



When an Orange is not a *Citrus sinensis*, is it a Sweet Orange-like Hybrid? – an International Perspective

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What will I cover?

- DAH's background
- IFU, a trade association for the fruit & vegetable juice industries
- The Codex Standard 247 (2005)
- What is citrus taxonomy?
- What are the ramifications of these changes?
- Effects of HLB on Citrus production in Florida
- Do these changes provide an opportunity for the juice industry?





DAH Experience

BSc and PhD in Chemistry	(Nottingham University)
Chair of IFU Legislation Commission	(2020 -)
Chair of AIJN Code of Practice Expert Group	(2019 -)
Chair of IFU Methods of Analysis Commission	(2004 – 2011)
Member of UK DEFRA Authenticity and Methodology Working Group (AMWG)	
Ex Chair of Technical Committee for Juice and Juice products	(USA)
General referee for fruit juices at AOAC	(2006 – 2012)
Eurofins authenticity and fruit juice expert {Nantes}	(2006 -)
Cadbury Schweppes central research Lab UK	(1981 - 2006)
Lead representative for IFU on many Codex committees	(CCMAS, CCPR, CCCF)

Been involved in the fruit juice area for nearly 40 yrs!!!



The background of the image consists of several slices of oranges arranged on a solid orange surface. The slices are cut into thin, circular sections, showing the internal segments and the central pith. The lighting is bright, highlighting the texture of the fruit. A semi-transparent orange horizontal band is overlaid across the center of the image, containing the text.

International fruit and vegetable Juice Association (IFU)



200+ members in 80 countries



Member types: Associations | Corporate | Friends | University





IFU Pillars

IFU PRODUCT PILLARS

1 SCIENCE

2 STANDARDS

3 SUSTAINABILITY

4 MARKETS

IFU VALUE PROPOSITION

INFLUENCE

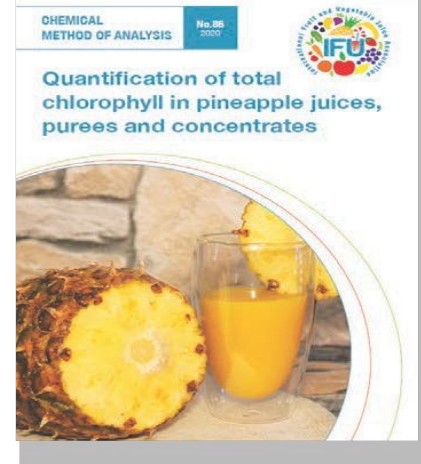
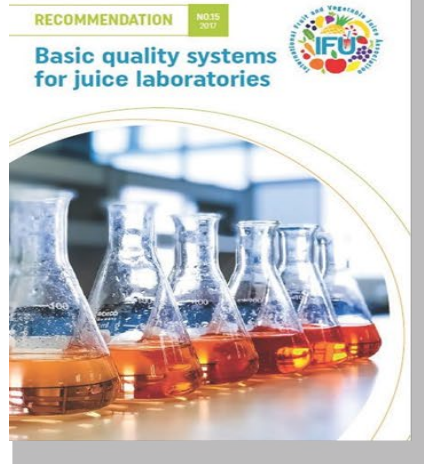
INDUSTRY BEST PRACTICE

INSIGHTS

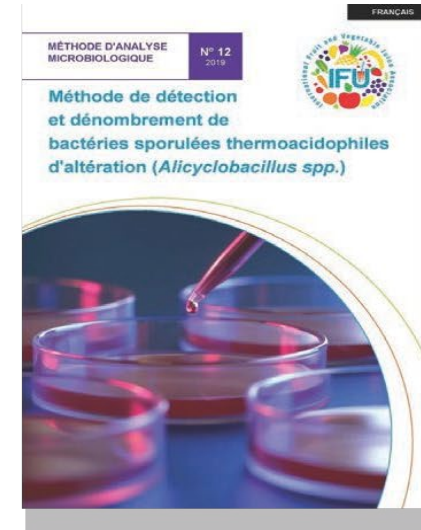
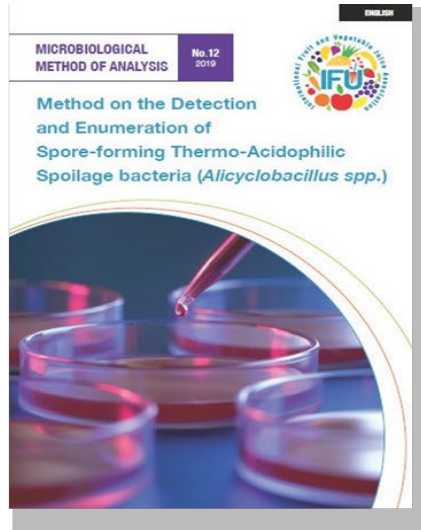
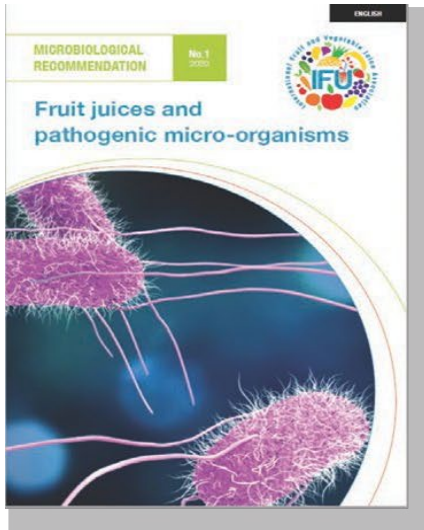
INNOVATION

