Key Technologies & New Developments in Processing High Quality Fruit Juice & Concentrate

International Symposium,

"Novel Technologies in Food Processing & Byproduct Untilization"

Ronald E Wrolstad

Oregon State University

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Goals of Fruit Juice Processors

- Superior color and flavor attributes
- Optimal nutritional quality
- Free of pathogens & toxicants
- Maximize yield

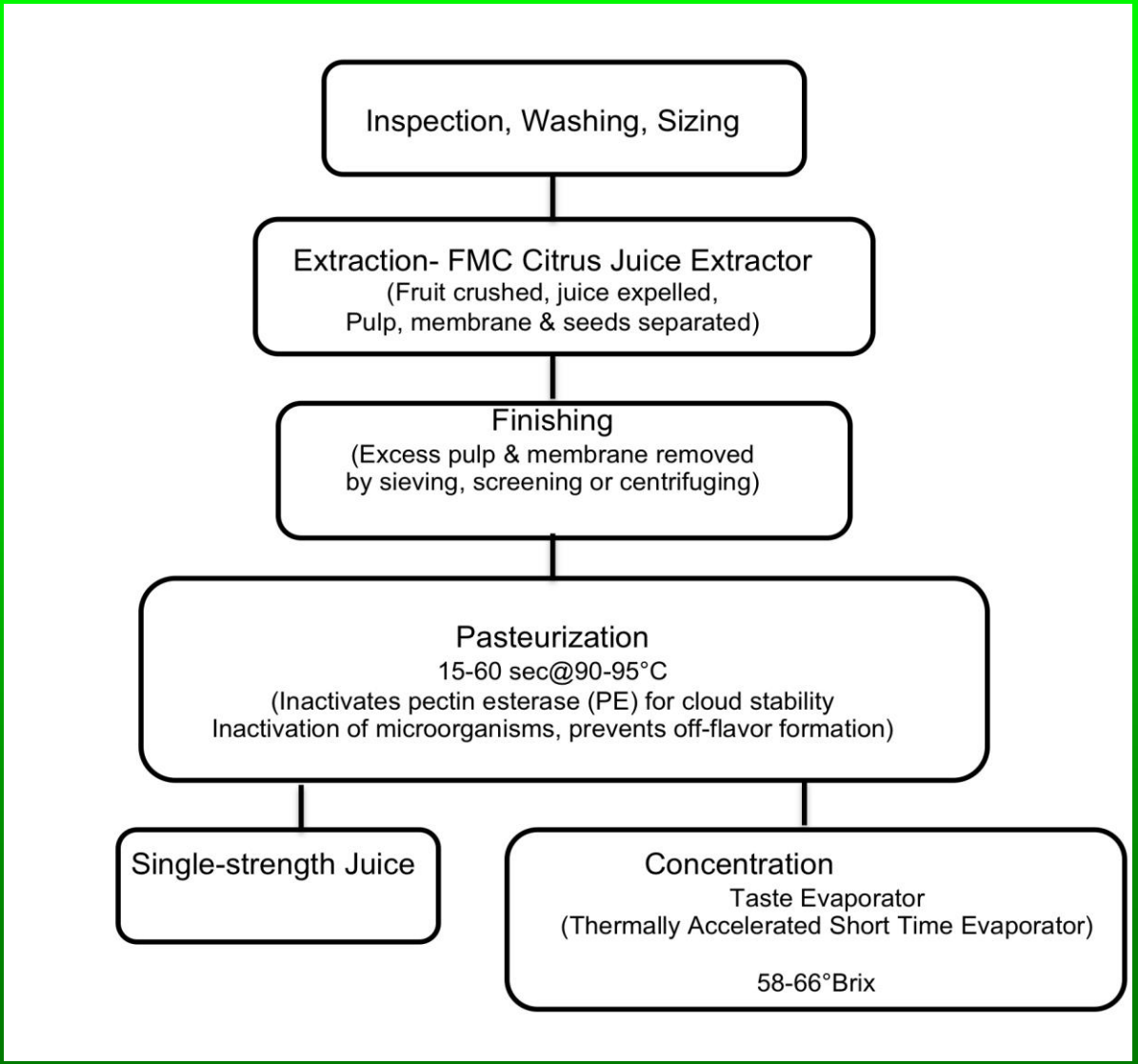
Application of New Technologies

- High-Pressure Processing
- Pulsed Electric Field Processing
- Ohmic Heating

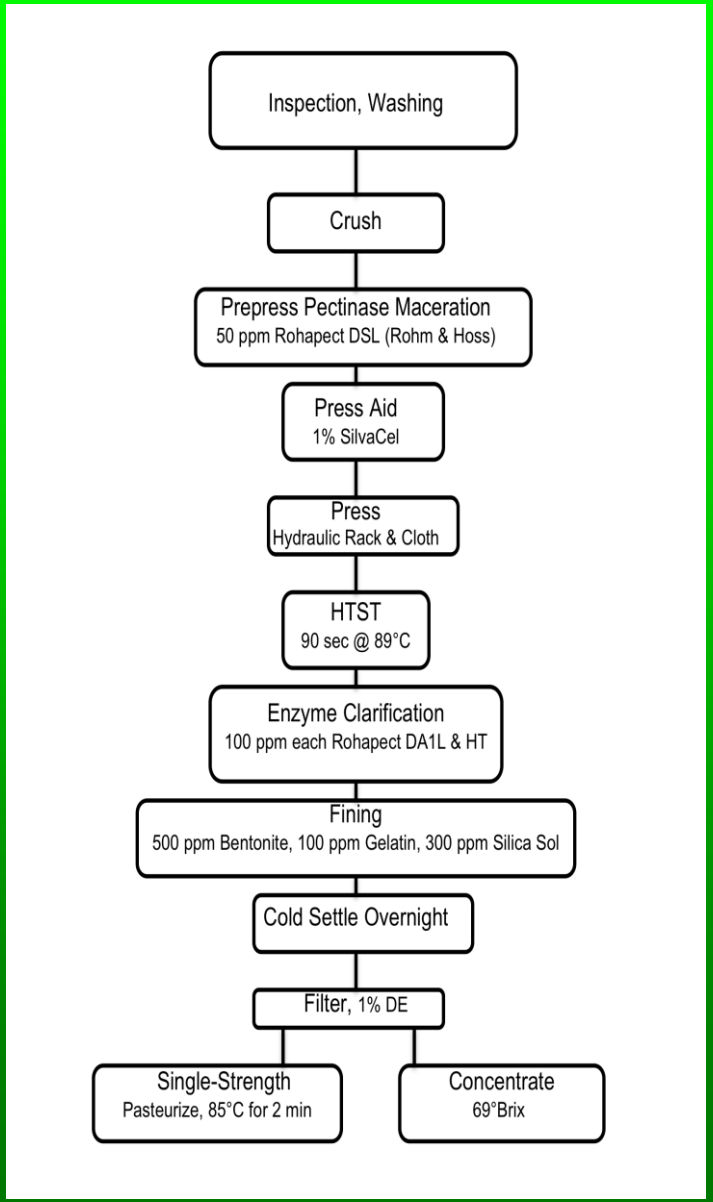
Effectiveness of new technologies—

- Commodity dependent
- “Apples are different from oranges”…

Orange Juice Unit Operations



Apple Juice Unit Operations



Spanos, Heatherbell & Wrolstad. 1990
J Agr Food Chem 38:1572-1579.

High-Pressure Processing of Fruit Juice

High-Pressure Processing Conditions

Pressure— 58,000 to 130,000 psi (400 - 900 MPa)

