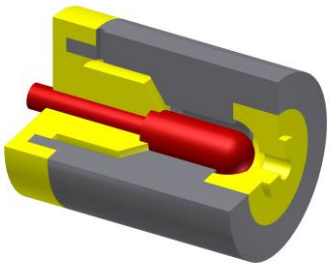
Sterilization & Extraction
by **Pulsed Electrical Fields (PEF)**:

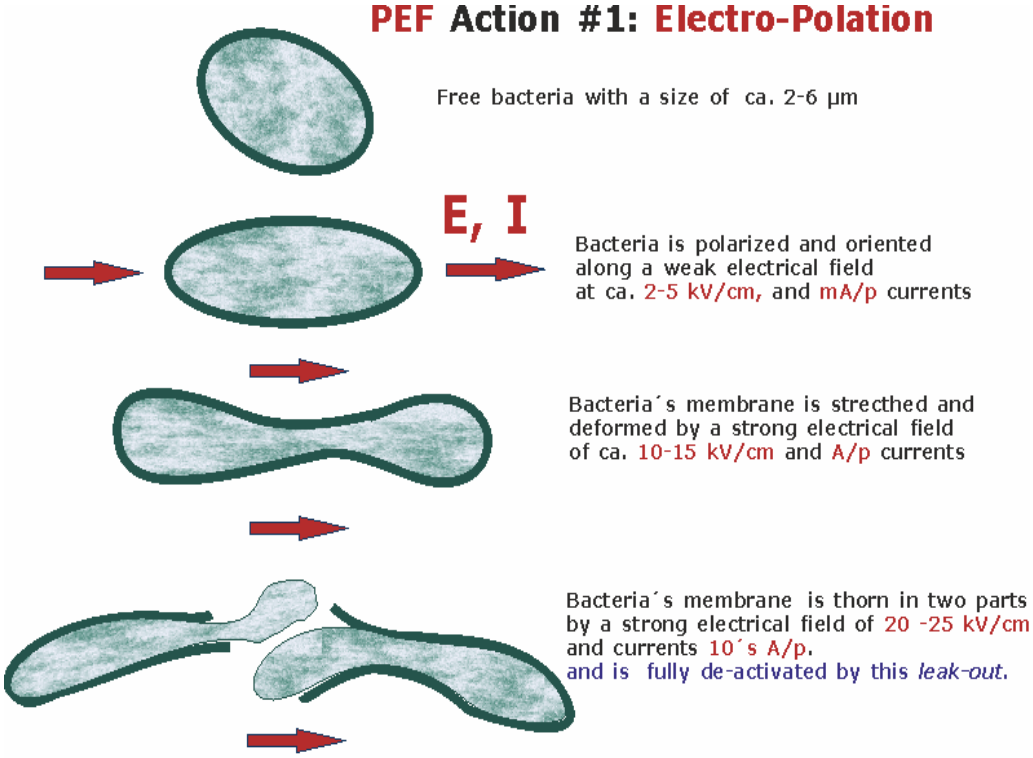
Sterilising Juices with One of Two Different Electrical Processes:

#1: by stretching <u>bacteria only</u> up to its ruptures by 20-40kV/cm electrical fields generated by short pulses in coaxial chambers with gaps between electrodes of 3 to 15mm:

HV electrode-red, insulator-yellow, ground electrode-black, juice flows from the left:



Pulsed parameters are found in evaluation tests for each treated media to *stretch* ALL bacteria to its disruption by so-called "electro-polation":

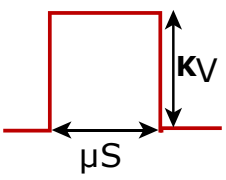


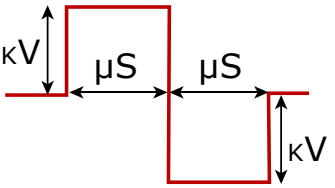
PEF action is not for a fully dielectric media - where no current flows through!

It requires electrical fields from 15 to 35kV/cm, pulse durations from ca. 2 to 20µs with sharp fronts and "tails" of just below 1µs (10^{-6} s) and repletion rates from ca. 25Hz to ca. 500Hz.