INFORMATION

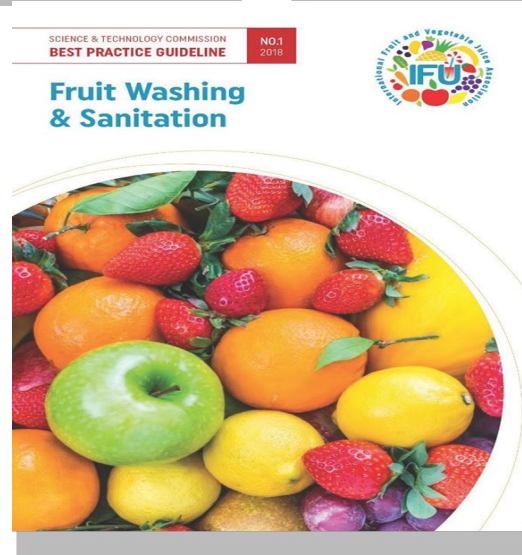
Methods & recommendations



Micro methods



Best practice advice





To join IFU

TO JOIN GO TO

https://ifu-fruitjuice.com/general/register_member_type.asp?

Or contact

John Collins at IFU

John@ifu-fruitjuice.com

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Codex Standard 247 (2005)

GENERAL STANDARD FOR FRUIT JUICES AND NECTARS (CODEX STAN 247-2005)

1. SCOPE

This Standard applies to all products as defined in Section 2.1 below.

2. DESCRIPTION

2.1 PRODUCT DEFINITION

2.1.1 Fruit Juice

Fruit juice is the unfermented but fermentable liquid obtained from the edible part of sound, appropriately mature and fresh fruit or of fruit maintained in sound condition by suitable means including post harvest surface treatments applied in accordance with the applicable provisions of the Codex Alimentarius Commission.

Some juices may be processed with pips, seeds and peel, which are not usually incorporated in the juice, but some parts or components of pips, seeds and peel, which cannot be removed by Good Manufacturing Practices (GMP) will be acceptable.

The juice is prepared by suitable processes, which maintain the essential physical, chemical, organoleptical and nutritional characteristics of the juices of the fruit from which it comes. The juice may be cloudy or clear and may have restored¹ aromatic substances and volatile flavour components, all of which must be obtained by suitable physical means, and all of which must be recovered from the same kind of fruit. Pulp and cells² obtained by suitable physical means from the same kind of fruit may be added.

A single juice is obtained from one kind of fruit. A mixed juice is obtained by blending two or more juices or juices and purées, from different kinds of fruit.

Fruit juice is obtained as follows:

2.1.1.1 **Fruit juice** directly expressed by mechanical extraction processes.

2.1.1.2 **Fruit juice from concentrate** by reconstituting concentrated fruit juice defined in Section 2.1.2 with potable water that meets the criteria described in Section 3.1.1(c).



Codex Standard 247

1. PROCESSING AIDS – Maximum Level of Use in line with Good Manufacturing Practices

Function	Substance	
Antifoaming Agent	Polydimethylsiloxane ⁵	
	Adsorbent clays (bleaching, natural or activated earths)	
	Adsorbent resins	
	Activated carbon (only from plants)	
	Bentonite	
	Calcium hydroxide ⁶	
	Cellulose	
	Chitosan	
	Colloidal silica	
	Diatomaceous earth	
	Gelatin (from skin collagen)	
	Ion exchange resins (cation and anion)	
	Clarifying Agents	Isinglass ⁷
		Filtration Aids Flocculating Agents
Perlite		
Polyvinylpolypyrrolidone		
Potassium casseinate ⁷		
Potassium tartrate ⁶		
Precipitated calcium carbonate ⁶		
Rice hulls		
Silicasol		
Sodium caseinate ⁷		
Sulphur dioxide ^{6, 8}		
Tannin		

⁵ 10 mg/l is the maximum residue limit of the compound allowed in the final product.

⁶ Only in grape juice.

⁷ Use of these processing aids should take into account their allergenic potential. If there is any carry over of these processing aids into finished product, they are subject to ingredient declaration in accordance with Sections 4.2.1.4 and 4.2.4 of the of the *General Standard for the Labelling of Prepackaged Foods*.

⁸ 10 mg/l (as residual SO₂).