Temperature— -20 to 80 ° C (typically 20 to 40 ° C)

Time— 1 to 10 minutes

HPP Effects on Enzymes & Microorganisms

- Enzymes *inactivated* with pressures >400 Mpa
- Some enzymes show *enhanced activity* after pressurization <400 Mpa
- Effective for inactivation of vegetative cells
- Spores very resistant to pressure

Commercialization

Fresh orange juice, refrigerated

Deactivation of pectin methyl esterase ensures cloud stability

Reduction of microbial load (yeasts, lactic bacteria)

Producer: Ulti, Pernod-Ricard, France, www.pernod-ricard.com, market introduction, 1995

Sensory Difference Test Results
Fresh vs. HPP

Apple juice – no significant difference

Orange Juice – no significant difference

Apple Juice Results

Batches	Correct	Incorrect	Critical Value
B1, n=101	32	69	38
B2, n=101	34	67	38
B3, n=101	30	71	38

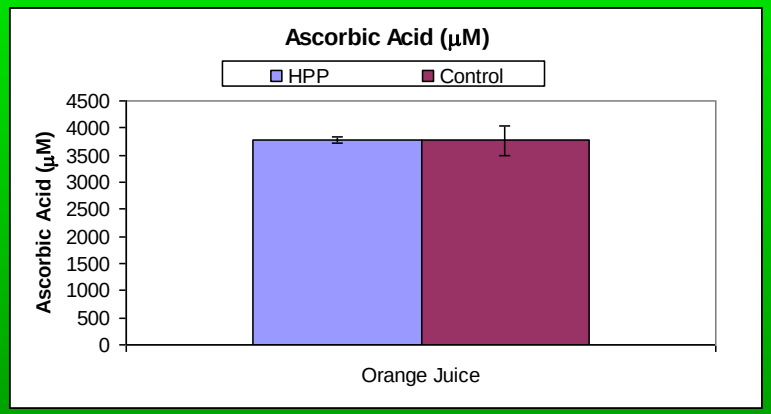
Orange Juice Results

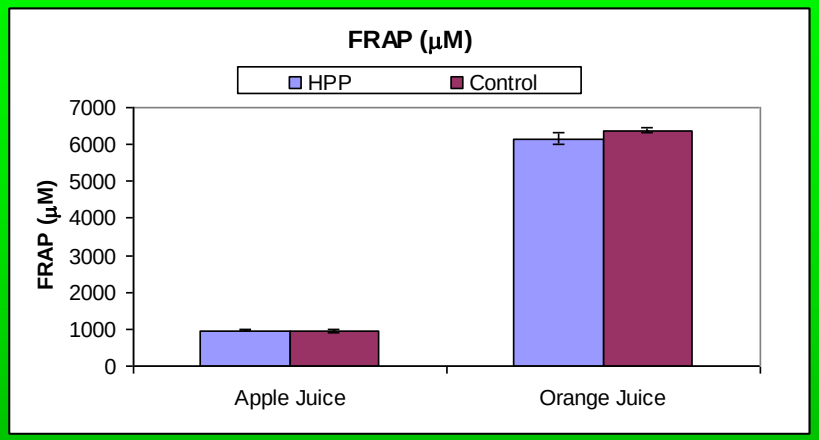
Batches	Correct	Incorrect	Critical Value
B1, n=74	26	48	29
B2, n=74	27	46	29
B3, n=73	24	49	29

