

Efficiency of Total Volatile organic compound of Climbing Plants *Ardisia pusilla* and *Ficus pumila*

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Object of Research

Formaldehyde and total volatile organic compounds are major contaminants of indoor air (Carpenter, 1998), and contemporary man spend 80% of their day indoors. IAQ (Indoor air quality) problems cause headache, fatigue, eye, nose, and throat irritation, skin irritation (US Environmental Protection Agency). A number of studies have said that FMR and TVOC are removed through the leaves and the stomata of plants. Also, the removal ability was improved when the plants were continuously exposed to air containing VOC (Kim and Kim, 2008). In this study, an empty chamber and a horticultural species *Hedera helix* were used controls to analyze the indoor pollutant removal efficiency and physiological response of the climbing native plants *Ardisia pusilla* and *Ficus pumila*.

Materials and Methods

Testing materials

Table 1. Initial values of climbing plants as materialized in the experiments.

Plant materials	Plant Height (cm)	Leaf size				
		Length (cm)	Width (cm)	Leaf number (ea)	Area (cm ²)	Plant weight (g)
<i>Hedera helix</i>	12.1 ± 0.4 ^z b ^y	3.3 ± 0.1 a	3.6 ± 0.1 b	88.4 ± 1.8 b	1066.6 ± 36.8 a	19.75 ± 7.1 b
<i>Ardisia pusilla</i>	16.8 ± 0.4 a	2.9 ± 0.1 b	4.8 ± 0.1 a	83.8 ± 3.4 b	1176.8 ± 5.9 a	246.0 ± 12.6 a
<i>Ficus pumila</i>	17.0 ± 0.5 a	1.7 ± 0.0 c	1.9 ± 0.0 c	181.2 ± 10.9 a	584.2 ± 38.0 b	264.6 ± 6.4 a

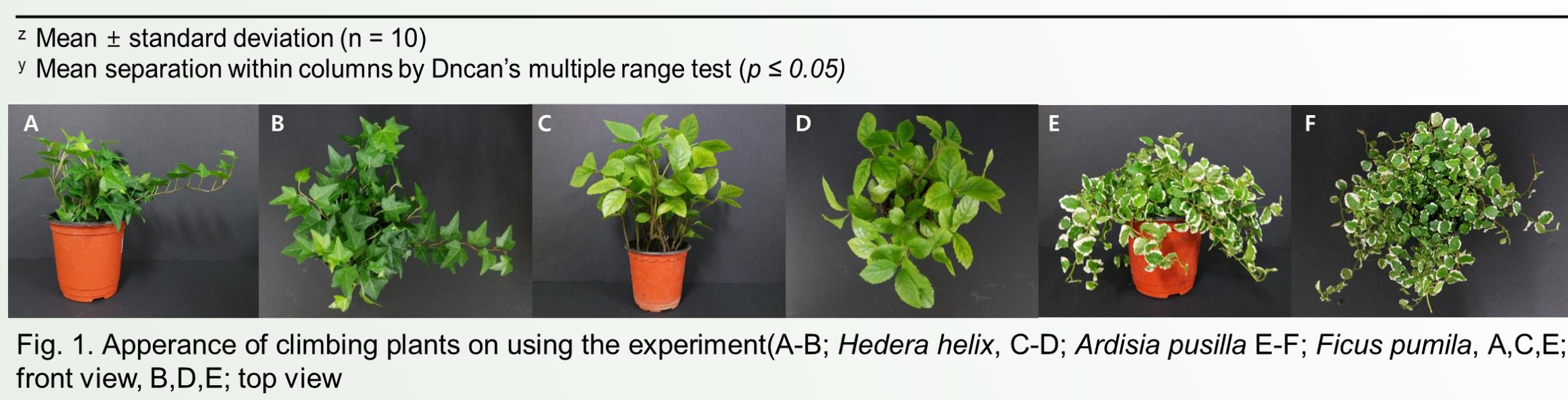


Fig. 1. Appearance of climbing plants used in the experiment (A-B: *Hedera helix*, C-D: *Ardisia pusilla* E-F: *Ficus pumila*, A, C, E: front view, B, D, E: top view)

