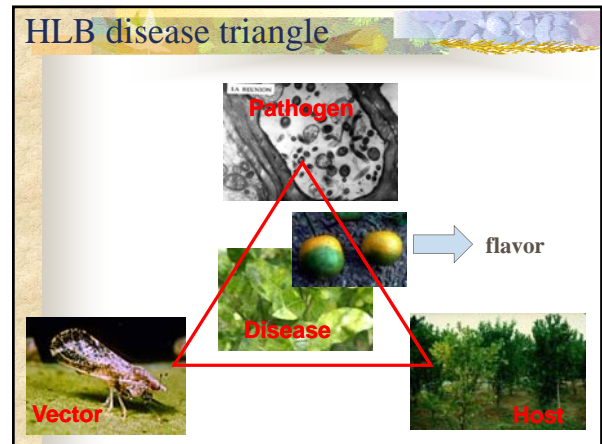


USDA **SOUTHERN GARDENS** **das**

The Effects of HLB and HLB Management Practices on Citrus Fruit Quality


Elizabeth Baldwin, Anne Plotto, Jinhe Bai, John Manthey, Smita Raithore Huqing Yang, Sophie Deterre and Sharon Dea, Wei Zhao
 US Horticultural Research Laboratory, Ft. Pierce, FL



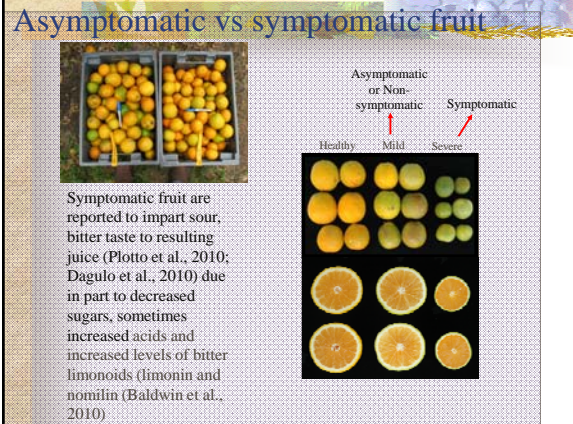


Flavor issues with HLB

- Imparts a bitter, sour taste due to lower sugars, sometimes higher acids and higher levels of defense compounds like bitter limonoids, flavonoids, alkaloids etc. (fruit act like they are slower to mature)
- Conducted sensory and analytical chemical studies comparing HLB to healthy juice to determine off-flavor drivers
- Conducted blending studies to see how much HLB juice could be blended with healthy before negatively affecting flavor
- Developed objective analytical methods to screen juice for HLB off-flavor
- Since bitter compounds were present in OJ at below reported thresholds, determined thresholds in OJ
- Since growers are using foliar nutritional treatments to mitigate HLB symptoms on the tree, tested effect on juice flavor



Asymptomatic vs symptomatic fruit



Asymptomatic or Non-symptomatic: Healthy

Symptomatic: Mild, Severe


Symptomatic fruit are reported to impart sour, bitter taste to resulting juice (Plotto et al., 2010; Dagulo et al., 2010) due in part to decreased sugars, sometimes increased acids and increased levels of bitter limonoids (limonin and nomilin (Baldwin et al., 2010)).

Quality aspects for orange juice

Sensory/health characteristics	Chemical/physical/microbial characteristics
<ul style="list-style-type: none"> Color Sweetness Sourness Bitterness Astringency Aroma Mouthfeel Nutrition/health benefits 	<ul style="list-style-type: none"> Carotenoids Sugars Acids Limonoids/Flavonoids Phenolics Volatiles Viscosity/pectin Vitamin C, folic acid, limonoids and flavonoids

Quality aspects for OJ juice affected by HLB

Sensory/health characteristics	Chemical/physical/microbial characteristics
<ul style="list-style-type: none"> Color Less sweet More sour More bitter More astringency Less top notes Mouthfeel Nutrition/health benefits 	<ul style="list-style-type: none"> Carotenoids Sugars down Acids up Limonoids/Flavonoids up Phenolics up Volatiles changed Viscosity/pectin Vitamin C, folic acid




