

POSTHARVEST FRUIT QUALITY OF YELLOW SWEET PEPPER GROWN UNDER RETRACTABLE ROOF GREENHOUSE WITH AND WITHOUT ANTI-INSECT NET AND SHADEHOUSE CONDITIONS AT CULIACAN, MEXICO



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Fruits of yellow color sweet pepper (cultivar Estefania – Syngenta) were harvested from three growing system under protected environment :

1. Retractable roof greenhouse (CRAVO unprotected) WITHOUT anti-insect net



2. Retractable roof greenhouse (CRAVO protected) WITH anti-insect net



3. Shade house



All protected growing systems are located in agricultural valley of Culiacan Sinaloa, México.

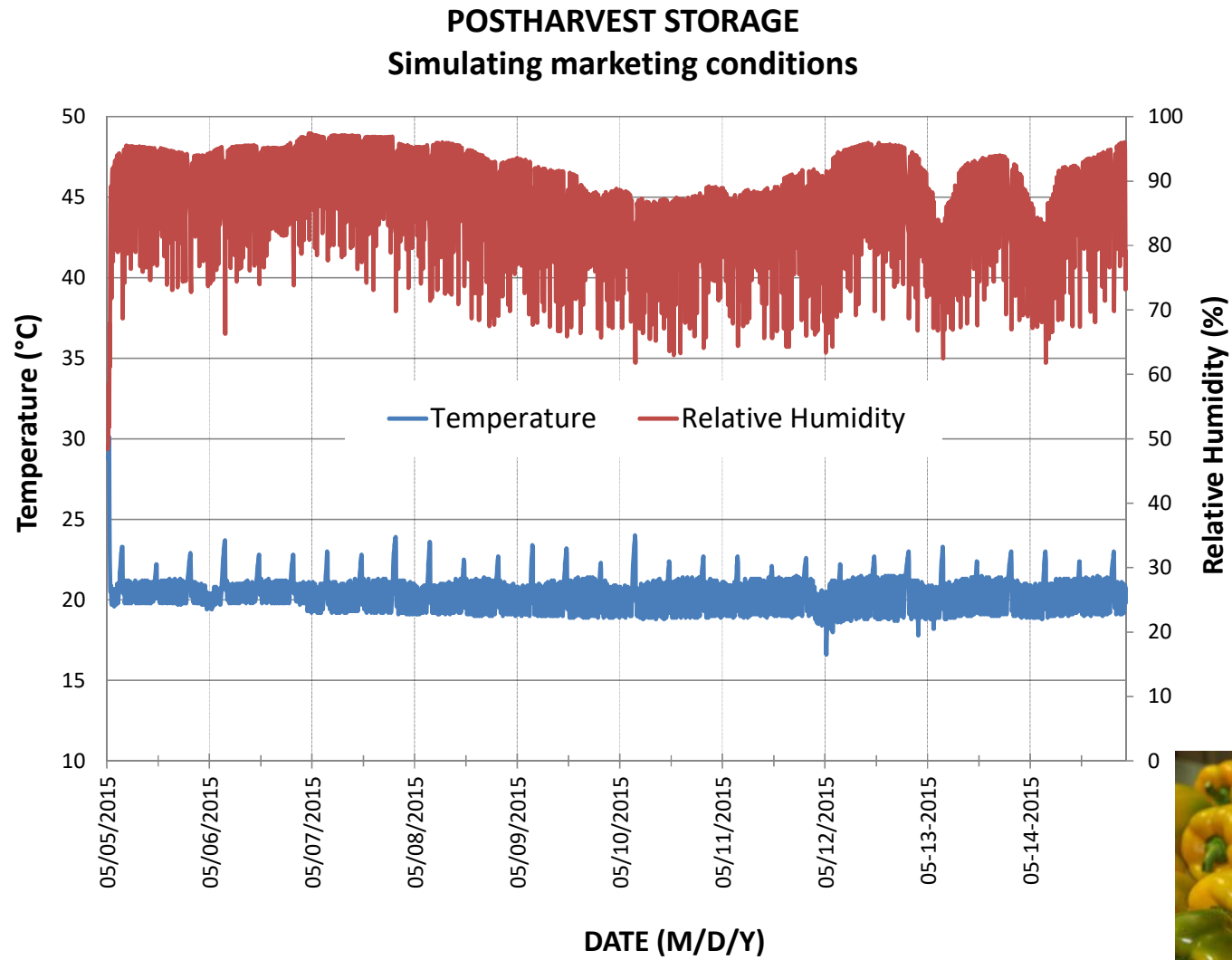
Fruits were harvested by CIAD staff on May 05th 2015 and then transported to postharvest Lab after 2-3 hours on plastic containers protected inside with plastic foam to avoid fruit damage.

Once in postharvest Lab., all fruits were:

- ❖ **Washed and disinfected with chlorine water at 300 ppm**
- ❖ **Dried at room temperature**
- ❖ **Homogenized by size, ripeness, absence of defects (injured, deformed, damaged, etc.)**
- ❖ **Sorted by size uniformity .**
- ❖ **Identified each to following up change of color during postharvest storage**

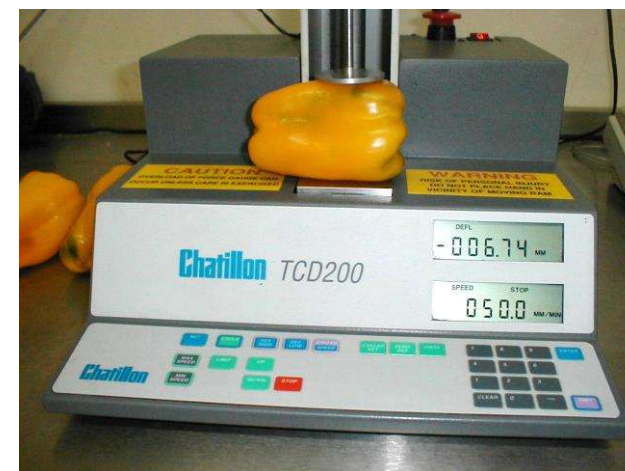


Subsequently, fruits of all treatments were stored for 14 days at 20 ° C and 70-90% RH to simulate marketing conditions and evaluating fruit quality and color changes regularly



During postharvest room storage, following fruit quality analysis were conducted:

