A close-up photograph of a hand holding a single, ripe strawberry with its green leaves. The strawberry is the central focus, showing its characteristic red color and small seeds. The background is softly blurred, showing the skin of the hand and more green leaves.

# **Optimizing Carbon Dioxide Enrichment in Controlled Environments to Enhance Production and Crop Quality**

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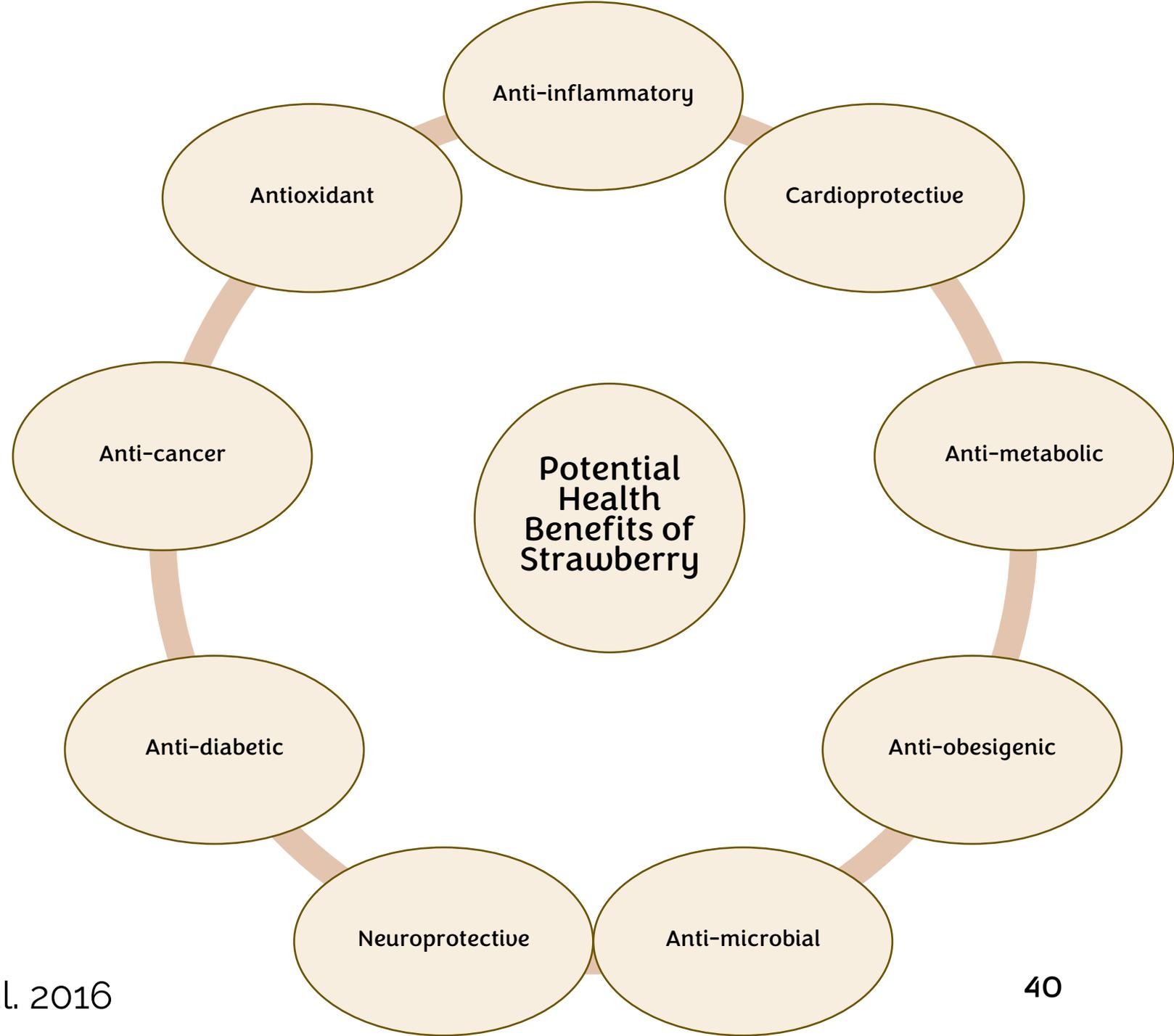
**Department of Horticulture and Landscape Architecture**