Experimental methods

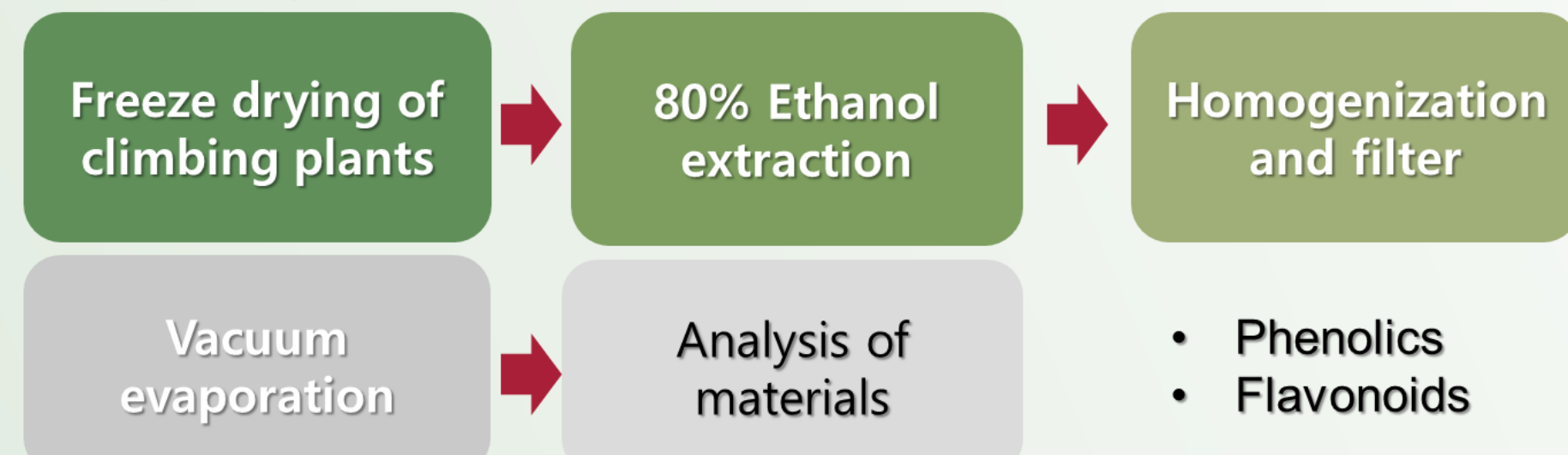
Toluene treatment in the chamber

- After treatment of 100 mg·L⁻¹ of toluene in the chamber, the pan is operated to investigate the concentration of contaminants every 30 minutes for 10 hours.

Chlorophyll fluorescence

- The QY (quantum yield) was measured using a portable fluorometer. The leaves were dark-adapted for 10 min. before starting the measurements using leaf clips provided by the manufacturer.

Physiological active substance



Investigating items

- Indoor pollutants removal (Formaldehyde, Total Volatile Organic Compounds)
- The vegetation index (the normalized difference vegetation index; NDVI; the simple ratio; SR; the carotenoid reflectance index 1-2; CRI 1-2)
- maximum quantum yield of PS II (F_v/F_m) chlorophyll fluorescence
- Physiological activity (the flavonoids and the phenolics)

Statistical analysis

- Removal of indoor pollutants and measurement of physiological responses were performed in 18 repetition, and analysis of physiologically active substances was performed in 15 replication
- Significance test was conducted to using Duncan's multiple range test method ($p \leq 0.05$)

Discussion

- Our results indicated that the pollutant removal amount by native plants tended to be larger than that by *H. helix* (2.973 mg·m⁻³·h⁻¹·m⁻² leaf area) and *F. pumila* (4.481 mg·m⁻³·h⁻¹·m⁻² leaf area) removed significantly more pollutant than *A. pusilla* (3.786 mg·m⁻³·h⁻¹·m⁻² leaf area).
- The NDVI, SR, and CRI 1 and 2 of *F. pumila* and *H. helix* decreased after 2 hr.; however, there was no difference before and after exposure to pollutants in *A. pusilla*. In addition, only *A. pusilla* had a normal F_v/F_m range of 0.78 to 0.84. These results indicated that *A. pusilla* metabolizes normally without negative effects when removing indoor pollutants. Additionally, phenolic content in *A. pusilla* did not change, but the flavonoid content increased after 2 hr..
- The physiological activity of *F. pumila* increased from 4 hr. and then decreased again at 6 hr..
- Therefore, the removal of total volatile organic compounds was effective in the order of *F. pumila*, *A. pusilla*, and *H. helix*, but regarding stress and physiological activity of plants after air purification, *A. pusilla* maintained a normal range compared to that in the other plants and increased antioxidant levels. *A. pusilla* is considered to be highly useful as an air purification plant because of the low damage to itself.

