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Advanced food technological solutions

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Food processing hand in hand with development of human civilization

Cooking



Sun drying



Baking



Fermentation





First "advanced" preservation method (1810s)



1. Appert canning jar (left: Wikimedia, 2014) and first book on modern food preservation (right: DeGruyter, 2009)

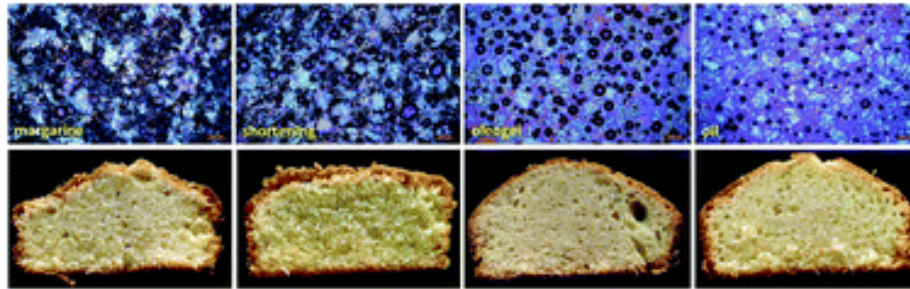


Food safe, stable, palatable and nutritious over storage





Next levels



From left to right: Microstructure of batter and corresponding pictures of cake prepared using margarine, shortening, oleogel and oil as fat phase.



Food microstructure



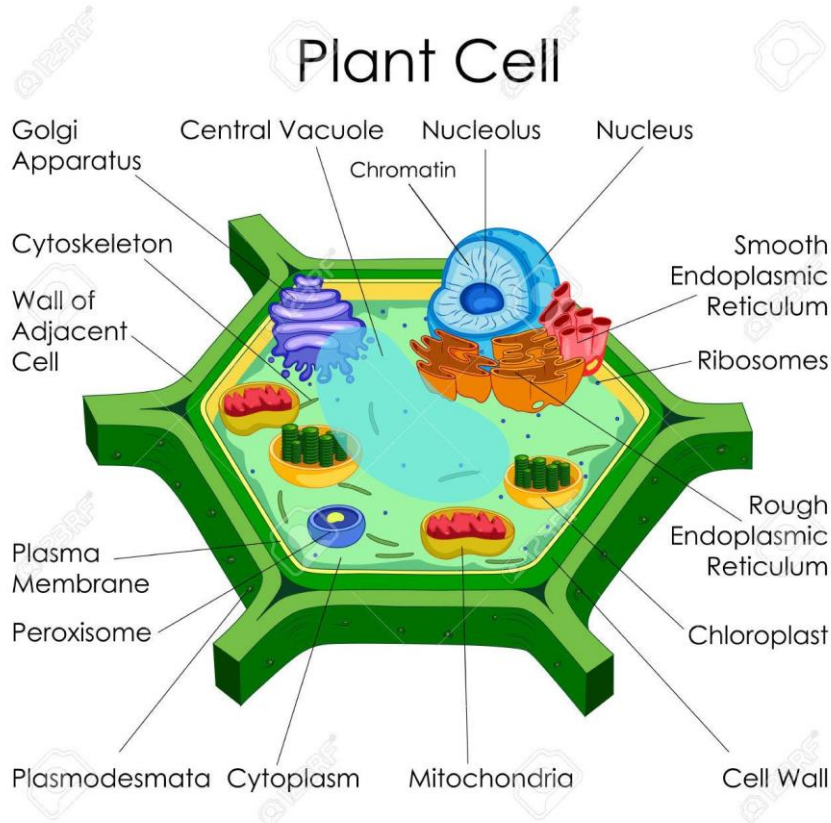
Interdisciplinary research



Extensive knowledge on what is happening to the food and in the food during processing