**Colorado State University**

## Experiment 3:

# Impacts of CO<sub>2</sub> Enrichment on Yield and Quality of Everbearing Strawberries

# Strawberries are Nutritionally Robust



Adapted from Figure 1 in Afrin et al. 2016

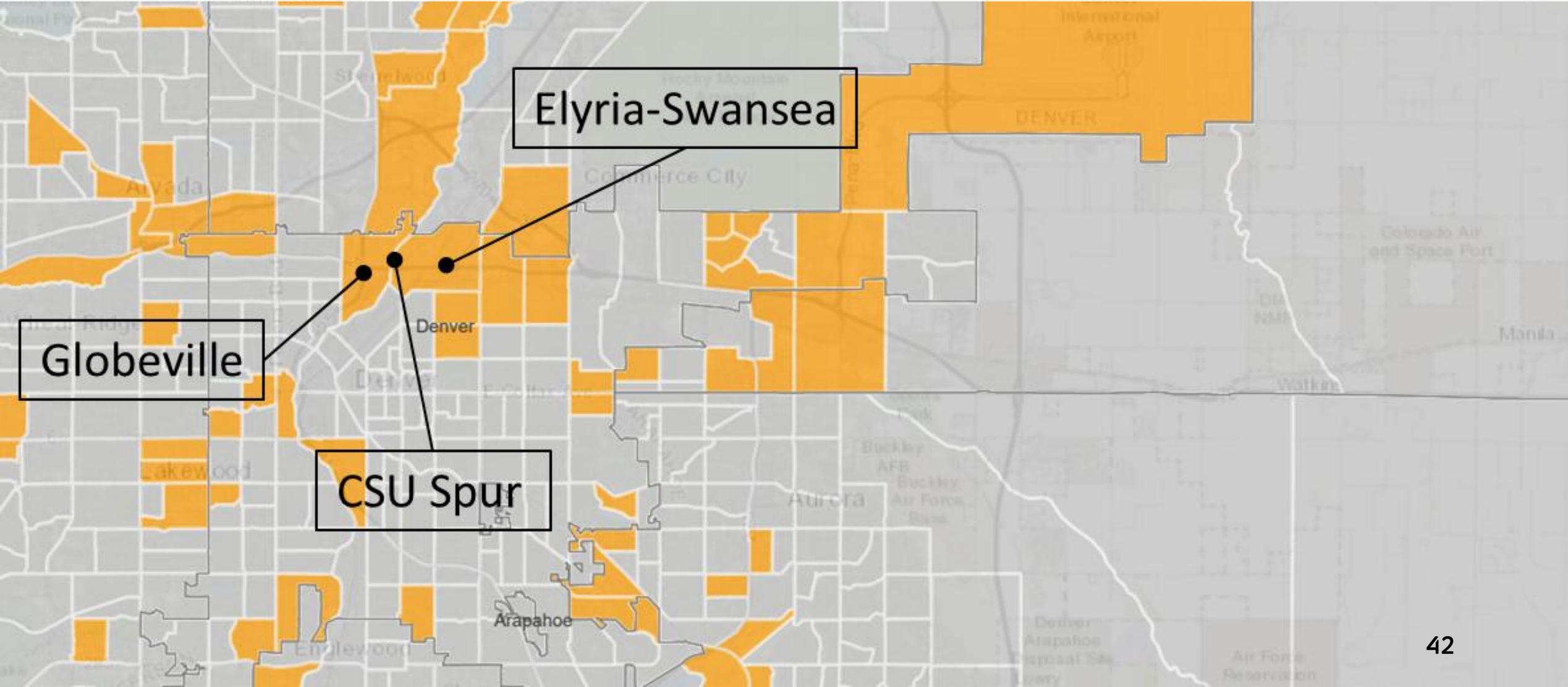
# Strawberries

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- Top consumed and produced berry in the U.S.
- Demand has increased interest in CEA production
- CO<sub>2</sub> enrichment has shown increased yields and value-added qualities