Codex Standard 247

Botanical Name	FRUIT'S COMMON NAME	Minimum Brix Level for Reconstituted Fruit Juices and Reconstituted Purée	Minimum Juice and/or Purée Content (% v/v) for Fruit Nectars
<i>Citrus limon</i> (L.) Burm. f. <i>Citrus limonum</i> Rissa	Lemon	8.0 ¹⁷	According to the legislation of the importing country
<i>Citrus paradisi</i> Macfad	Grapefruit	10.0 ¹⁷	50.0
<i>Citrus paradisi</i> , <i>Citrus grandis</i>	Sweetie grapefruit	10.0	50.0
<i>Citrus reticulata</i> Blanca	Mandarine/ Tangerine	11.8 ¹⁷	50.0
<i>Citrus sinensis</i> (L.)	Orange	<p>11.8 – 11.2¹⁷ and consistent with the application of national legislation of the importing country but not lower than 11.2.</p> <p>It is recognized that in different countries, the Brix level may naturally differ from this range of values. In cases where the Brix level is consistently lower than this range of values, reconstituted juice of lower Brix from these countries introduced into international trade will be acceptable, provided it meets the authenticity methodology listed in the General Standard for Fruit Juices and Nectars and the level will not be below 10°Brix.</p>	50.0

¹⁷ Acid corrected as determined by the method for total titratable acids in the Section on Methods of Analysis.

The image features a vibrant orange background with several slices of orange scattered across it. A semi-transparent orange horizontal band runs across the center, containing the text "Citrus Taxonomy" in a bold, white, sans-serif font. The orange slices are shown in cross-section, revealing their internal structure and bright orange color.

Citrus Taxonomy

What is Citrus taxonomy?

Citrus taxonomy refers to the botanical classification of the species, varieties, cultivars, and graft hybrids within the genus *Citrus* and related genera, found in cultivation and in the wild.



Orange
Citrus sinensis

Grapefruit
Citrus paradisi



Pumelo
Citrus maxima

Mandarin
Citrus reticulata



Lemon
Citrus limon



Lime
Citrus latifolia &
Citrus aurantiifolia



Why is Citrus taxonomy suddenly a topic for discussion?

- Taxonomists have decided that the “Latin names” we use for many of the fruits within the “citrus family” are inaccurate!
- It has been known for many years that “sweet orange” {*Citrus sinensis*} is not a true “citrus species” but is a complex mandarin {*Citrus reticulata*}/pomelo {*Citrus maximus*} cross.



+



Why is Citrus taxonomy suddenly a topic for discussion?

- Similarly grapefruit {*Citrus paradisi*} is a natural cross between pomelo {*Citrus grandis*} and mandarin {*Citrus reticulata*} which happened in the Caribbean in the 1700's!