Processing of fruit and vegetables

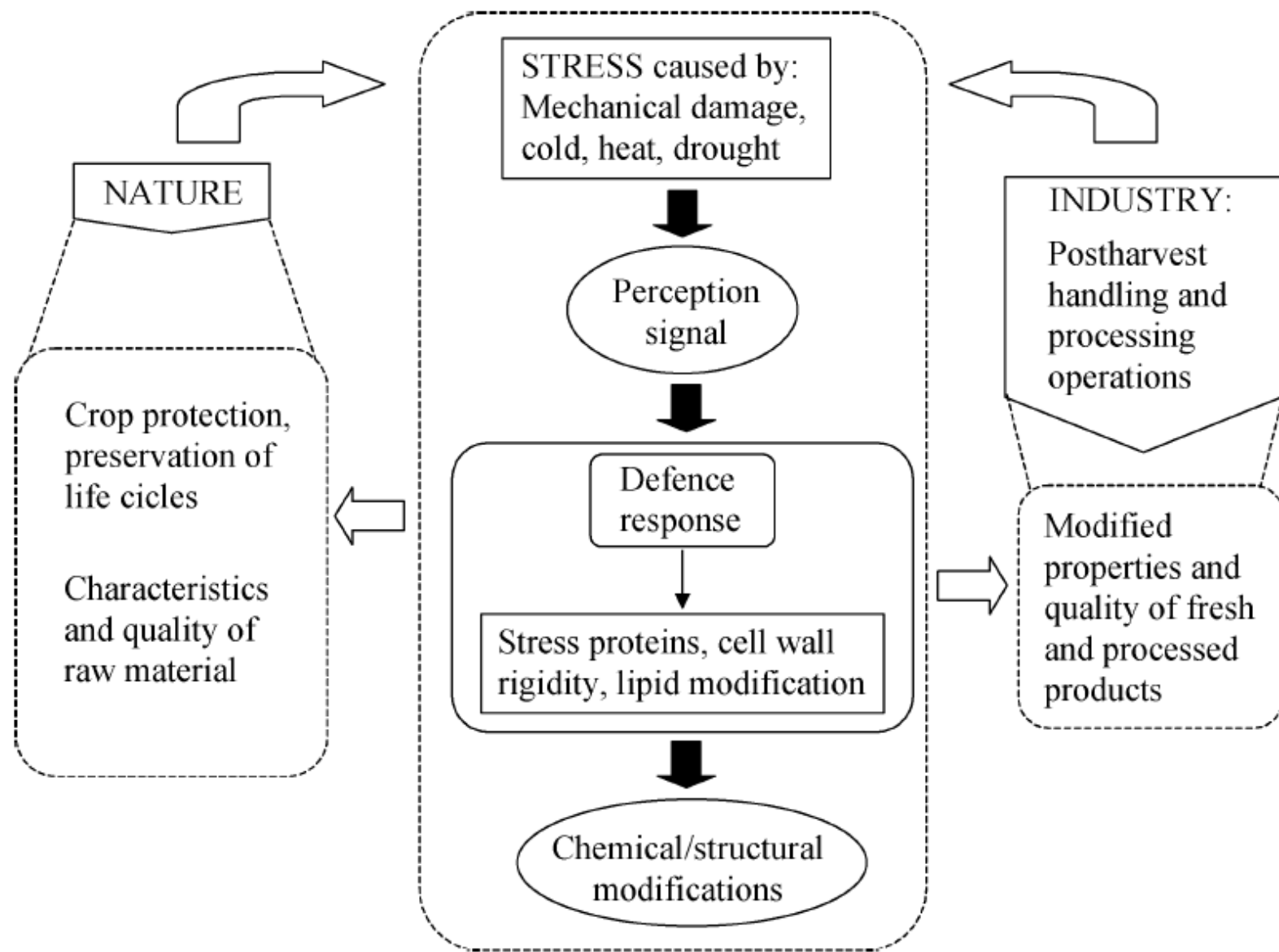


My work:

“physiological/metabolic”
food engineering



To develop novel
technological solutions





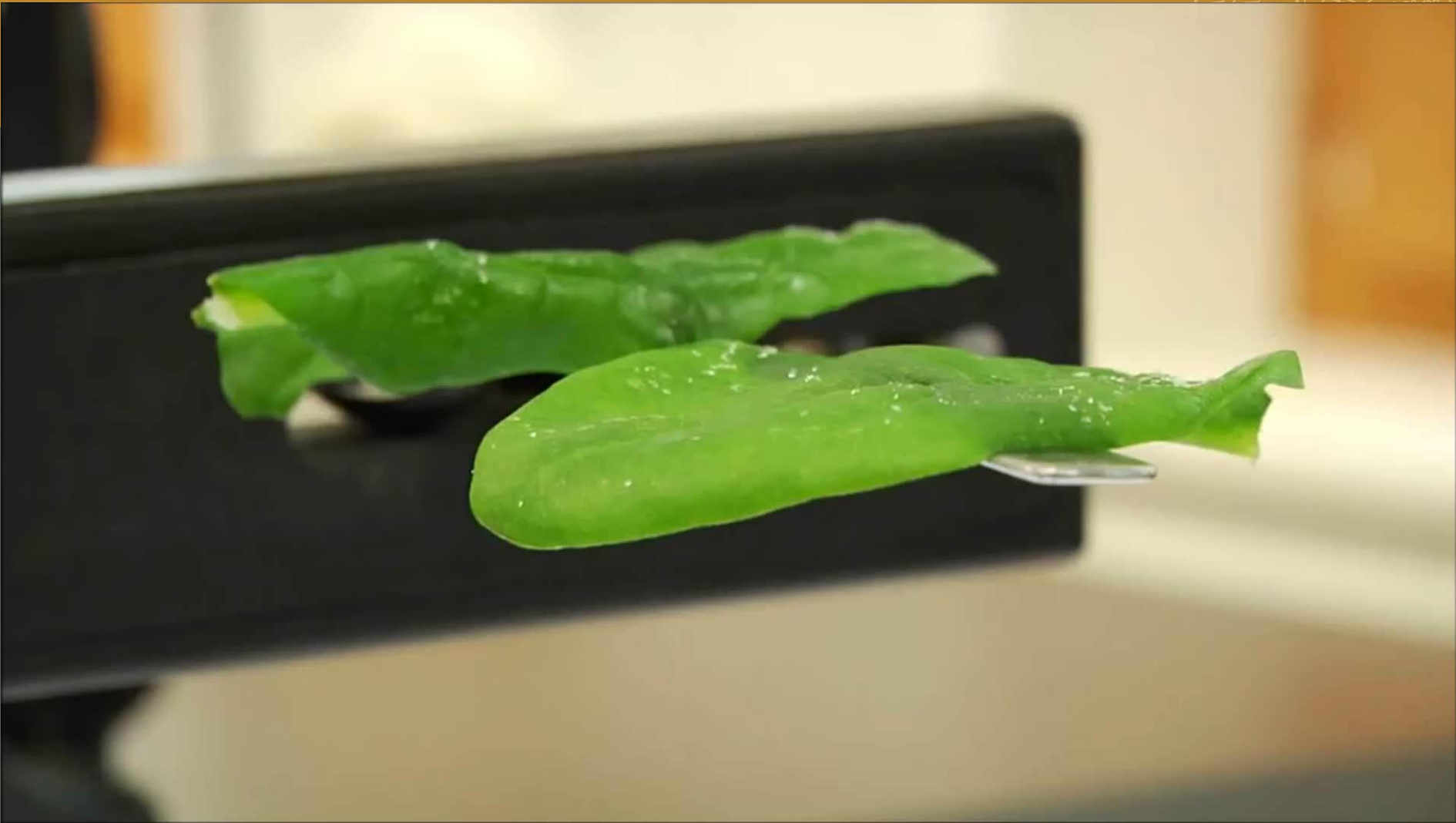
Most of the literature deals with postharvest handling and minimal processing:

- Responses to mechanical stress/injury (wounding stress)
- Low temperature stress/chilling injury
- Heat stress/heat shock

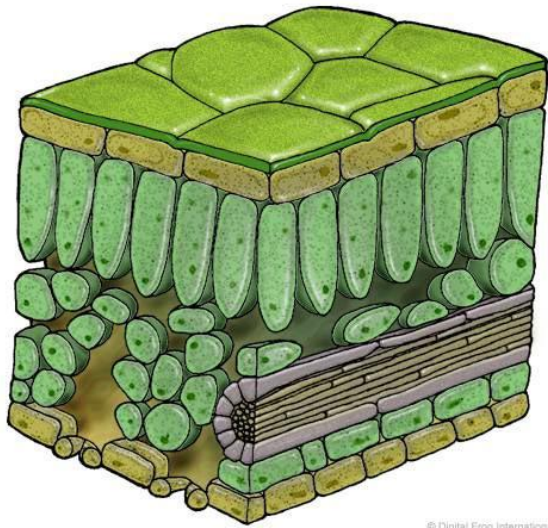


How about inducing stress to improve the quality of processed vegetables?





