Caneberry Production Meeting
April 11, 2014, UC Hansen Ag Center, Ventura

Postharvest Quality Considerations for Caneberries--Blackberries

Overview Berry Composition & Quality
CDFA Berry Irrigation Project
Postharvest reminders & information

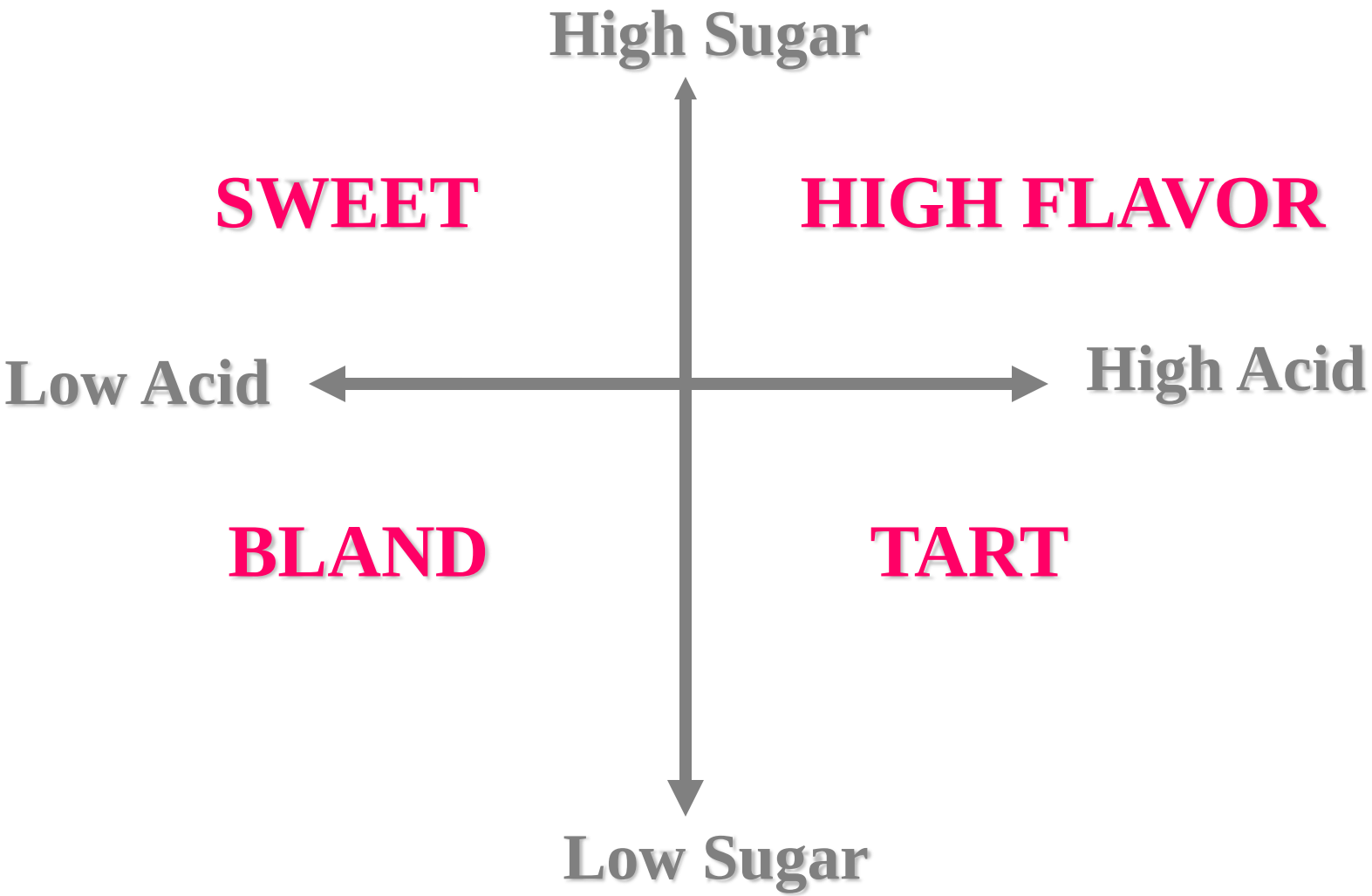
Marita Cantwell, UC Davis
Postharvest Specialist Vegetables
micantwell@ucdavis.edu

UCDAVIS POSTHARVEST TECHNOLOGY

UC Cooperative Extension | University of California Agriculture and Natural Resources

Sugars, Acids, Aroma Volatiles = Flavor

Fruit Composition & Flavor

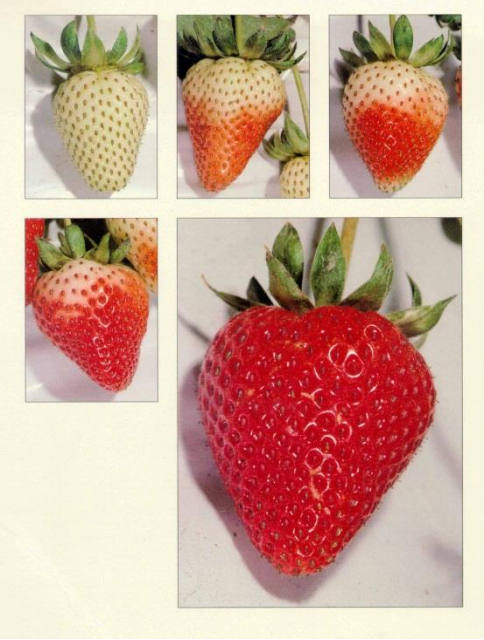


Measuring Sugar Concentrations

- ✓ Both °Brix and % soluble solids can be measured by a refractometer
- ✓ °Brix is a measurement of solids in a pure sucrose solution
- ✓ % soluble solids is an estimate of sugars because a juice solution contains sugars, but also other soluble constituents: organic acids, amino acids, soluble pectins and other soluble compounds.
- ✓ A fruit juice sample is composed of various sugars and soluble components; therefore "% soluble solids" should be used.