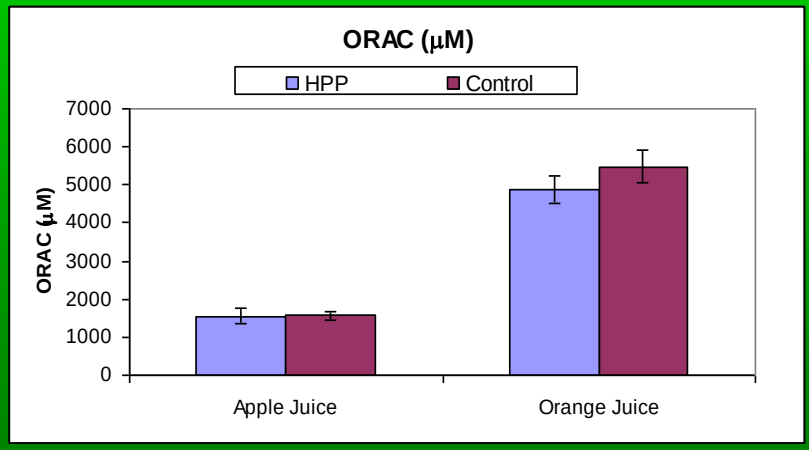
Courtesy Avure Technologies &
Tom Shellhammer Laboratory, OSU

Antioxidant levels– HPP Fresh Juice

Fresh vs. HPP







No significant difference, $p > 0.05$, $n = 3$

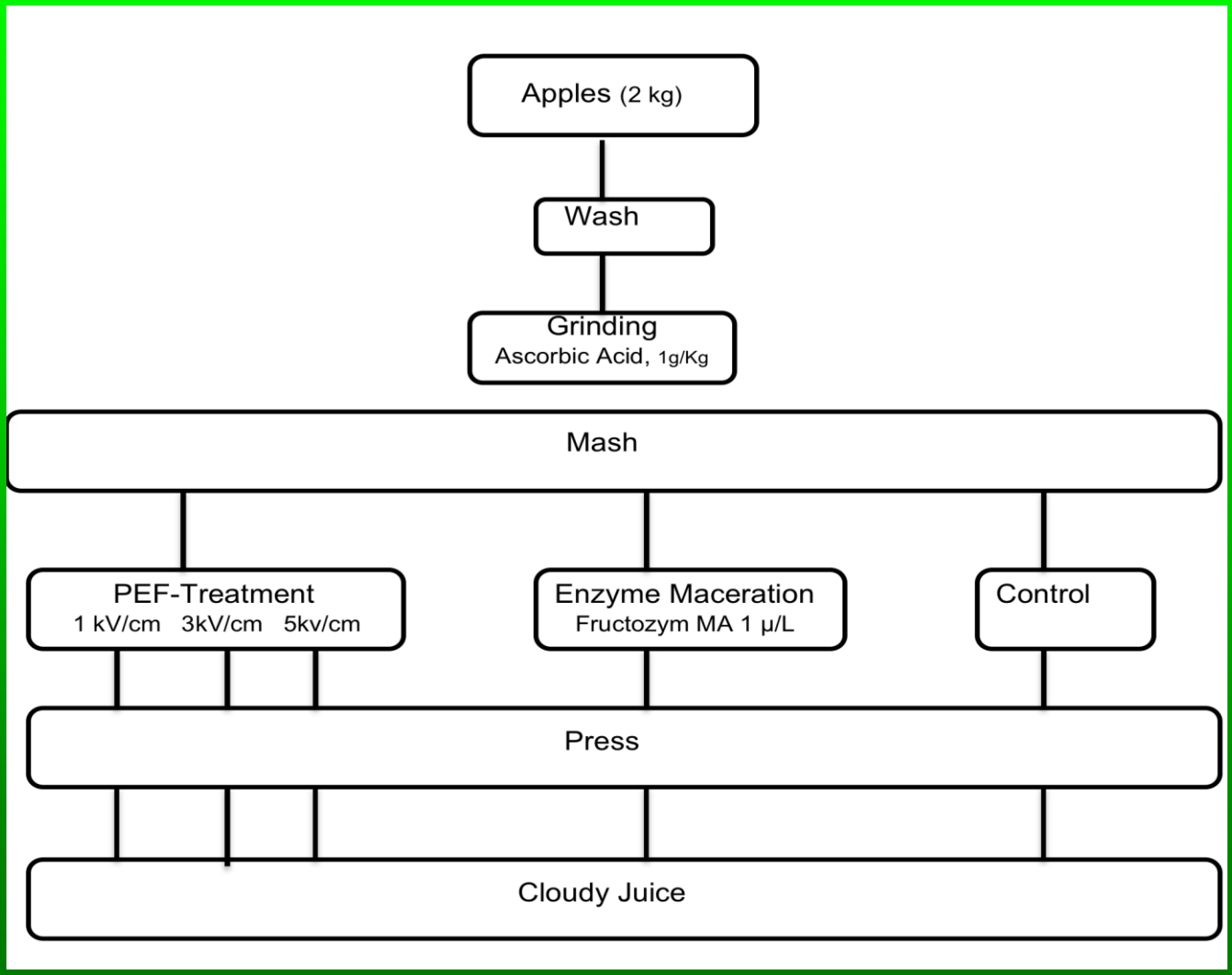
Courtesy Avure Technologies,
Tom Shellhammer Laboratory, OSU