Vacuum impregnation of cryoprotectant



© Digital Frog International

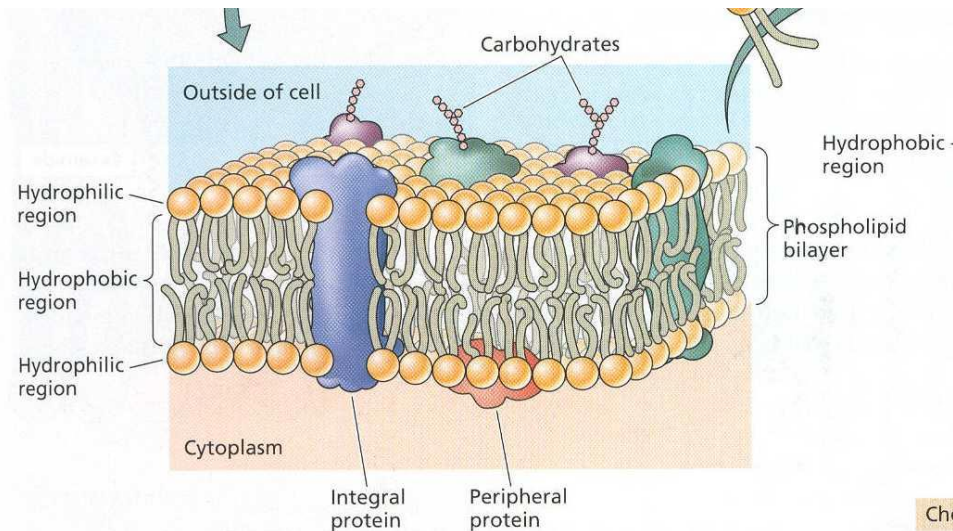


Impregnated substances will be transported into the cells and influence their metabolism.



Pulsed electric fields (PEF)

Apply electricity (voltages from 300 – 2000 V) to a biological system



Plant/animal cells/tissues

Microorganisms

Times ranging in
milliseconds/microseconds or
even nanoseconds



Low intensity PEF

Irreversible/Reversible

- Strength of electric field
- Duration of pulse electric field
- Number of pulses



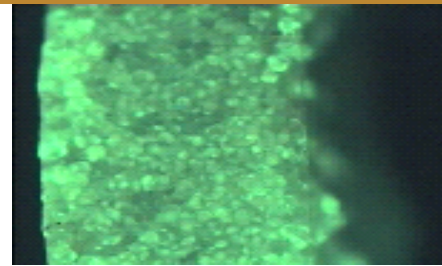
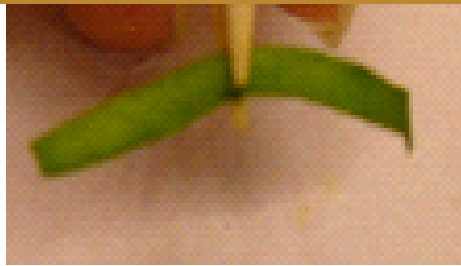
Cells survives
PEF



Stress

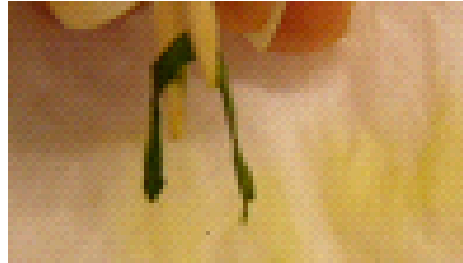


(a)



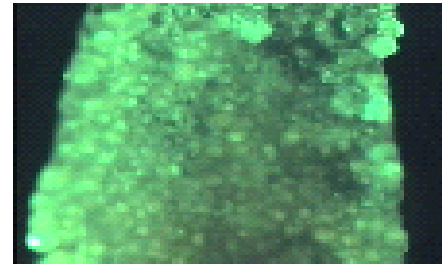
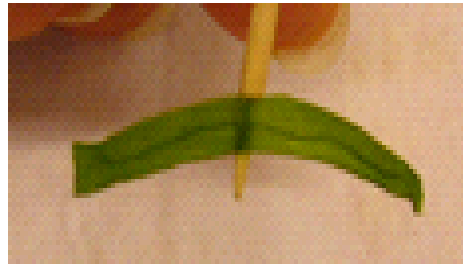
fresh

(b)



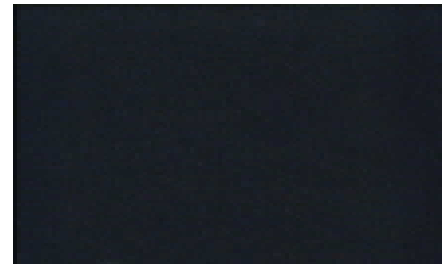
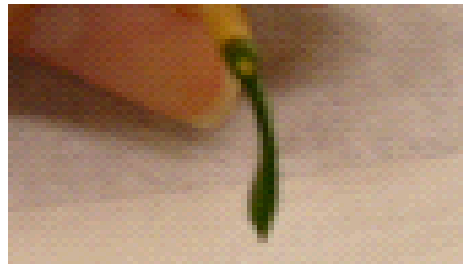
control

(c)



PEF + VI

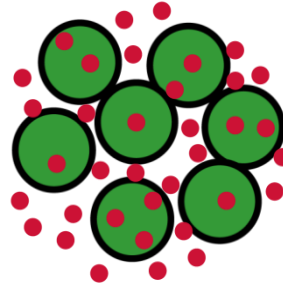
(d)



Only
VI



Role of PEF



- Gets the cryoprotectant in the cells, helping its distribution between the intra and extracellular space
- PEF effect is only due to stress
- PEF effect is both ways: transport and stress