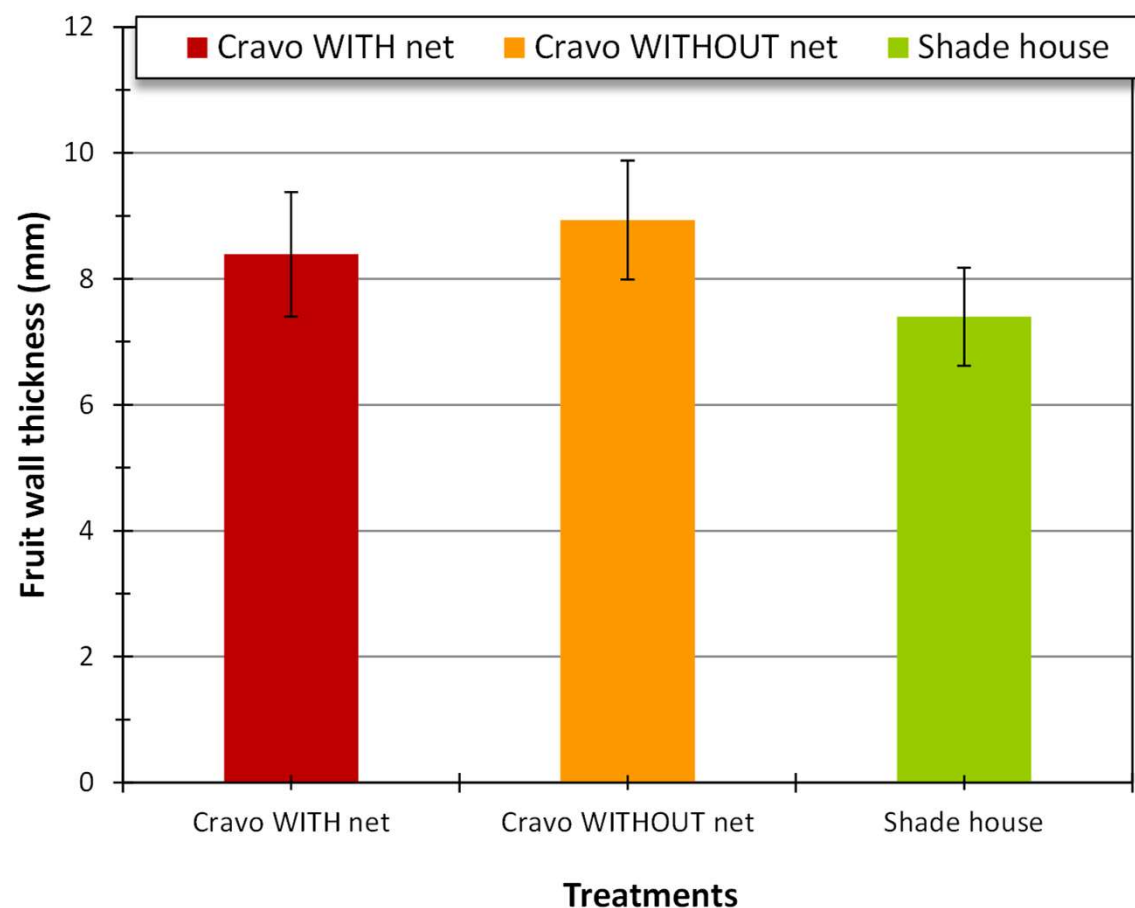
- ❖ Physical analysis: wall thickness (mm), weight loss (%), firmness (millimeters deformed by applying a constant force), peel color (brightness, chrome and Hue angle)
- ❖ Chemical analysis: titratable acidity (% of citric acid), total soluble solids (° Brix) and pH



RESULTS. Sweet pepper



RESULTS. Wall thickness



**Digital caliper AutoTec
150 mm (d=0.01 mm)**

General Linear Model: Wall thickness versus Treatments

Grouping Information Using Tukey Method and 95.0% Confidence

Treatment	N	Mean	Grouping
Cravo WITHOUT net	32	8.932	A
Cravo WITH net	32	8.387	B
Shade house	32	7.397	C

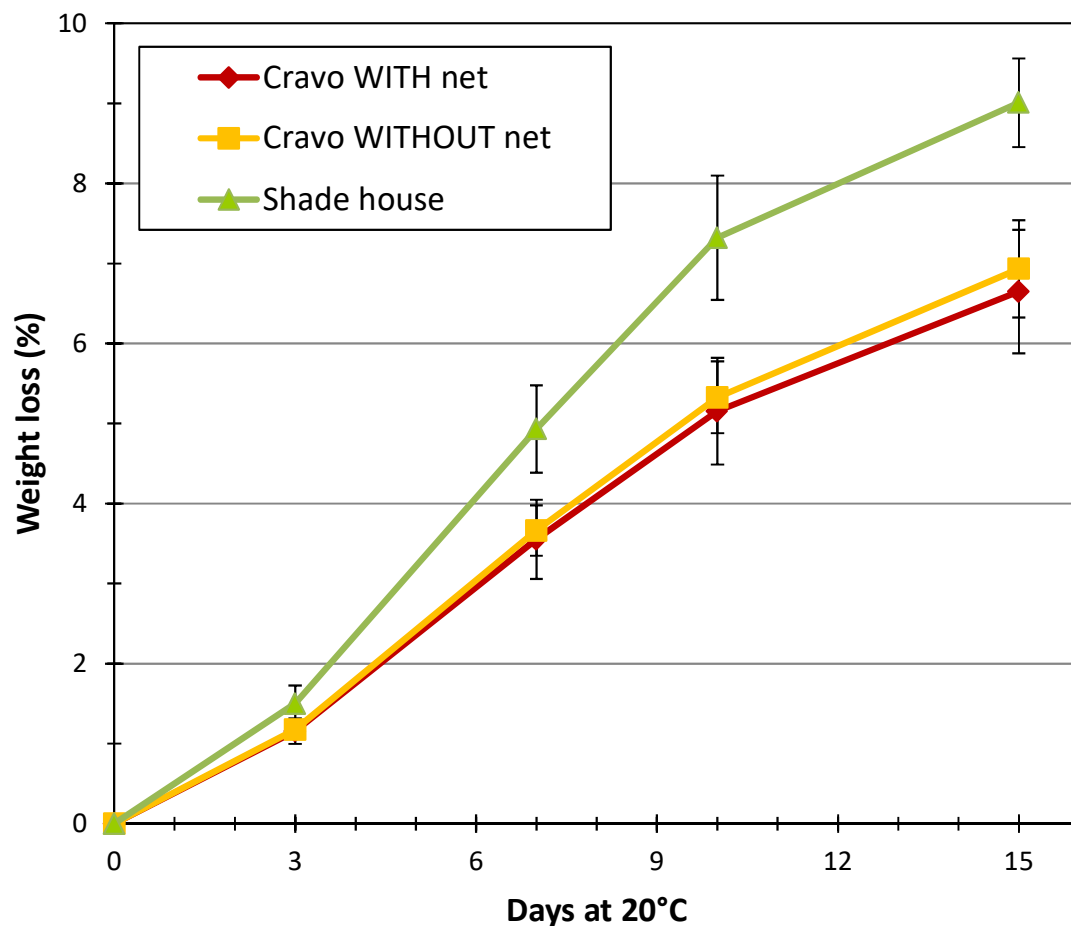
Means that do not share a letter are significantly different.

Fruits of greater wall thickness are associated with firmer fruits and longer postharvest life

Average of 32 fruits

Fruit variability within each treatment is given by length of standard deviation bar

RESULTS. Weight loss (%)



General Linear Model: Cumulative weight loss versus Treatments

Grouping Information Using Tukey Method and 95.0% Confidence

Treatment	N	Mean	Grouping
Shade house	24	4.53209	A
Cravo WITHOUT net	25	3.41995	B
Cravo WITH net	25	3.30269	B

Means that do not share a letter are significantly different.

In sweet peppers, cumulative weight loss between 6 and 8% causes fruit wilting and shriveling.

