Advanced Technologies for cherry processing and packaging

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Outline

- Cherry perishability
- Mind Map of traditional and innovative cherry processing technologies
- Development of mild technologies in cherry processing and preservation
- Emerging technologies to assure cherry safety and improving processing kinetics
- Packaging technologies and shelf-life prolongation
- Next research opportunities @ UNIBO on cherry processing
HIGH PERISHABILITY DUE TO

☆ high rate of transpiration and respiration,
☆ mechanical damages
☆ microbial infections
☆ dramatically reduction storability and marketing acceptability after harvest.

Short shelf-life of 2–4 weeks at 0°C with 90–95% relative humidity, but traditional cold storage method generally causes some physiological disorder, such as surface pitting and anthocyanins degradation.

processing of cherries to prolong the shelf life is an important way to offer a diverse array of the products year-round.
Mind Map of traditional and innovative cherry processing technologies

- Reversible PEF
- Irreversible
- Homogenization HPH
- Hydrostatic HPP
- High Pressure Technologies
- Sanitation / Decontamination
- Cold Plasma
- Vacuum Impregnation
- Infusion
- Emerging Technologies
  - Direct Osmosis (Dewatering-Impregnation)
  - Partial dehydration
- PEF-DO
- Ultrasound - DO
- Osmo-Deydro-Freezing
- Osmo-Deydro-Drying

Traditional Technologies
- Canning
- Jams
- Cherries in Liqueur
- Juice extraction
- Fresh Juices
- Drying
  - Air Drying
  - Freeze-Drying
  - Candy

Emerging Technologies
- Syrupsed cherries
- Concentrated Juices
- Nectars

Edible Coatings
- Conventional in air
- Modified Atmosphere Packaging
- Plastic material
- Active
- Passive
- Biodegradable
Traditional cherry processing technologies

• Traditional pasteurization techniques
  • jams, syrup cherries and juices.
• Thermal processing of fruit (e.g. jams) caused a loss of 70% of the vitamin C content

3 months of storage at 20°C, antioxidant capacity of cherry jams from both and sour cherries does not induce statistically significant changes in FRAP antioxidant activity

Total phenolics, monomeric anthocyanins, vitamin C were changed with statistical significance.
Traditional cherry processing technologies

3 months of storage led to significant and highly significant alterations. Thermal processing of jam (sweet cherries and sour cherries) resulted in significant losses of antioxidant capacity (30-41%), phenolics compounds (25-43%), vitamin C content (54-78%) the better tolerance by the sour cherry jam was found (Poiana et al., 2011).

As a consequence, the optimization of the thermal treatments and storage time is a fundamental key point to improve the quality of processed cherries in jams or canned products (Jensen, 2017).
Cherry processing by mild technologies

- Hurdle technology approach could be assumed in order to reduce the impact of the processing on the product’s quality

- combination of a mild heat treatment with other technologies like partial dehydration, freezing and/or refrigerated storage;

- in processing Juices, membrane filtration technologies such as ultrafiltration, microfiltration or nanofiltration can be used to obtain stable products other than for clearing or concentrating juice;

- this result can be obtained with filter with a pore size of less than 45 μm in order to remove bacteria, yeasts and fungi.
Osmotic dehydration

Osmotic dehydration (OD) is a partial dewatering impregnation process carried out by the immersion of cellular tissue in hypertonic solution.

Main results OD application: uptake of solids from the osmotic solutions, increasing in sugar/solutes content, partial protection from enzymatic activity, low energy demand for water removal, improvement in flavor, taste and color of the final product.

Osmotic dehydration (OD) is a pre-treatment commonly applied prior to air-drying or other stabilization techniques like freezing, in the last case resulting an osmo-dehydration-freezing process.
Osmo-dehyro-freezing

Pitted cherries were able to loss up to 40% of the initial water after 8 hours of osmotic treatment and around 55% after 16 hours.

- reduction of total latent heat of freezing;
- higher freezing rate;
- increasing of micro crystallization owing to the lower solids/crystals ratio;
- weight and volume reduction of frozen fruit;
- better texture and taste of the thawed fruit;
- less drip loss at thawing.