Results

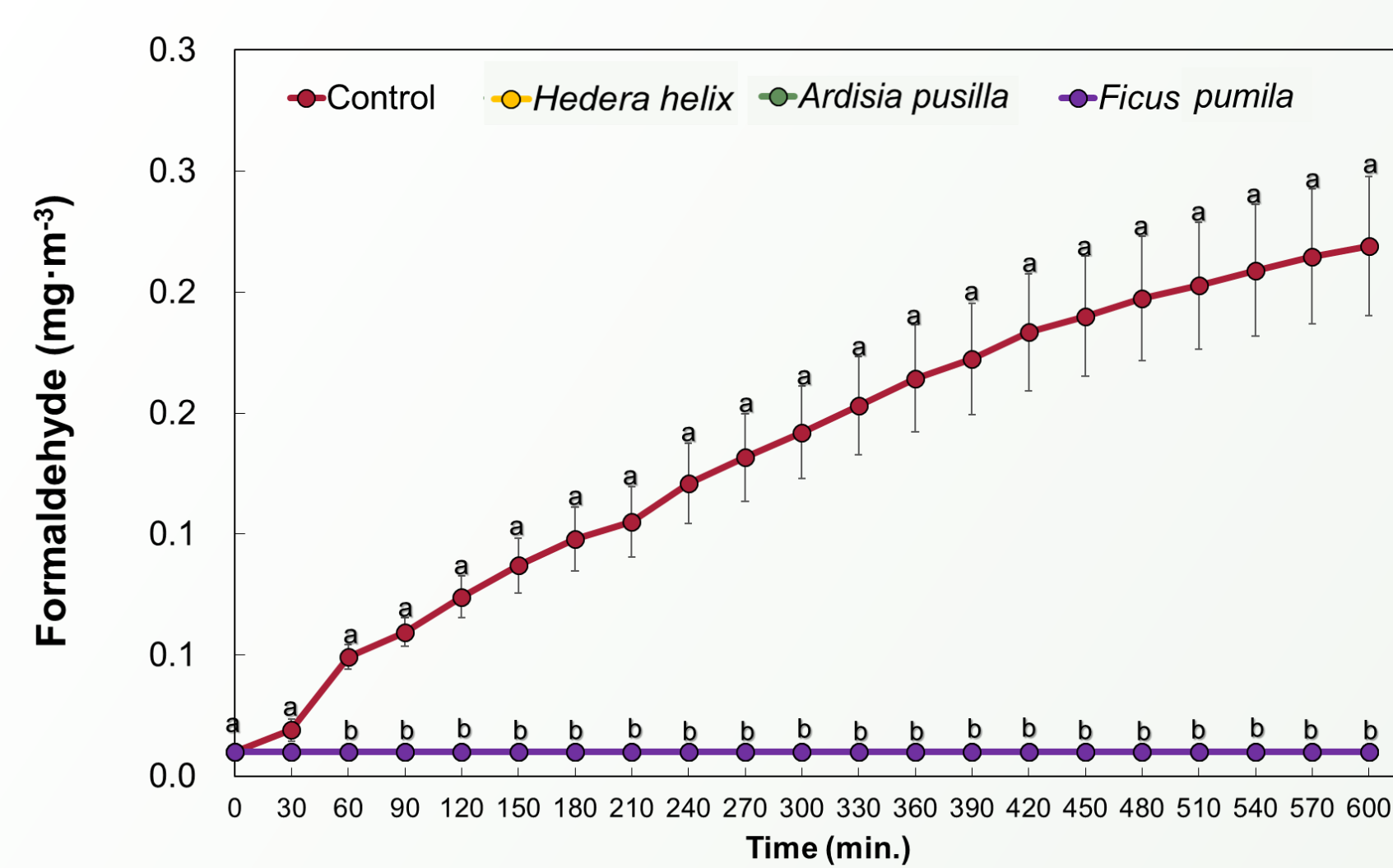


Fig. 2. The change of formaldehyde to control (empty chamber), *Hedera helix*, *Ardisia pusilla* and *Ficus pumila*. Vertical bars represent standard error of the means (n=18). Values with different letters on the bar are significantly different by Duncan's multiple range test ($p \leq 0.05$).