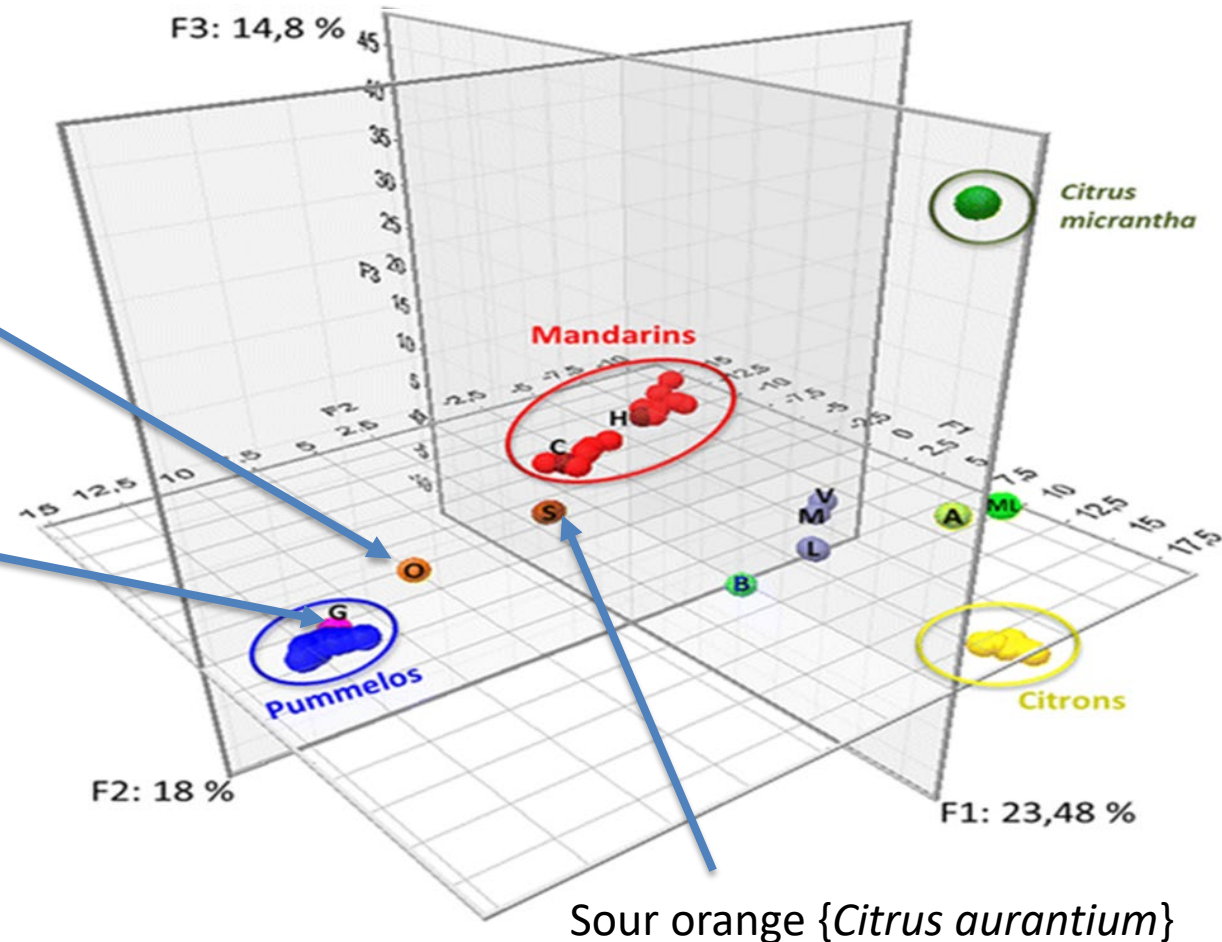
DNA study of part of the Citrus genome

Several DNA studies have concluded that orange is not a **true citrus species** but a cross between two different existing mandarin/pummelo hybrids, hence its position on the genetic plot.

Citrus sinensis showing an intermediate position between the mandarin {*Citrus reticulata*} & pummelo species {*Citrus maximus*}

Grapefruits {*Citrus paradisi*} sitting very close to pumelos {*Citrus maximus*}

Key:- ML: 'Mexican' lime; A: 'Alemow'; V: 'Volkamer' lemon; M: 'Meyer' lemon; L: Regular and 'Sweet' lemons; B: Bergamot; H: Haploid clementine; C: Clementines; S: Sour oranges; O: Sweet oranges; G: Grapefruits



Sour orange {*Citrus aurantium*}

(1) Curk F., Ancillo G., Garcia-Lor A., Luro F., Perrier X., Jacquemoud-Collet J.-P., Navarro L. & Ollitrault P. (2014).

Next generation haplotyping to decipher nuclear genomic interspecific admixture in Citrus species: analysis of chromosome 2. BMC Genetics 2014 15 152, <http://www.biomedcentral.com/1471-2156/15/152/abstract>

DNA study of part of the Citrus genome

- From this and other studies, taxonomists have decided to better reflect the nature of these fruits, they are recommending that many citrus fruits should be renamed to reflect their hybrid nature
- The hybrids should now be considered a *Citrus aurantium*. So
 - **Orange becomes:** *Citrus aurantium var sinensis*
 - **Grapefruit becomes:** *Citrus aurantium var paradisi*
 - **Sour orange:** *Citrus aurantium var myrtifolia*