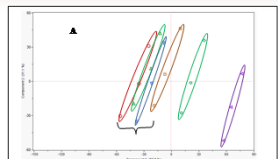
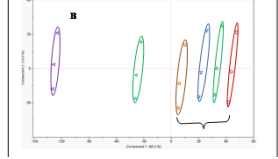
E-nose



E-tongue




Separation of juice blends by e-tongue

100% separated from 50% and both separated from all other blends


PCA of the blends of Healthy juices with HLB symptomatic juices. Blends were composed of mL/100 mL HLB Juice: 0% (○), 6.25% (△), 12.5% (▽), 25% (□), 50% (◇) and 100% (⊙). A = Hamlin, B = Valencia

Chemical analyses of healthy and HLBs juice used in blending study

		Sugars and acids			
Cultivar		(% SSC ^a)	pH	TA ^a	SSC/TA ratio
Hamlin	Healthy	11.4 ± 0.6	4.0 ± 0.0	0.52 ± 0.00	21.8 ± 1.1
	HLBs	11.8 ± 0.3	3.9 ± 0.0	0.55 ± 0.03	21.6 ± 1.6
Valencia	Healthy	12.2 ± 0.2	3.8 ± 0.2 ^a	0.68 ± 0.01 ^b	17.9 ± 0.1 ^a
	HLBs	11.8 ± 0.3	3.6 ± 0.1 ^b	1.15 ± 0.03 ^a	10.2 ± 0.1 ^b

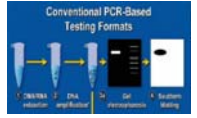
		Bitter limonoids		
		Hamlin (ppm)	Limonin	Nomilin
Valencia	Healthy		0.53	0.07
	HLBs		2.14	0.38
Hamlin	Healthy		0.53	0.17
	HLBs		1.23	0.57

Valencia flavor problem was ratio, while Hamlin was L&N




Biochemical analysis (Wei Zhao/Jinhe Bai)

- qPCR of OJ - relative presumed HLB pathogen *Candidatus liberibacter asiaticus* (CLAs) titer determined by analyzing the 16S rDNA gene
- qPCR of off-flavor microbial (*Alicyclobacillus acidoterrestris*, *Saccharomyces* spp.) and a human pathogen (*E. coli*)
- A patent application has been filed for this process and its use to determine quality in juice and cider




Managing HLB in the field

- Rigorous control, scouting and removal of infected trees is optimal and proven the best practice to limit the spread of HLB
- Today most growers have reached their actual or perceived economic threshold and can no longer afford to or are no longer willing to remove infected trees (Spann, T.M., Schuman, A.W., Rouse, B., Ebel, B., 2011, Citrus Industry)
- Therefore, many growers have chosen to maintain the health and productivity of their trees through an enhanced foliar nutrition program.
- This policy has basically led to ~ 80% infection



Nutritional programs

- Maury Boyd initiated the original foliar nutrition program.
- HLB symptomatic trees receiving a comprehensive foliar nutrition treatment have improved visually in some cases and appear to be maintaining some level of productivity.
- Investigated whether fruit can be grown on HLB-infected trees with a good foliar nutrition program and their internal quality improved due to the nutrition treatment.



Harvests and treatments

Harvests

Hamlin

- December 2009
- December 2010
- January 2011
- January 2012
- December 2012
- January 2013
- December 2013
- January 2014