Exploration of stress responses to PEF Gross metabolic effects



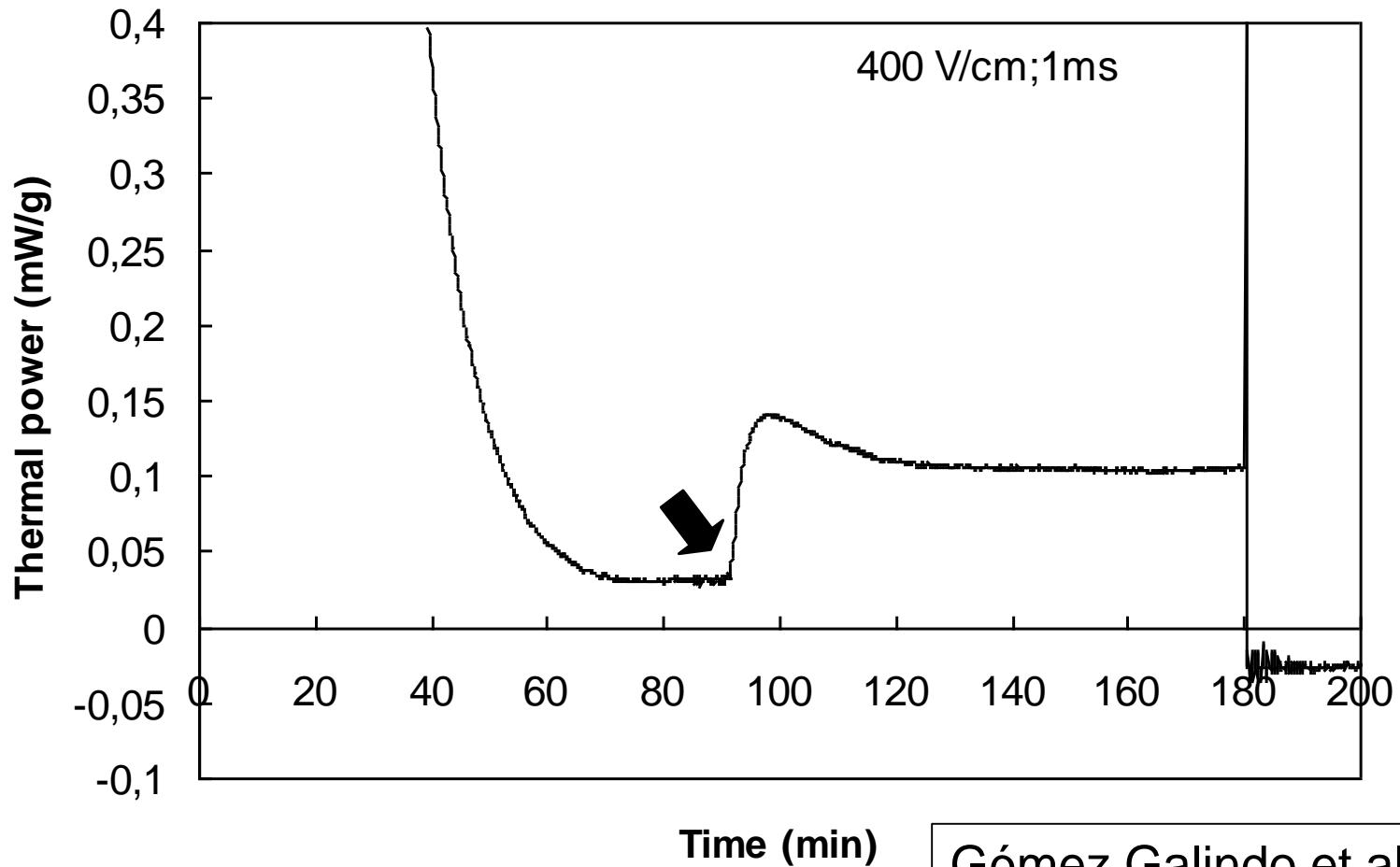
Isothermal calorimetry measures the rate of metabolic heat produced by the sample (thermal power, mW/g) at constant temperature

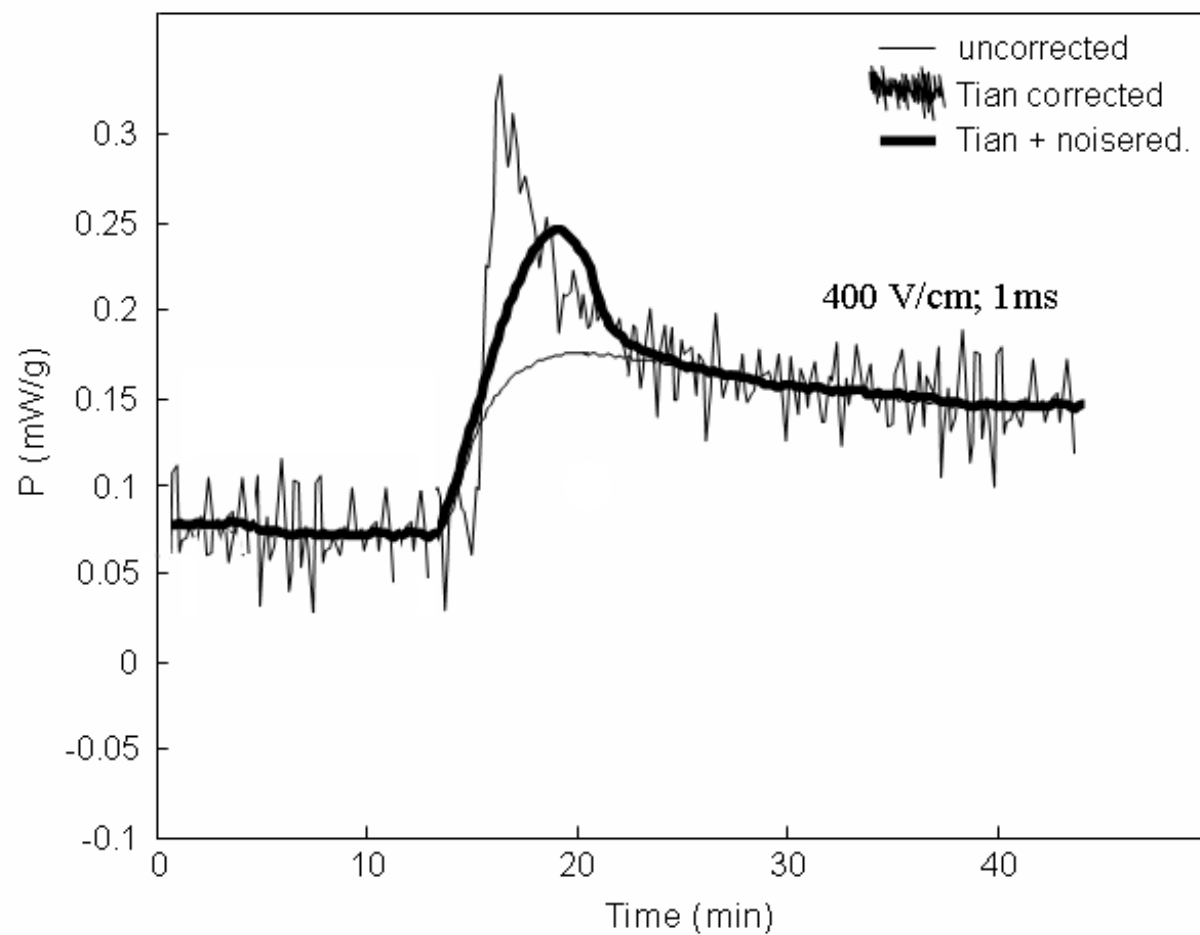
Thermal power is a direct measurement of the total metabolic heat that includes respiration and stress (overall metabolic responses)