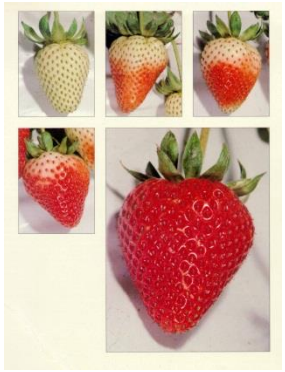
Composition of ‘Seascape’ Strawberries

Constituent	Concentration (%)	Percent of SS
Total sugars	5.28	57.3
Total acids	0.97	10.6
Others	2.95	32.1
Total Soluble solids	9.20	100.0



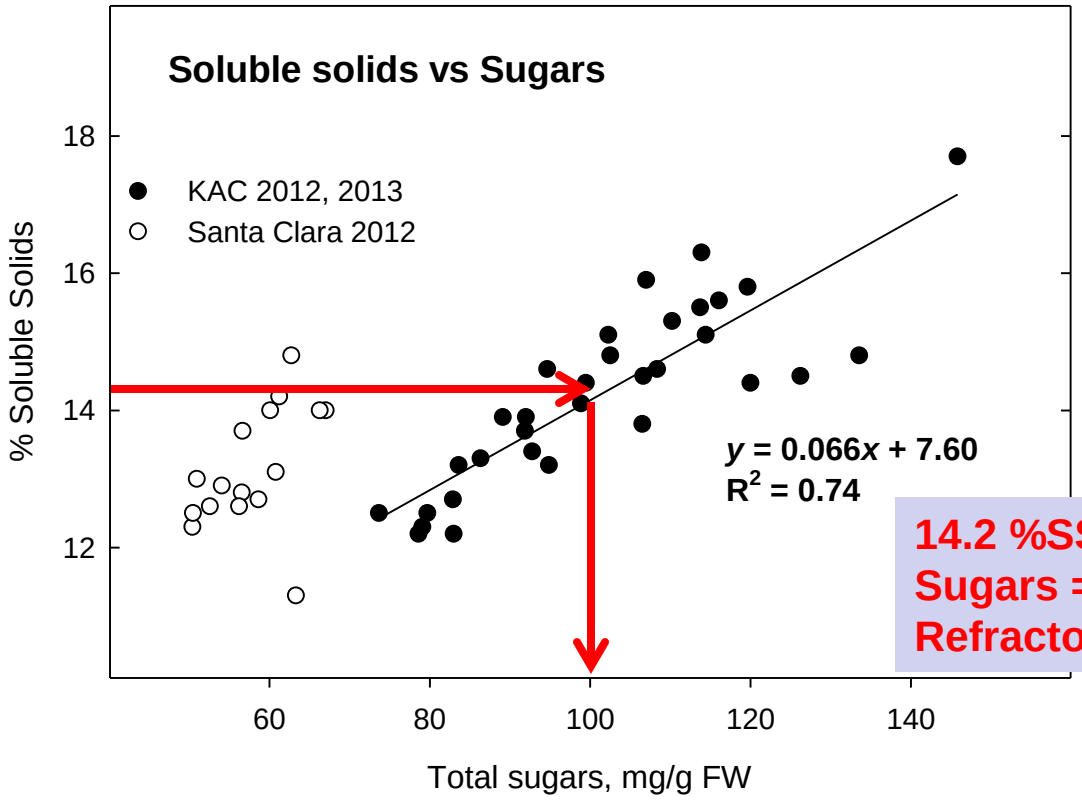
What are the Other Constituents?

Constituent	Contribution to refractometer reading	% of TSS
Anthocyanins	1.95	21.2
Soluble pectins	0.60	6.5
Ascorbic acid	0.21	2.3
Phenolics	0.19	2.1
Total	2.95	32.1



A. Kader and colleagues, UC Davis

Blackberry
Relationship between
Soluble solids (refractometer) and Total sugars (HPLC)



14.2 %SS = 100 mg/g sugars
Sugars = about 70% of Refractometer reading

Analysis from separate sets of berries (postharvest and composition)

Relative Sweetness of Sugars

- 15% solutions
- Sucrose = 100
- Fructose = 150-160
- Glucose = 70-80

Pancoast & Junk. 1980. Handbook of sugars. AVI

Range of reported composition of 4 berries

Cultivar
Climate and production conditions
Stage ripeness

	Sucrose (%)	Glucose (%)	Fructose (%)	°Brix	Total Solids (%)
Strawberry	0.1-2.3	1.0-2.7	1.2-4.2	5.8-13.1	3.8-13.8
Raspberry	0.2	2.6	3.0	9.3-10.5	14.2-18.0
Blackberry	0.1-0.3	1.6-2.6	2.1-3.4	10.8-11.4	8.2-13.6
Blueberry	0.1-1.1	3.3-3.9	3.3-3.9	10.9-15.8	15.7-17.2

(compiled from Talcott, 2007; Spanos, 1987; Cantwell Berry Irrigation project, 2013; Bremer et al., 2008)

Range of reported composition of 4 berries

Cultivar
Climate and production conditions
Stage ripeness

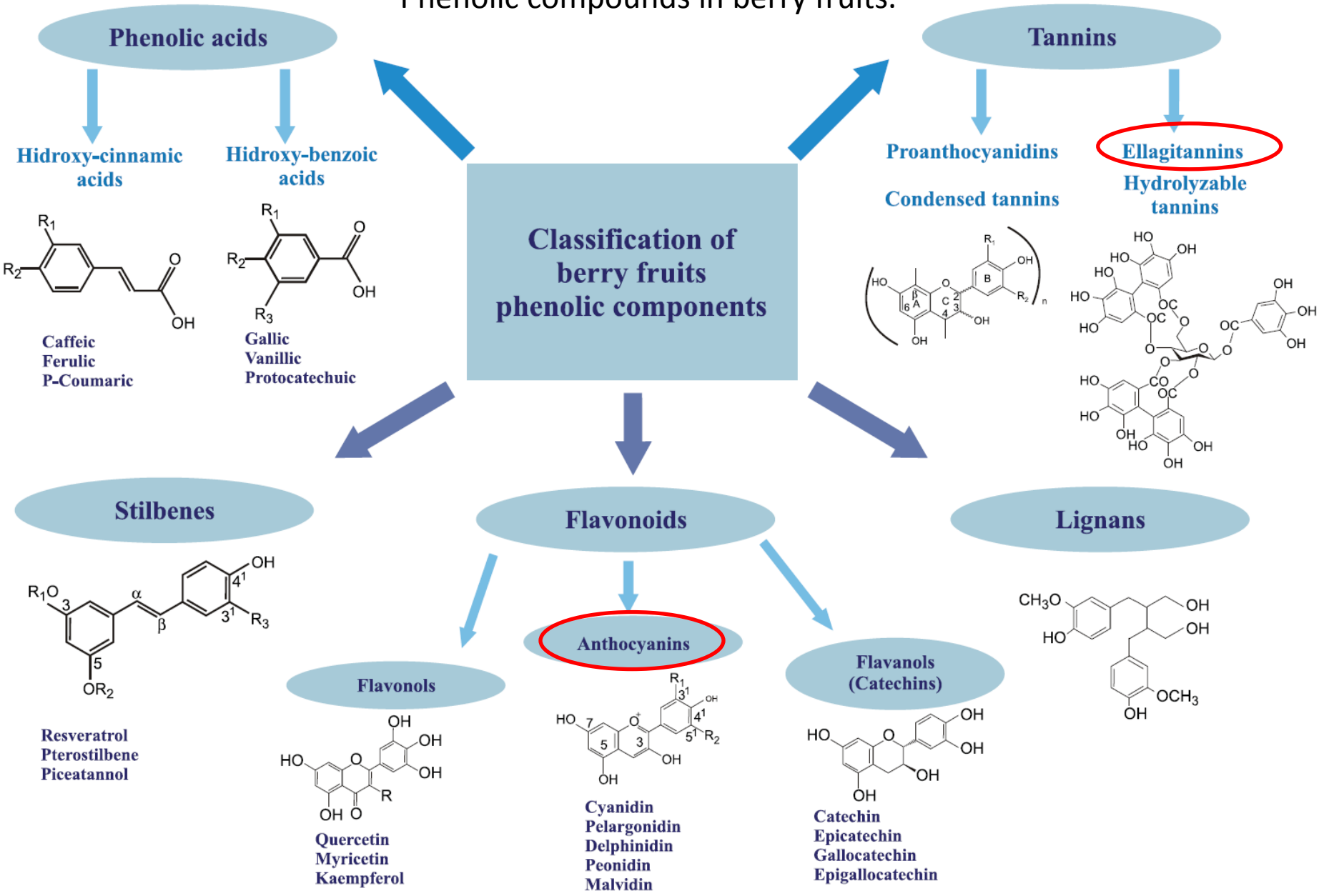
Fruit	Ascorbic acid (mg/100g)	Citric acid (%)	Malic acid (%)	pH	Titratable acidity (%)
Strawberry	37-104	0.1-2.0	0.1-0.5	3.18-3.70	0.53-1.72
Raspberry	21-31	1.3-1.8	0.1-0.2	2.65-3.88	1.67-2.38
Blackberry	13-39	0.1-0.4	0.1-1.1	2.55-4.28	0.16-4.22
Blueberry	14-16	0.2-0.5	0.1-1.1	-	0.27-1.00