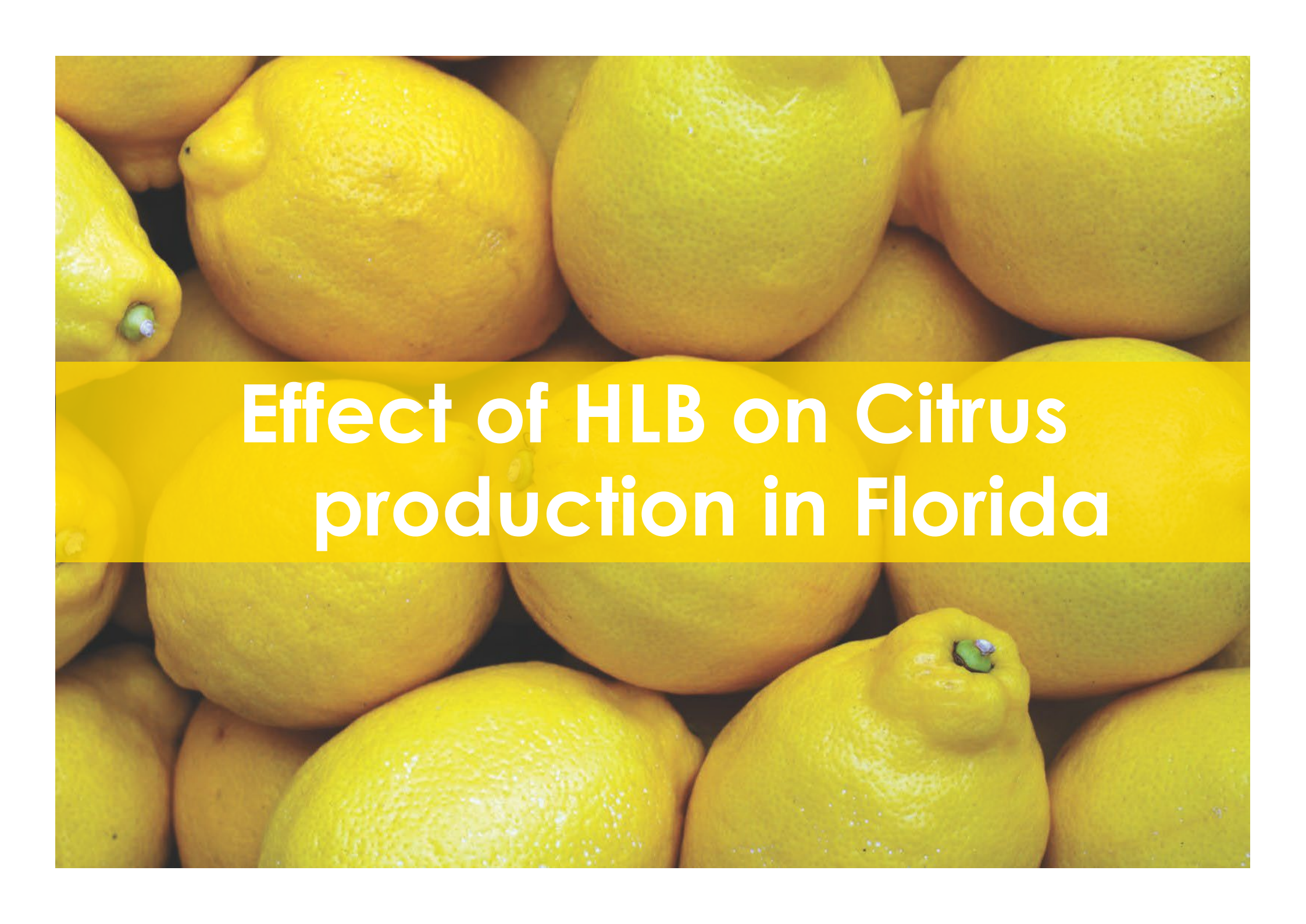


Ramifications of the name changes

Fruit juice standards

- Due to these changes in taxonomical classifications for these fruits, the existing regulatory standards would need updating e.g.
 - Codex 247 (2005),
 - EU Fruit juice directive 12 2012,
 - US 21 CFR 146.146 (OJC) + others related to orange juice (146.....) and grapefruit juice (146.132)
- The up to date names should be used in the all relevant standards





Effect of HLB on Citrus production in Florida

“Citrus greening” (Huanglongbing, HLB)

- HLB is caused by a bacteria *Candidatus Liberibacter* spp.
- This bacteria is carried by a Psyllid *Diaphorina citri*,
- As the psyllid feeds on the tree the bacteria is injected into the sap
- This then limits flow of the phloem and reduces/stops transport of nutrients from the roots to the leaves and throughout the plant
- In the short term this causes lower fruit yields, early fruit drop, poor quality fruits (appearance and flavour of juice) and ultimately tree death



Asian citrus psyllid – *Diaphorina citri*

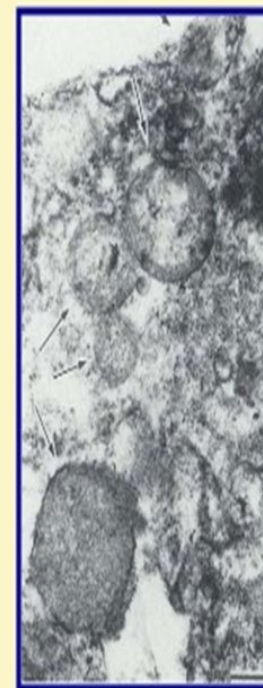


First found in Florida June 1998

Citrus Greening: The Pathogen

Candidatus Liberibacter asiaticus

- Phloem-limited bacterium
- Transmitted by psyllids
- Graft transmissible
- Not currently cultured



Issues with citrus greening

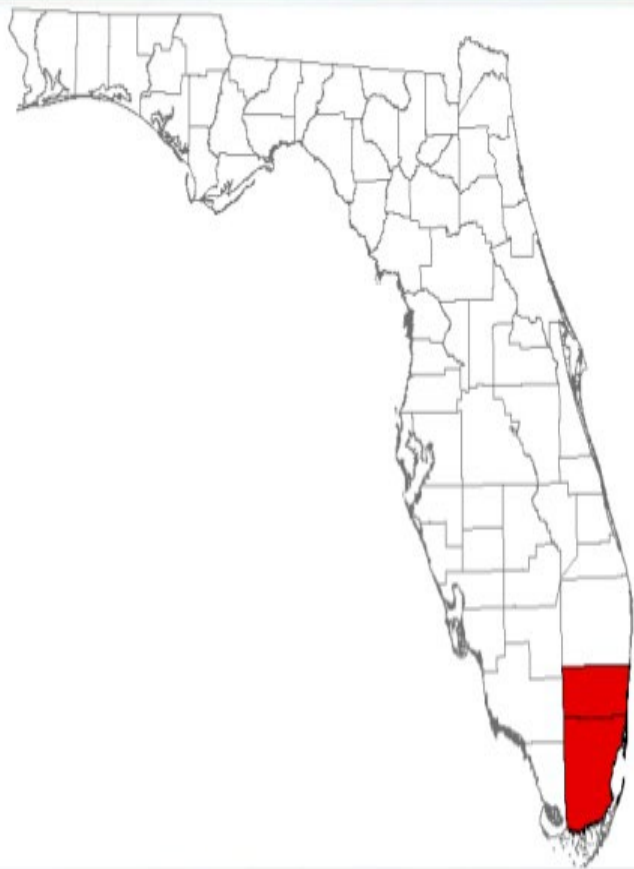
- In the 80's and 90's Florida was producing *ca* 200 million boxes of oranges which was *ca* 2/3 of Brazilian production (300 – 400 million boxes)
- However, due to the effects of Citrus greening, Citrus canker, hurricanes & reduced production areas in Florida the predicted production for 2021/22 was only *ca* 38 million boxes (USDA estimate Feb 2022)! In the end it came in at around 40 million!
- Thus Floridian producers are struggling to obtain sufficient fruits to process at economic prices!
- At present there is no cure for HLB
- Florida is badly affected by HLB. However, HLB is also in Brazilian production areas, but presently better controlled, and could/will affect other production areas in the longer term
- This could/will lead to fruit shortages in the medium to long term