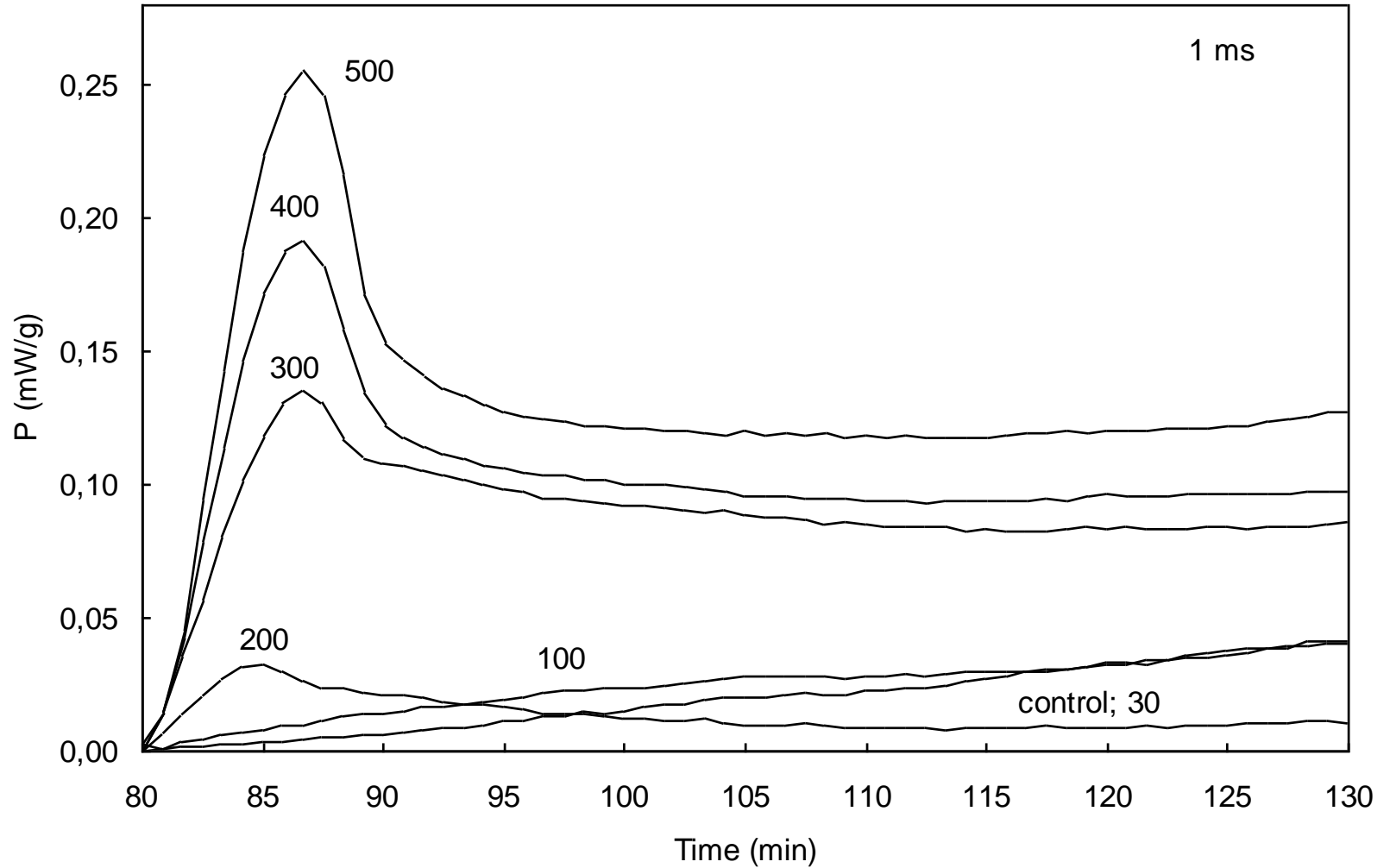
Wadsö and Gómez Galindo, 2009

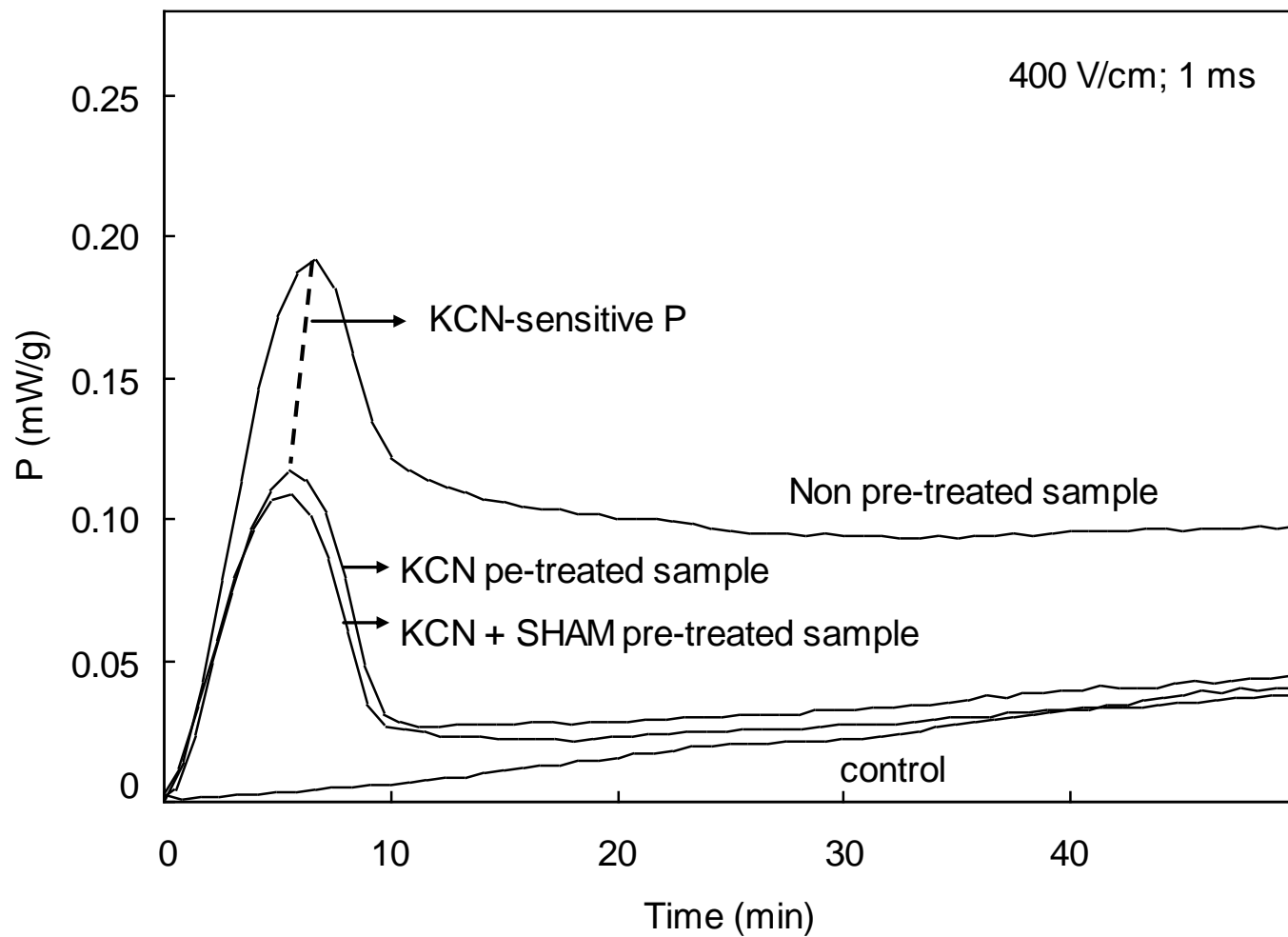


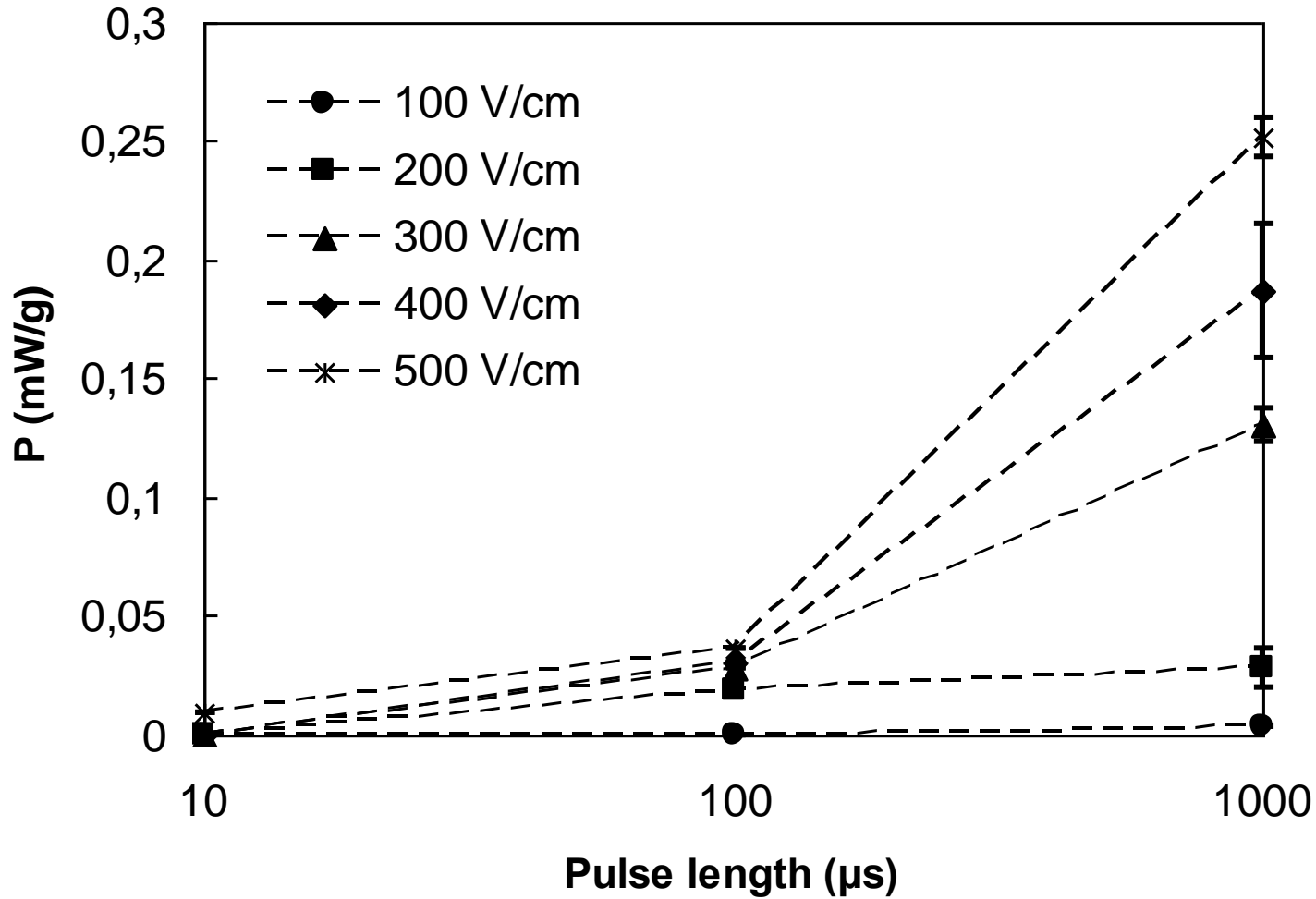
Investigation on PEF-induced stress













Field width : 1 ms

Field strength V/cm	P_{\max} (mW/g)	% KCN-sensitive P_{\max}	% KCN-insensitive P_{\max}
200	0.032 ± 0.008	51.8 ± 8.4	48.2 ± 8.4
300	0.135 ± 0.007	56.0 ± 6.6	44.0 ± 6.6