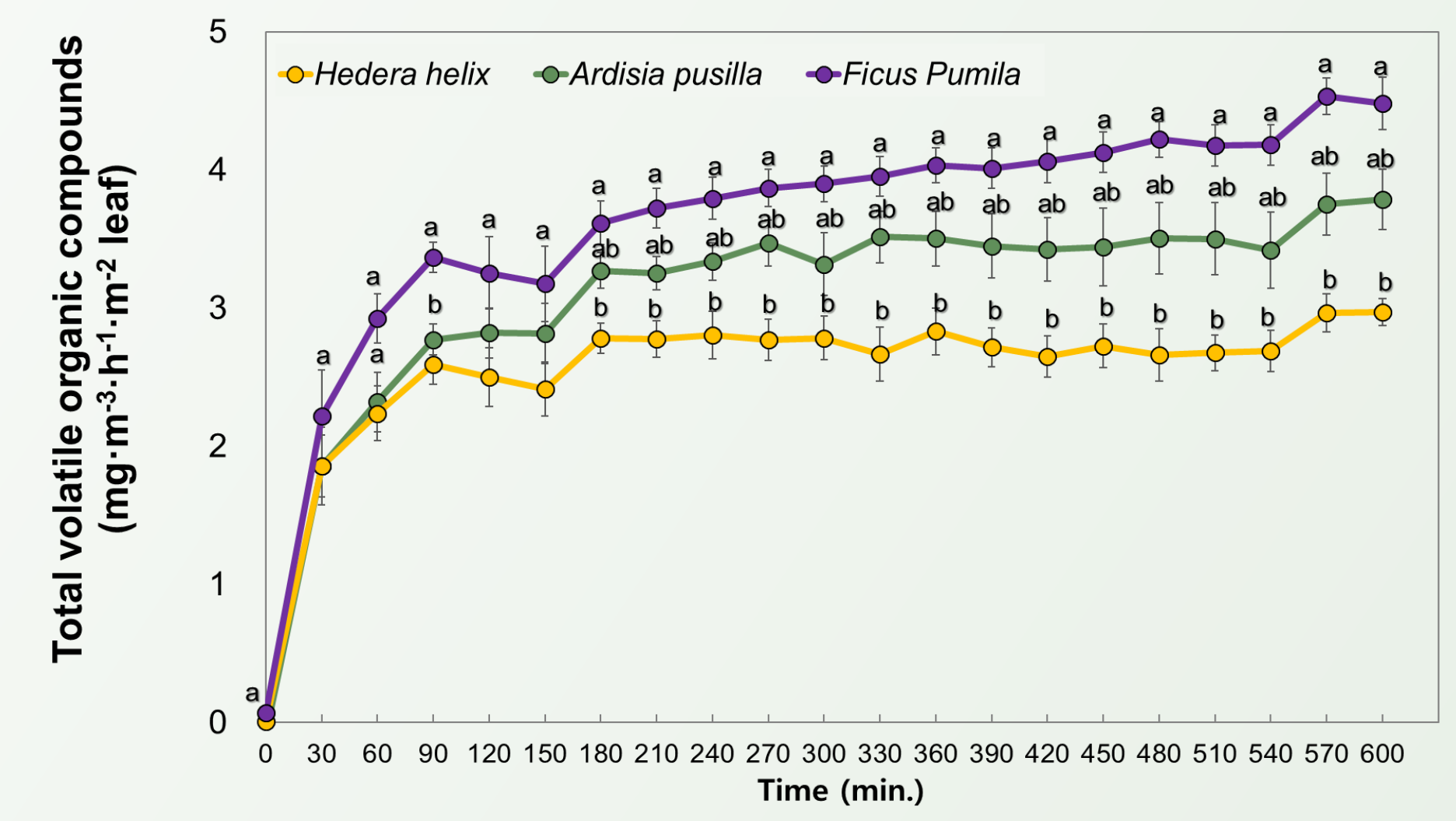


Fig. 3. The change of the volatile organic compounds to *Hedera helix*, *Ardisia pusilla* and *Ficus pumila*. The measured TVOC value was calculated as calibration value by aligning the control (Kim and Kim, 2008). Vertical bars represent standard error of the means (n=18). Values with different letters on the bar are significantly different by Duncan's multiple range test ($p \leq 0.05$).