Issues with citrus greening



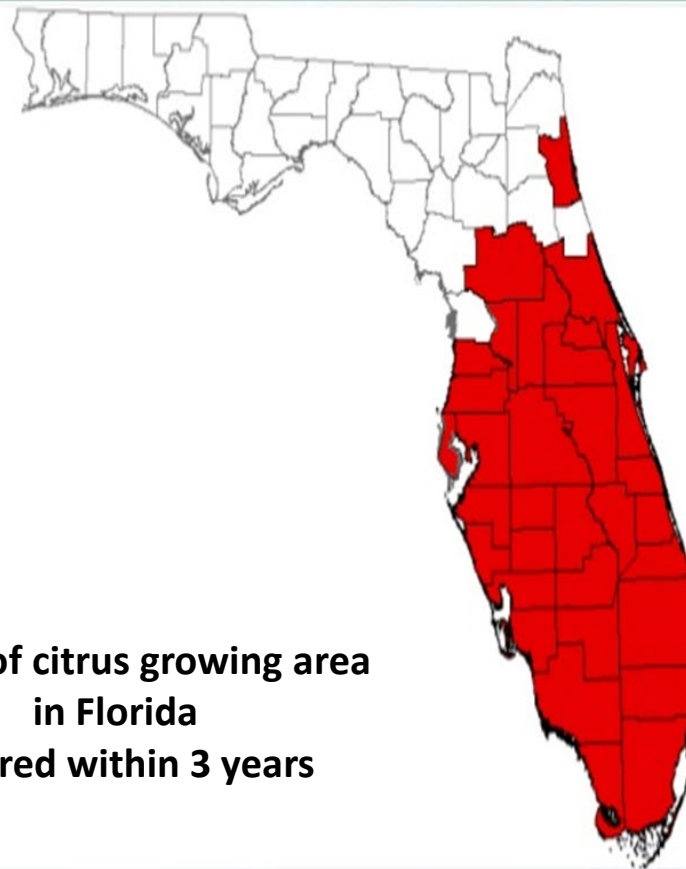
HLB Increasing Throughout the State October, 2005



2 counties



HLB Increasing Throughout the State August, 2008



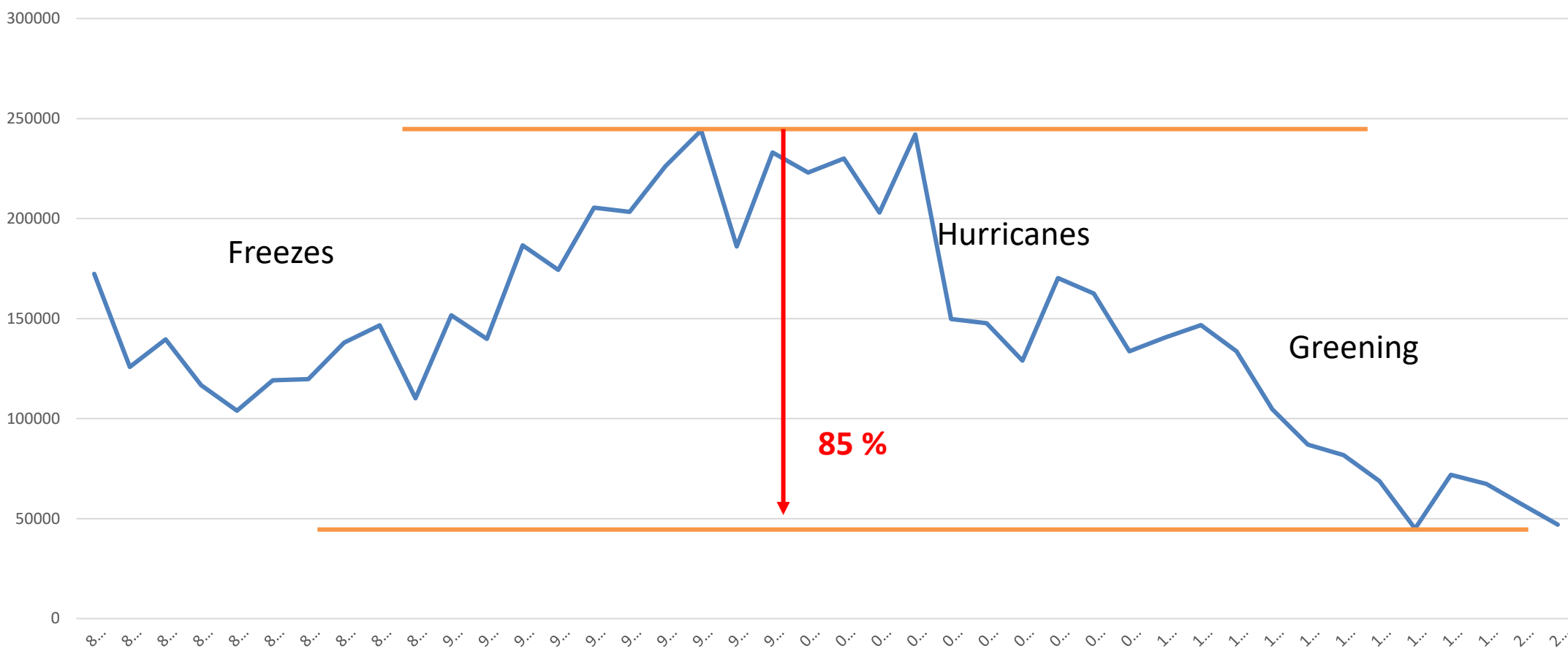
Whole of citrus growing area
in Florida
covered within 3 years

