology)

**What are the methods of pasteurization?**

1. Slow pasteurization: longer treatment time with lower temperature (e.g. bottled fruits, pickles, jams
2. Fast pasteurization: around 100°C, 1-2 sec. (half-aseptic, aseptic products)
3. UHT (ultra-high temperature) process: 150°C, 1 sec.
4. Fractionated pasteurization (tyndalization): 80-90°C, 15-30 sec., repeated pasteurization with intervals for the growing of spores.

**What is the most dangerous microbe concerning thermal processe?**

The most heat-resistant pathogenic bacterial spore is *Clostridium botulinum.*

**What influences the length of time required to sterilization?**

- the heat resistance of micro-organisms or enzymes likely to be present in the food
- the heating conditions
- the pH of the food
- the size of the container
- the physical state of the food.

**What factors influence the rate of heat penetration into a food during pasteurization?**

- Type of product (liquid or particulate foods)
- Size of the container
- Agitation of the container
- Temperature of the retort

- Shape of the container
- Material of container

## Course 10: Fermentation processes: lactic acid fermentation, methods and products

Fermentation processes have a very important role in the food preservation industry. We can widen the variety of food; fermented foods have a good nutritional value and pleasant taste and longer shelf-life; we can digest them more easily. In the food fermentation industry, we tell alcoholic (anaerobic process), lactic acid (anaerobic process) and acetic acid (aerobic process) fermentations. Thy typical types of them and the working microorganisms are:

1. Lactic acid fermentation: pickles (lactic acid bacteria)
2. Alcoholic fermentation: wine and spirits (yeasts)
3. Acetic acid fermentation: vinegar (acetic acid bacteria)

**What is the base process in lactic acid fermentation?**

The activity of lactic acid bacteria is doing the fermentation. They convert carbohydrates to lactic acid. For this purpose, we can inoculate our raw material with pure lactic acid bacteria. Another possibility is the spontaneous lactic acid fermentation where we can promote the work of the bacteria with salting and anaerobic circumstances.

**What is the role of salting?**

- Salt is increasing the release of cell fluid (osmotic potential and diffusion).
- Salt if selecting microbes (lactic acid bacteria can stand max. 2.5 % salt).
- Salty pickling liquid is used for cucumber.
- Crystalline salt is used for cabbage.

**What circumstances are during lactic acid fermentation?**

Pickling liquid is providing anaerobic circumstances during the fermentation. The salt content of the liquid is selecting microbes. Only lactic acid bacteria can stand high salt concentration. The forming lactic acid is resulting low pH which also protects the product against other microbes, and during the pasteurization can increase the result of heat treatment.

**During artificial (chemical) preservation what materials have to be added to the liquid?**

Eating acids (acetic acid, lactic acid), salt, spices and preservatives.

- Acetic acid: 1.5-2 %
- Lactic acid: 0.1-0.3 %
- pH reduction
- Preservatives: benzoic acid, sorbic acid
- Organic acids together with preservatives have synergist effect.

**What physical changes are going on during picking?**

Osmotic and diffusion processes are going on:

- The lactic acid fermentation is undergoing in the liquid.

- The salt content of the pickling liquid is decreasing in parallel with the increasing of the salt content of the vegetable.
- The tissues of the vegetable release the certain part of their water content due to salt.
- The volume of the vegetable is decreasing at first and then increasing.

**What chemical changes are going on during picking?**

- Dry material content of raw materials: 5-10 %
- They contain fermentable carbohydrates: 2-5 %
- Sugar content is decreasing.
- Resulting acid production: 1-2 % (max. 3.5 %)
- Resulting pH: 3.5
- Gas production: $CO_2$, $H_2$
- Other forming compounds in small amount: ethanol, esters, flavour and aroma compounds (They are very important owing to the forming final pleasant taste.)
- Cellulose and certain part of pectin content are remaining.

**What deterioration processes are during or after pickling?**

- Pickling liquid becomes viscous/sticky
- Colour defect, browning
- Surface film formation, moulding
- Rotting
- Becoming spongy
- Softening
- Starting of fermentation (in the case of artificial pickling)

# Course 11: Fermentation processes: alcoholic and acetic acid fermentation, methods and products

**What are the steps of fruit wine production before fermentation?**

1. Preparation of the raw material (fresh or preserved (cooled or frozen) fruits or fruit juice, concentrated fruit juice, pasteurized fruit juice; e.g. apple, pear, currant, plum, sour cherry): washing, sorting, size reduction/crushing, juice treatment
2. Enzymes: decomposing pectin, more juice extract, colour control, better clarification, better filtration
3. Fruit extraction (pressing, shell fermentation, extraction)
4. Sulphurization
5. Correction of chemical parameters (water, sugar, nutritive salts, selected yeast culture):
    a) Decreasing acid content until 7 g/l with diluting with water.
    b) 220 g/l sugar concentration is needed to produce 11 V/V% alcohol content. (Fruits are containing 50-100 g/l sugar which results 3-6 % ethanol.)
    c) Adding nutritive salts of 2 g/l in order to provide better circumstances for microbes.