Pulsed Electric Field (PEF) Processing

- Non-thermal method of food preservation using short bursts of electricity for microbial inactivaton with minimum (20-80 kV)effect on food quality attributes.
- Pulse time = 1-10 μsec, # pulses = 2-50; temp = ambient
- PEF breaks cell membranes & expands pores (electroporation)
- Restricted to food products with no air bubbles & low electrical conductivity
- Fruit juices very suitable for PEF processing, typically pasteurization as opposed to sterilization

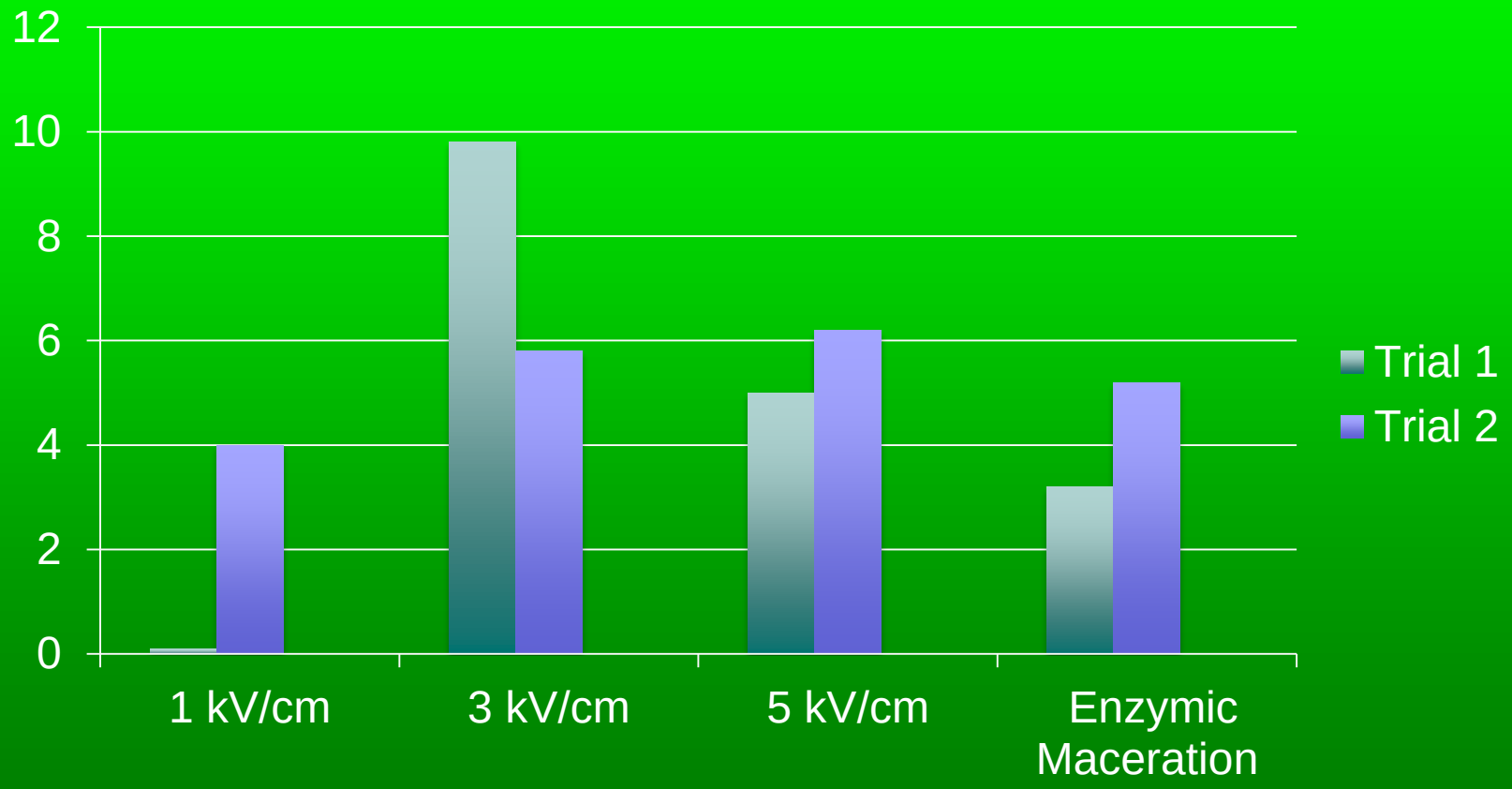
Effects of PEF on yield & quality attributes of apple juice

Schilling et al. 2007. Innov Food Sci Emerg Technol 8:127-134.



% Δ Juice Yield Compared to Control

Schilling et al., 2007



Effects of PEF on Composition & Quality

Schilling et al., 2007

- Polyphenolic profile— no significant difference
- Antioxidant capacities (TEAC FRAP, DPPH)— no significant difference
- Composition (pH, ° Brix, TA, sugar profile, malic acid, pectin)— no significant difference

Products with low electrical conductivity, low viscosity & high density are the easiest and most energy efficient for PEF processing…

	Electrical Conductivity @ 22° C	Viscosity @ 22° C	Density @ 22° C
Apple Juice	0.239	0.001372	1055
Cranberry Juice	0.090	0.001475	1058
Grape Juice	0.083	0.001350	1052
Orange Juice	0.360	0.003407	1054

Ruhlman, Jin & Zhang in *Pulsed Electric Fields in Food Processing* (Barbosa-Cánovas & Zhang, Editors)

Enhanced anthocyanin extraction from red cabbage with PEF processing…

Gachova et al. 2010. J Food Sci 75:E23-E29.