(compiled from Talcott, 2007; Spanos, 1987; Cantwell Berry Irrigation project, 2013; Bremer et al., 2008)

Vitamin C and Antioxidant Activity

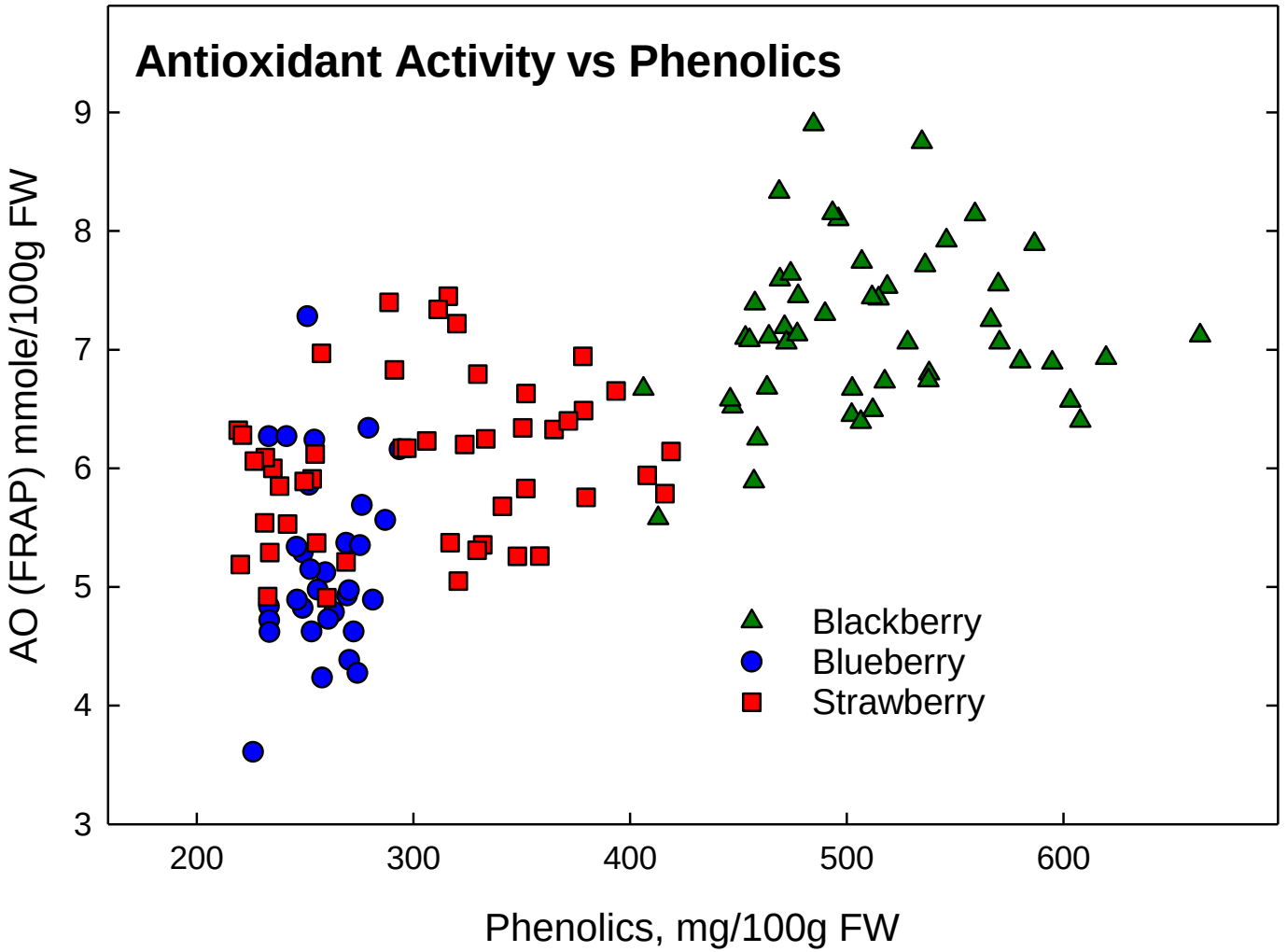
- **Vitamin C**
  - a specific vitamin required by humans
  - Active forms are sum of ascorbic acid and dehydroascorbic acid
  - 90% of Vitamin C comes from fruits and vegetable
  - needed for cell repair; protects against oxidative stress
  - Is a labile vitamin (degrades easily)
  - Often measured in storage studies of fruits and vegetables
- **Antioxidant activity**
  - With aging, there is increase in oxidative damage
  - Antioxidants can reverse early stages of oxidation
  - In fruits and vegetables, many constituents provide antioxidant activity (phenolics, Vitamin C, Vitamin E, carotenoids and others
  - Various assays can estimate total activity of antioxidant compounds in fruits and vegetables

Phenolic compounds in berry fruits.



