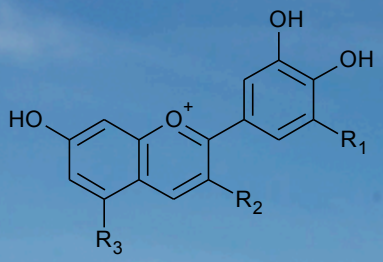
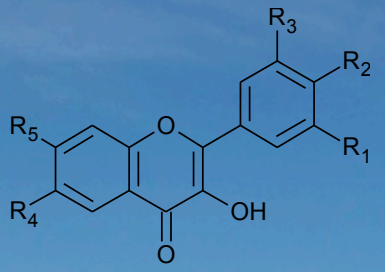
Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences




# Variation in content of polyphenols and ascorbic acid as influenced by genotype, year and location

Michael Vagiri*[1], Staffan Andersson[2], Eva Johansson[2] & Kimmo Rumpunen[1]

[1] *Department of Plant Breeding, SLU Balsgård, Fjälkestadsvägen 459, SE-291 94 Kristianstad, Sweden*
[2] Department of Plant Breeding, SLU, Box 104, SE-230 53 Alnarp, Sweden

**CLIMAFRUIT meeting-Jork, 2013**

Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

# Background

- Increasing interest in the inclusion of fruits and berries in human diet
- Convincing evidence about the positive contributions of black currant on human health
- This is due to high levels of phenolic compounds and ascorbic acid
- Quality and composition of different compounds could be affected by factors such as genotype, climate, location, cultivation practices etc.
- It is essential for processing sector that quality of fruit is as little as possible affected by environmental conditions
- Processing sector demands for berries with high content of various compounds, together with low acidity and high content of soluble solids
- From breeding viewpoint knowledge on phenotypic and genetic data on berry quality is essential

Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

# Objectives

Investigate the role of genotype, location and year on the single and total phenolic compounds, ascorbic acid, total anthocyanins, soluble solids and titratable acidity in black currant berries from three cultivars and two advanced selections grown by organic field management principles in the north and south of Sweden over a three year period.

Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

# Experimental design

Plantation established in the south (Balsgård) and north (Öjebyn) of Sweden in 2006

Randomized block design

Five blocks (rows) and a plant (genotype) per plot (total Five plants per genotype)

Planting distance 4m between rows and 2m between plants

Berries harvested at full ripeness during July in the south and August in the north

# Plant material

‘Ben Finlay’

‘JHI 8944-13’

‘Poesia’

‘BRi 9504-2-227’

‘Titania’

# Methods

**HPLC-DAD:** Phenolic compounds

**UV Spectrophotometer**: Total phenolics and Total anthocyanins

**HPLC-UV:** Ascorbic acid

**Refractometer:** Total solube solids

**Automatic titrator:** Titratable acid

# Results

## 1. Relative amounts of variance ( % based on $R^2$ values from regression analyses)

A. Monomeric Anthocyanins (relative variance, %)

| Source | Del-glu | Del-rut | Cya-glu | Cya-rut |
|---|---|---|---|---|
| Genotype | 0.2 | 3.5 | 19.3 | 13.9 |
| Location | 2.4 | 1.3 | 2.1 | 1.2 |
| Year | 18.2 | 4.5 | 6.7 | 7.7 |
| Genotype x Location x Year | 23.4 | 11.7 | 23.8 | 19.8 |

B. Flavonols (relative variance, %)

| Source | Myr-mal-glu | Que-rut | Que-glu | Que-mal-glu | Kae-glu | Iso-glu |
|---|---|---|---|---|---|---|
| Genotype | 5.4 | 14.3 | 0.4 | 0.1 | 34.9 | 45.5 |
| Location | 9.4 | 10.6 | 5.0 | 18.5 | 1.1 | 2.2 |
| Year | 4.5 | 6.2 | 2.4 | 6.6 | 2.7 | 12.4 |
| Genotype x Location x Year | 22.8 | 29.0 | 7.0 | 29.3 | 36.0 | 53.1 |