- Fruit & vegetable juices are approved food colorants exempt from certification in the USA
- Natural colorants & nutraceuticals have high economic value
- PEF extraction increased total anthocyanins by 142-379% compared to control.

Some Additional Extraction Technologies

Ohmic heating-assisted extraction

Supercritical extraction with $CO_{2/}$

Pressurized liquid extraction

Microwave-assisted extraction

Ultrasound-assisted extraction

Continuous counter-current extraction

Solid-phase extraction

Micro-extraction

Ohmic Heating… (Joule heating, Resistance heating)

- Rapid, uniform heating induced by passing electrical current through food, which serves as an electrical resistor.
- Suitable for liquids containing up to 1 inch particle size.
- Microorganisms inactivated by heat.
- Electroporation effect on cell membranes.

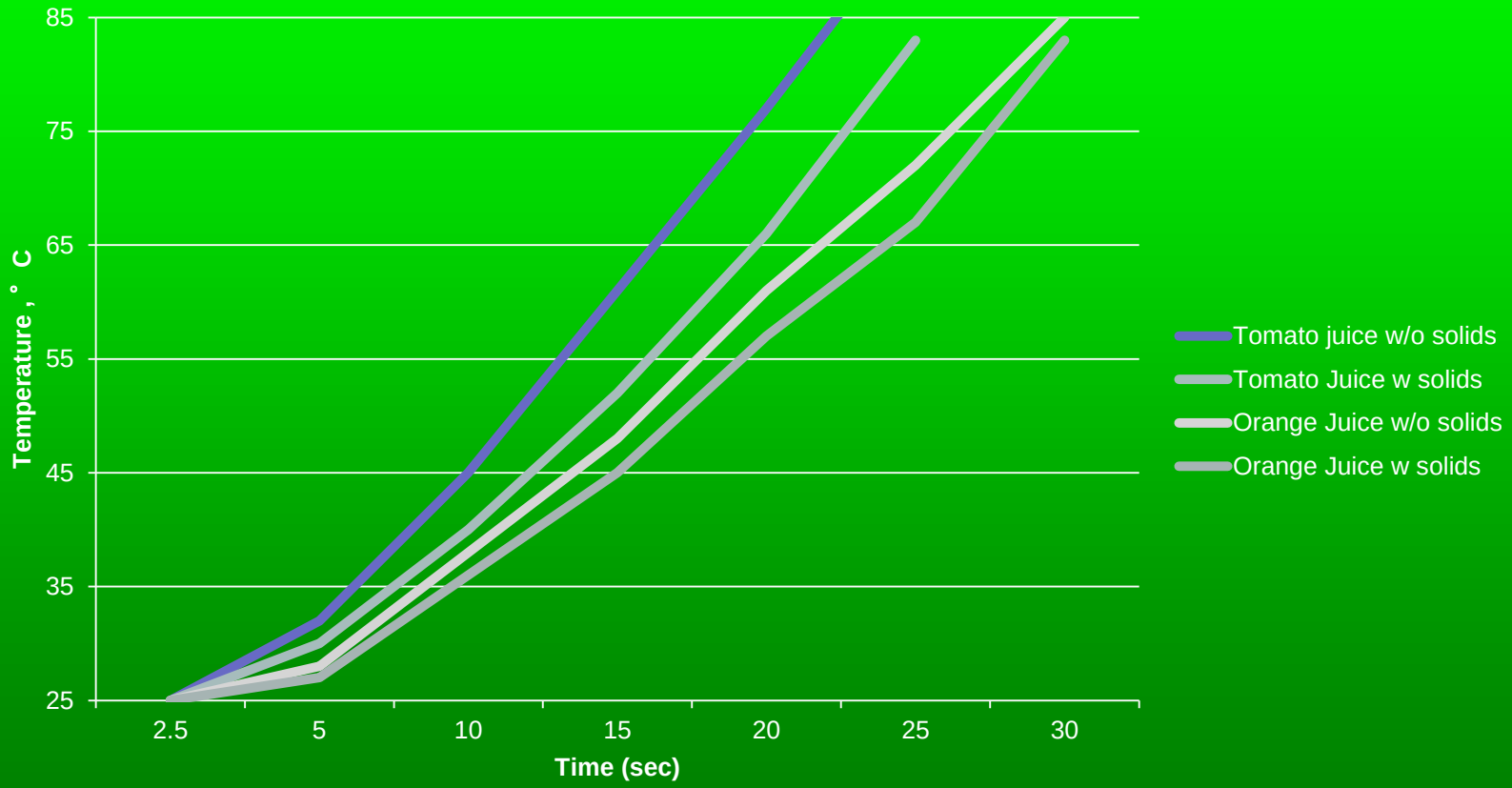
Fruit juice unit operations using heat…

- Blanching (enzyme inactivation)
- Pre-press enzymic maceration
- Pasteurization
- Concentration

Ohmic Heating Curves for Tomato & Orange Juices

Tomato— Greater electrical conductivity than orange

Presence of 17% solids decrease electrical conductivity



Palaniappan & Sastry. 1991. J Food Process Eng 14:247-260.

