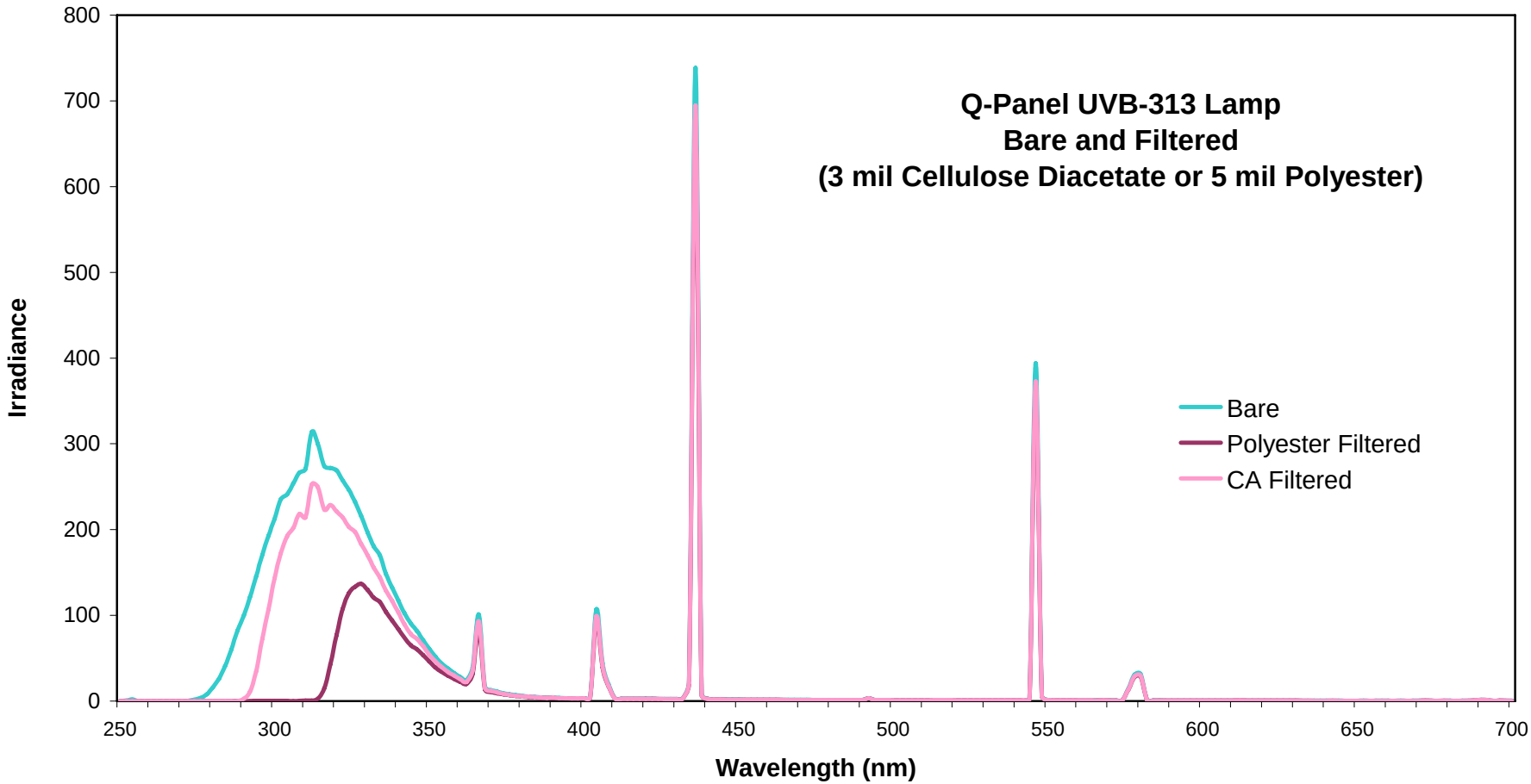
Salad Daze
or
Supplemental UV Radiation Differentially Increases Phenolic Acid Esters & Flavonoids in Cultivars of Greenhouse-grown Red and Green Leaf Lettuce