32 counties



Issues with citrus greening on orange production

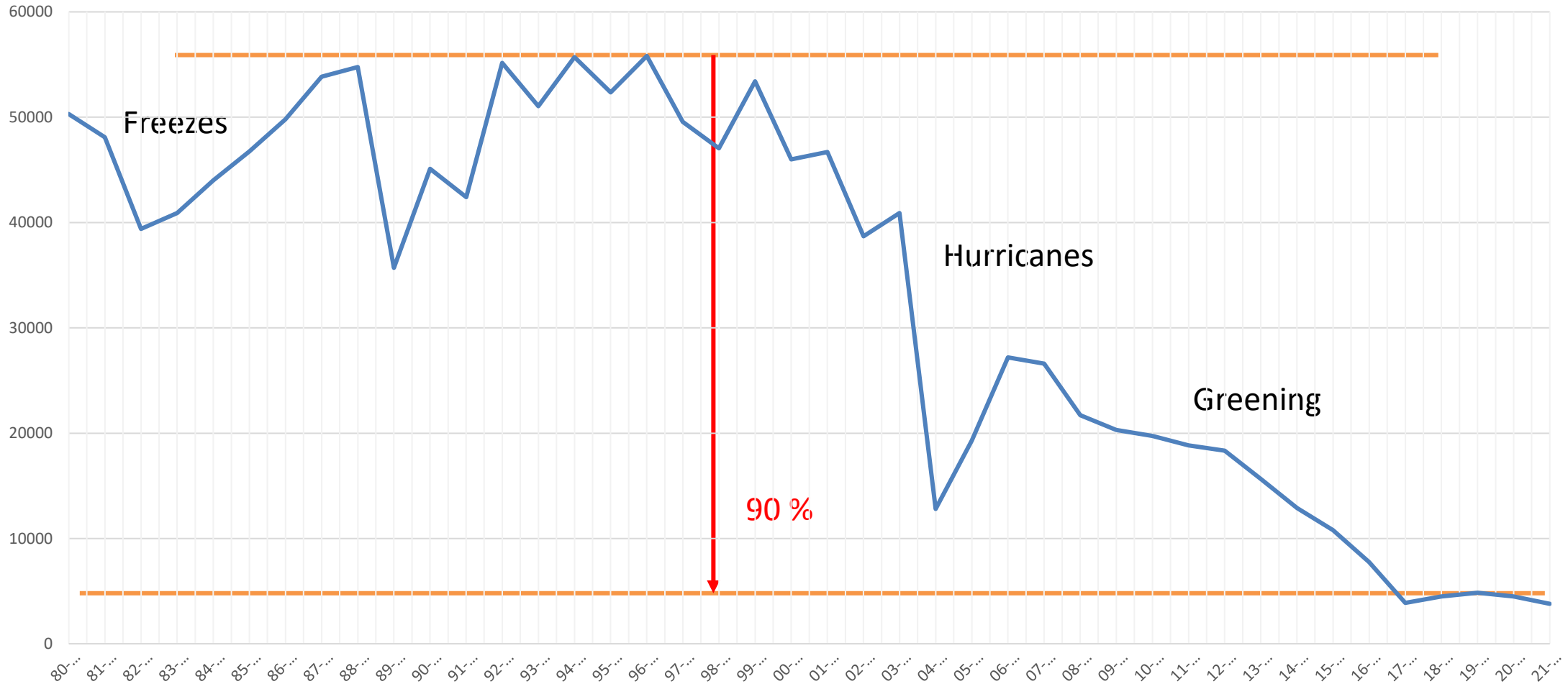
Florida orange production (1000 boxes)





Issues with citrus greening on grapefruit production

Florida grapefruit production (1000 boxes)





Some citrus trees more resistant to HLB than others

- Studies in Florida indicate that some “mandarin hybrids” show significant resistance to HLB and it is possible that other new hybrids could be developed with this resistance using natural breeding techniques but would produce “juice” like orange
- Sugar belle growing for 8+ yrs with HLB**

Citrus sinensis with HLB





Due the changes in Citrus Taxonomy could this introduce the possibility of more flexibility for fruit selection?