400	0.191 ± 0.028	43.4 ± 3.4	61.3 ± 3.4
500	0.256 ± 0.008	32.8 ± 7.3	67.2 ± 7.3

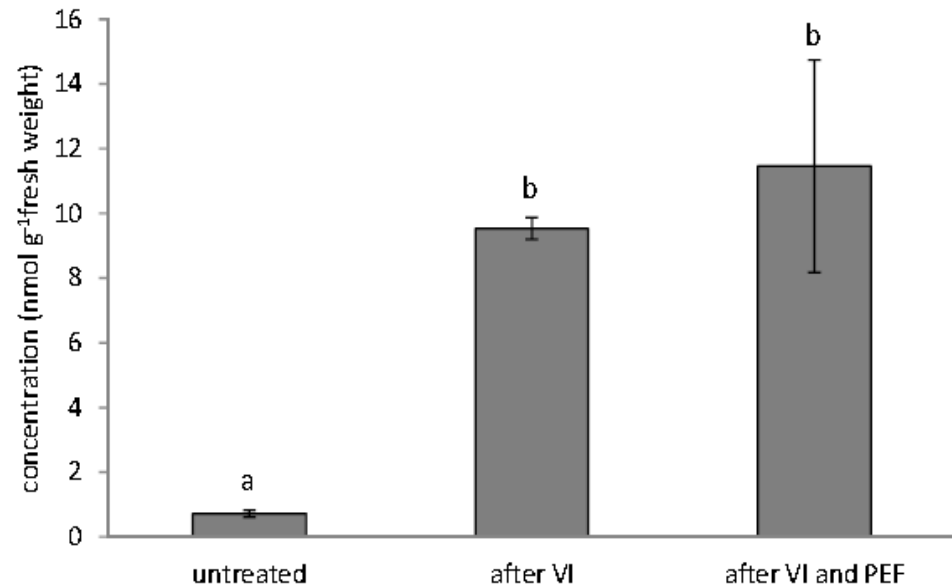
Field width : 100 μ s

Field strength V/cm	P_{\max} (mW/g)	% KCN-sensitive P_{\max}	% KCN-insensitive P_{\max}
200	0.023 ± 0.008	100.0 ± 0.0	0.0 ± 0.0
300	0.032 ± 0.004	76.8 ± 12.2	23.2 ± 12.2
400	0.035 ± 0.025	48.6 ± 8.2	51.4 ± 8.2
500	0.040 ± 0.008	55.0 ± 8.6	45.0 ± 8.6