Greenhouse Lettuce

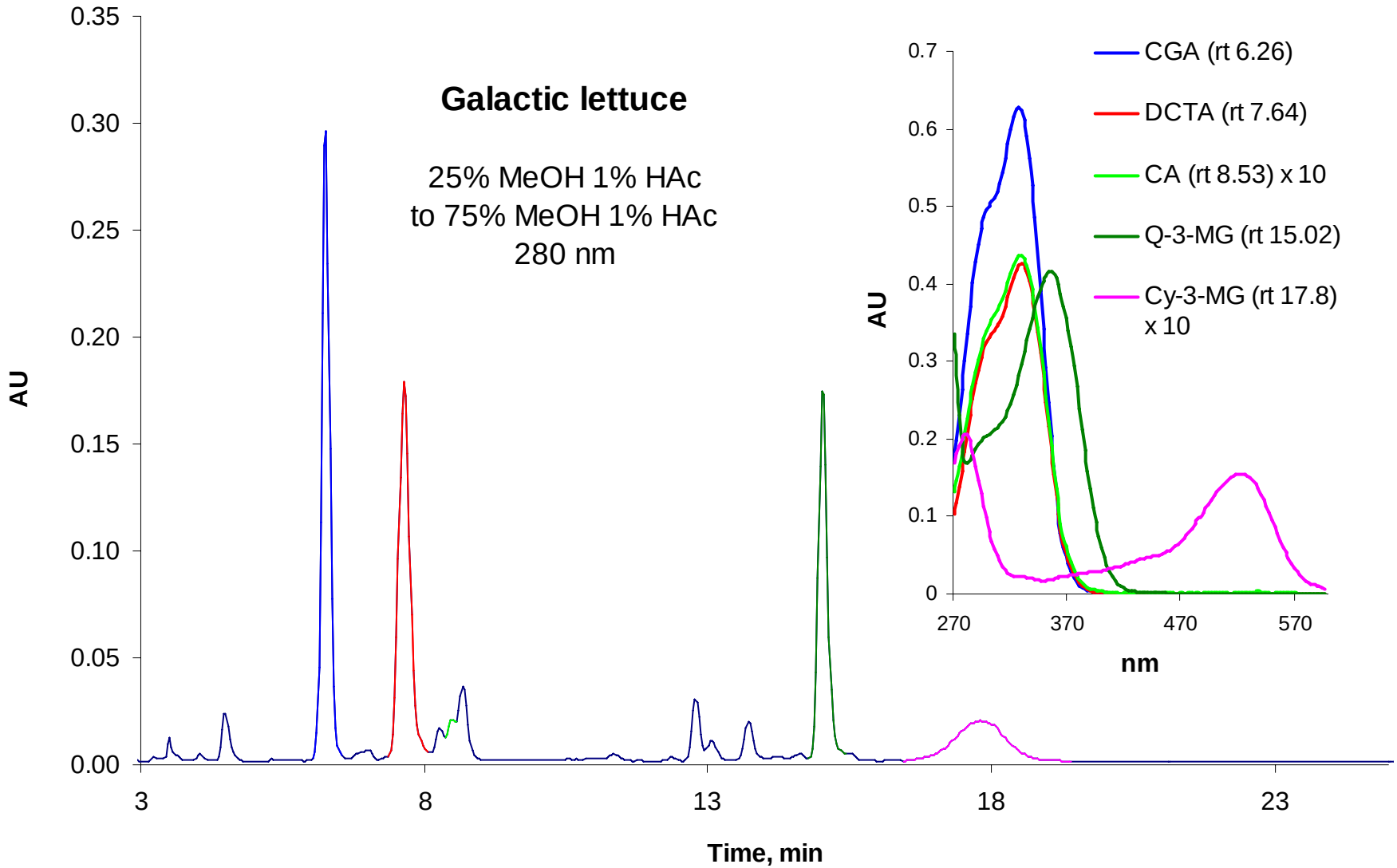
- Low UV environment
  - plants deficient in polyphenols
  - supplemental UV lamps
- Why lettuce?
  - grows quickly; many varieties
  - consumption increasing
    - leaf lettuce compares well to spinach
  - eaten fresh - less leaching or degradation
  - simple profile
    - Phenolic acid esters
      - e.g., caffeoyl quinic acid [CQA], aka chlorogenic acid
    - Flavonoids
      - Quercetin-3-MG
      - Cyanidin-3-MG
  - non-acylated anthocyanins