Impact of Heating on Apple Juice Yield

Treatments	Temperature, ° C	Juice Yield (ml/Kg apple)
Control (raw)	Ambient	596[a]
Ohmic Heating	40	636[b]
	50	653[c]
Microwave Heating	40	639[b]
	50	618[d]

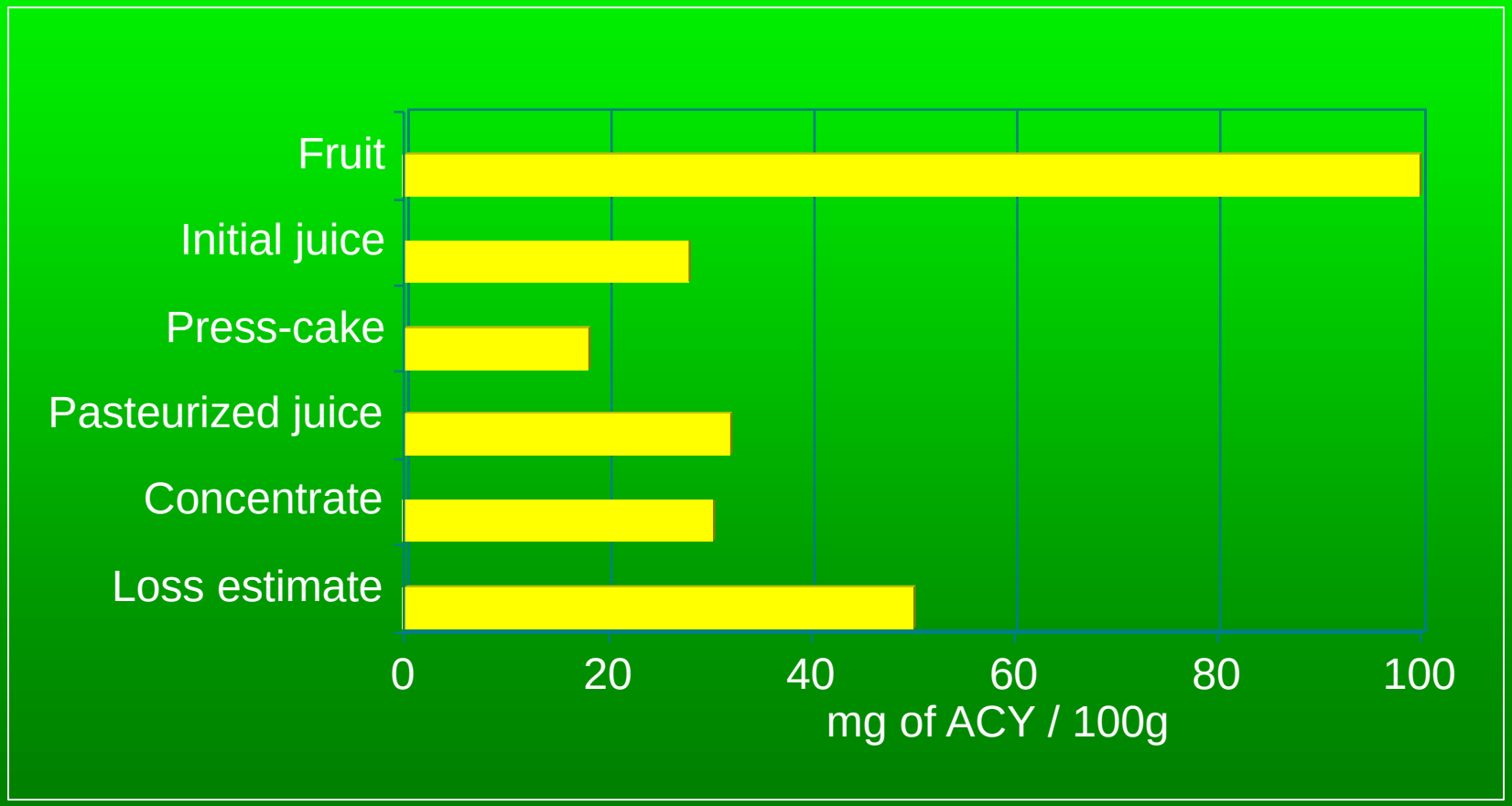
Wang & Sastry. 2002. Innov Food Sci & Emerg Technol 3: 371-377.