From Berries: Improving human health and healthy aging and promoting quality life—a review.
O. Paredes-López et al. 2010. Plant Foods Human Nutrition 65: 299-308.

Data from Berry Irrigation Project, 2012 and 2013



California Berry Crops: Improving Water-Use Efficiency While Maintaining Crop Quality

- **2011-2014, Blackberry, blueberry, strawberry**
- **4 irrigation regimes, 50, 75, 100, 125% CIMIS ET**
- **Field performance and yields, marketable quality, composition, postharvest quality, consumer sensory**
- Shermain Hardesty PI, UCCE Ag Econ Nat. Res. UC Davis
- Larry Schwankl, UCCE Irrigation specialist, KAC
- Aziz Baameur, UCCE Santa Clara County
- Mark Gaskell, UCCE Santa Barbara County
- Manuel Jimenez, UCCE Tulare County
- Ramiro Lobo, UCCE San Diego County
- Beth Mitcham, UCCE Postharvest specialist, UC Davis
- Marita Cantwell, UCCE Postharvest specialist, UC Davis
- Cooperating growers

Irrigation Project
Composition of Berries

- **Soluble solids** (refractometer)
- **pH and titratable acidity** (pH meter, titration)
- **Sugars** (individual sugars by HPLC)
- **Acids** (individual acids by HPLC)
- **Vitamin C** (ascorbic + DHAA by HPLC)
- **Anthocyanins** (total by spectrophotometry)
- **Phenolics** (total by spectrophotometry)
- **Antioxidant Activity** (FRAP, spectrophotometric assay)

Berries harvested during peak of production
Berries harvested at typical commercial maturity
Berries were of marketable quality, no defects

Blackberry Irrigation Project
2012 and 2013 Samples
Fruit weight, % Dry weight

Table 1. Berry weight and percent dry weight of 2012 and 2013 'Ouchita' blackberries grown under 4 irrigation regimes. For each trial, data are averages from 4 field replicates of marketable quality fruit.

Irrigation Treatment	Weight per berry, g				Dry weight, %			
	KAC 2012 Jimenez	Santa Clara 2012 Baameur	KAC 2013 Jimenez	SLO 2013 Gaskell	KAC 2012 Jimenez	Santa Clara 2012 Baameur	KAC 2013 Jimenez	SLO 2013 Gaskell
50% ET	7.04	4.95	7.12	ND	20.18	22.31	17.11	ND
75% ET	6.96	5.76	7.12	ND	19.52	21.17	17.26	ND
100% ET	8.29	5.39	7.32	ND	19.91	20.00	16.88	ND
125% ET	7.69	6.11	6.89	ND	18.88	19.50	17.71	ND
Average	***7.50***	***5.55***	***7.11***		***19.62***	***20.74***	***17.24***	
LSD.05	ns	ns	ns		ns	1.60	ns	

Blackberry Irrigation Project 2012 and 2013 Samples Sugars and Acids

Table 2. Total sugar and total acid concentrations of 2012 and 2013 'Ouchita' blackberries grown under 4 irrigation regimes. For each trial, data are averages from 4 field replicates of marketable quality fruit.

Irrigation Treatment	**Total Sugars, mg/g FW**				**Total acids, mg/g FW**			
	KAC 2012 Jimenez	Santa Clara 2012 Baameur	KAC 2013 Jimenez	SLO 2013 Gaskell	KAC 2012 Jimenez	Santa Clara 2012 Baameur	KAC 2013 Jimenez	SLO 2013 Gaskell
50% ET	129.9	61.22	82.52	77.82	7.82	10.27	8.70	12.26
75% ET	112.3	54.46	89.26	76.36	7.65	10.69	8.10	11.66
100% ET	108.2	59.15	86.58	77.96	6.84	11.05	8.44	11.70
125% ET	110.6	57.15	92.43	77.14	7.32	11.36	7.55	11.22
Average	***115.25***	***58.00***	***87.70***	***77.32***	***7.41***	***10.84***	***8.20***	***11.71***
LSD.05	13.5	ns	ns	ns	0.71	ns	ns	*ns*

In blackberry, sugars are about 50% glucose, 50% fructose
In blackberry, acids are 40% citric, 30% malic and 30% tartaric

Blackberry Irrigation Project
2012 and 2013 Samples
Sugars: Acid Ratio and Vitamin C

Irrigation Treatment	Sugar: Acid Ratio			
	KAC 2012 Jimenez	Santa Clara 2012 Baameur	KAC 2013 Jimenez	SLO 2013 Gaskell
50% ET	16.64	6.02	9.69	6.38
75% ET	14.74	5.12	11.09	6.55
100% ET	16.09	5.36	10.33	6.67
125% ET	15.22	5.09	12.34	7.19
Average	***15.67***	***5.40***	***10.86***	***6.70***
LSD.05	ns	ns	ns	ns

Irrigation Treatment	Vitamin C, mg/100g FW	
	KAC 2012 Jimenez	Santa Clara 2012 Baameur
50% ET	24.77	31.46
75% ET	24.10	27.28
100% ET	25.33	33.63
125% ET	24.70	28.84
Average	***24.98***	***30.30***
LSD.05	ns	3.12

Blackberry Irrigation Project 2012 and 2013 Samples Anthocyanins and Phenolics

Table 4. Anthocyanin and phenolic concentrations of 2012 and 2013 'Ouchita' blackberries grown under 4 irrigation regimes. For each trial, data are averages from 4 field replicates of marketable quality fruit.

