The Impact of Supplementary Short–term Red LED Lighting on the Antioxidant Properties of Microgreens

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The aim – to evaluate the impact of supplementary short–term red LEDs lighting on the antioxidant properties of microgreens.

Object - 10 species of microgreens: **amaranth** (*Amaranthus cruentus* L., 'Red Army'), **basil** (*Ocimum basilicum* L., 'Sweet Genovese'), **kale** (*Brassica oleracea* L., 'Red Russian'), **broccoli** (*Brassica oleracea* L.), **mustard** (*Brassica juncea* L., 'Red Lion'), **tatsoi** (*Brassica rapa* L., 'Rosularis'), **borage** (*Borago officinalis* L.), **beet** (*Beta vulgaris* L., 'Bulls Blood'), **parsley** (*Petroselinum crispum* Mill.) and **pea** (*Pisum sativum* L., 'Meteor').

Growth conditions – microgreens were grown up to harvest time (about 7-10 days) in a greenhouse (November, Lithuania, lat. 55° N) using peat substrate.

At pre-harvest stage of 3 days, HPS lamps were supplemented by 638 nm LEDs (R), whereas reference plants continue staying under lighting conditions identical to those of growth (K300). *PPFD* generated by illuminator was 170 µmol m^{-2} s^{-1} and net *PPFD* generated by the illuminator in combination with HPS lamps - 300 µmol m^{-2} s^{-1} (16-h; 19-22/15-18°C).

Results

Table 1. The variation of antioxidant activity after light treatment in various microgreens.

Species	Treatment	Total phenols, mg g^{-1}, FM	Antioxidant capacity, µmol g^{-1}, FM	Ascorbic acid, mg g^{-1}, FM	Total anthocyanins, mg g^{-1}, FM
Amaranth	HPS	0.54±0.02^a	9.40±0.14^a	0.48±0.01^c	53.71±1.85^c
	HPS+638nm	* 0.46±0.03^C	9.17±0.35^B	* 2.34±0.11^A	* 86.63±4.15^B
Basil	HPS	0.39±0.03^b	7.75±0.31^c	1.02±0.19^a	60.49±13.82^c
	HPS+638nm	* 0.51±0.02^B	* 9.17±0.16^C	* 0.47±0.00^C	92.84±17.70^B
Kale	HPS	0.39±0.04^b	8.47±0.22^c	0.41±0.02^c	57.72±0.34^c
	HPS+638nm	* 0.59±0.04^A	* 10.07±0.07^A	* 1.04±0.03^C	* 103.14±7.13^B
Broccoli	HPS	0.52±0.02^a	10.44±0.21^a	0.47±0.01^c	58.14±1.93^c
	HPS+638nm	* 0.60±0.05^A	10.51±0.14^A	* 1.15±0.05^B	* 105.95±5.13^A
Mustard	HPS	0.50±0.02^a	9.14±0.27^a	0.42±0.01^c	59.57±1.58^c
	HPS+638nm	* 0.55±0.01^B	* 9.81±0.24^B	* 0.56±0.02^C	* 47.12±2.85^C
Tatsoi	HPS	0.29±0.07^c	7.72±0.27^c	0.42±0.03^c	41.38±1.65^c
	HPS+638nm	* 0.49±0.01^C	* 9.51±0.24^B	0.46±0.01^C	* 63.22±4.46^C
Borage	HPS	0.46±0.02^b	9.24±0.14^a	1.96±0.27^a	93.09±4.20^a
	HPS+638nm	* 0.63±0.03^A	* 10.26±0.09^A	*1.04±0.10^B	* 44.89±8.24^C
Beet	HPS	0.38±0.01^b	7.73±0.06^c	0.55±0.04^c	61.46±2.09^c
	HPS+638nm	*0.47±0.01^C	* 7.11±0.13^C	0.62±0.03^C	* 34.87±1.08^C
Parsley	HPS	0.30±0.01^c	6.88±0.17^c	0.42±0.04^c	106.84±13.94^a
	HPS+638nm	* 0.44±0.02^C	* 10.67±0.75^B	0.45±0.04^C	* 46.39±12.34^A
Pea	HPS	0.52±0.03^a	10.47±0.14^a	1.10±0.08^a	174.42±10.43^a
	HPS+638nm	* 0.66±0.02^A	10.38±0.18^A	* 3.16±0.13^A	*204.18±10.61^A

The mean values of different microgreens differ significantly (P≤0.05, n=3) between species in the HPS treatment (a,b,c) and in the HPS+638nm treatment (A,B,C). Significant differences between treatments for each species are indicated by (*) (P≤0.05, n=3). Means ± SD are shown. FM – fresh mass.

Table 2. Correlation coefficient between total phenols and DPPH free-radical scavenging capacity in microgreens.

Treatment	Ama-ranth	Basil	Kale	Bro-ccoli	Mus-tard	Tat-soi	Bora-ge	Beet	Pars-ley	Pea	Total
HPS	0.91	0.71	0.61	0.99	0.81	0.90	0.83	1.00*	0.95	0.98	0.90*
HPS+638nm	0.90	0.99	0.99	1.00*	0.98	1.00*	0.94	0.99	0.78	0.84	0.72*

Marked correlations are significant at P≤0.05 (n=3).