C. Phenolic Acids, Total Phenols, Total Anthocyanins, Ascorbic Acid, Soluble Solids and Titratable Acidity (relative variance, %)

| Source | Neo-chl | Chl | TP | TA | AsA | SS | TTA |
|---|---|---|---|---|---|---|---|
| Genotype | 15.5 | 23.1 | 60.4 | 1.7 | 50.0 | 39.6 | 7.7 |
| Location | 7.1 | 1.9 | 6.8 | 6.3 | 17.1 | 14.0 | 1.9 |
| Year | 0.2 | 0.7 | 6.3 | 13.5 | 9.3 | 0.2 | 0.7 |
| Genotype x Location x Year | 24.7 | 25.1 | 68.7 | 21.4 | 71.2 | 57.5 | 9.8 |

## 2. Means (averages of locations and years) for different genotypes.

A. Monomeric Anthocyanins ($\mu$g/g DW)[a]

| Genotype | Del-glu | Del-rut | Cya-glu | Cya-rut | Sum |
|---|---|---|---|---|---|
| 'Ben Finlay' | 2534 b | 4561 c | 1173 b | 4509 b | 12777 ab |
| 'JHI 8944-13' | 2195 c | 3795 d | 1807 a | 4974 a | 12772 ab |
| 'BRi 9504-2-227' | 1272 d | 6158 a | 479 c | 4955 a | 12863 b |
| 'Poesia' | 3066 a | 4641 c | 1182 b | 4660 ab | 13550 a |
| 'Titania' | 2260 c | 5326 b | 558 c | 3630 c | 11774 b |

B. Flavonols ($\mu$g/g DW)[a]

| Genotype | Myr-mal-glu | Que-rut | Que-glu | Que-mal-glu | Kae-glu | Iso-glu | Sum |
|---|---|---|---|---|---|---|---|
| 'Ben Finlay' | 92 b | 217 b | 147 d | 8 d | 140 b | 41 a | 715 c |
| 'JHI 8944-13' | 70 c | 267 a | 337 a | 94 c | 191 a | 42 a | 1001 a |
| 'BRi 9504-2-227' | 51 d | 257 a | 218 c | 112 b | 95 c | 24 b | 757 c |
| 'Poesia' | 147 a | 249 a | 305 b | 134 a | 66 d | 21 c | 922 b |
| 'Titania' | 88 b | 127 c | 160 d | 80 d | 61 d | 14 d | 530 d |

C. Phenolic Acids ($\mu$g/g DW)[a] ,Total Phenols (mg/g GA DW), Total Anthocyanins (mg cya-glu/g DW), Ascorbic Acid (mg/100 g FW), Soluble Solids (°Brix) and Titratable Acidity (mL 0.1 M NaOH)

| Genotype | Neo-chl | Chl | Sum | TP[a] | TA[a] | AsA[b] | SS[b] | TTA[b] |
|---|---|---|---|---|---|---|---|---|
| 'Ben Finlay' | 203 a | 449 b | 652 b | 31.8 a | 11.6 a | 310 a | 12.6 e | 9.0 c |
| 'JHI 8944-13' | 121 b | 1016 a | 1137 a | 22.0 b | 10.6 b | 219 b | 13.3 d | 8.7 d |
| 'BRi 9504-2-227' | 205 a | 227 c | 432 c | 21.0 c | 9.9 c | 166 d | 15.4 c | 12.6 a |
| 'Poesia' | 101 c | 217 c | 318 d | 21.8 c | 11.4 a | 190 c | 16.7 a | 10.2 b |
| 'Titania' | 51 d | 248 c | 299 d | 19.2 d | 10.5 b | 148 e | 15.9 b | 10.1 b |

[a]Mean based on two replicate analyses for each sample. [b]Mean based on three replicate analyses for each sample. Different letter/letters within each column indicate significant differences between the cultivars at $p<0.05$ using Duncan Post-hoc test.

