



Background

Anthocyanins are water-soluble pigments that provide blue, purple and red colors to fruits and vegetables

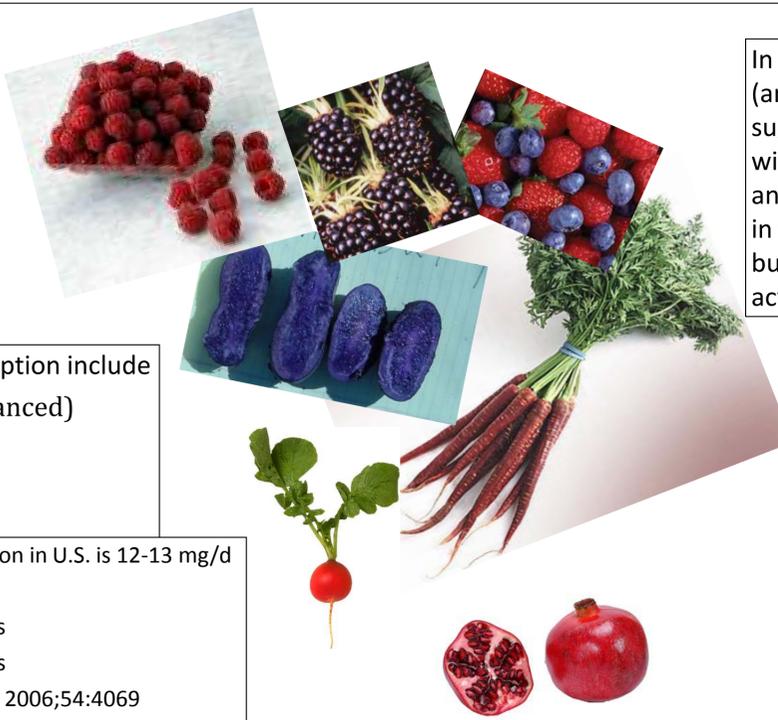
Purported health benefits of anthocyanin consumption include

- improved brain health (memory, balance enhanced)
- reduced inflammation and oxidative stress
- improved gluco-regulation
- cancer protection

Estimated consumption in U.S. is 12-13 mg/d

- 8.7 from fruit
- 2.2 from vegetables
- 1.7 from beverages

J Agric Food Chem 2006;54:4069



In nature, anthocyanin pigments (anthocyanidins) are linked with various sugar molecules and may contain acylations with aliphatic or aromatic acids. Thus anthocyanins are numerous, varying not only in their anthocyanin (pigment) component, but also in number and type of sugars and acylations.

Acylated groups

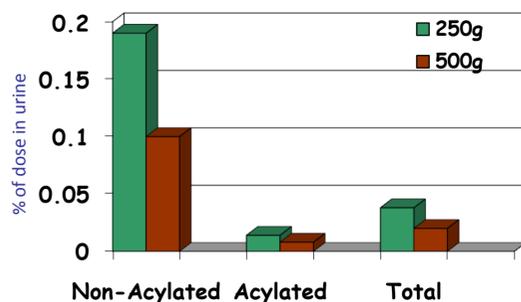
Aliphatic acid	Aromatic acid
acetic acid	p-hydroxybenzoic acid
propionic acid	p-coumaric acid
oxalic acid	caffeic acid
malonic acid	ferulic acid
succinic acid	sinapic acid
malic acid	

Research Goals

- To determine why some anthocyanins are more bioavailable than others
- To determine how amount of anthocyanin consumed relates to amount absorbed.....is more better?

Research Findings

Urinary Recovery of Non-Acylated and Acylated Anthocyanins from Subjects Consuming 250 or 500 g Purple Carrot



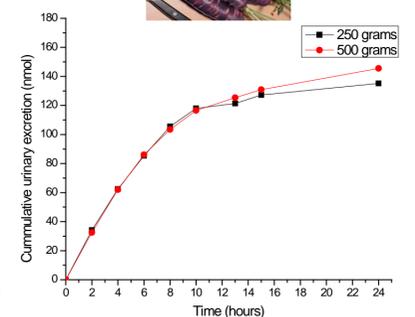
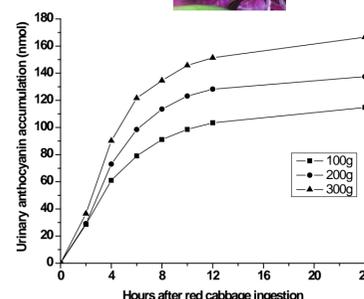
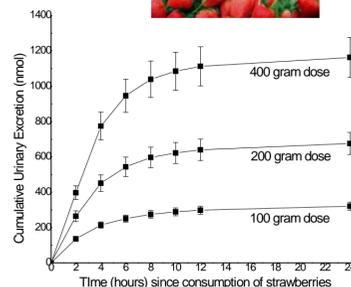
1. Acyl groups reduce anthocyanin absorption

For purple carrots, acylation resulted in an 11 – 14 fold decrease in anthocyanin recovery in urine. For red cabbage, acylation resulted in a 4 fold decrease in anthocyanin recovery in urine.

2. Hydrophobic anthocyanins appear to be less efficiently absorbed

In the Red Cabbage Study, we observed a negative correlation between HPLC elution order of anthocyanins and their recovery in urine. (Compounds of higher hydrophobicity characteristically elute later than less hydrophobic compounds.) Thus anthocyanin recovery in urine was inversely related to anthocyanin hydrophobicity. We propose that hydrophobicity is a determinant of anthocyanin bioavailability.

Factors that May Influence Dose-Response



3. More is not always better: Comparison of amount of anthocyanin-rich food consumed to the amount of anthocyanin in urine

- Strawberries -- dose-response was linear over a range of 100 to 400 g (15 to 60 μmol anthocyanins); 2% of anthocyanin recovered in urine for each dose.
- Red cabbage -- doubling the dose size from 100 to 200 g (138 to 276 μmol anthocyanins) produced only a 20% increase in urinary anthocyanins; increasing from 100 to 300 g (138 to 415 μmol) produced only a 55% increase in urinary anthocyanins (0.04 to 0.02% for 100 and 300 g doses).
- Purple carrots -- doubling dose size from 250 to 500 g (357 to 714 μmol anthocyanins) produced no difference in amount recovered as urinary anthocyanins (0.04 and 0.02% recovered for 250 and 500 g doses).

Dose	Acylation	Anthocyanin backbone
15-60 μmol	None	Pelargonidin
138-415 μmol	86%	Cyanidin
357-714 μmol	79%	Cyanidin

Citations for our anthocyanin bioavailability studies

- Kurilich, AC, Clevidence BA, Britz SJ, Simon PW, Novotny JA. Plasma and urine responses are lower for acylated vs nonacylated anthocyanins from raw and cooked purple carrots. J Agric Food Chem. 2005, 53:6537.
- Charron, CS, Clevidence BA, Britz SJ, Novotny JA. Effect of dose size on bioavailability of acylated and nonacylated anthocyanins from red cabbage (*Brassica oleracea* L. Var. *capitata*). J Agric Food Chem. 2007, 55:5354.
- Carkeet C, Clevidence BA, Novotny JA. Anthocyanin excretion by humans increases linearly with increasing strawberry dose. J Nutr. 2008, 138:1.
- Charron CS, Kurilich AC, Clevidence BA, Simon PW, Harrison D, Britz SJ, Baer DJ, Novotny JA. Bioavailability of anthocyanins from purple carrot juice: effects of acylation and plant matrix. J Agric Food Chem. 2009, 57:1226.