Commercialization Status

1st Commercial Food Product On Market In 2005

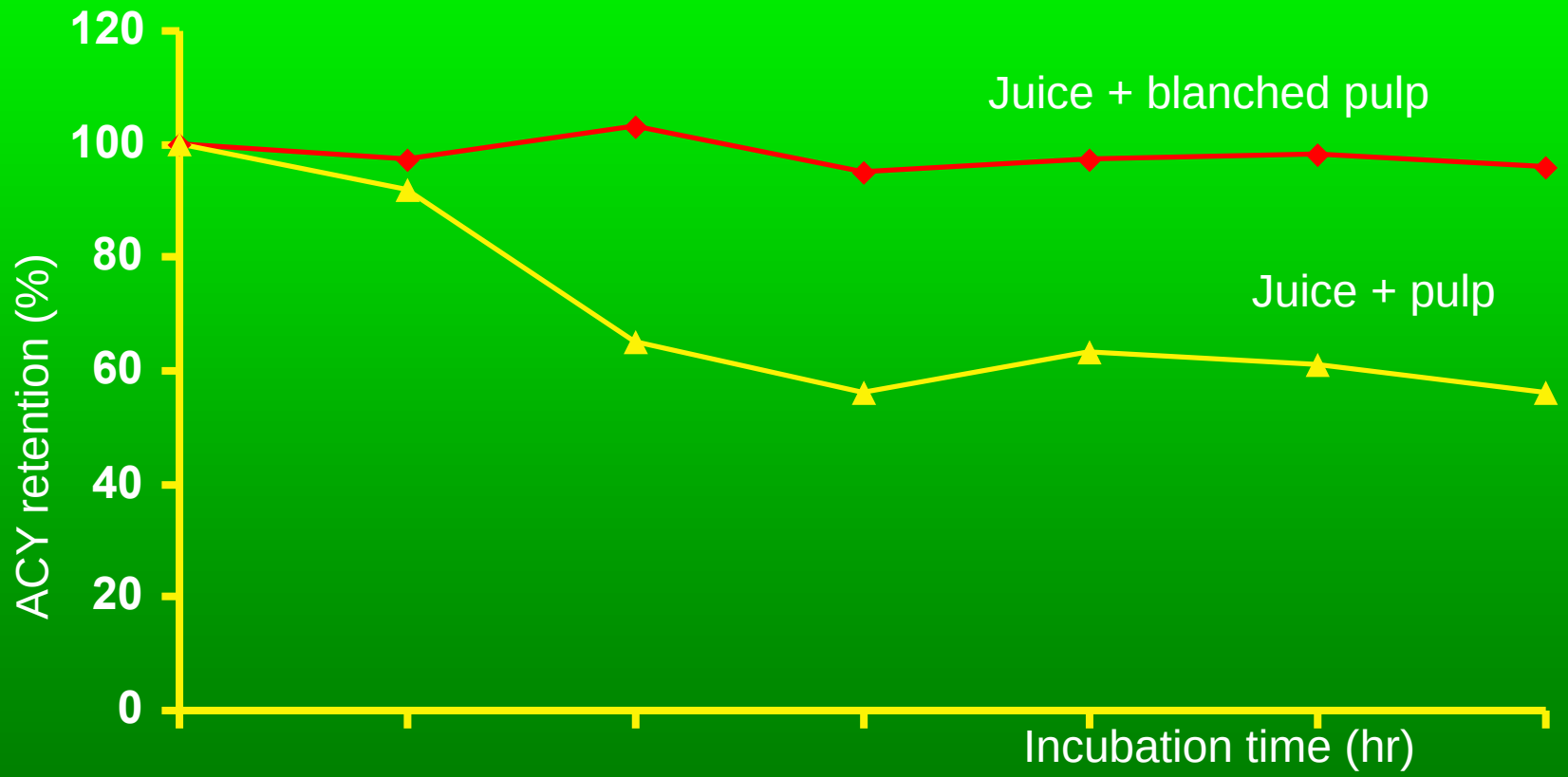
- Genesis Juice (OR)
- Full FDA Approval
- Enthusiastic Market Acceptance