# There is a Need for Increased Access to More Nutritional Foods in Denver, Colorado



**Evaluate the impact of CO<sub>2</sub> enrichment during reproductive growth on everbearing strawberry yield and fruit quality**

**Increase opportunities for the Denver community to participate in CEA strawberry production**

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Research Objectives

*Fragaria ×ananassa* 'Albion'



Photo Credit: Oliver Fulton, Fulton Farms

*Fragaria ×ananassa* 'Ozark Beauty'



# CO<sub>2</sub> Fruit: Experimental Design

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4 Conviron GR64 Walk-In Growth Chambers

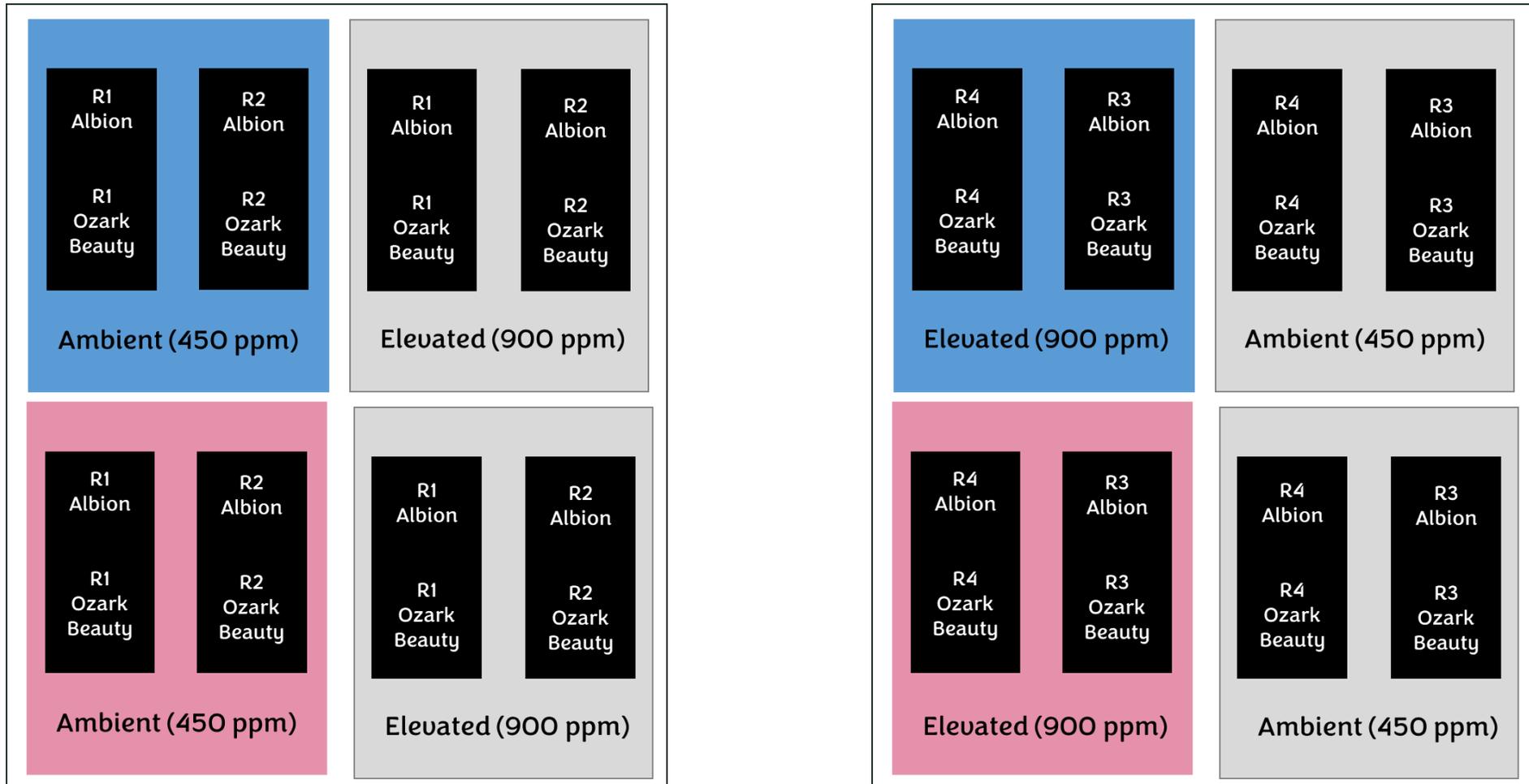
- Temperature 22/18 °C (day/night)
- Relative Humidity 55/65% (day/night)
- DLI ~20
- 18-h Photoperiod
- 4 chambers, 2 at 450 or 900  $\mu\text{mol}\cdot\text{mol}^{-1}$  CO<sub>2</sub>