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^z Mean ± standard deviation (n = 10)

^y Mean separation within columns by Duncan's multiple range test ($p \leq 0.05$)

Table 3. The change of the vegetation index to *Hedera helix*, *Ardisia pusilla* and *Ficus pumila*.

Index ^z	Treatment	0hr.	2hr.	4hr.	6hr.	8hr.	10hr.
NDVI	<i>Hedera helix</i>	0.6188±0.0099 ^y b ^x	0.5991±0.0057 b	0.5914±0.0214 b	0.5992±0.0056 b	0.6063±0.0050 b	0.6026±0.0071 b
	<i>Ardisia pusilla</i>	0.6833±0.0097 a	0.6748±0.0093 a	0.6661±0.0128 a	0.6600±0.0112 a	0.6667±0.0067 a	0.6458±0.0103 a
	<i>Ficus pumila</i>	0.6072±0.0082 b	0.6099±0.0063 b	0.5847±0.0135 b	0.5663±0.0204 b	0.5696±0.0132 c	0.5693±0.0086 c
SR	<i>Hedera helix</i>	4.2952±0.1123 b	4.0074±0.0785 b	4.0536±0.1788 b	4.0073±0.0695 b	4.0985±0.0612 b	4.0631±0.0888 b
	<i>Ardisia pusilla</i>	5.9759±0.1010 a	5.3418±0.1570 a	5.3270±0.1112 a	5.1021±0.1727 a	5.0432±0.1214 a	4.9060±0.1551 a
	<i>Ficus pumila</i>	4.1292±0.1050 b	4.1493±0.0831 b	3.8857±0.1285 b	3.7471±0.1719 b	3.4892±0.2007 c	3.8020±0.1070 b
CRI 1	<i>Hedera helix</i>	1.2443±0.0554 c	1.1986±0.0336 c	1.1895±0.0719 b	1.1329±0.0236 b	1.2461±0.0309 b	1.2030±0.0249 b
	<i>Ardisia pusilla</i>	1.9164±0.0530 a	1.9019±0.0533 a	1.9191±0.0853 a	1.8321±0.0669 a	1.8140±0.0524 a	1.7687±0.0716 a
	<i>Ficus pumila</i>	1.3996±0.0388 b	1.3828±0.0304 b	1.3545±0.0629 b	1.2387±0.0651 b	1.2349±0.0648 b	1.2541±0.0406 b
CRI 2	<i>Hedera helix</i>	1.7911±0.0750 c	1.6888±0.0465 c	1.6738±0.0946 b	1.5904±0.0302 b	1.6994±0.0299 b	1.6451±0.0310 b
	<i>Ardisia pusilla</i>	2.7628±0.0857 a	2.6995±0.0771 a	2.7573±0.1133 a	2.5834±0.1074 a	2.5057±0.0856 a	2.4693±0.0950 a
	<i>Ficus pumila</i>	1.9457±0.0643 b	1.9021±0.0395 b	1.8282±0.0779 b	1.7103±0.0832 b	1.7354±0.0751 b	1.6684±0.0487 b

^z The vegetation index; NDVI (the normalized difference vegetation index), SR (the simple ration), CRI 1 (carotenoid reflectance index 1), CRI 2 (carotenoid reflectance index 2)

^y Mean ± standard deviation (n = 18)

^x Mean separation within columns by Duncan's multiple range test ($p \leq 0.05$)