Fruits grown on shade house conditions lost more weight than those produced at retractable roof greenhouse (CRAVO) with and without anti-insect net

These results may be due to differences in fruit cuticle composition during growth as a result of environmental conditions, crop management and nutrition, among other factors.

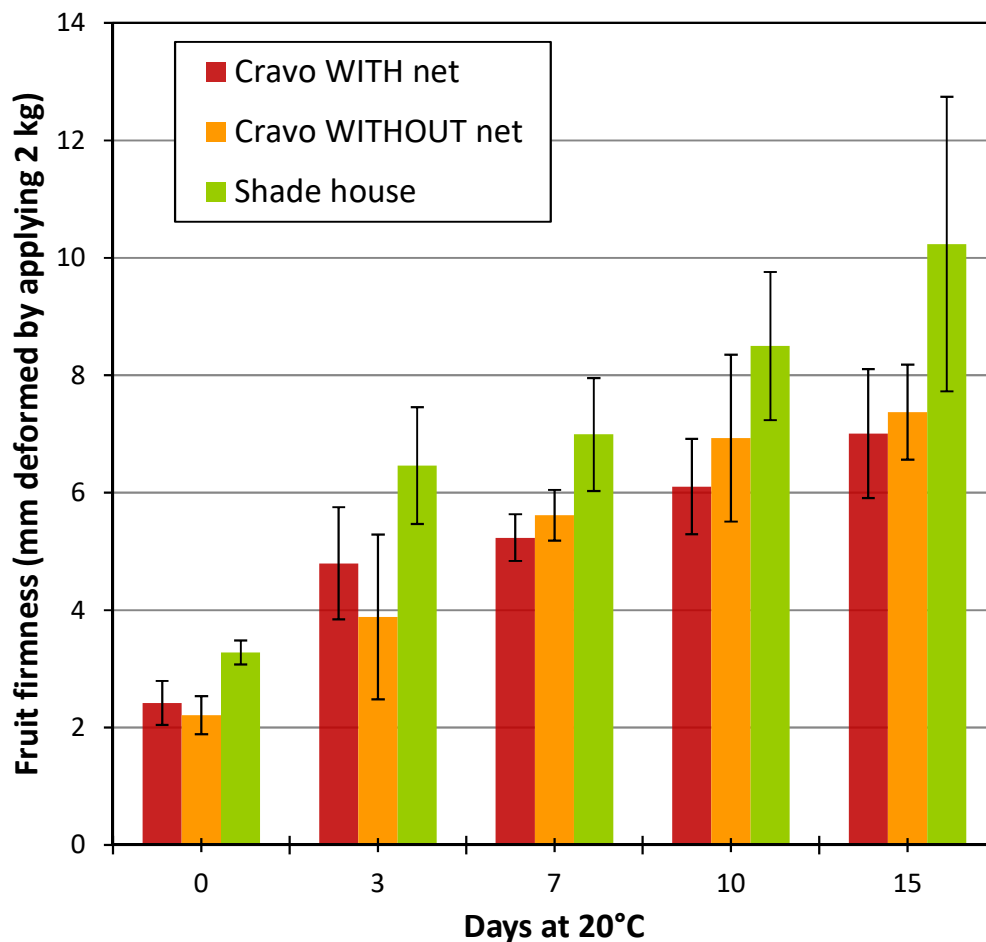
Average of 5 fruits (Repeated measurement in same fruits at each evaluation time)



DIGITAL SCALE
Sartorius mod. BP4100 d=0.01 g

Individual weight of 5 fruit per treatment. Same fruits were weighted at each evaluation date

RESULTS. Fruit firmness (mm deformed)



Greater deformation means more flabby fruit

Deformations above 10 mm are considered unsuitable for marketing since fruits are too flabby.

In sweet peppers, fruit firmness values are directly related to water loss

Average of 4 fruits (Destructive measurement. 5 different fruits at each evaluation time)
Fruit variability within each treatment is given by length of standard deviation bar

General Linear Model: Fruit firmness (mm) versus Treatments

Grouping Information Using Tukey Method and 95.0% Confidence

Treatment	N	Mean	Grouping
Shade house	20	7.092	A
Cravo WITHOUT net	20	5.204	B
Cravo WITH net	20	5.113	B

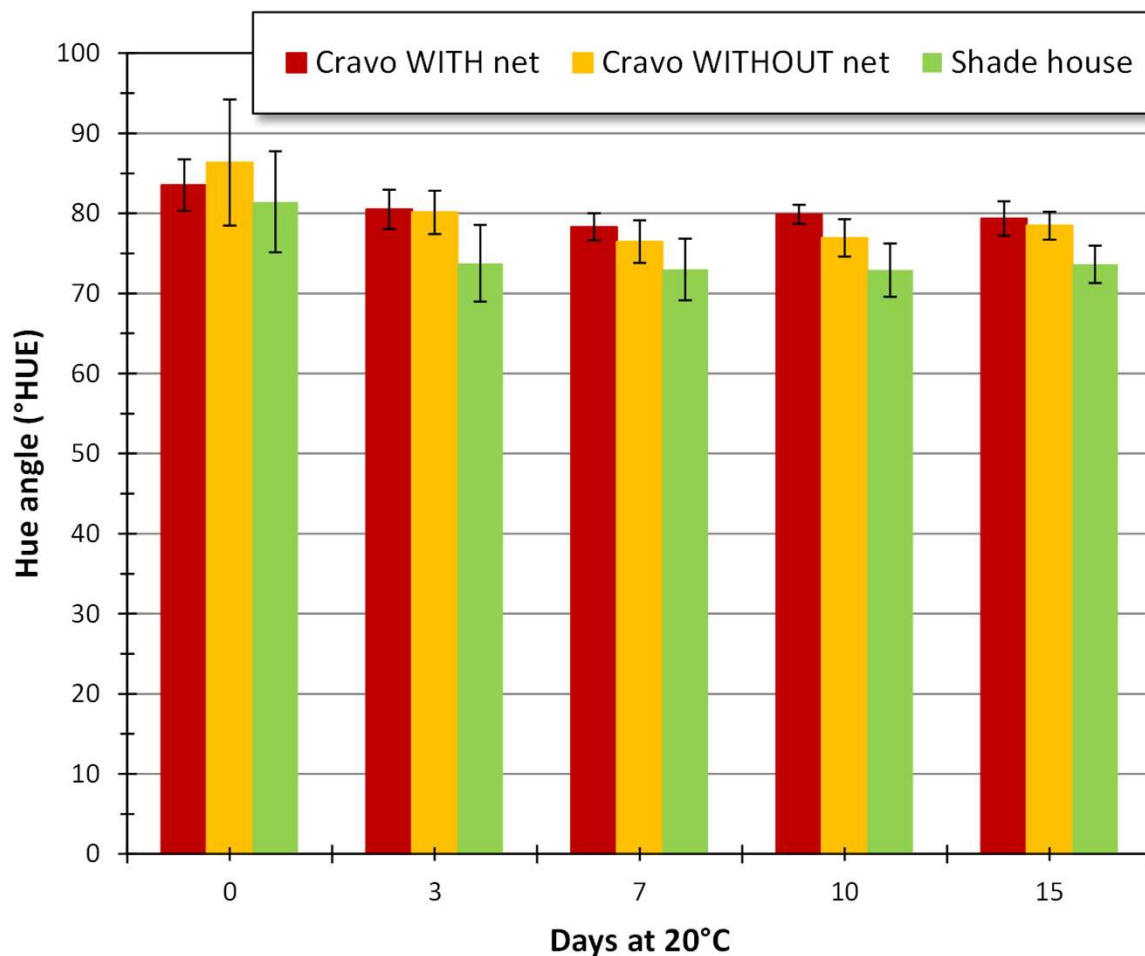
Means that do not share a letter are significantly different.