**What is going on during fermentation?**

Fermentation chemistry: $C_6H_{12}O_6 \rightarrow 2\ CH_3\text{-}CH_2\text{-}OH + 2\ CO_2 + heat$

- Spontaneous fermentation (wild yeasts, other microbes)
- Directed fermentation by inoculation of selected yeast culture.

Optimum temperature is 22-27°C. Above 25°C the $CO_2$ production is too intensive. Due to this flavour and taste materials can decrease.

Cooling and $CO_2$ draining are necessary.

After fermentation the $CO_2$ production is decreasing, so protection against oxidation is needed.

**What are the steps of handling fruit wine?**

- Basic technology:
    - Decanting (from the precipitated deposit)
    - Pouring (excluding air)
    - Sulphurization (aseptic, reducing, colour-stabilizing)
- Quality fruit wine technology:
    - Clarification
    - Separating
    - Filtration
    - Cold and warm treatment
    - Blending

**What is the process during acetic acid fermentation?**

Acetic acid bacteria are forming from ethanol to acetic acid with the help of oxygen:

$$CH_3\text{-}CH_2\text{-}OH + O_2 \rightarrow CH_3\text{-}COOH + H_2O + 494\ kJ$$

$$CH_3\text{-}COOH + 2O_2 \rightarrow 2\ CO_2 + 2H_2O$$

From about 10 % alcohol they produce 5 % acetic acid containing vinegar.

**What acetic acid bacteria do you know?**

*Acetobacter:* ethanol → acetic acid → $CO_2$ and water

*Gluconobacter* (*Acetomonas*): ethanol → acetic acid

**What physiological properties are characterizing acetic acid bacteria?**

- Nutrition demand (C, N, minerals, N and P containing nutritive salts, vitamins, organic nutrients: yeast autolysate, malt extraction)
- Alcohol tolerance: 6-15%
- Acid producing ability: 10-13%
- Optimum temperature: 25-32°C
- Heat decay: 50-60°C
- Oxygen demand of acetic acid bacteria of 1 g dry material: 7750 ml $O_2$/hour

**What are the two types of acetic acid fermentation technology?**

1. Surface method: acetic acid production is on the air connected surface of the mash
2. Submerged fermentation: acetic acid production is inside of the mash

**What are the after-treatment steps of fruit wine vinegar?**

1. Colour correction (natural colour agents)
2. Clarification, filtration
3. Acid content correction
    - Wine vinegar: 6 g / 100 ml
    - Cider vinegar: 5 g / 100 ml
4. Sulphuration: 100 mg/l total $SO_2$
5. Pasteurization (75°C–80°C for 30–40 s)
6. Filtration
7. Bottling

## Course 12: Wine production

**What are the steps of wine-making process?**

1. Harvesting
2. Destemming
3. Crushing
4. Juice separation (pressing)
5. Must treatment (pasteurization, addition of pectin-splitting enzymes, clarification)
6. Fermentation (adding $SO_2$ to suppress undesirable microorganism growth)
7. Postfermentation treatment
8. Clarification (fining, filtration, centrifugation, refrigeration, ion exchange, heating)
9. Aging and bottling

(https://www.britannica.com/topic/wine#ref66652)

## Course 13: Preservation by irradiation and chemical preservation

Irradiation literally means exposure to radiation. In practice three types of radiation may be used for food preservation: Gamma (γ) rays, X-rays or high-energy electron beams (β particles). These are termed ionising radiations. Although the equipment and properties differ, the three radiation types are all capable of producing ionisation and excitation of the atoms in the target material, but their energy is limited so that they do not interact with the nuclei to induce radioactivity. Gamma rays and X-rays are part of the electromagnetic spectrum, and are identical in their physical properties, although they differ in origin. (J. G. Brennan (ed.) 2006. Food Processing Handbook)

**What are the main advantages of irradiation in preservation?**

- Little or no heating of the food and therefore negligible change to sensory characteristics
- Packaged and frozen foods may be treated
- Fresh foods may be preserved in a single operation, and without the use of chemical preservatives
- Energy requirements are very low
- Changes in nutritional value of foods are comparable with other methods of food preservation
- Processing is automatically controlled and has low operating costs.