New developments

- As the fruits that may be used to prepare orange juice are controlled by national and international regulations. Plant breeders and horticulturalist have not been keen to spend time (money) developing any new varieties, that might be resistant to HLB, but could not be used to prepare orange juice and have no significant market!
- The citrus producers in Florida have approached IFU to see if there is anything that can be done jointly to assist in this area.
- The Floridian producers are also in discussion with the FDA about a possible revision of the US standards related to orange juice (in 21 CFR) to accommodate the proposed name changes developed by taxonomists
- They have also highlighted the possibility of an extension of the scope of fruit used to prepare OJ.
 - There is already a national precedence for this in the US as in the mid 90's "Ambersweet" a *Citrus sinensis* (1/2), *Citrus reticulata* (3/8) & *Citrus paradisi* (1/8) cross was approved for use in the production of orange juice.
 - eCFR :: 21 CFR 146.135 -- Orange juice.

A way forward in this area

- Extensive discussions have taken place within IFU on this topic up to and including the Executive Commission and it was decided to progress, in a stepwise process, with these developments
- Legislation commission has set up an expert group to assess this issue with ca 10 people with different expertise
 - Horticulture, chemical analysis, aroma analysis & experts in Citrus DNA
- They will look to define what tests should be used to determine if there are other “citrus hybrids” that liberate juice sufficiently close to orange juice so that they could be used in its production?
- Presently drawing up a set of traits that they consider critically defines orange juice
- Approaches that are likely to be used are:-
 - Characteristic flavour/aroma volatiles in the juice
 - Sensory analysis
 - General analytical considerations including secondary metabolites e.g. polyphenols
 - DNA similarities to existing varieties presently considered *Citrus sinensis*



Suitable traits for “sweet orange” group

		Orange	Mandarin
Total carotenoids	(mg/l)	15 max	10 - 25
Hydrocarbons as % of carots	%	5	10
Carotenoid esters as a % total carots	%	15	20
Xanthophylesters as % of total Carots	%	15	13
Phlorin	(mg/l)	60	50
1,6- flavonoid glucosides		Present (hesperidin, narirutin)	Ppresent (hesperidin, narirutin)
1,2-flavonoid glucosides (bitter)		absent < 1 mg/l)	can be present in mandarin hybrids
DNA analysis		Similarity to <i>Citrus sinensis</i> ?	
Taste		Similarity to <i>Citrus sinensis</i>	
Aroma		Similarity to <i>Citrus sinensis</i>	
Colour		Similarity to <i>Citrus sinensis</i>	



Suitable traits for “sweet orange” group

Typical volatiles		Orange	Mandarin
2-Méthylbutanol-1		£	
3-Méthylbutanol-1		£	
2(3)-Méthylbutanol-1			
2-Méthyl-3-butèn-2-ol		£	
2-Phényléthanol		£	
Ethyl acetate		£	
alpha-Ionone		£	
beta-Ionone		£	
beta-Myrcène			\$
Ethyl Butanoate		£	
Butanol-1		£	
Carvéol 1		?	
Carvéol 2		?	
Carvone		?	
Cis-3-Hexén-1-ol		?	
Ethyl-2-méthylbutanoate		£	
Ethyl-3 hydroxyhexanoate		£	
Hexanal		£	
Hexyl Hexanoate			\$
Hexanol-1		£	
Nootkatone		£	
Ethyl Octanoate (=caprylate)		£	
Terpinène-4-ol			\$
Trans-2-Hexénal		£	
Trans-2-Hexénol		£	
Valencène		£	

Conclusions

- If this approach is successful and the outcome is approved by the IFU Leg. and Exec. Commissions
- IFU will consider setting up an International Cultivar registry (ICRA) for Citrus plants.
- The ICRA would list the Citrus cultivars that are acceptable to prepare different types of citrus juices e.g. orange, grapefruit etc
- Once established, take this proposal to the Executive Committee of Codex (CCEXE) to seek their approval for new work, possibly under CCPFV or a new fruit juice task force, to allow modification of the fruit juice and nectars Standard 247 (2005) to accommodate these changes. IFU will need a Codex member country's support to make the proposal and to front the work at Codex
 - Due to the importance of OJ to Brazil their fronted the original task in the early 00's
- While doing this IFU will also propose that the Standard should be updated with new technological developments since its original publication in 2005.



Thank you for your attention.

Any questions?

Or contact me at

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