DIGITAL CHATILLON PENETROMETER modelo CS225 Series

Firmness (millimeters deformed by applying 2 kg force with a 5 cm diameter flat plate in equatorial fruit side).

RESULTS. Peel color (°Hue)



The color perception is composed of three variables: **Hue angle (° Hue)**, Chromaticity and Lightness.

The **HUE ANGLE (° Hue)** in the color circle represents values from 0 to 360°. Counter clock wise (0°=red; 90°=yellow; 180°=green; 270°=blue and 360°=violet-purple) (SEE FIGURE)

In yellow sweet peppers, HUE angle decreases slightly during postharvest life to orange colors as a result of senescence. Lower values of ° Hue means more orange fruit.

SPECTROPHOTOMETER Konica Minolta CM-700d

Two lectures per fruit in equatorial opposite sides.

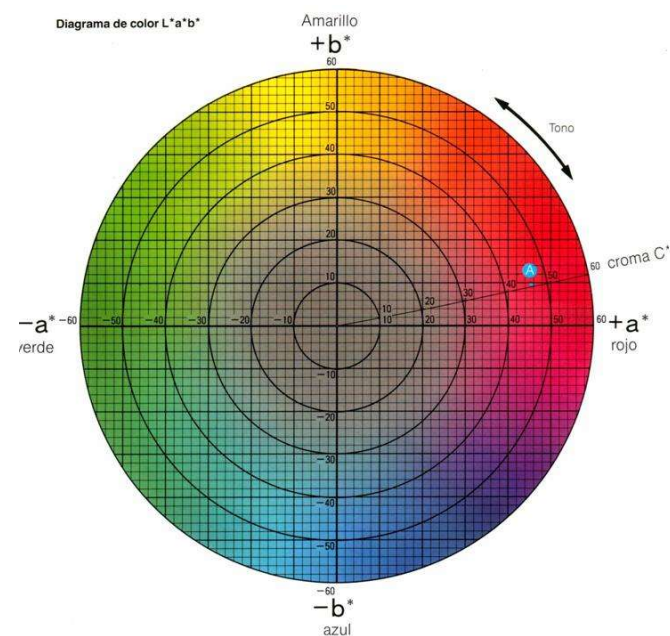
N=10 fruits/treatment

General Linear Model:
Hue angle (°HUE) versus Treatments

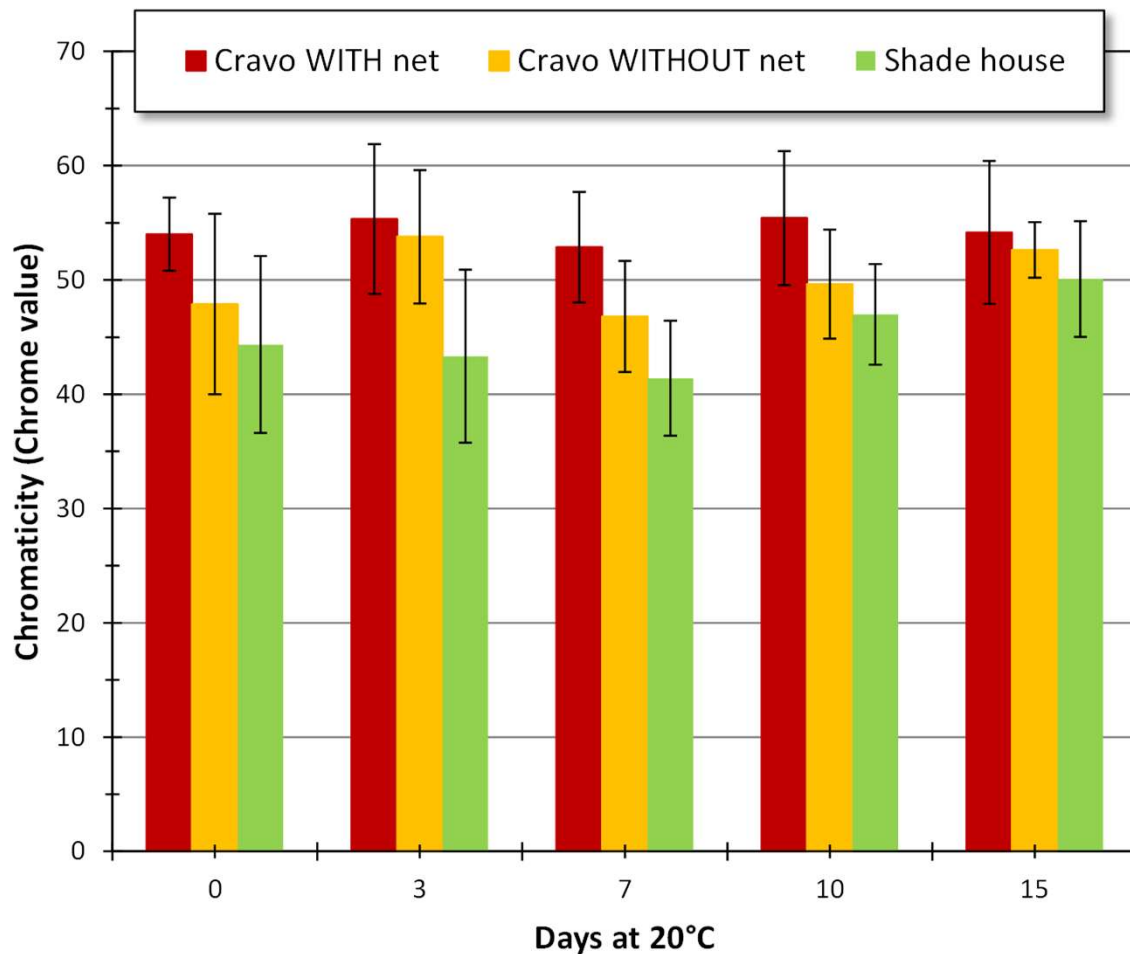
Grouping Information Using Tukey Method and 95.0% Confidence

Treatment	N	Mean	Grouping
Cravo WITH net	50	80.31	A
Cravo WITHOUT net	50	79.67	A
Shade house	48	74.98	B

Means that do not share a letter are significantly different.



RESULTS. Peel color (Chromaticity)



The color perception is composed of three variables: Hue angle ($^{\circ}$ Hue), **Chromaticity** and Lightness.

CHROMATICITY mean color intensity. Higher values indicate fruit with more intense or pure coloration (less gray) (SEE FIGURE)

In sweet peppers, there are no significant changes in fruit color chrome during postharvest room storage period. Higher values mean more intensity or saturated color fruit (SEE FIGURE).

There were differences among treatments.

SPECTROPHOTOMETER Konica Minolta CM-700d

Two lectures per fruit in equatorial opposite sides.