Valencia







- April 2011
- April 2012
- April 2013
- April 2014

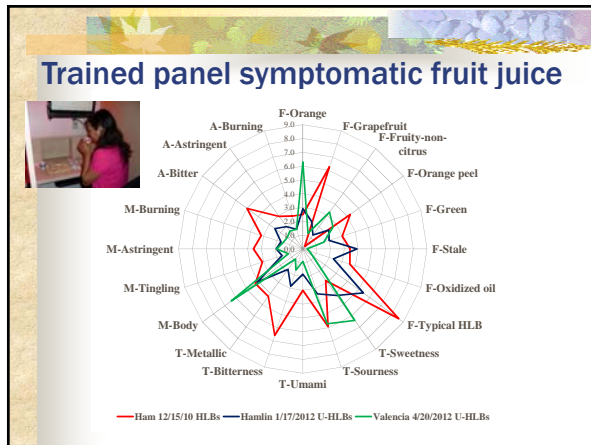
Typical nutritional treatment ingredients

- Oxidate
- Renew 14-7-8
- Magnesium sulfate
- Techmargum
- Zinc sulfate
- Sodium molybdate
- Potassium nitrate 13-0-44 spray grade
- 435 spray oil

Healthy and HLB fruit, different nutritional programs

No effect on fruit appearance – size and color



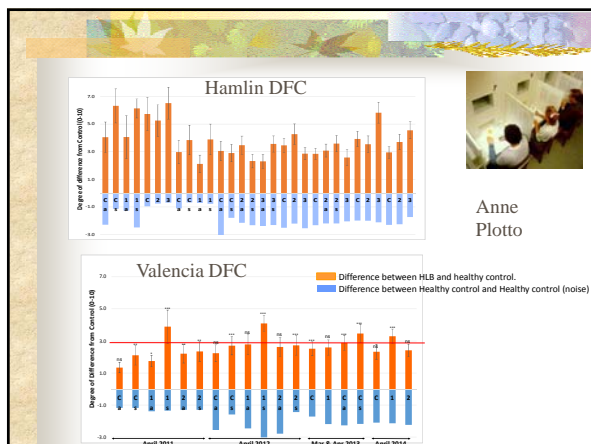
December Hamlin differences in aroma or taste

Nutritional DFC – Healthy HLBa, HLBs

Treatment: Conv Healthy vs Conv HLB					
Hamlin	Aroma	Taste	Descriptors	SS/TA	L+N (ppm)
Dec, 2009	H/HLB	H/HLB	Smell: ND	H/HLB	H/HLB
Asymptomatic	ND	1.4/4.1	Taste: Bitter, sour, grapefrt	27/21	3.6/4.7
Symptomatic	1.0/2.6	1.1/6.3	Smell: Lime, grapefrt	27/30	3.6/7.9
			Taste: Bitter, sour, astringent, metallic, grapefrt		




Treatment: Conv Healthy vs N3 HLB					
Hamlin	Aroma	Taste	Descriptors	SS/TA	L+N (ppm)
Dec, 2010	H/HLB	H/HLB	Smell: Less orange	H/HLB	H/HLB
Asymptomatic	0.5/1.4	0.9/6.6	Taste: Bitter, sour, grapefrt	18/15	2.2/11.9

Treatment: N3 Healthy vs N3 HLB					
Hamlin	Aroma	Taste	Descriptors	SS/TA	L+N (ppm)
January, 2012	H/HLB	H/HLB	Smell: ND	H/HLB	H/HLB
Asymptomatic	ND	ND	Taste: ND	24/27	1.6/2.7
Symptomatic	ND	2.3/2.6	Smell: ND	24/23	1.6/2.0
			Taste: Bitter, off-flavor		



Conclusions

- Generally, HLB has more effect earlier than later in the season since fruit seem to mature more slowly – harvest later?
- Generally flavor of HLBa still similar to healthy, while HLBs is different so need to be screened out.
- In some cases (2012), nutritional treatments to maintain health and productivity in the field seemed to result in higher sugars and perceived sweetness, but was not consistent in subsequent seasons.
- Secondary infection by *Diplodia Natalensis* is causing more SER for early fruit, especially if degreened with ethylene– use a color add instead of degreening?

Conclusions for qPCR of juice

- Useful to determine infection of tree by *Clas*
- Useful to determine *Clas* titer in juice for fruit batches coming in from infected groves
- Useful to predict quality of juice based on *Clas* titer for classification of juice for different products



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Questions?

Thank you!