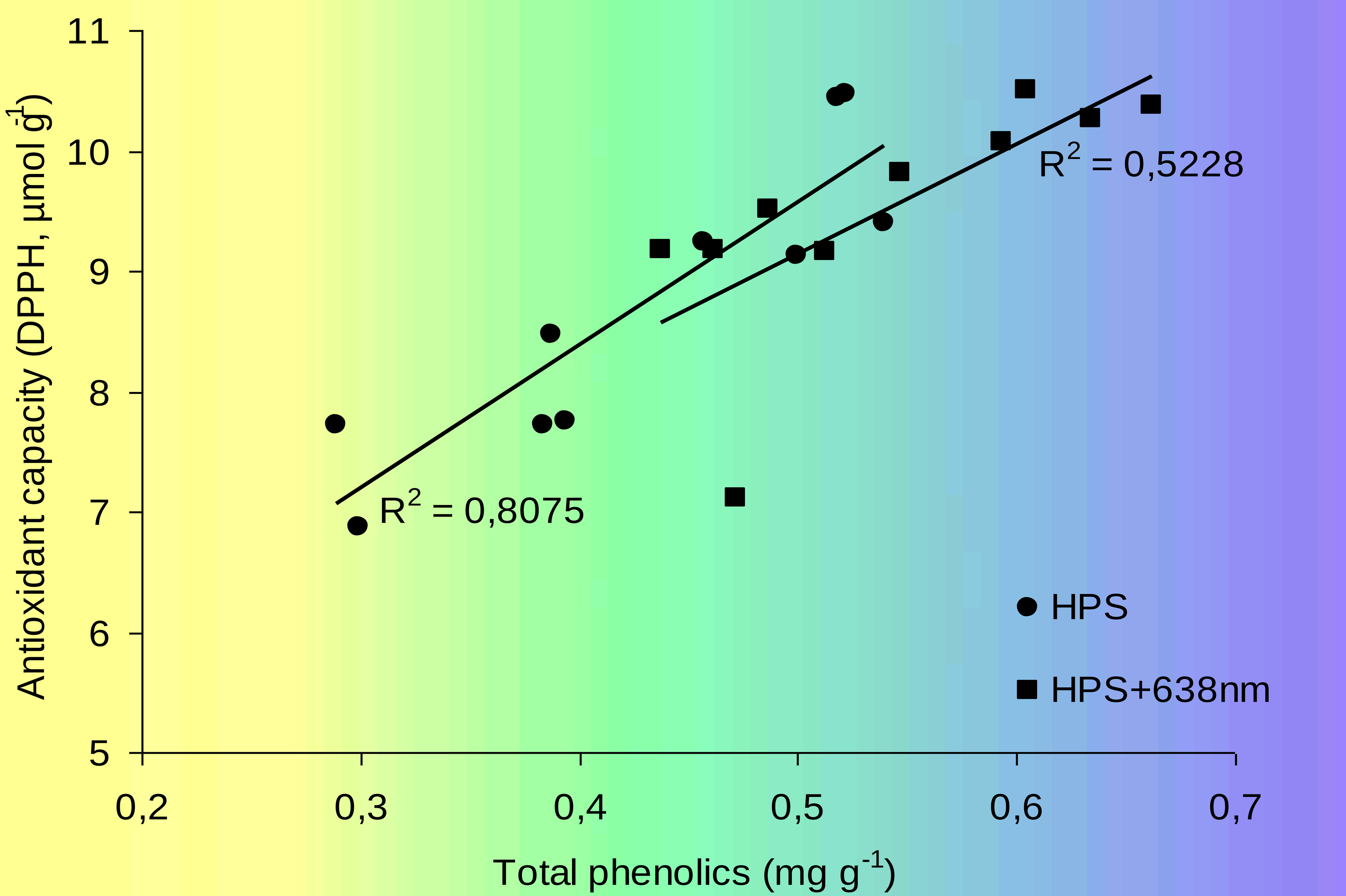

Fig. 1. Correlation analysis between total phenolics and antioxidant capacity (DPPH• free-radical scavenging capacity) of all microgreens. (P≤0.05; n=30).

CONCLUSIONS

The short-term pre-harvest treatment with high photosynthetic photon flux density red LEDs lighting enabled to alter the level of phytochemicals such as tested secondary metabolites in harvested plant tissues. Due to the increased activity of the metabolic system for the protection from a mild photooxidative stress antioxidant properties (contents of ascorbic acid, total anthocyanins, total phenols and DPPH• free-radical scavenging capacity) of microgreens were changed. Natural antioxidant compounds were in order: pea > broccoli > borage > mustard = amaranth > basil = kale > beet = parsley > tatsoi. Total phenols concentration increased with supplemental red in all microgreens from 9.1% in mustard to 40.8% in tatsoi, except of amaranth, where decrease of 14.8% was observed. Supplemental red conditioned an increase of ascorbic acid content from 25.0 % in mustard to 79.5 % in amaranth, and had no significant effect in tatsoi, beet and parsley. Total anthocyanins significant increased from 14.6 % in pea to 45.1 % in broccoli, significant decrease was detected in borage, mustard and beet and was not significantly affected in basil. Supplemental high *PPFD* red LED lighting evoked a metabolic disbalance in vegetables thus resulting mentioned changes of antioxidative compounds. However, the effect of supplementary red LED light was found to be species dependent. Sensitivity of species to lighting conditions depended on natural amount of antioxidant compounds.