Lettuce growth conditions

- Greenhouse 30 days Jan.-Feb. 2003
- 6 in. pots with Jiffy-Mix
- Temperature 21 ± 3 °C (23/19 °C day/night)
- Daily PAR ca. 9.5 mol m^{-2}
  - Incl. 12 h supplemental HPS (100 μmol m^{-2} s^{-1})
- Supplemental UV 7 h daily centered around solar noon (Q-Panel UVB313 lamps)
  - UV-B + UV-A (0.08 mm cellulose diacetate)
    - 6.4 mJ m^{-2} biologically effective radiation
  - UV-A (0.13 mm polyester)
  - No supplemental UV controls


Q-Panel UVB-313 Lamp
Bare and Filtered
(3 mil Cellulose Diacetate or 5 mil Polyester)
Irradiance
Wavelength (nm)
Bare
Polyester Filtered
CA Filtered
0
100
200
300
400
500
600
700
800
250
300
350
400
450
500
550
600
650
700

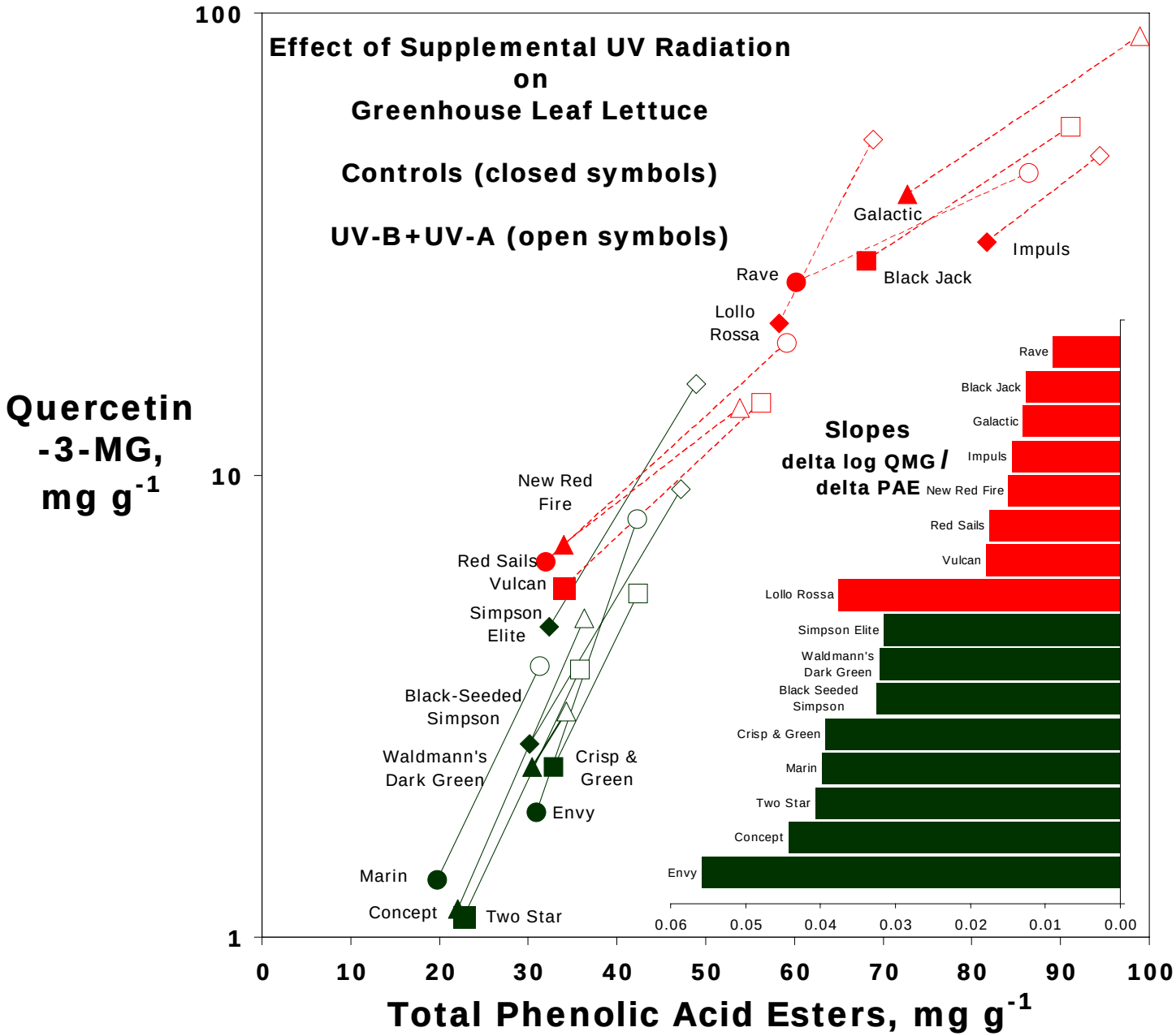

Lolla Rossa
Dark Red
GH
UV-A
UV-B


Galactic lettuce
25% MeOH 1% HAc
to 75% MeOH 1% HAc
280 nm
AU
Time, min
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
3
8
13
18
23
CGA (rt 6.26)
DCTA (rt 7.64)
CA (rt 8.53) x 10
Q-3-MG (rt 15.02)
Cy-3-MG (rt 17.8) x 10
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
270
370
470
570
nm

Average Values and UV Effects Relative to Controls (8 cultivars each of red and green lettuce)

Compounds	Lettuce	Control Values	UV-B Effect	UV-A Effect
Total Phenolic Acid Esters (mg g^{-1} DM)	Green	27.67 ± 1.85	1.458 ± 0.064	1.022 ± 0.035
	Red	55.12 ± 6.88	1.445 ± 0.085	1.095 ± 0.086