## 3. Means (averages of genotypes and years) for different locations.

A. Monomeric Anthocyanins ($\mu$g/g DW)[a]

| Location | Del-glu | Del-rut | Cya-glu | Cya-rut | Sum |
|---|---|---|---|---|---|
| South | 2440 a | 5237 a | 922 b | 4457 a | 13056 a |
| North | 2092 b | 4623 b | 1118 a | 4619 a | 12451 b |

B. Flavonols ($\mu$g/g DW)[a]

| Location | Myr-mal-glu | Que-rut | Que-glu | Que-mal-glu | Kae-glu | Iso-glu | Sum |
|---|---|---|---|---|---|---|---|
| South | 103 a | 252 a | 214 b | 120 a | 96 b | 28 a | 812 a |
| North | 78 b | 194 b | 254 a | 82 b | 119 a | 27 a | 754 b |

C. Phenolic Acids ($\mu$g/g DW)[a] ,Total Phenols, Total Anthocyanins, Ascorbic Acid, Soluble Solids and Titratable Acidity

| Location | Neo-chl | Chl | Sum | TP[a] (mg/g GA DW) | TA[a] (mg cya-glu/g DW) | AsA[b] (mg/100 g FW) | SS[b] (°Brix) | TTA[b] (mL 0.1 M NaOH) |
|---|---|---|---|---|---|---|---|---|
| South | 108 b | 352 b | 459 b | 25.0 a | 11.3 a | 226 a | 15.7 a | 10.1 b |
| North | 160 a | 481 a | 642 a | 22.6 b | 10.2 b | 170 b | 14.0 b | 10.5 a |

[a]Mean based on two replicate analyses for each sample. [b]Mean based on three replicate analyses for each sample. Different letter/letters within each column indicate significant differences between the cultivars at $p<0.05$ using Duncan Post-hoc test.

## 4. Means (averages of genotypes and locations) for different years

A. Monomeric Anthocyanins ($\mu$g/g DW)[a]

| Year | Del-glu | Del-rut | Cya-glu | Cya-rut | Sum |
|---|---|---|---|---|---|
| 2008 | 1844 c | 4430 c | 940 b | 4383 b | 11598 c |
| 2009 | 2273 b | 4925 b | 989 ab | 4429 b | 12617 b |
| 2010 | 2617 a | 5357 a | 1119 a | 4778 a | 13872 a |

