Variations in Glucosinolate Contents and Quinone Reductase-inducing Activities among Florets, Leaves, and Roots of Broccoli Plants

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Introduction

- Glucosinolates (GLS) are a group of sulfur- and nitrogen-containing phytonutrients generally found in cruciferous vegetables.
- Glucosinolates (e.g., glucoraphanin) are hydrolyzed by myrosinase (EC 3.2.3.1) to produce thiocyanates, isothiocynates (e.g., sulforaphane), or nitriles.
- Sulforaphane, an isothiocyanate is a strong inducer of quinone reductase [NAD(P)H: (quinine-acceptor) oxidoreductase, EC 1.6.99.2, QR], a chemoprotective Phase 2 enzyme that detoxifies carcinogens in body.
- Broccoli (*Brassica oleracea* L.) florets and sprouts containing high GLS are well-known and widely consumed as health-promoting vegetable.
- However, information on GLS contents or QR-inducing effects of rarely used organs: leaves and roots of broccoli are very limited.

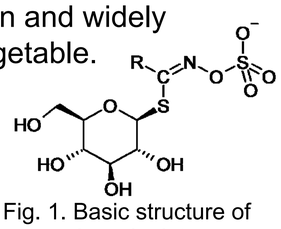

Fig. 1. Basic structure of glucosinolates.

Objective

- To characterize and compare glucosinolates profiles and QR-inducing chemopreventive effects among different organs: florets, leaves and roots of broccoli plants.

Materials and methods

- Broccoli varieties: 'Broccoli Neri', 'Broccoli Grande Precoce', 'Arcadia', 'Sultan', 'VI-158' were cultivated at Univ. of Illinois Vegetable Research Farm.
- Florets, leaves and roots from harvested broccoli were separated, freeze-dried, powdered and kept at -20°C.
- For glucosinolate analysis, plant samples were extracted with 70% MeOH, desulfated and quantified with an HPLC by using UV relative response factors of each glucosinolate to sinigrin as an internal standard according to Ku, et al. (2014)

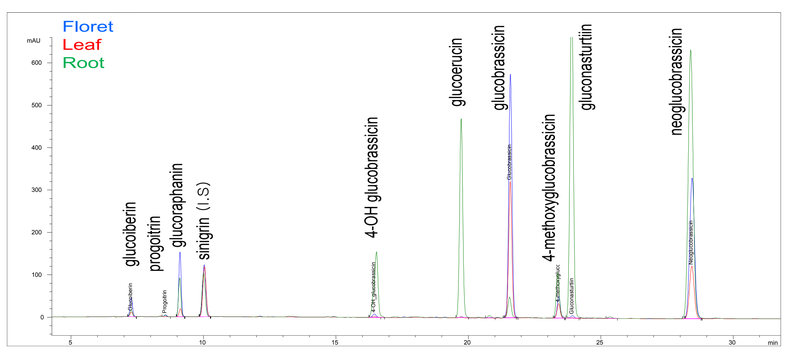

Fig. 2. Chromatograms of glucosinolates in floret (blue), leaf (red), and root (green) of broccoli ('Neri').

- Quinone reductase-inducing activities of plant extracts in murine hepatoma cells (Hepa1c1c7) were assayed and expressed as specific activity (nmol MTT reduced /mg/min) ratio relative to control cells (Ku et al., 2014).