A major disadvantage is the high capital cost of irradiation plant. (P. Fellows 2000. Food Processing Technology)

**What are the most important application fields of using irradiation?**

- Low dose (<1 kGy)
    - Sprouting inhibition
    - Insect and parasite disinfection
    - Delay of ripening
- Medium dose (1-10 kGy)
    - Reduction of spoilage microorganisms
    - Reduction of nonspore pathogens
    - Microbial reduction in dry products
- High dose (10-50 kGy)
    - Sterilization
- Very high dose (10-100 kGy)
    - Reduces or eliminates virus contamination

(M. Shafiur Rahman 2007. Handbook of food preservation)

**Chemical preservation:** The use of chemicals in foods is a well-known method of food preservation. Wide varieties of chemicals or additives are used in food preservations to control pH, as antimicrobes and antioxidants, and to provide food functionality as well as preservation action. Some additives are entirely synthetic (not found in nature), such as phenolic antioxidant, and others are extracted from natural sources, such as vitamin E. Irrespective of origin, food additives must accomplish some desired function in the food to which they are added, and they must be safe to consume under the intended conditions of use. (M. Shafiur Rahman 2007. Handbook of food preservation)

**List different legally permitted preservatives in foods!**

1. Inorganic compounds: sulfites, nitrites,
2. Organic compounds: acetic acid, citric acid, lactic acid, sorbic acid, benzoic acid, sodium diacetate, sodium benzoate, methyl paraben, ethyl paraben, propyl paraben, and sodium propionate.
3. Compounds of biological origin: antibiotics, active antimicrobial agents of herbs and spices, natural antioxidants

## Course 14: Combined preservation and novel methods in preservation

Many food products owe their safety and shelf-stability not to a single preservation technique but to the combined effect of a number of mechanisms, acting simultaneously. While each mechanism alone would be insufficient to provide the desired protection, the combination does the job. It is acknowledged that the hurdle concept illustrates only the well-known fact that complex interactions of different food preservation techniques are significant for the microbial stability of foods. With respect to procedures that slow down or prevent the growth of microorganisms in foods, major successes have been seen and new applications are steadily being made in the use of combination preservation techniques or hurdle technology. (M. Shafiur Rahman 2007. Handbook of food preservation and Z. Berk 2009. Food Process Engineering and Technology)

**Which are the most common combined processes?**

- Thermal process + heat extraction
- Thermal process + preservatives or chemicals
- Water extraction + chemicals
- Water extraction + heat extraction
- Water extraction + irradiation
- Irradiation + thermal process
- Irradiation + heat extraction
- Irradiation + chemicals

**What does Pulsed Electric Field (PEF) Processing mean?**

Pulsed electric field processing is a technique in which a food is placed between two electrodes and exposed to a pulsed high voltage field (typically 20–80 kV $cm^{-1}$). For preservation applications, treatment times are of the order of less than 1 s, achieved by multiple short duration pulses typically less than 5 μs. This process reduces levels of microorganisms whilst minimising undesirable changes in the sensory properties of the food. It is important to stress that although heat may be generated in the food product (and may need to be controlled by cooling), microbiological inactivation is achieved by non-thermal means, that is, due to the electrical field not just due to any induced thermal effects. However, there is a clear synergy between a moderate degree of heating (for example 40–45°C) and the applied PEF. (J. G. Brennan (ed.) 2006. Food Processing Handbook)

**What does High Hydrostatic Pressure Preservation (HHP) mean?**

HHP preservation technologies based on the exposure of foods to high hydrostatic pressures in the range of 500–1000 MPa have been investigated from 1990's years. These technologies are based on the observation that microorganisms are inactivated due to lethal structural and biochemical alterations caused to the cells as a result of residence under such high pressures.

Different types of systems have been proposed for the industrial application of high pressure processes. Continuous processing of liquid foods in bulk does not seem to be technologically feasible. The system for processing packaged products consists of a pressure chamber and high

pressure pumps. The food in flexible packages is placed in the pressure chamber. The pressure transmission medium, usually water, is introduced and pressurized by special pumps. The food is maintained under pressure for the required residence time. Since temperature affects the sensitivity of the microorganisms to high pressure the temperature of the process has to be controlled. Finally, the pressure is released and the packages of processed food are removed from the chamber. At any rate, the cost of the process, for the rate of production, is high. At present, the commercial application of high hydrostatic pressure processing is very limited and apparently stationary. It includes mainly pasteurization of some fruit juices and jams. (Z. Berk 2009. Food Process Engineering and Technology)

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