Campbell CR1000X data logger



# CO<sub>2</sub> Fruit: Experimental Design

# CO<sub>2</sub> Fruit: Experimental Design



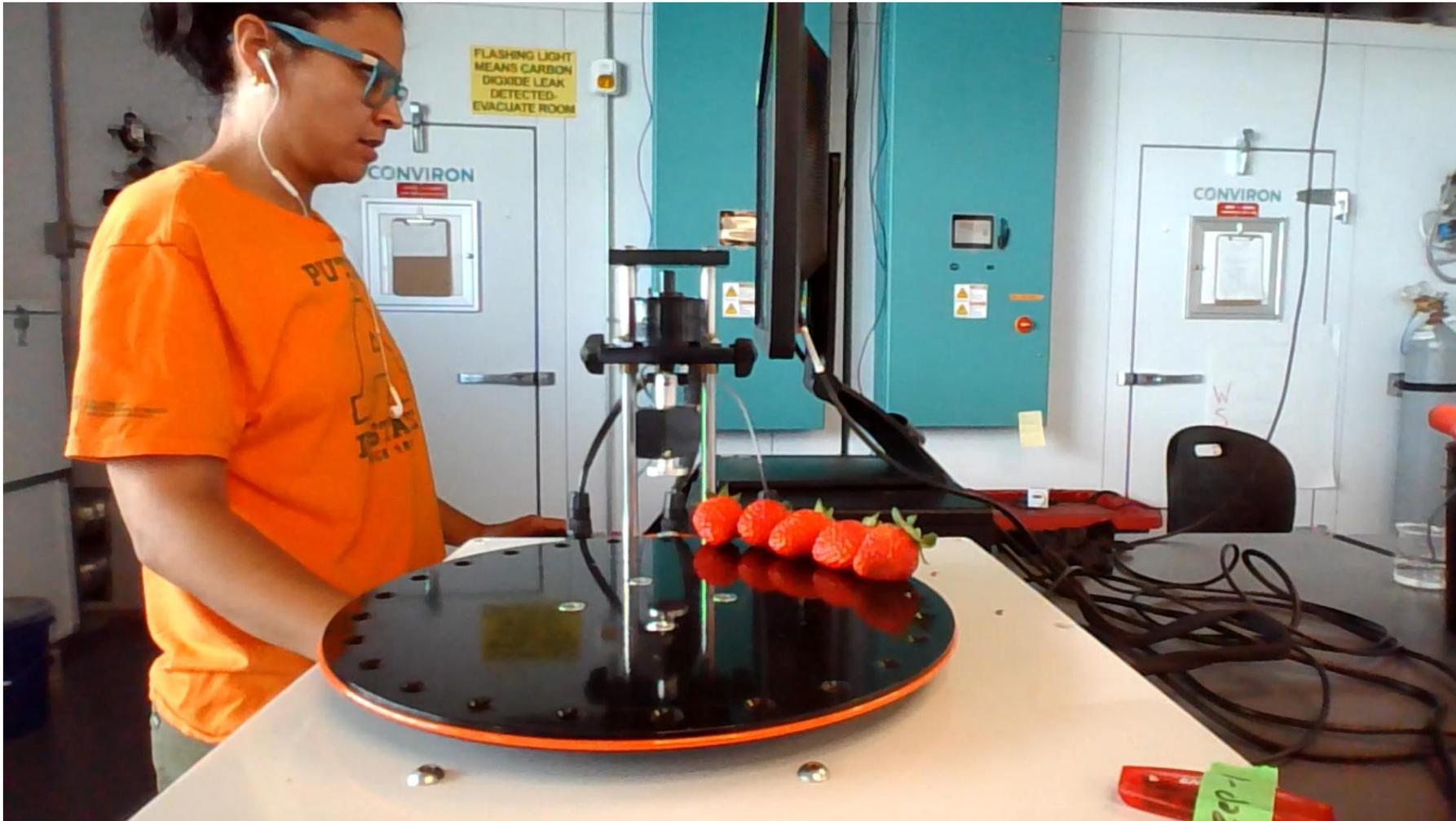
# CO<sub>2</sub> Fruit: Gas Exchange

- 7 days of consecutive survey measurements
- “Old” and “new” leaves
- A/C<sub>i</sub> Curves on days 7 and 14 on old and new leaves
- Fit Farquhar-von Caemmerer-Berry model with SAS OnDemand for Academics



# CO<sub>2</sub> Fruit: Harvest

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- Day to first harvest