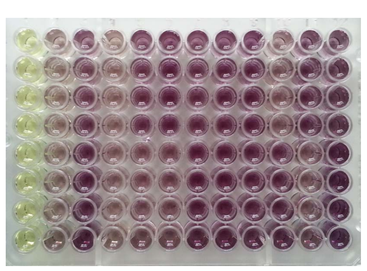

Fig. 3. QR assay

Results

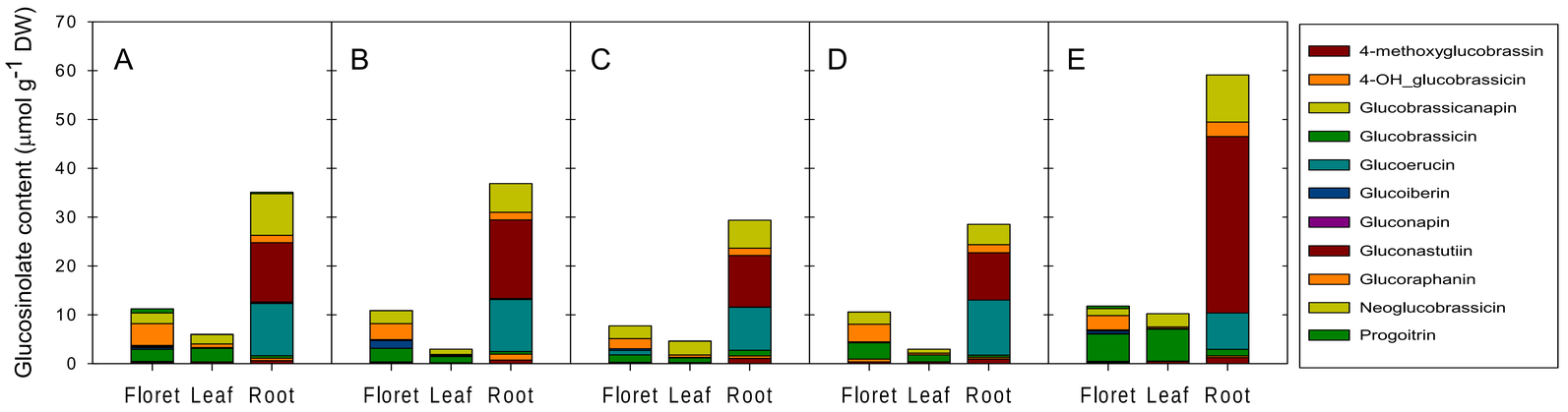

Fig. 4. Glucosinolates in floret, leaf, and root of 5 broccoli varieties. A: 'Arcadia', B: 'Broccoli Neri', C: 'Broccoli Grande Precoce', D: 'Sultan', E: 'VI-158'

Table 1. Glucosinolate content (μmol g^{-1} dw) in floret, leaf, and root of broccoli varieties.

	Floret					Leaf					Root				
	Neri	Precoce	Arcardia	Sultan	VI-158	Neri	Precoce	Arcardia	Sultan	VI-158	Neri	Precoce	Arcardia	Sultan	VI-158
4-methoxy glucobrassicin	.21	.22	.26	.34	.18	.18	.20	.31	.32	.43	.72	1.09	.61	.96	1.25
4-OH glucobrassicin	.14	.03	.17	.58	.18	-	.01	.02	.04	.04	1.23	.50	.48	.33	.35
Glucobrassicanapin	-	.01	-	-	.10	-	-	.02	-	.05	-	-	-	-	-
Glucobrassicin	2.77	1.52	2.50	3.34	5.61	1.28	.95	2.77	1.43	6.53	.52	1.15	.52	.43	1.32
Glucoerucin	-	.93	-	.19	.11	-	.02	-	-	.03	10.67	8.80	10.70	11.31	7.46
Glucoiberin	1.59	.33	.34	-	.51	.22	.05	.14	-	-	.20	.03	.05	-	-
Gluconapin	-	-	.23	-	.05	-	-	-	-	-	-	-	.23	-	-
Gluconasturtiin	.18	-	.21	-	.16	-	.05	-	-	.13	16.10	10.57	12.16	9.69	36.13
Glucoraphanin	3.30	2.07	4.48	3.61	2.94	.19	.49	.77	.35	.30	1.56	1.49	1.50	1.64	2.95
Neoglucobrassicin	2.65	2.62	2.18	2.49	1.43	1.10	2.82	1.93	.83	2.73	5.89	5.74	8.53	4.17	9.65
Progoitrin	.02	-	.86	.02	.52	-	.03	.06	-	-	-	-	.30	-	-
Total glucosinolates	10.87	7.73	11.22	10.57	11.79	2.97	4.62	6.02	2.96	10.23	36.88	29.37	35.09	28.53	59.11
Average	10.43					5.36					37.80				