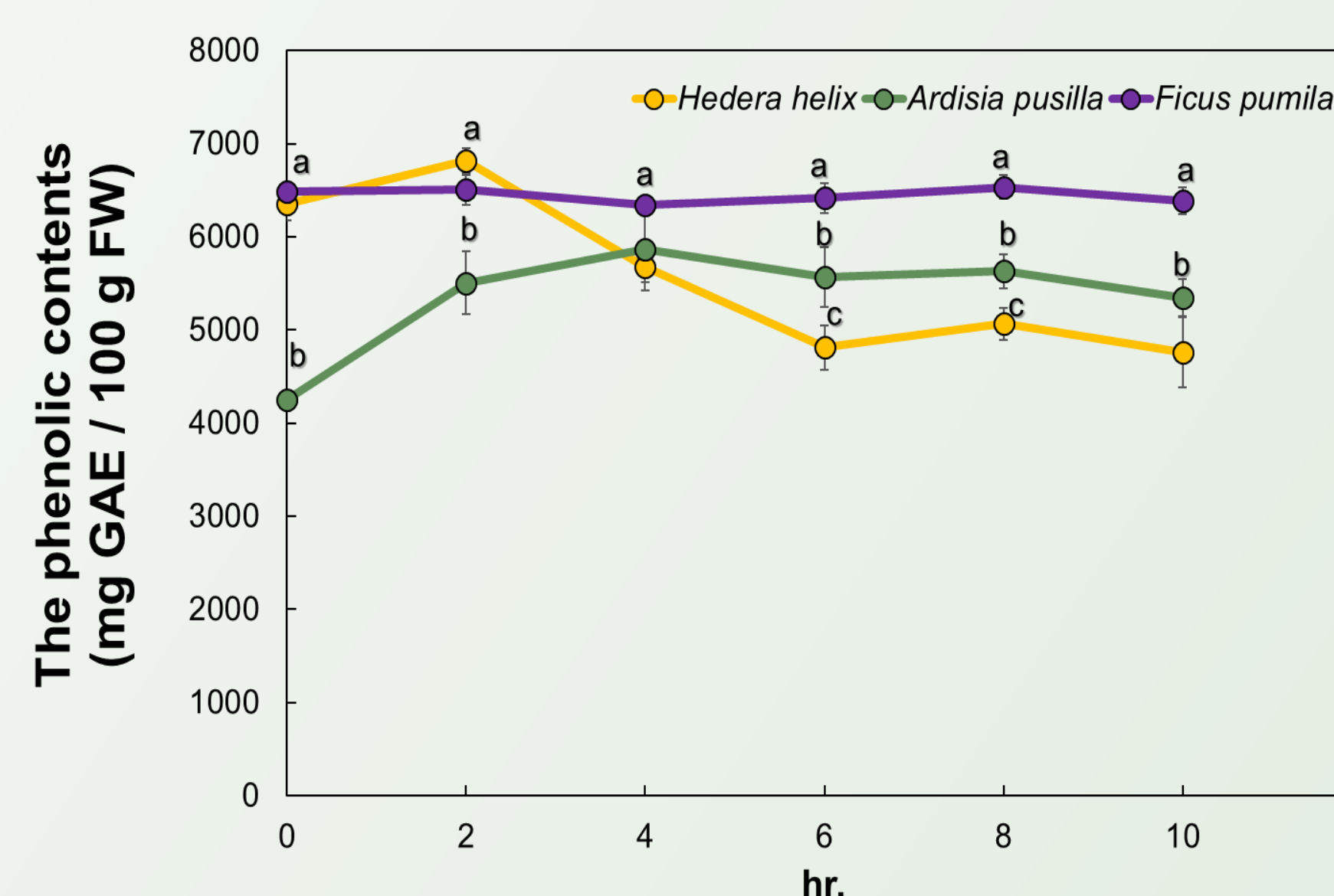


Fig. 4. The change of the phenolic to *Hedera helix*, *Ardisia pusilla* and *Ficus pumila*. Vertical bars represent standard error of the means (n=15). Values with different letters on the bar are significantly different by Duncan's multiple range test ($p \leq 0.05$).