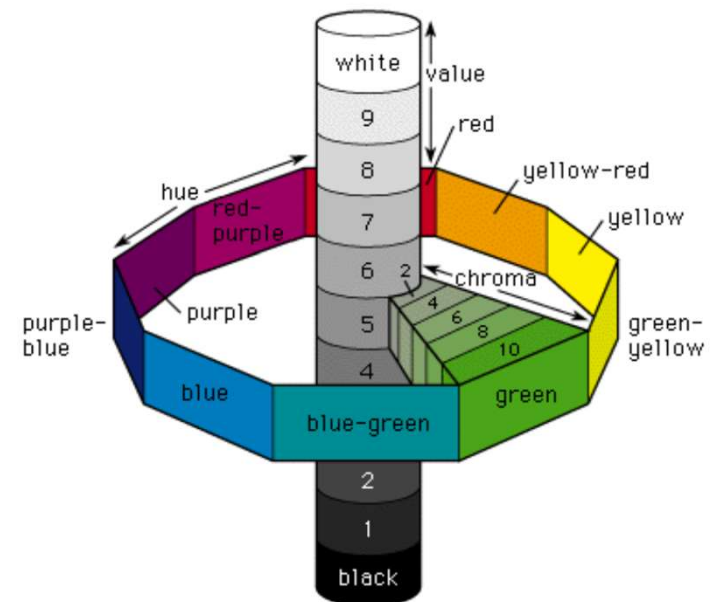
N=10 fruits/treatment

General Linear Model: Chromaticity versus Treatments

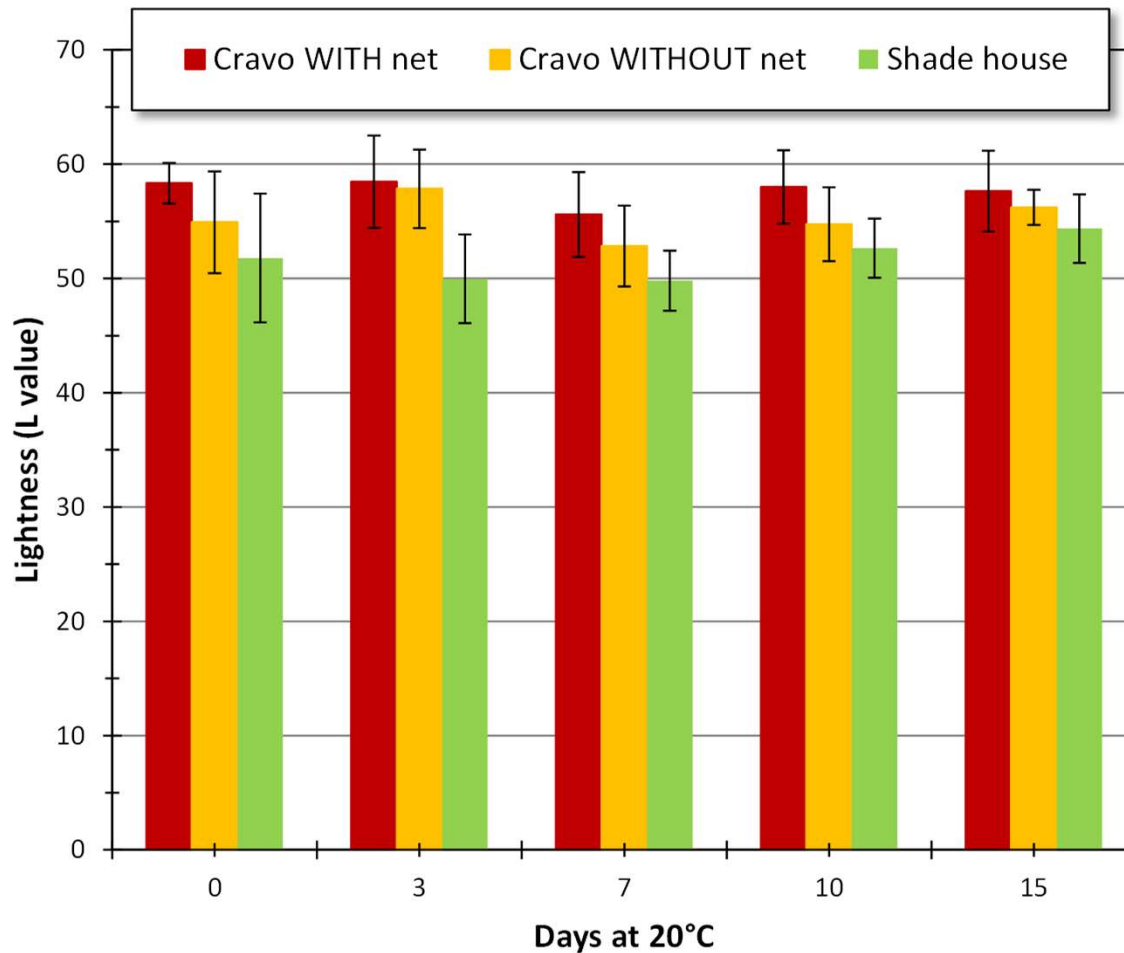
Grouping Information Using Tukey Method and 95.0% Confidence

Treatment	N	Mean	Grouping
Cravo WITH net	50	54.36	A
Cravo WITHOUT net	50	50.15	B
Shade house	48	45.20	C

Means that do not share a letter are significantly different.



RESULTS. Peel color (Lightness)



The color perception is composed of three variables: Hue angle ($^{\circ}$ Hue), Chroma and **Lightness**.

LIGHTNESS shows values from 0 to 100 in a vertical scale, where higher values indicate brighter or lighter fruit color and low values near 0 are related with dark colors (SEE FIGURE).

In yellow sweet peppers, the brightness values did not show significant changes during postharvest. Lower values mean less bright or less clear color fruit (see figure)

There were differences among treatments.

SPECTROPHOTOMETER Konica Minolta CM-700d

Two lectures per fruit in equatorial opposite sides.

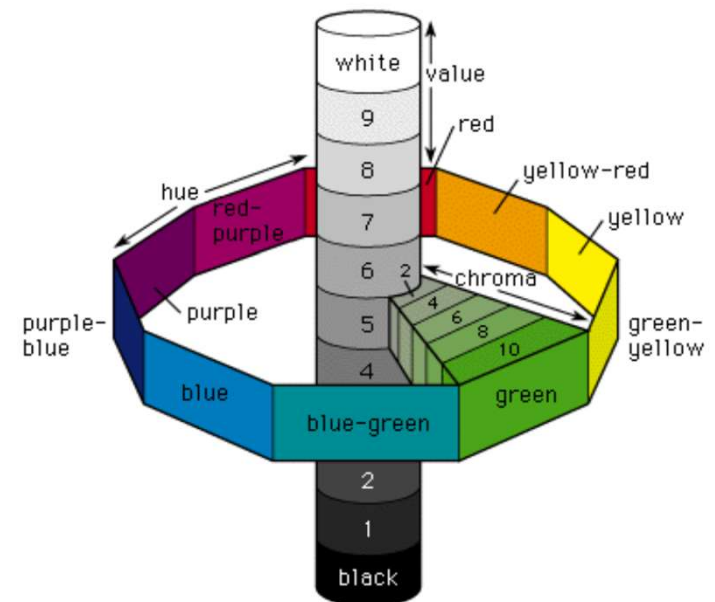
N=10 fruits/treatment

General Linear Model: Lightness versus Treatments

Grouping Information Using Tukey Method and 95.0% Confidence

Treatment	N	Mean	Grouping
Cravo WITH net	50	57.61	A
Cravo WITHOUT net	50	55.32	B
Shade house	48	51.71	C

Means that do not share a letter are significantly different.