- Fruit number
- Fruit width (in)
- Fruit weight (g)
- USDA fruit grade
- Firmness (N·m<sup>-2</sup>)\*
- Brix\*

# CO<sub>2</sub> Fruit: Sensory Analysis

Appearance liking

Rate all that apply

Example attributes:

- Sweet
- Sour
- Fruity
- Floral



Overall liking

Demographics

- Residence
- Perceptions
- Local

0

10

Not Present

Very Strong  
49

# CO<sub>2</sub> Fruit: Morphological Collection

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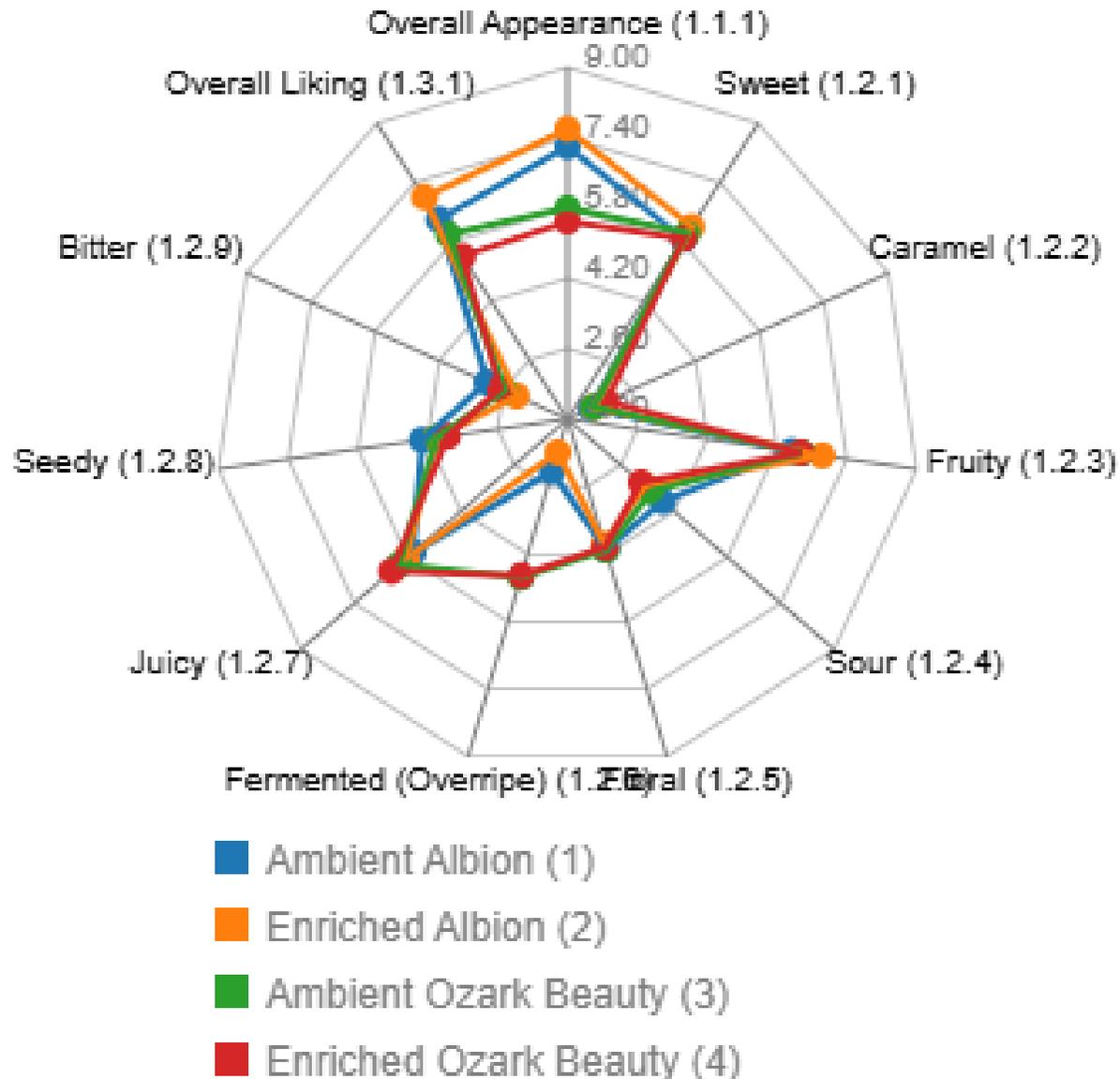