Irrigation Treatment	**Anthocyanins, mg/100g FW**				**Phenolics, mg/100g FW**			
	KAC 2012 Jimenez	Santa Clara 2012 Baameur	KAC 2013 Jimenez	SLO 2013 Gaskell	KAC 2012 Jimenez	Santa Clara 2012 Baameur	KAC 2013 Jimenez	SLO 2013 Gaskell
50% ET	173.1	132.9	177.4	ND	576.7	578.0	456.2	ND
75% ET	209.7	133.4	173.7	ND	529.9	557.3	460.9	ND
100% ET	211.2	134.7	184.9	ND	545.2	508.3	472.9	ND
125% ET	237.9	130.1	184.2	ND	498.2	496.5	452.5	ND
Average	***208.0***	***132.8***	***180.1***		***537.3***	***535.0***	***460.6***	
LSD.05	23.1	ns	ns		ns	ns	ns	

Sensory Attributes and Fruit Composition

- All fruit components (sugars, acids, volatiles, etc…) combine to generate a unique sensory experience for the consumer

- Physical-chemical methods give accurate measurements of fruit composition

- It is difficult to relate these measurements to fruit quality without information about sensory perceptions

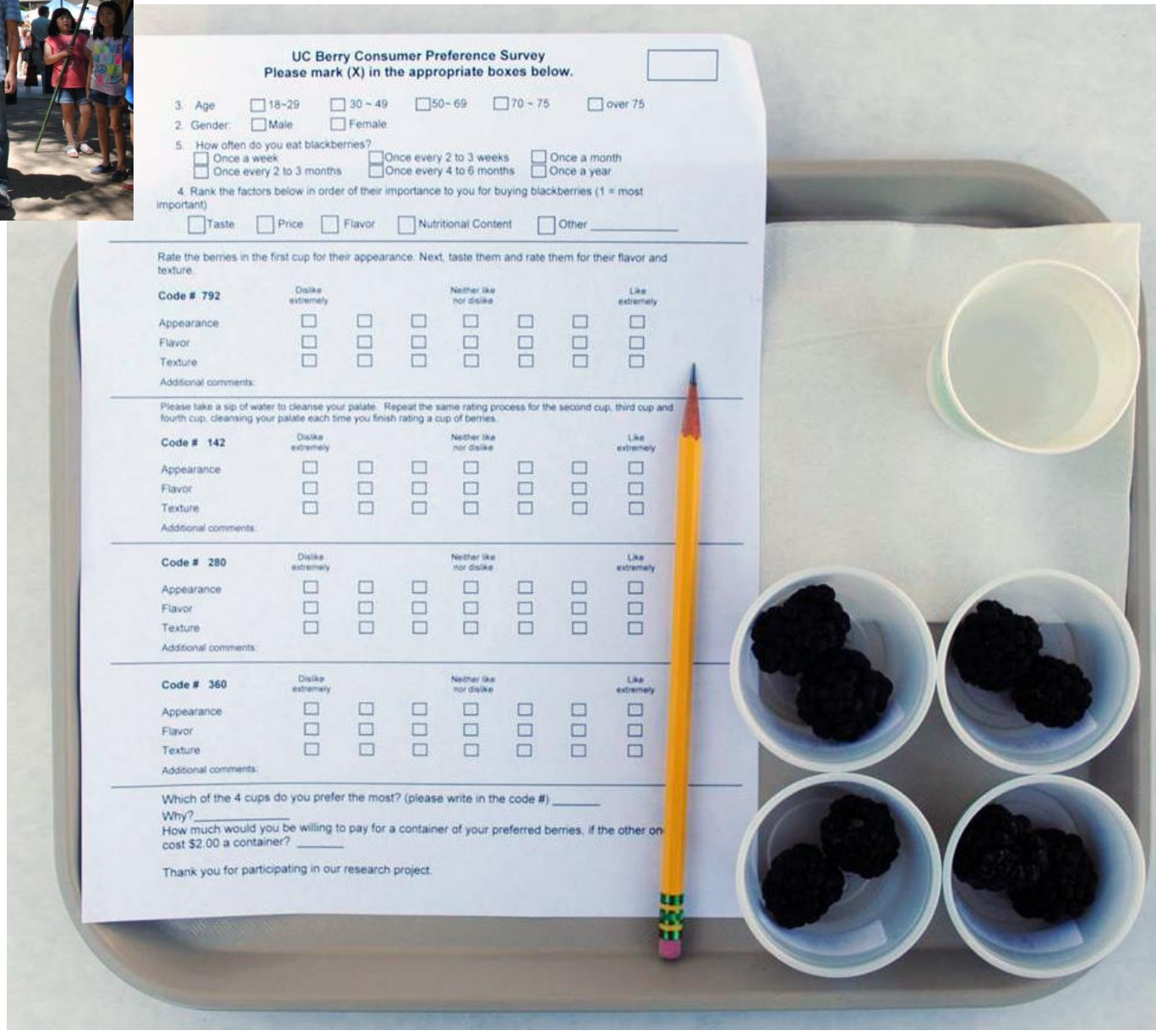
Berry Irrigation Project
Consumer Sensory Evaluation

- Consumers evaluated the following sensory parameters: Appearance, Flavor and Texture

- Consumers indicated price they would pay for clamshell of their preferred irrigation treatment
  - 6 oz. for blackberries and blueberries
  - 1 lb. for strawberries

- We recorded consumer's age, gender, how often they consumed the specific berry, and their preference among irrigation treatments

Davis Farmer's Market
6-29-12



UC Berry Consumer Preference Survey
Please mark (X) in the appropriate boxes below.

3. Age ☐ 18~29 ☐ 30 ~ 49 ☐ 50~ 69 ☐ 70 ~ 75 ☐ over 75
2. Gender: ☐ Male ☐ Female
5. How often do you eat blackberries?
☐ Once a week ☐ Once every 2 to 3 weeks ☐ Once a month
☐ Once every 2 to 3 months ☐ Once every 4 to 6 months ☐ Once a year
4. Rank the factors below in order of their importance to you for buying blackberries (1 = most important)
☐ Taste ☐ Price ☐ Flavor ☐ Nutritional Content ☐ Other _____

Rate the berries in the first cup for their appearance. Next, taste them and rate them for their flavor and texture.

Code # 792	Dislike extremely			Neither like nor dislike			Like extremely
Appearance	☐	☐	☐	☐	☐	☐	☐
Flavor	☐	☐	☐	☐	☐	☐	☐
Texture	☐	☐	☐	☐	☐	☐	☐

Additional comments:

Please take a sip of water to cleanse your palate. Repeat the same rating process for the second cup, third cup and fourth cup, cleansing your palate each time you finish rating a cup of berries.