RESULTS. Chemical analysis



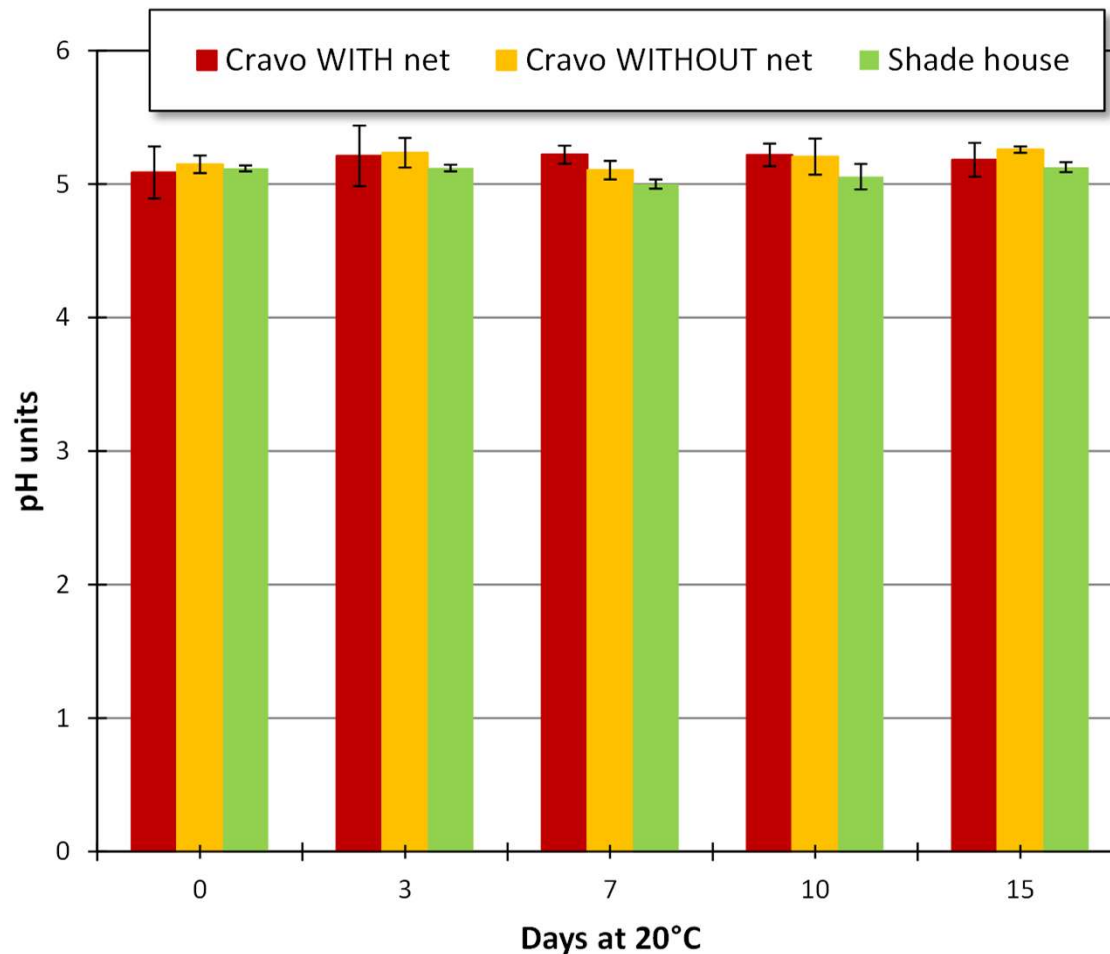
10 g of fresh fruit taken from same fruit utilized for measuring firmness, were homogenized with 50 ml of distilled water in a commercial blender and then filtered to obtain an extract.

With the extract, pH, TA and °Brix were measured.

pH & titratable acidity (TA). An aliquot of 50 ml of the extract was placed in an automatic titrator Mettler Toledo mod. T50 equipped with a glass electrode DGi 111-SC.

Total Soluble Solids (TSS or ° Brix). One drop of the extract was placed in a refractometer Mettler Toledo mod. RM40 with temperature compensation.





General Linear Model: pH versus Treatments

Grouping Information Using Tukey Method and 95.0% Confidence

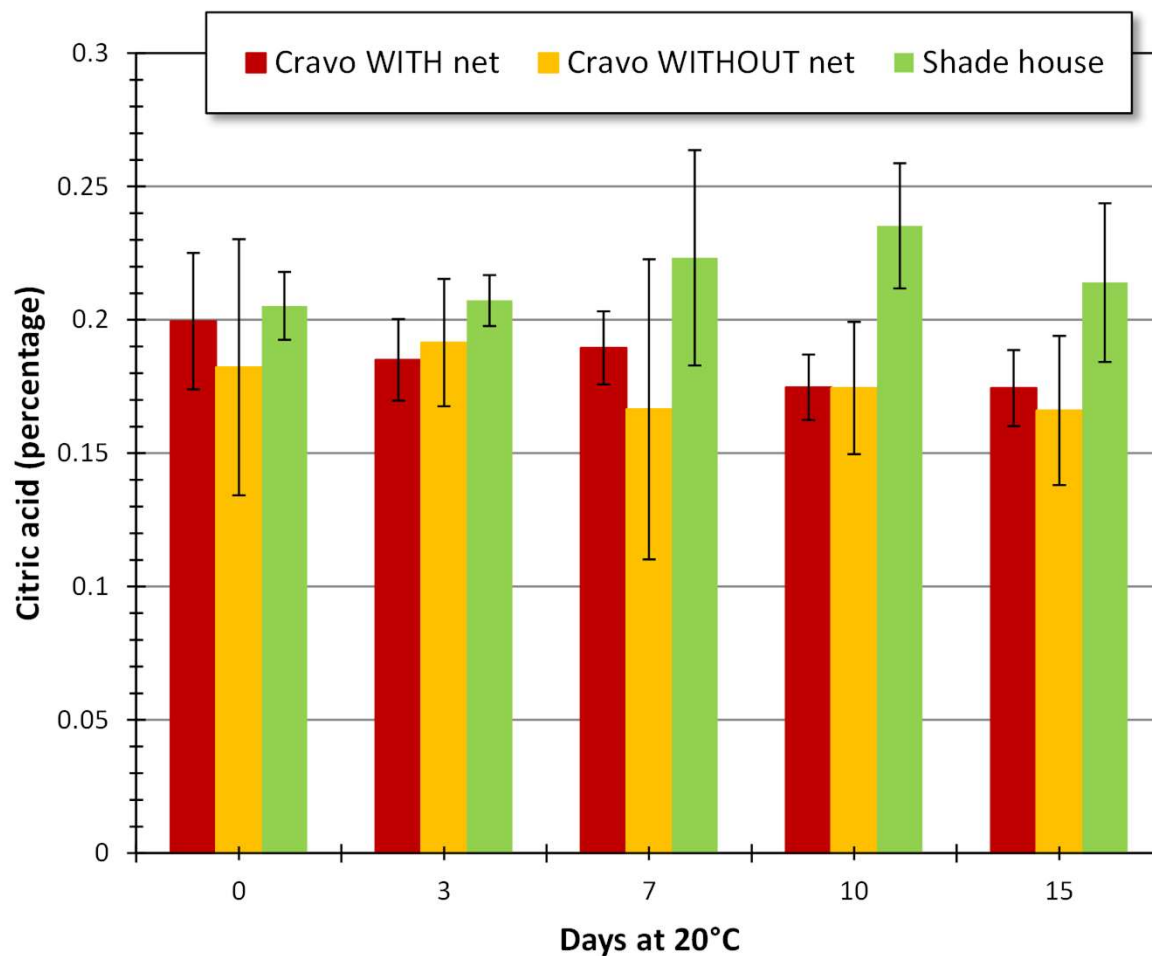
Treatment	N	Mean	Grouping
Cravo WITHOUT net	20	5.191	A
Cravo WITH net	20	5.185	A
Shade house	20	5.085	B