B. Flavonols ($\mu$g/g DW)[a]

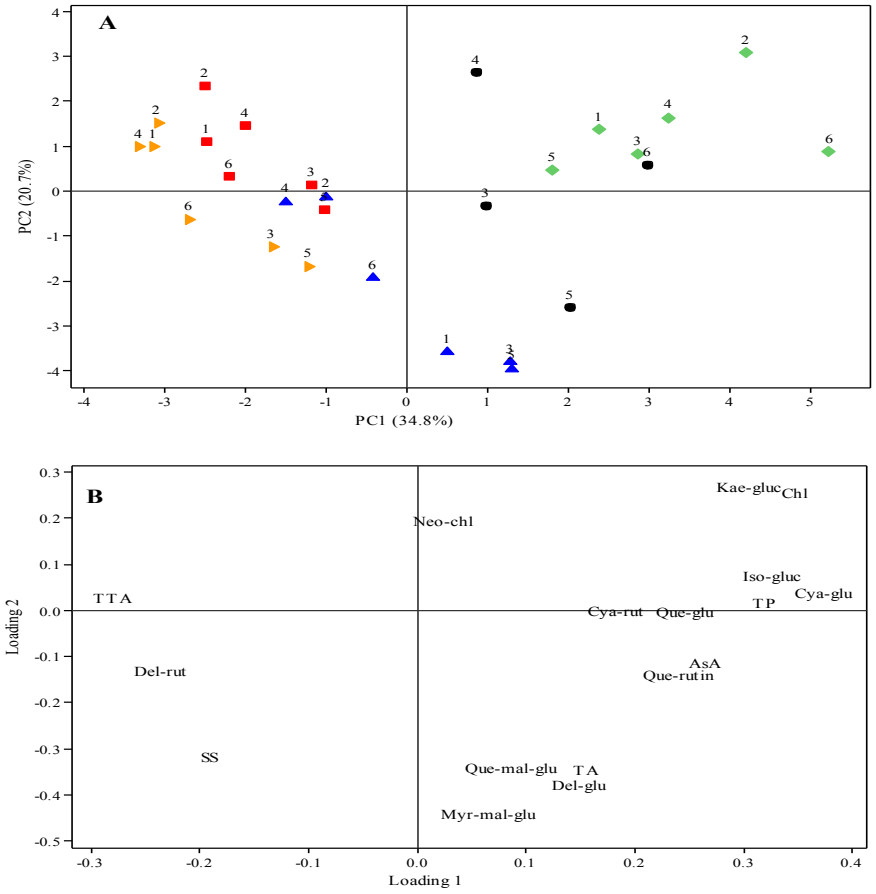
| Year | Myr-mal-glu | Que-rut | Que-glu | Que-mal-glu | Kae-glu | Iso-glu | Sum |
|---|---|---|---|---|---|---|---|
| 2008 | 85 b | 204 b | 230 b | 89 b | 114 a | 24 b | 746 b |
| 2009 | 84 b | 217 b | 220 b | 93 b | 99 b | 26 b | 740 b |
| 2010 | 101 a | 243 a | 252 a | 117 a | 110 a | 32 a | 855 a |

C. Phenolic Acids ($\mu$g/g DW)[a]

| Year | Neo-chl | Chl | Sum | TP[a] (mg/g GA dw) | TA[a] (mg cya-glu/g DW) | AsA[b] (mg/100 g FW) | SS[b] (°Brix) | TTA[b] (mL 0.1 M NaOH) |
|---|---|---|---|---|---|---|---|---|
| 2008 | 82 b | 441 a | 523 b | 22.9 c | 10.0 c | 161 c | 14.4 c | 10.4 a |
| 2009 | 219 a | 380 b | 599 a | 23.7 b | 10.8 b | 206 b | 14.9 b | 10.2 b |
| 2010 | 96 b | 433 a | 529 b | 24.7 a | 11.3 a | 217 a | 15.3 a | 10.2 b |

[a]Mean based on two replicate analyses for each sample. [b]Mean based on three replicate analyses for each sample. Different letter/letters within each column indicate significant differences between the cultivars at $p<0.05$ using Duncan Post-hoc test.

# Principal component analysis




●, Ben Finlay; ■, 'BRi 9504-2-227'; ◆, 'JHI 8944-13'; ▲,'Poesia'; ▶, 'Titania', grown in the south and north of Sweden and sampled during three years. (Abbreviations used: 1 = 2008/south, 2 = 2008/north, 3 = 2009/south, 4 = 2009/north, 5 = 2010/south, 6 = 2010/north)

Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

# Conclusions

- Genotypic effects were larger than location and year for most of the compounds
- Content of d-glu, d-rut, myr-glu, q-rut, q-glu, sum of anthocyanins and flavonols, TP, TA, AsA and TS were higher in the south of Sweden
- Content of c-glu, q-glu, k-glu, phenolic acids and TTA was higher in the north of Sweden
- Black currants growing in lower location with high content of AsA, SS, lower phenolic acids and TTA have better sensory characters than those from the north
- ‘Ben Finlay’, ‘JHI-8944-13’ and ‘Poesia’ high in most parameters could be suitable parents
- The effects of location on the composition of bioactive compounds should be considered while selecting cultivation site and plant material

Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

# Thank you!