Code # 142	Dislike extremely			Neither like nor dislike			Like extremely
Appearance	☐	☐	☐	☐	☐	☐	☐
Flavor	☐	☐	☐	☐	☐	☐	☐
Texture	☐	☐	☐	☐	☐	☐	☐

Additional comments:

Code # 280	Dislike extremely			Neither like nor dislike			Like extremely
Appearance	☐	☐	☐	☐	☐	☐	☐
Flavor	☐	☐	☐	☐	☐	☐	☐
Texture	☐	☐	☐	☐	☐	☐	☐

Additional comments:

Code # 360	Dislike extremely			Neither like nor dislike			Like extremely
Appearance	☐	☐	☐	☐	☐	☐	☐
Flavor	☐	☐	☐	☐	☐	☐	☐
Texture	☐	☐	☐	☐	☐	☐	☐

Additional comments:

Which of the 4 cups do you prefer the most? (please write in the code #) _____
Why?_____
How much would you be willing to pay for a container of your preferred berries, if the other on
cost $2.00 a container? _____

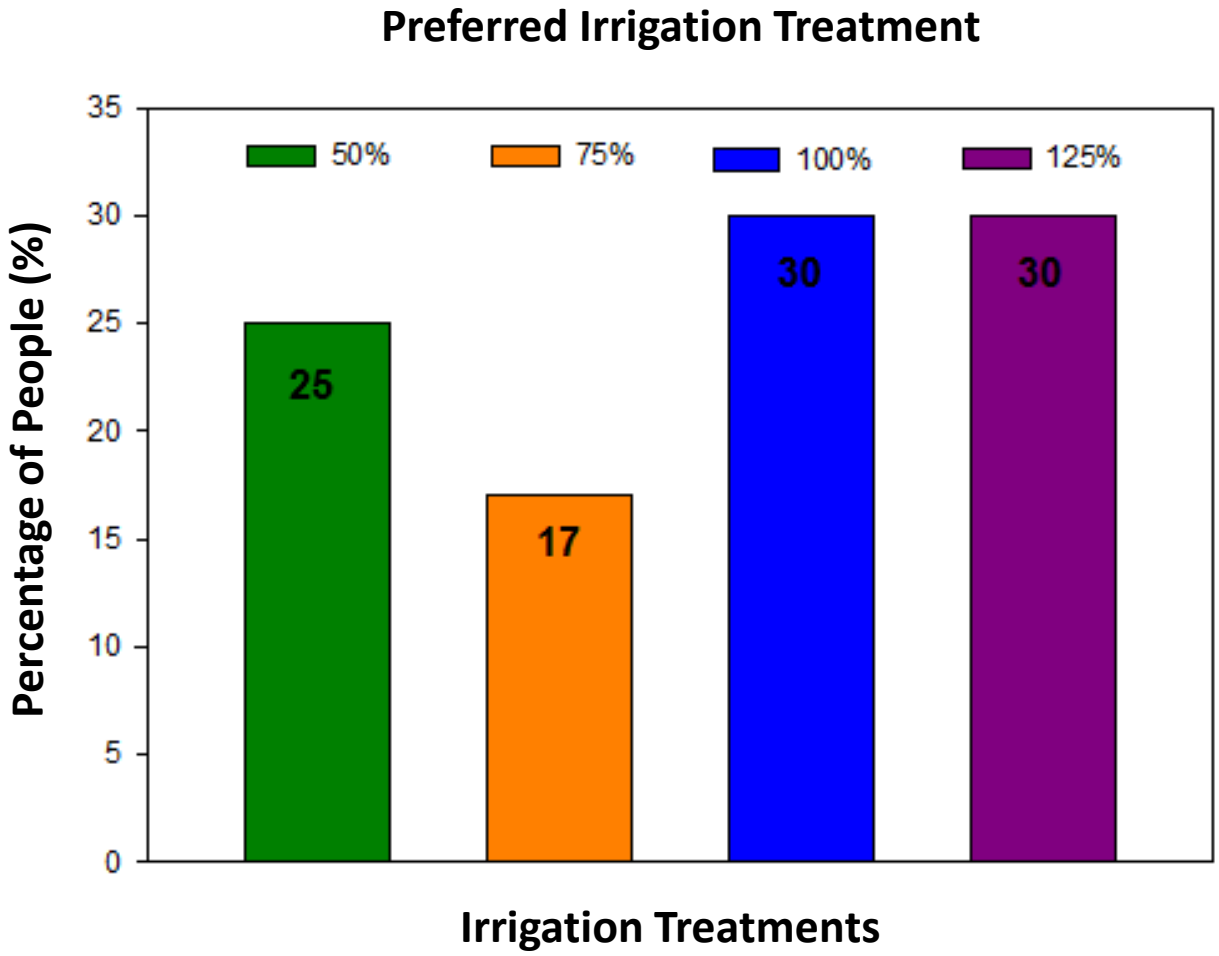
Thank you for participating in our research project.

Blackberry from Kearney, CA
Davis Farmer's Market
6-29-12

- FLAVOR ranked #1 as most important factor for quality

- How much would pay for preferred if others cost $2.00?

- Ave. $2.91
- Min. $2.25
- Max. $5.00



Postharvest Quality Measurements

Overall Quality:
Visual appearance of clamshells rated
Scale: 1=Excellent, 2=Good, 3=Fair, 4=Poor/Unmarketable

Diseases: Number of fruit with diseases in clamshell

Shrival/Calyx Browning:
Scale: 1=None, 2=Slight, 3=Moderate, 4=Severe

Blackberry Postharvest Conclusions (1 storage test)

- 50% ET and 75% ET consistently had higher firmness initially and throughout storage
- 50% ET displayed poorest overall quality and the most decay after 10-12 days of storage
- 100% ET and 125% ET displayed best quality and least decay after 10-12 days of storage

Berry Irrigation Project Conclusions to date--Blackberries

- Berry weight not affected by irrigation regimes
- Sugars and acids were affected by irrigation treatments only in 1 of 4 blackberry trials
- Variation from location to location much greater than variation due to irrigation
- 1 consumer sensory test showed no trend in preference due to irrigation treatment
- Higher irrigation rates resulted in less decay (1 storage test)
- More information in 2014

Causes of Quality & Postharvest Losses

Berry Fruits

Blackberry
Blueberry
Cranberry
Currants
Loganberries
Raspberry
Strawberry

- Mechanical damage
- Maturity, immature, overmature
- Poor ripening, conditioning
- Softening, texture loss
- Changes in composition
- Water loss
- Microbial growth