Anthocyanin loss during blueberry juice processing

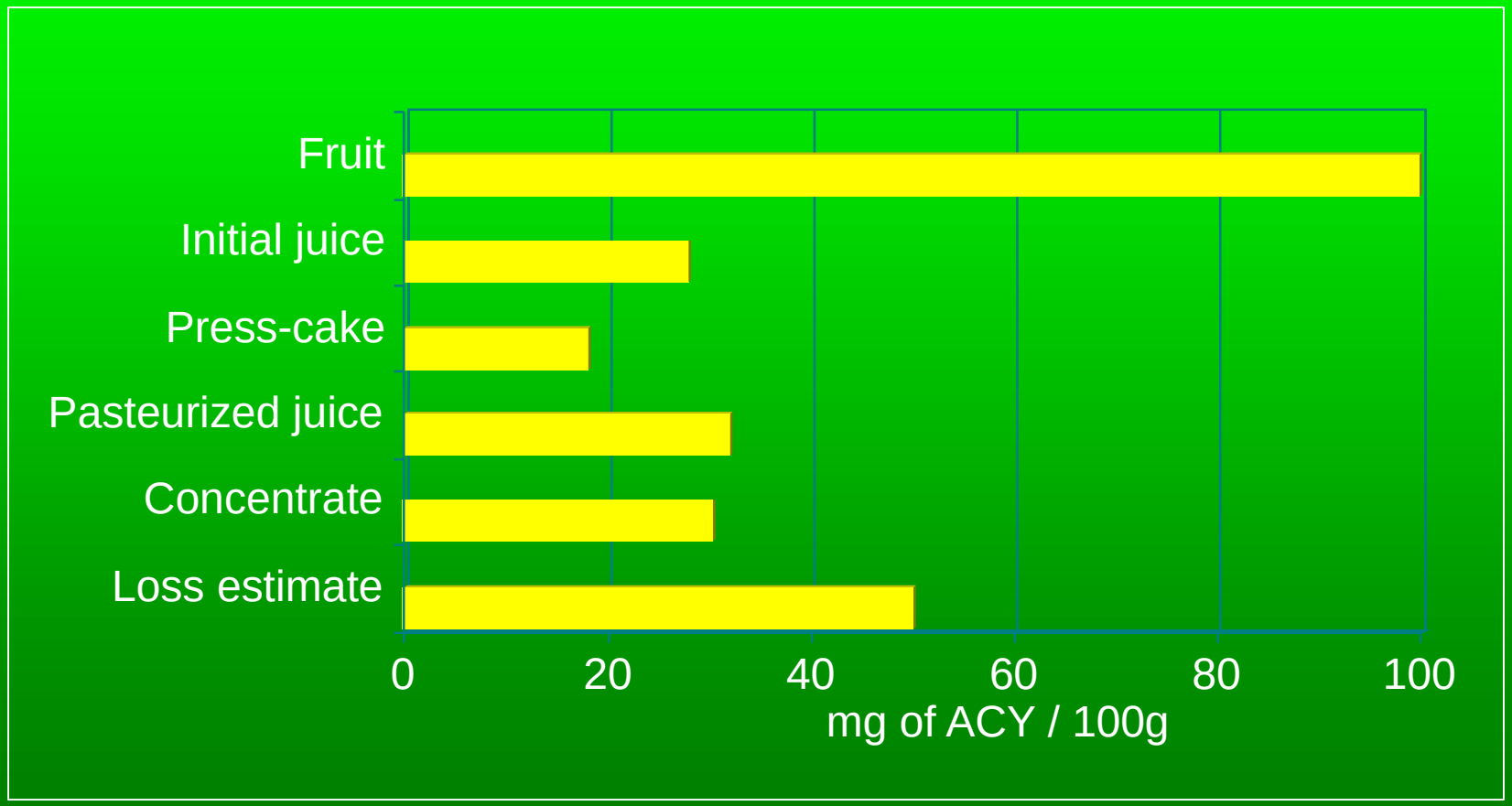


G. Skrede, R.E. Wrolstad & R.W. Durst. 2000. J. Food Sci. 85: 357-364.

Anthocyanin Content of Pasteurized Blueberry Juice with Pulp Addition



Anthocyanin loss during blueberry juice processing



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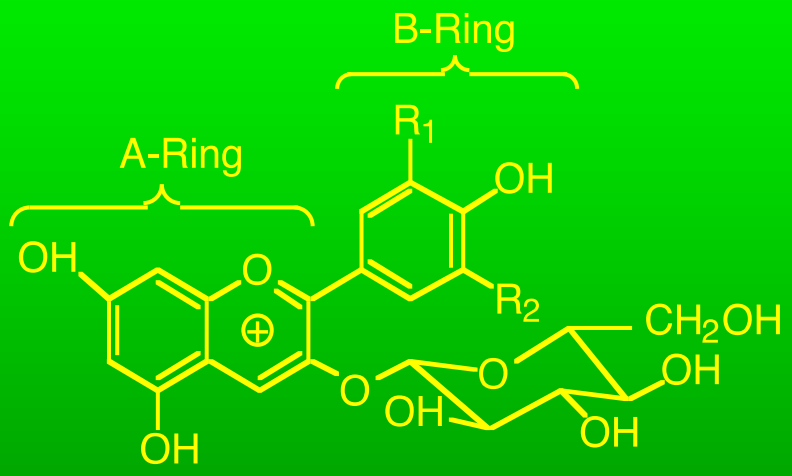
Potential application for ohmic heating…

- Recovery of natural colorants and nutraceuticals from processing wastes
- Inactivation of oxidase enzymes
- Increased extraction yield from electroporation effect
- “Anthocyanins isolated from red raspberry pomace more stable to heat thatn anthocyanins in juice”—Losso et al., Berry Health Benefits Symposium, 2011

Anthocyanin Stability



- Tremendous variation with commodity
- Large structural variation (>600 in nature)
- Reactive juice components removed in processing

R_1 + R_2 = H, OH, or OMe
Glycosidic Substitution on 3, 5, or 7
Acylation Possible on Sugar

Anthocyanin Degradation in Juice & Model Systems

System	1st order rate constant	Half-life (days)
Strawberry Juice	7.9×10^{-2}	8
Strawberry Juice Fortified w/ Pgd-3-glu	5.7×10^{-2}	12
Juice Concentrate	2.1×10^{-1}	3.5
Juice Concentrate Fortified w/ Pgd-3-glu	1.4×10^{-1}	4
Pgd-3-glu, Aw=1.0, pH3.4	3.74×10^{-3}	186
Pgd-3-glu, Aw=0.90, pH3.4	2.08×10^{-3}	332

Garzon & Wrolstad, J. Food Sci., 2001.

Forward Osmosis (FO) Dewatering of Foods, Beverages & Nutraceuticals

- Direct osmosis membrane technology developed by Hydration Technologies, Inc., Albany, OR www.htiwater.com
- Low temperature (5-20˚ C) & low pressure (10-30 psig)
- Acomodates products with wide range of suspended solids with high flavor retention

HTI™
Hydration Technology Innovations

Forward Osmosis (FO) Dewatering of Foods, Beverages & Nutraceuticals

Product	Starting ° Brix	Final ° Brix	Temp, •C
Red Raspberry Juice	10	45	10
Cranberry Juice	10	50	10
Strawberry Puree	10	35	10
Passion Fruit Puree	15	36	25
Soursop Puree	16	31	15
Banana Puree	18	33	25
Pulpy Pineapple Juice	10	50	10
Mango Puree	15	30	25
Tamarind Juice	--	50	25

Courtesy Keith Lampi, Hydration Technologies, Inc.

Additional Natural Colorant & Nutraceutical Processing Technologies

- Enzymes as processing aids to increase recovery
- Filtration & microfiltration technologies
- More efficient evaporators and dryers, e.g., Rapid Zone Drying RZM™
- Resin treatments, membrane processes for flavor removal & pigment concentration

Thanks!

Yanyun Zhao & Pei Zhou
Chairs,Symposium Organization Committee

Tom Shellhammer, OSU

Avure Technologies

Keith Lampi, Hydration Technologies, Inc.

Carlos Fajardo, OSU