CQA/Total Phenolic Acid Esters	Green	0.523 ± 0.014	1.064 ± 0.021	0.997 ± 0.035
	Red	0.560 ± 0.037	0.959 ± 0.088	0.953 ± 0.027
DCTA/Total Phenolic Acid Esters	Green	0.432 ± 0.025	0.906 ± 0.017	1.003 ± 0.047
	Red	0.403 ± 0.040	1.096 ± 0.082	1.106 ± 0.085
Quercetin-3-malonylglucoside (mg g^{-1} DM)	Green	2.18 ± 0.41	3.19 ± 0.35	1.008 ± 0.044
	Red	21.05 ± 4.69	2.17 ± 0.17	0.940 ± 0.063
Cyanidin-3-malonylglucoside (mg g^{-1} DM)	Green	ND	-	-
	Red	0.57 ± 0.17	3.55 ± 0.39	1.020 ± 0.061

(Means ±1 standard error of the mean)


Effect of Supplemental UV Radiation
on
Greenhouse Leaf Lettuce
Controls (closed symbols)
UV-B+UV-A (open symbols)
Quercetin
-3-MG,
mg g-1
100
10
1
0
10
20
30
40
50
60
70
80
90
100
Total Phenolic Acid Esters, mg g-1
Galactic
Impuls
Rave
Black Jack
Lollo
Rossa
New Red
Fire
Red Sails
Vulcan
Simpson
Elite
Black-Seeded
Simpson
Waldmann's
Dark Green
Crisp &
Green
Envy
Marin
Concept
Two Star
Slopes
delta log QMG /
delta PAE
Rave
Black Jack
Galactic
Impuls
New Red Fire
Red Sails
Vulcan
Lollo Rossa
Simpson Elite
Waldmann's
Dark Green
Black Seeded
Simpson
Crisp & Green
Marin
Two Star
Concept
Envy
0.06
0.05
0.04
0.03
0.02
0.01
0.00

Conclusion

- UV radiation increases polyphenolics
  - Red > Green
  - Select varieties
- Possible to avoid/minimize inhibition
- Interaction with visible (photosynthetic?) radiation
- New technology
  - LED's

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