10 Basic Postharvest Principles

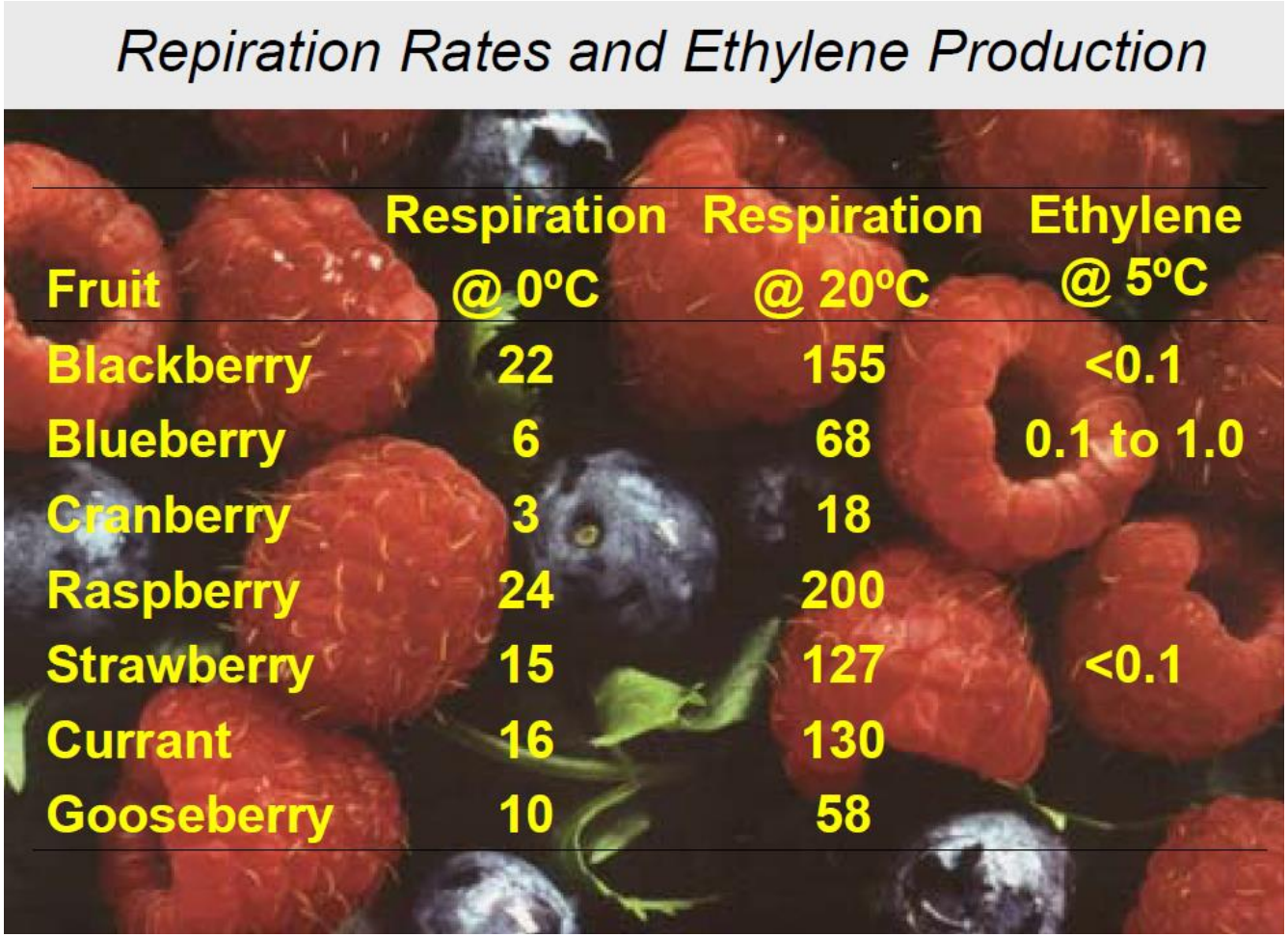
1) Harvest at correct maturity
2) Reduce physical handling
3) Protect product from sun
4) Keep packingline or area simple and clean; ensure good worker hygiene
5) Select, classify, and pack carefully
6) Align cartons, strap pallet
7) Cool as soon as possible
8) Know market and product requirements
9) Coordinate efficient & rapid handling
10) Train and compensate workers adequately

Postharvest Handling of Berries

Forced-Air Cooling is Standard for Berries

- **Cool fruit to 0°C as quickly as possible**
  - **Cool within 2 hours of harvest**
- **When cooled, 90 – 95% RH**
  - **Reduce water loss**
  - **Reduce decay**
  - **Reduce respiration rate and extend postharvest life**
- **Maximum postharvest life**
  - **Strawberry – 2 weeks**
  - **Raspberry and blackberry – 1 week**
  - **Blueberry – 4 weeks**

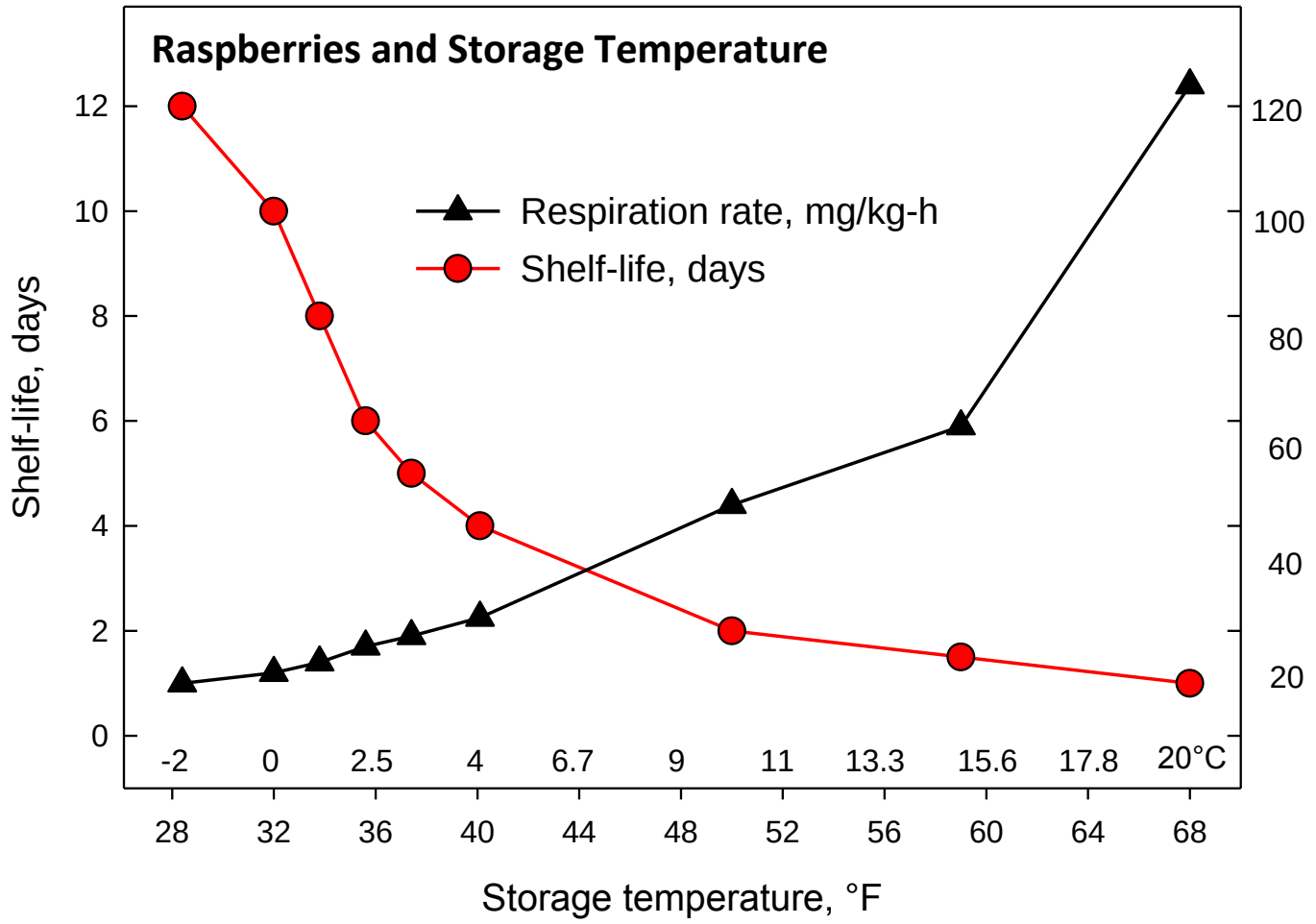
Higher respiration rates are generally correlated with shorter postharvest life