PEF pulsing can be one and bi-polar:

Pulsing can be one-polar or bi-polar where the reverse pulse follows the direct pulse immediately or with a few µs delay:





Advantages and drawbacks of bi-polar pulsing vs. one-polar pulsing:

Stretching bacteria in one direction can be immediately followed by its stretching in the opposite direction by a pulse with the same parameters but of the opposite polarity. This causes an additional mechanical stress - a wearing by an alternating load as for metal parts.

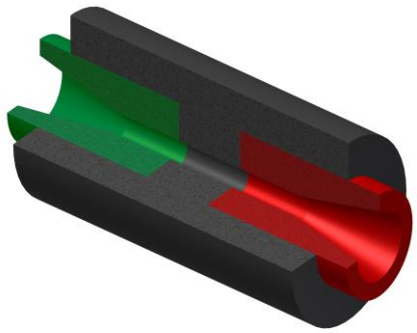
Three drawbacks of bi-polar:
#1: It requires up to twice as much electrical energy,
#2: a free floating in juice bacteria can start turning around in this opposite field direction to stretched as before.
#3: it increases costs of the HV block by 3 three times as much die to its more complexity.

Both types of this #1 PEF process are not for a fully conductive media, neither for a fully insulated media (like in a liquid enclosed in a plastic bag). A small current has to flow through a treated media to allow PEF to work. This process, in its best performance, should not heat the treated media more than a few °C. The required energy deposition here is **ca. 5-10kJ/l-**

The dis-advantage of the PEF with electro-polation as above is its inability to deactivate spores and fungi!

PEF process #2 *with volume discharges* does it!

It employs sharp and short high power electrical pulses *to form volume discharges* in rather small PEF co-liner chambers as below. Free energetic electrons of these discharges collide with both bacteria and spores till its full deactivation.



Red- HV electrode, green-ground, black-insulator. Electrodes often electrostatically focus el. fields by its shape (as above) to increase power density in volume discharges.

This process requires the energy deposition in a treated juice from ca. 50-100kJ/l (50-100J/cm³ or 12-24 kal/cm²) which leads to the juice heating of about 20 to 30°C.

Yet this process can go only if the juice conductivity is around 5mS to 8mS whereas a conductivity for a cold juice often does not exceed ca. 1mS.

Increasing juices conductivity mostly is done by a controlled preheating of juices to up ca. 40°C, so the overall juice temperature after such PEF processing is yet below 70C – the pasteurization border.

Then juices are cooled down. So formally it is a cold processing.

wek-tec offers both above PEF methods with our new PEF pilot system >.

The PEF sterilization method is well known since over 120 years made with sin-wave electrical fields, it mostly heated treated media. It was mostly used for small scale processes because:

- it depends on a treated media,
- *some electrode erosion in large systems,*
- former high costs of HV sub-systems and components for required square pulses.

PEF sterilization /extraction is getting far more acceptance due to restrictions of gamma, heat and other invasive sterilization techniques, which create harmful by-products and considerably degrade nutrients in treated foods.

COLD PEF EXTRACTION

of Juices and colors in brief:

A cold pressing does not allow a rupture of all plant cells to obtain a high extraction yield. The application of PEF pre-treatment before pressing significantly increases the extraction yield and increases its quality.

PEF can be also used for the recovery of specific substances (proteins, vitamins, antioxidants) from targeted cells without the use of chemical or thermal treatments known to degrade such substances.

PEF is used to enhance a cold extraction of up to 80% for juices, proteins, nutrients, vitamins and natural colors *from* -- *roots,* -- fruits, -- *vegetables,* -- grass and leaves, -- *protein rich original products.*

PEF extraction keeps original properties of nutrients unchanged plus can simultaneously sterilize it.

Prior to the PEF processing natural products have to be converted to a mash unless. This is to assure a uniform flow through a PEF treatment chamber, where having air bubbles or large solid pieces can lead to local electrical breakdowns.

Step-by-step PEF extraction: - electrical fields polarize and stretch bacteria cells up to a break-up of its membranes. (bacteria get from 3V to 5V across its length (ca. 1-3 µm), sufficient for this process). - - resulting rapture of cell walls releases a liquid content of cells. PEF fields of 5 to 10 kV/cm are sufficient for the extraction.

Advantages and limitations of PEF extraction are just the same as for PEF sterilization and are listed above.

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