Means that do not share a letter are significantly different.

In sweet peppers, there are no significant changes in pH values during postharvest room storage period.

pH values were remained between 5.08 and 5.19 for all treatments during evaluation period, although significant differences were showed among treatments.

TITRATABLE ACIDITY (% of citric acid)



General Linear Model: Titratable acidity versus Treatments

Grouping Information Using Tukey Method and 95.0% Confidence

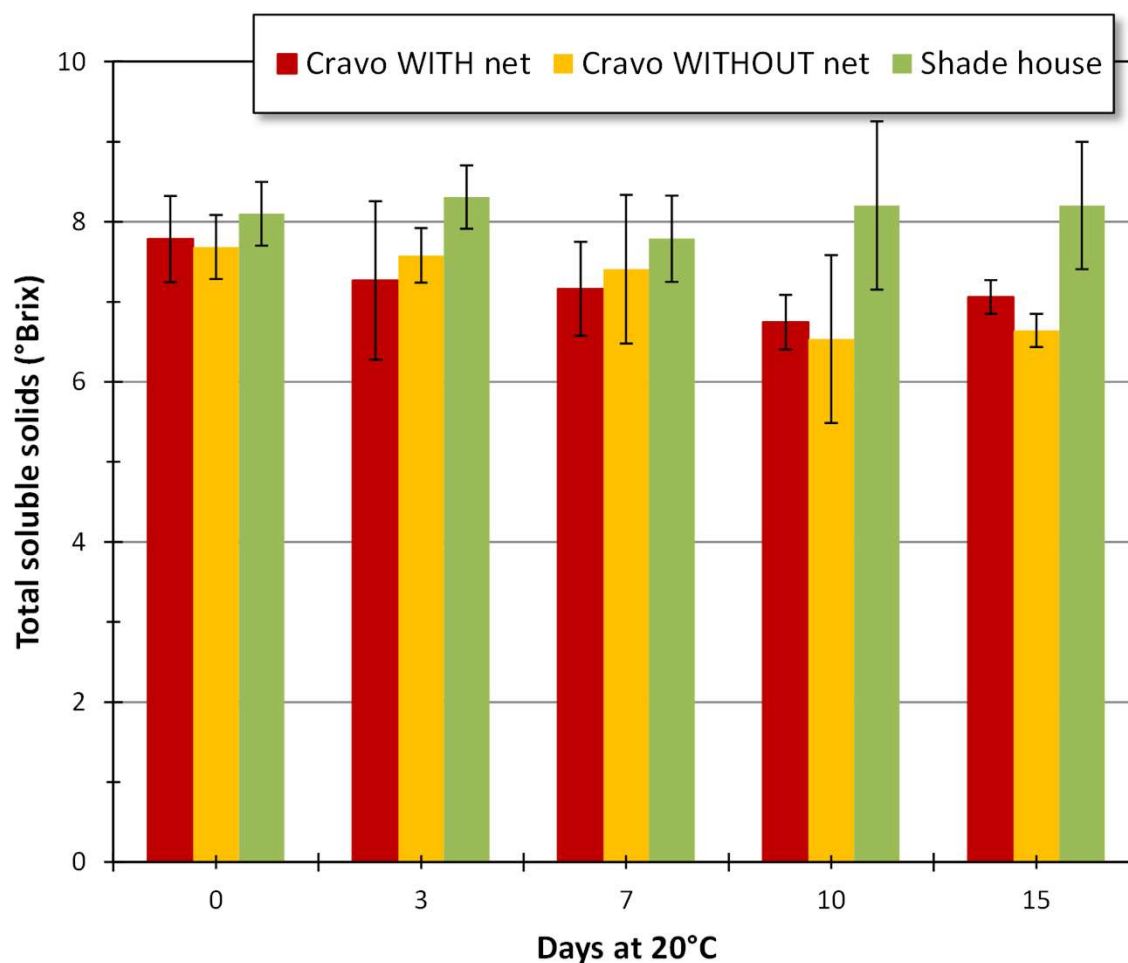
Treatment	N	Mean	Grouping
Shade house	20	0.2170	A
Cravo WITH net	20	0.1847	B
Cravo WITHOUT net	20	0.1761	B

Means that do not share a letter are significantly different.

Acidity content in yellow sweet peppers showed no significant changes during postharvest storage, although there were differences among treatments. Fruits grown in shade house conditions showed higher values in citric acid content, being statistically different although it had been only 0.04% .

Values were remained between 0.17 and 0.21% among treatments.

TOTAL SOLUBLE SOLIDS (° Brix)



General Linear Model: °Brix versus Treatments

Grouping Information Using Tukey Method and 95.0% Confidence

Treatment	N	Mean	Grouping
Shade house	20	8.121	A
Cravo WITH net	20	7.203	B
Cravo WITHOUT net	20	7.170	B

Means that do not share a letter are significantly different.