From EJ Mitcham, UC Davis

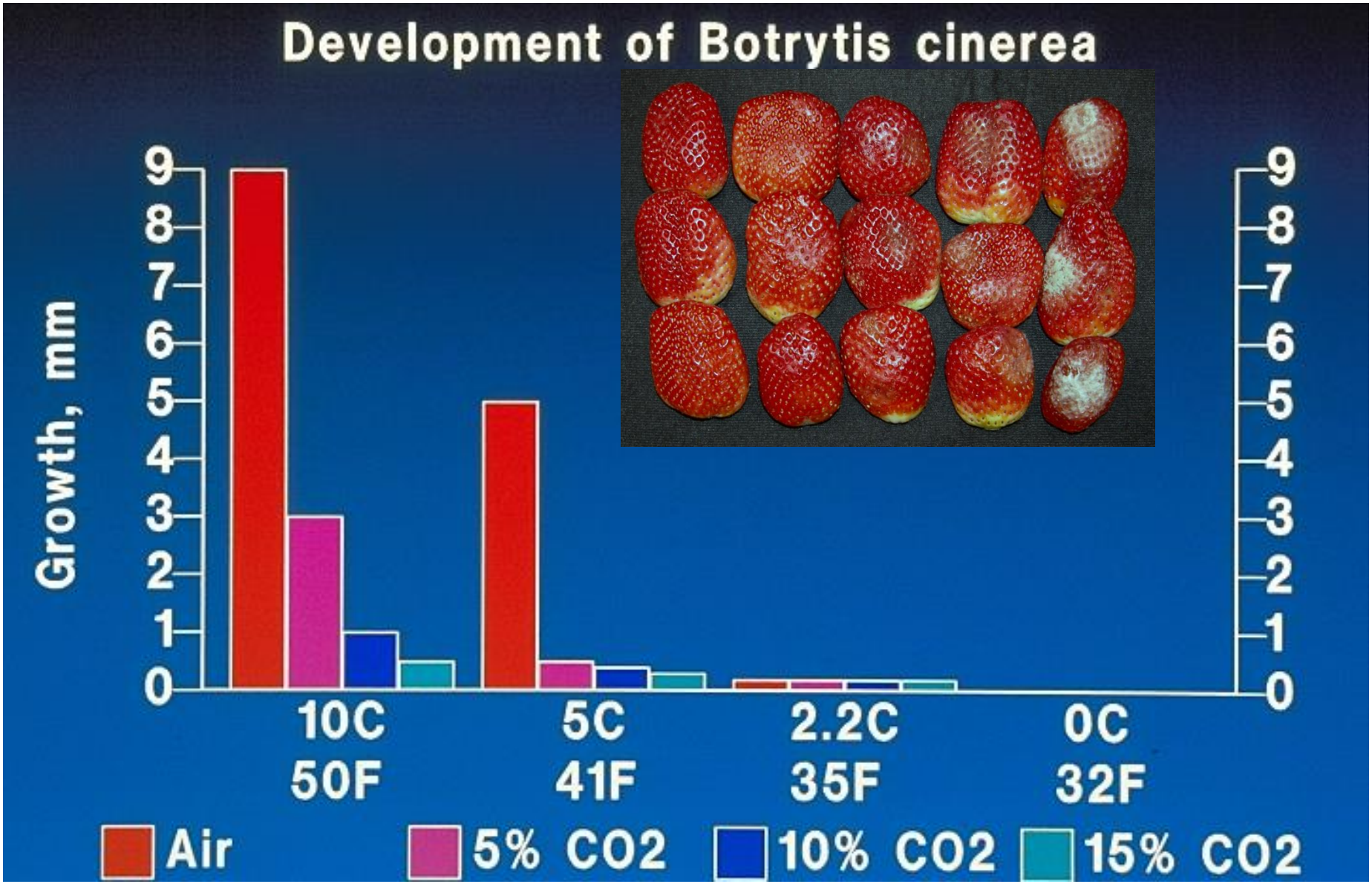
Respiration rates, mg/kg-h

Temperature affects shelf-life by controlling metabolism and decay



from data of Perkins-Veazie, Raspberries, USDA Agric Hdbk66

Effect of Temperature and Carbon Dioxide on Growth of *Botrytis cinerea*



Berry Quality Resources

- UC Postharvest website
  http://postharvest.ucdavis.edu/libraries/publications/

  Produce facts for bushberries and strawberries

  http://postharvest.ucdavis.edu/PFfruits/Bushberries/

  http://postharvest.ucdavis.edu/PFfruits/Strawberry/
- USDA Handbook 66, The Commercial Storage of Fruits, Vegetables, and Florist and Nursery Stocks

  http://www.ba.ars.usda.gov/hb66/contents.html
- Berry Fruit. Value-added Products for Health Promotion. Ed. Y. Zhao. 2007. CRC Press.
- Soft Fruit by L.A. Terry. 2012. In: Crop Postharvest Science and Technology, Wiley Publisher.
- Bioactive Compounds and Health-Promoting Properties of Berry Fruits: A Review. 2008. A. Szajdek, E.J. Borowska. Plant Foods Human Nutrition 63: 147-156.

http://postharvest.ucdavis.edu

Produce Facts

- Harvest indices
- Quality indices
- Temperature and RH
- Freezing point/damage
- Respiration rates
- Ethylene production
- Effects of ethylene
- Effects of modified atmospheres
- Physiological disorders
- Postharvest diseases
- Mechanical injury
- Photos

140
Fruits
Vegetables
Flowers

English, Spanish, French, Arabic

Free, content-rich website averages over 3 million views annually,
And encompasses more than 640 pages and 1750 pdf documents.










Thank you!