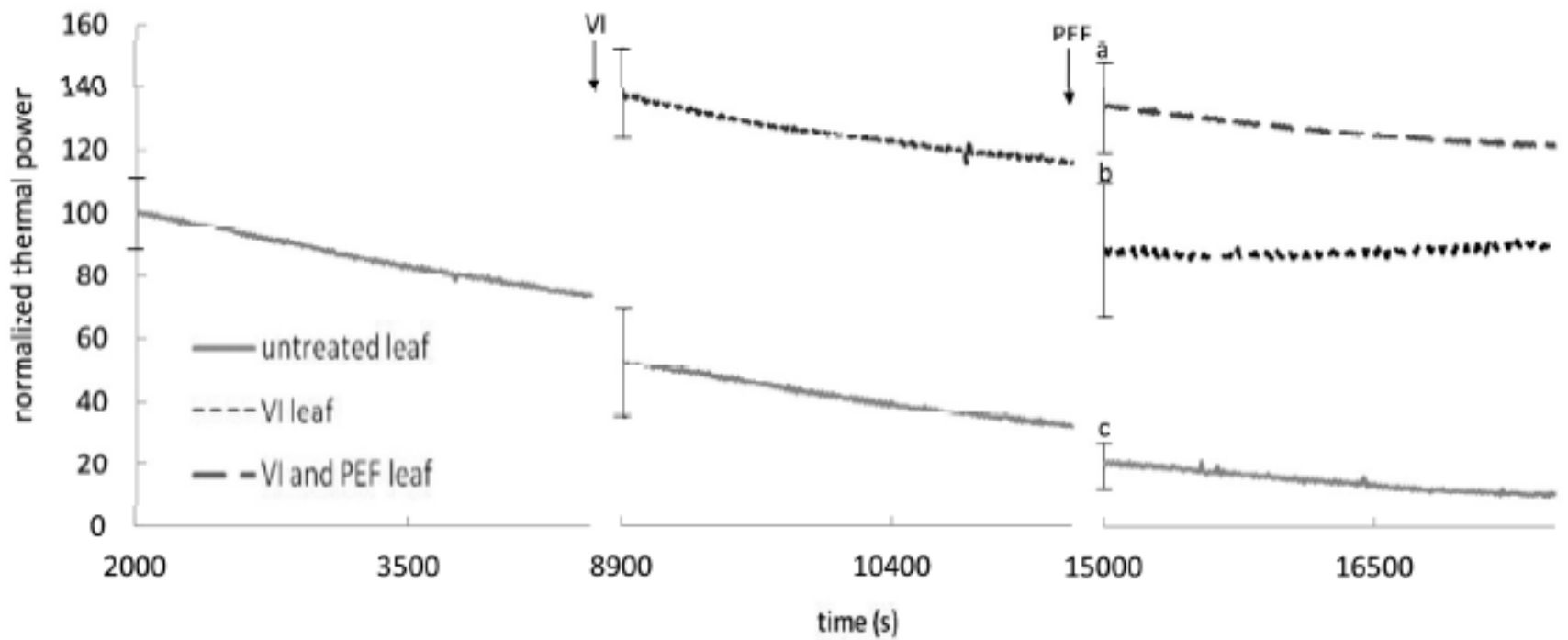


Impregnated substances get inside the cells by transporters and/or endocytosis

T6P concentration after trehalose impregnation



Dymek et al., 2016





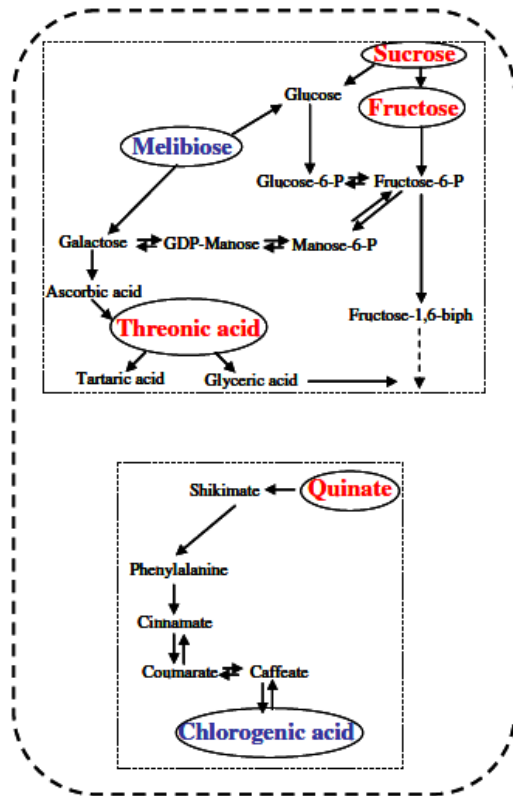
Greenhouse-grown spinach



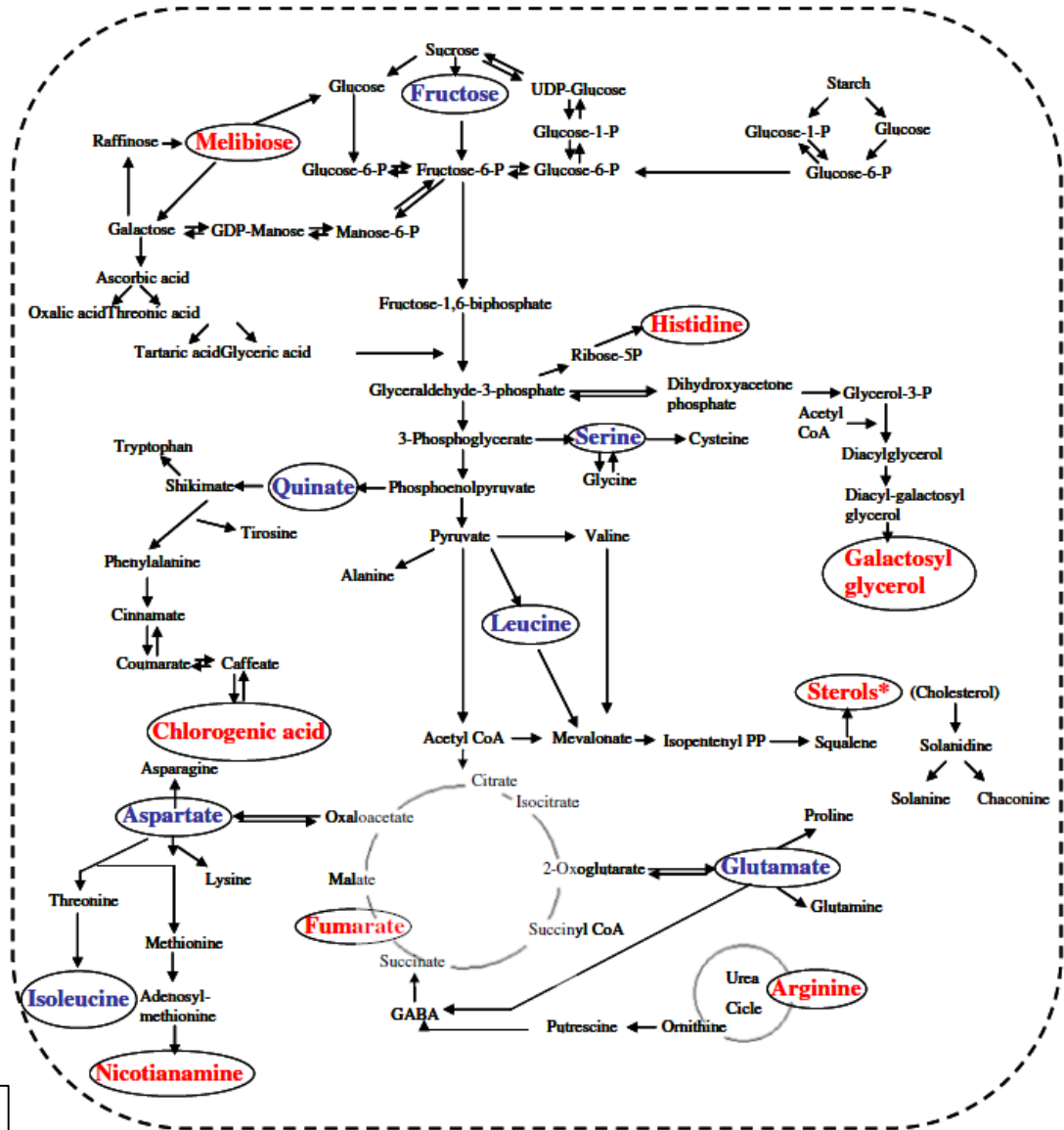
When cultivation temperature changed from 20 °C to 5 °C for 3 days, freezing survival of harvested leaves improved.

Possible cold acclimation process

PEF-specific effects



Wounding-specific effects



Actively metabolizing carbon energy sources



- Consequences of oxidative stress (tissue produces ROS upon PEF)
- More “omics” research
- PEF for dehydration

Slower physiological deterioration



15 days of storage at 4 C, packed in polypropylene bags



PEF-treated



Control