- Relative chlorophyll content
- Crown number
- Crown caliper (mm)
- Truss number
- Unripe fruit number
- Flower/bud number
- Leaf number
- Leaf area (cm<sup>2</sup>)
- Stem, leaf, truss, crown, unripe fruit, flower/bud dry mass (mg)
- Leaf mass area (LMA; mg·cm<sup>2</sup>)

# CO<sub>2</sub> Fruit: Enrichment Increased Fruit Yield in These Cultivars

	Fruit Number	Average Fruit Weight (grams)	Average Fruit Width (inches)	% USDA Grade 1	Average Firmness (N·m <sup>-2</sup> )
<b>Albion</b>					
Ambient	233	23.0	1.4	82%	200.0
Enriched	280	25.6	1.4	84%	199.2
<b>Ozark Beauty</b>					
Ambient	242	10.1	1.1	81%	136.1
Enriched	386	10.3	1.2	78%	135.9

# Mean scores for 'RATA'



**CO<sub>2</sub> Fruit:  
Consumers May  
Prefer 'Albion'  
Over 'Ozark  
Beauty'**



# CO<sub>2</sub> Fruit: Enrichment Increased Strawberry Yield While Maintaining Quality



Increased Yield



Crop Quality



Consumer Preferences



Nutritional Quality

# Next Steps: Phytochemical Analysis

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# Summary

- All of the plants in these experiments acclimated to CO<sub>2</sub> enrichment
- Despite acclimation, there are clear benefits to enriching in CEA
- Based on the preliminary data, there are no differences in quality under enriched CO<sub>2</sub> concentrations

*Optimizing CO<sub>2</sub> enrichment in CEA by overcoming acclimation may provide an even greater net benefit to producers while improving resource use efficiency.*

# Grower's Guide to Straw'

**Temperature:** 20/12 °C day/night (optimal range 20

**Relative Humidity:** 55/65% day/night (optimal ra

**Light:** A 16-hour photoperiod of 348  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$   $\approx$  20  $\text{mol}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$  (optimal range 20-25  $\text{mol}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$ ) cultivars are facultative long day plants. The r hours.

**Fertigation:** Water-soluble fertilizer provi 26 K Strawberry Part A and Jack's 15-0-0 down between waterings. Nutrient solut target: 1.0 and pH target: 5.5-6.0.

**Pollination:** Hand-pollinated daily

**Harvesting:** From the time of plant harvest after 10 weeks of growth for the next 7 weeks.

**Pest:**  
Spider Mites, Thrips, Aphids



**Our  
Work  
Has  
Reached  
Over  
900  
People**

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**The Semilla Project**

# Western Region Sustainable Agriculture Research & Education Program Outreach Survey

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