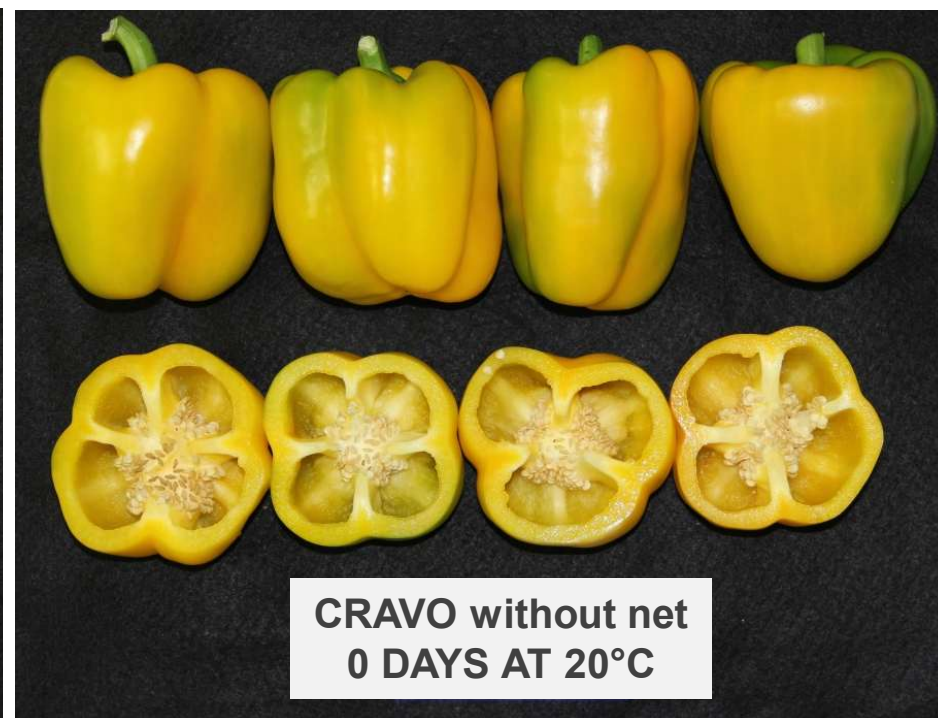
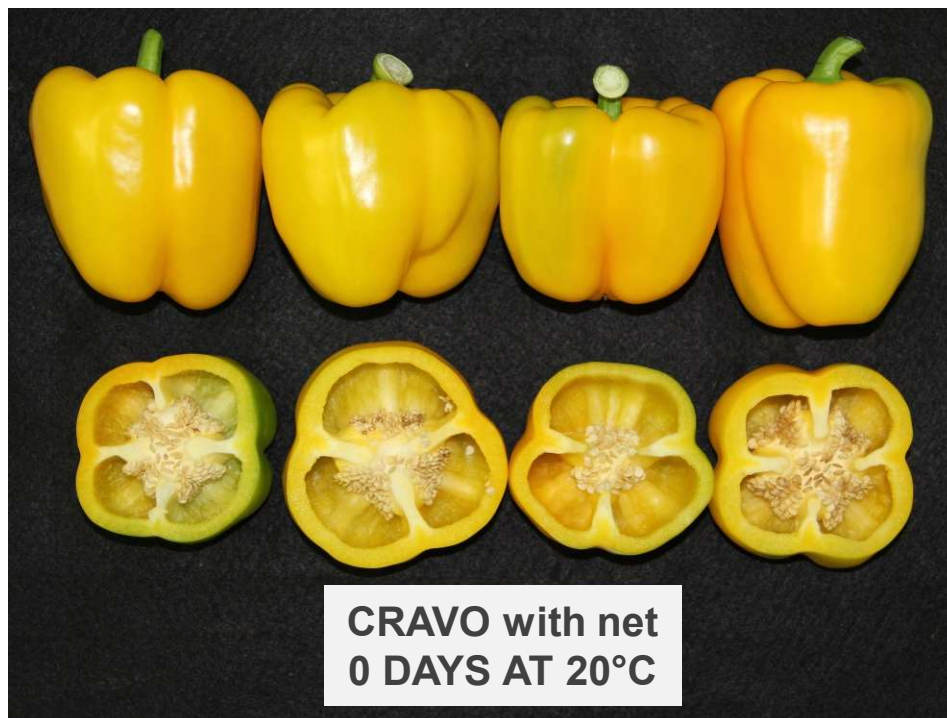
Soluble solids content (° Brix), showed differences among treatments. Highest values were for fruit grown in shade house, being generally 13% sweeter than fruit grown in Cravo WITHOUT anti-insect net, perhaps by an accumulation of sugar due to increased dehydration of fruits in postharvest storage.



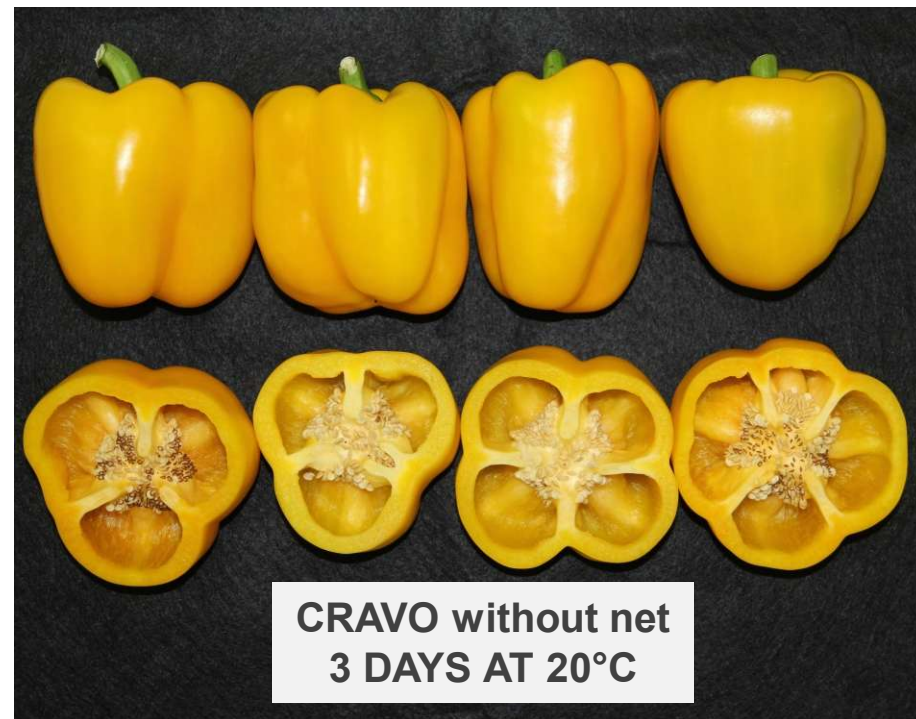
- ❖ Sweet peppers grown in Cravo greenhouses with and without anti-insect net, had statistically greater fruit thickness wall (13%-21%) than those grown in shade house conditions.
- ❖ After 15 days of postharvest storage, cumulative weight loss associated with fruit dehydration was 30-35% higher in sweet peppers grown in shade house versus Cravo greenhouse without and with anti-insect net respectively.
- ❖ Sweet pepper fruits grown in Cravo greenhouses with and without anti-insect net were significantly 40% firmer than those fruits grown in shade house.
 - ❖ The characteristic yellow color of the fruit became more orange during postharvest (lower values of ° Hue) in sweet peppers grown in shade house conditions being different to the fruits cultivated in Cravo greenhouse with or without anti-insect net.
- ❖ Greater color intensity (chrome) and brightness was obtained in fruits grown in Cravo greenhouses with anti-insect net protection.
- ❖ Titratable acidity content was increased and consequently lower pH value was observed in fruits grown in shade house conditions as highest ° Brix content.

PHOTOGRAPHS OF FRUIT COLOR
CHANGE DURING POSTARVEST ROOM
STORAGE
(same fruits)

INITIAL / HARVEST DAY (DAY 0 AT 20 °C)



3 DAYS AT 20 °C



7 DAYS AT 20 °C



10 DAYS AT 20 °C



15 DAYS AT 20 °C



Shade house

CRAVO without net

CRAVO with net

15 DAYS AT 20°C