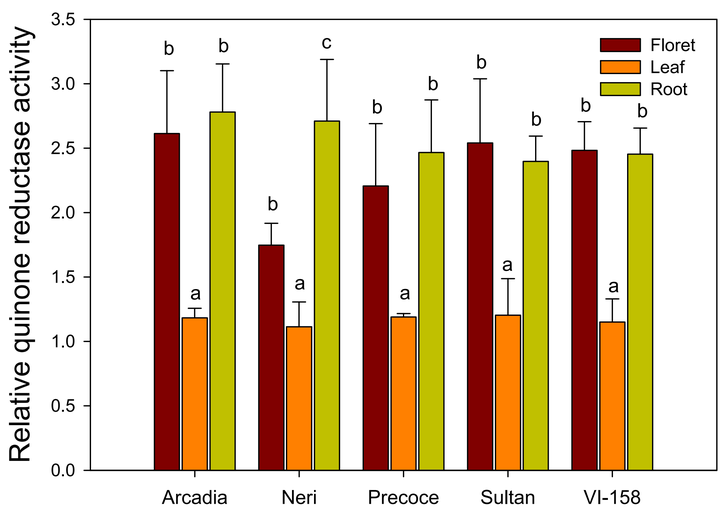

Fig. 5. QR-inducing effects of floret, leaf, and root of broccoli plants. Different letters above error bar indicate significantly different at LSD at *P* =0.05 within the same cultivar.

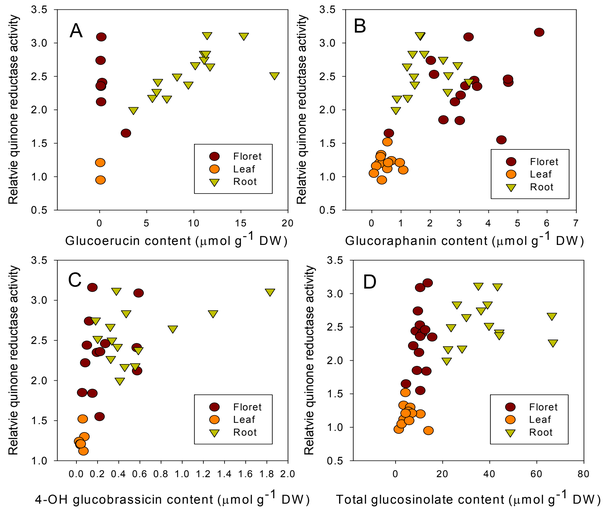

Fig. 6. Relationship between QR-inducing activity and glucoerucin (A), glucoraphanin (B), 4-OH glucobrassicin (C), and total glucosinolate (D) contents in florets, leaf, and roots of broccoli plants (n=15).

Conclusions

- Average content of total glucosinolates from five broccoli cultivars' root (37.8 μmol g^{-1} DW) was higher than floret (10.4 μmol g^{-1} DW) and leaf tissue (5.36 μmol g^{-1} DW) of broccoli plants.
- Major glucosinolates were glucoraphanin (30%) and glucobrassicin (29%) in florets, glucobrassicin (47%) and neoglucobrassicin (34%) in leaves, and gluconasturtiin (45%) and glucoerucin (26%) in roots of broccoli plants, suggesting good biomarkers for broccoli parts.
- Broccoli roots exhibited comparable QR-inducing effects to florets and significantly higher than leaves.
- Correlations between QR-inducing activity and each or total glucosinolate contents were not significant, requiring further experiment in hydrolysis products and bioavailability in QR system.