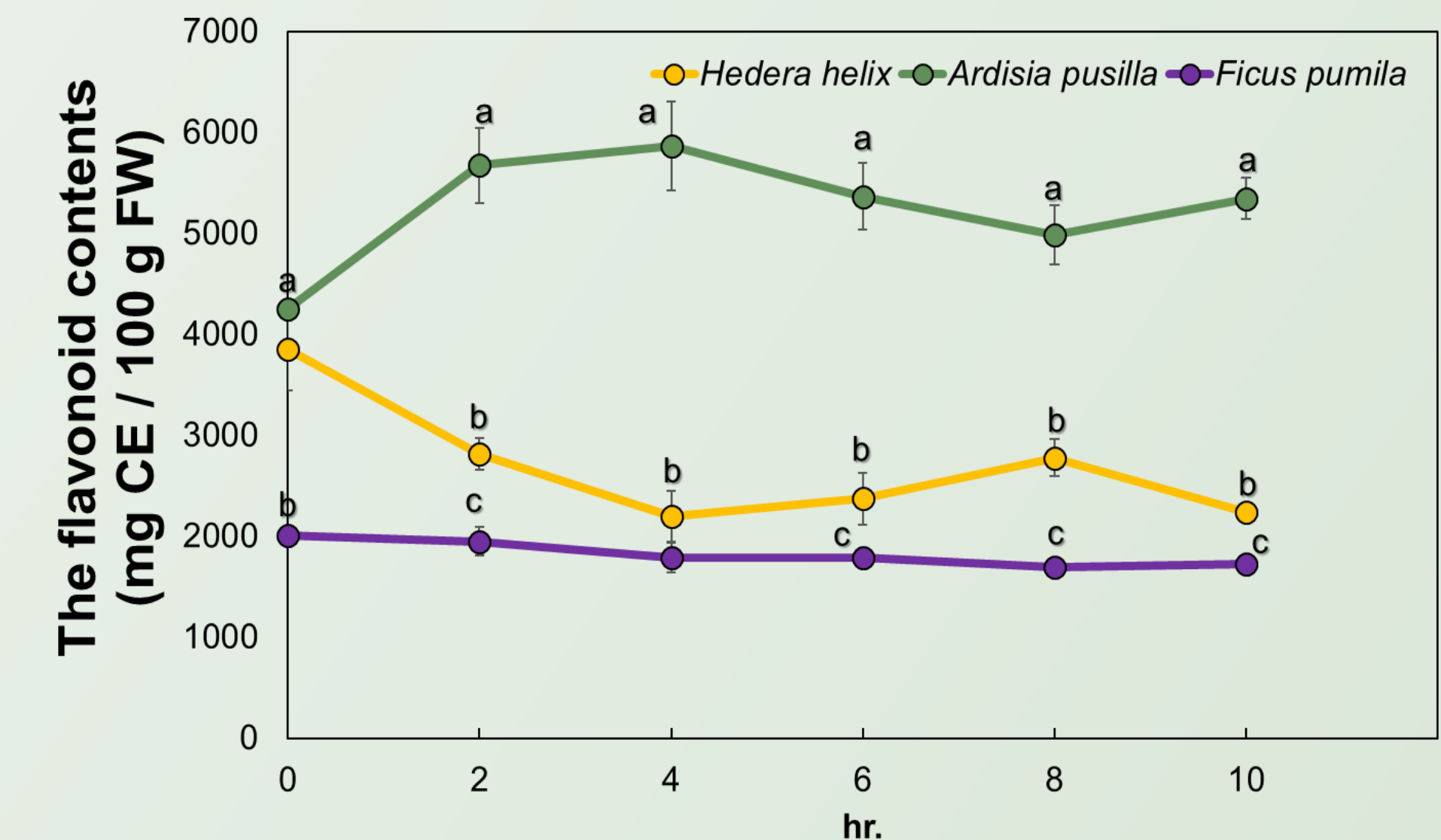


Fig. 5. The change of the flavonoid contents to *Hedera helix*, *Ardisia pusilla* and *Ficus pumila*. Vertical bars represent standard error of the means (n=15). Values with different letters on the bar are significantly different by Duncan's multiple range test ($p \leq 0.05$).

Reference

- Carpenter DO (1998) Human health effects of environmental pollutants: New insights. Environ Monitoring Assessment 53:245-258
- U.S. Environmental protection agency(US.EPA). Factors affecting indoor air quality. <https://www3.epa.gov>.
- Kim KJ, Kim HD (2008) Development of model and calculating equation for rate of volatile formaldehyde removal of indoor plants. Hort Environ Biotechnol 49:155-161