Less Energy demand

(Pinnavaia, Dalla Rosa and Lerici, 1988)
Osmo-dehyro-freezing

★ OD Frozen cherries showed higher sensorial score for better taste, flavor, color and a more rich aroma profile than the fresh fruit.
★ Other than the consumption facilitation, the stone removing is useful to improve the mass transfer since the cherry waxy skin
★ osmo-dehydro-frozen cherries showed a well-firm texture but still pleasant to consume them and thus successfully used as an ingredient in low temperature final product as into an ice-cream formulation
Osmotic dehydration + convective drying

✔️ process combination to enable to reduce the air drying to reach water activity values close to 0.75 reducing the risk of microbial spoilage

Benefits:

✔️ Better maintenance of natural color, flavor, aroma, and the reduction of the oxidative reactions and enzymatic degradation reactions.

✔️ In particular for sour cherries, the osmotic water removal is able to improve the dried sour cherry consumers’ acceptability

✔️ Easy to obtain high value cherry snacks
Ultrasound pre-treatment

**Purposes:**

- osmo-convective drying is time-consuming and energetically demanding
- cherry skin, offering a serious barrier against effective diffusion during both osmotic dehydration and the drying process
- ultrasound (US) pretreatments can improve the process efficiency (osmo and drying kinetics) in term of time consumption and mass transfers.

**Actions:**

- Since fruits are rich in water content, power ultrasound promotes alternately compression and expansion of material (“sponge effect”), rupture of the native cellular structure of the material and microchannels formation.
- The microstructural changes enhance the mass and/or heat transfer based processes
Ultrasound pre-treatment

- Homogenization
- Separation
- Inactivation of microbes and enzymes
- Extraction of enzymes, protein & antioxidant compounds etc.

Mass transfer improvement

Ultrasound treatment + OD

Dipping + OD

Nowacka M.¹, Tylewicz U.², Laghi L.²,³, Dalla Rosa M.²,³, Witrowa-Rajchert D.¹

International Cherry Symposium 22-05-2019

7th International Conference on Water in Food, June 3-5th, 2012 Helsinki, Finland
The application of US at the stage of dried sour cherry production resulted in the enhancement of mass transfer after osmotic dehydration, which led to a higher dry matter content and lower water activity.

On bioactive components, US assistance could generally be considered as neutral for bioactive component retention but excessive sonication time can lead to some anthocyanin degradation.
High Pressure Processing

Fully emerged technology

[Diagram showing the process of High Pressure Processing]

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Leaders in Food Safety, Quality and Innovation

Fresh Fruit Squeezed and Juiced
Bottled in a Triangular Shaped Bottle
Cold High Pressure Processing never Heat Pasteurised
Pure Fresh Tasting Juice

International Cherry Symposium 22-05-2019
Treatment of HPP at 550 MPa/2 min had no significant effect on cherry juice pectin, total phenol, vitamin C, pelargonidin-3,5-diglucoside, and the content of catechol improved 4.6%.

The total number of bacteria after HPP and HTST sterilization was less than 100 CFU/mL, and the mould and yeasts were not detected.

HPP cherry juice had a better sensory quality in the aroma, taste, color than HTST cherry juice.

HPP cherry juice maintained a better quality during storage at 4°C.

Peng, P., Hou, Z., Xu, Z., Liao, X. (2018)

Queirós, R.P., Rainho, D., Santos, M.D., Fidalgo, L.G., Delgadillo, I. and Saraiva, J.A. (2015)
Pulsed Electric Fields (PEF)
new electro-technology introduced as a method for pasteurization of juice and inactivation of enzymes

non-thermal and preservation technology consisting in applying electric pulses through a biological tissue placed between two electrodes (nano, micro- to milli-seconds), causing structural changes in the cell membrane

Reversible electroporation as a mild PEF intensity treatment can facilitates extraction of bioactive compounds such as anthocyanins and polyphenolics
Pulsed Electric Fields (PEF)

PEF treatment mainly used on cherry juices

growth of different bacteria and fungi

quality of the juice

Sour cherry juice at pH 3.1 inoculated with *Penicillium expansum* and treated with a PEF at 30 kV cm\(^{-1}\) field strength for 218 μs completely inhibited spore germination.

PEF treatment of sour cherry juice at 20 kV cm\(^{-1}\) for 123 μs inhibited spore germination of *Botrytis cinerea* inoculated into the juice.

*conditions were not enough to completely eliminate most of the pathogen species*
Cold Plasma

Gas partially or totally ionized, consisting of:
free electrons, cations, anions, excited molecules, free radicals

Plasma technology ensures microbial safety to maintain natural flavors and nutritional value of the original food material.

A short exposure of 3 min to an argon gas phase including a resultant heating to about 50°C of sour cherry juice reporting a higher content of anthocyanins and phenolic acids than by a traditional pasteurization at 80°C for 2 min.
Lower levels of oxygen (O$_2$) and higher levels of carbon dioxide (CO$_2$) in the storage atmospheres have been shown to reduce respiration rates, chemical oxidation rate, and growth of aerobic microorganisms thus to improve the storage life of cherries.

- Active O$_2$-enriched MAP has also been reported to effectively delay the respiration peak of cherry fruits, retarding ethylene production, and maintaining firmness and soluble protein and sugar contents in the fruits.

- Primary effects of low O$_2$ and high CO$_2$ suppressing cherry fruit respiration rate, changes in the levels of O$_2$ and CO$_2$ can also affect other quality parameters such as pigment metabolism, phenolic metabolism and volatile compound metabolism.
Active packaging has been experimented by using essential oils in combination with MAP. The use of eugenol, thymol, and menthol essential oils in MAP have been showed to enhance the effects of MAP in terms of delaying stem browning, retarding TA loss, reducing the proliferation of moulds, yeasts, and aerobic mesophilic bacteria during the storage of sweet cherry, Chockchaisawasdee et al. (2016)
Edible coatings

- Slowing post-harvest ripening process
- Control of metabolic gas exchange
- Modification of internal atmosphere
- Shelf-life prolongation

Alginate treatments at 1% and 3% can be used as natural postharvest treatments to improve cherry quality after harvest delaying weight and acidity losses, softening and color changes in the cultivars Big Lory and Grace Star

CHIABRANDO* and G. GIACALONE, Ital. J. Food Sci., vol. 27 - 2015

Sucrose ester, fatty acid are used in commercial products for cherry coating (SEMPERFRESH™)
Conclusions

Sweet & sour cherries contain high levels of nutrient and non-nutrient compounds useful for human health

Technologies for preservation and processing should be improved to better maintain their quality attributes to approach the increasing of the global market value, the production and the harvested area

Valorization of market-second grade cherries is an important component to add-value to this currently under-utilised resource

Using new or emerging technologies with lower process impact on the fruit quality more research and development on cherry preservation and processing is needed
6th PEF School

6th School on Pulsed Electric Field Applications in Food and Biotechnology
University of Bologna (Campus of Food Science in Cesena)
3 – 7 June 2019, Cesena, Italy

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http://pefschool2019.electroporation.net/
Thank you for your attention

GRAZIE PER L’ATTENZIONE

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Vacuum Impregnation

Vacuum impregnation technology (VI) is a mass transfer operation between a liquid medium and a solid porous food. Pressure gradients created in the system with the capillary pressure in the pores entrance promote a significant gas and liquid transfer between the liquid and the solid. Based on the porous structure of some foods and the existence of gas occluded on it, explained the hydrodynamic mechanism, as the main phenomenon involved in the VI operation.

degasification of the porous structure depending on the applied pressure occurs, and on the other hand a penetration of liquid by capillarity when the equilibrium is reached.

Impregnation process applied on cherries was using a calcium rich solution. Authors showed that the process of VI with calcium treatment had no significant effect on the content of cell wall polysaccharides but VI with calcium treatment significantly affected the chain widths of the chelate-soluble pectins with more chains with higher width (120~160 nm) than those in the control group and calcium ions could enhance crosslinking between pectin molecules.