

The Climafruit transnational trial

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The James
Hutton
Institute



Future-proofing berryfruit
CLIMAFRUIT

The Interreg IVB
North Sea Region
Programme



Transnational trials

- *Ribes nigrum*

- Ben Alder
- Ben Gairn
- Ben Vane
- Ben Klibreck
- Ben Hope



- *Rubus idaeus*

- Glen Ample
- Glen Fyne
- Octavia
- Tulameen
- Autumn Treasure
- (Polka)
- (Erika)



- *Rubus fruticosus*

- Karaka black
- (Loch Ness)



Biochemical analysis

- LC-MS

- Anthocyanins

- ▶ Cyanidin-3-O-Sophoroside
- ▶ Cyanidin-3-O Rutinoside
- ▶ Cyanidin-3-O-Glucoside
- ▶ Cyanidin-3-O-Sambubioside
- ▶ Cyanidin-3-Glucosyl-2-Rutinoside
- ▶ Cyanidin-Sambubioside-Rhamnoside
- ▶ Pelargonidin-3-Glucosyl-Rutinoside
- ▶ Pelargonidin-3-Sophoroside

- Flavonols

- ▶ Quercetin-3-O-Glucuronide
- ▶ Hyperoside

- HPLC PAD (pulse amperometry)

- Glucose, Sucrose and Fructose

- HPLC conductivity

- Citrate
- Malate



Biochemical analysis

- 5 varieties

- Glen Ample
- Glen Fyne
- Tulameen
- Octavia
- Autumn Treasure

- 2 years

- 2011
- 2012

- 5 Locations

- Denmark
- Germany
- Norway
- Sweden
- United Kingdom

- Minimum 3 blocks

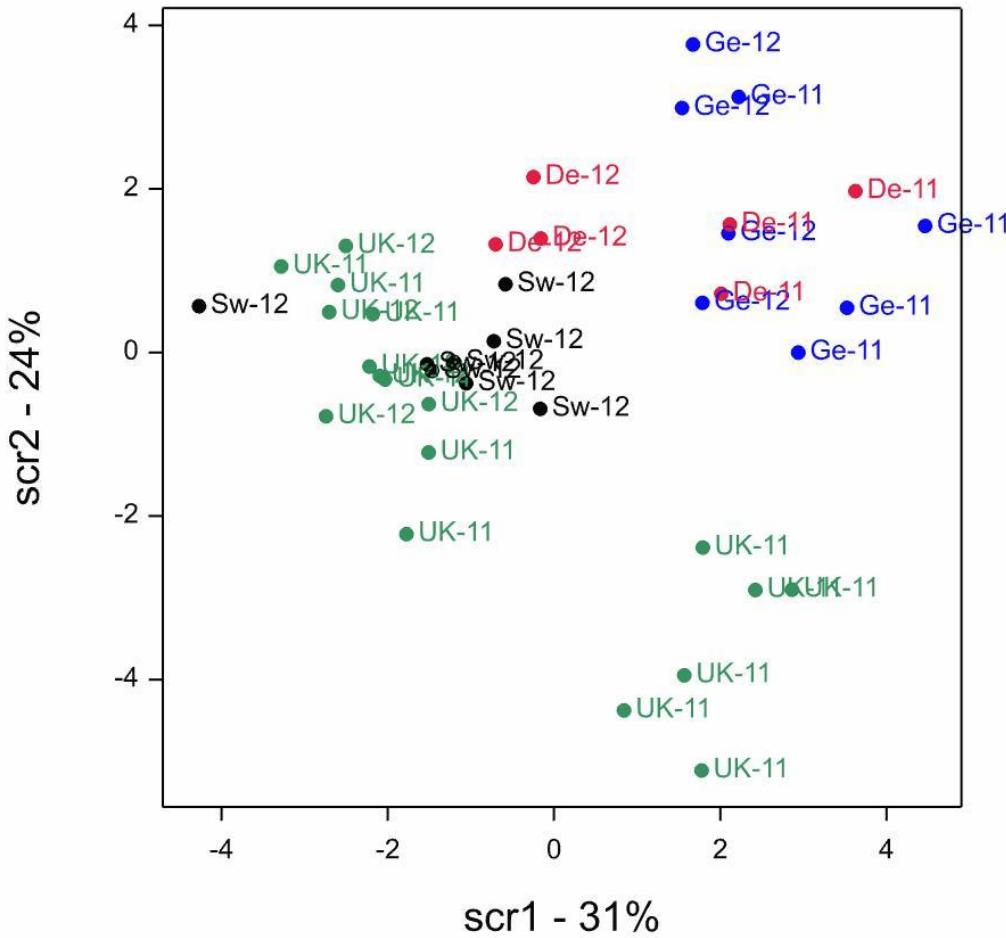
- 4 different chromatography batches

**Minimum of 150
samples to be
analysed**

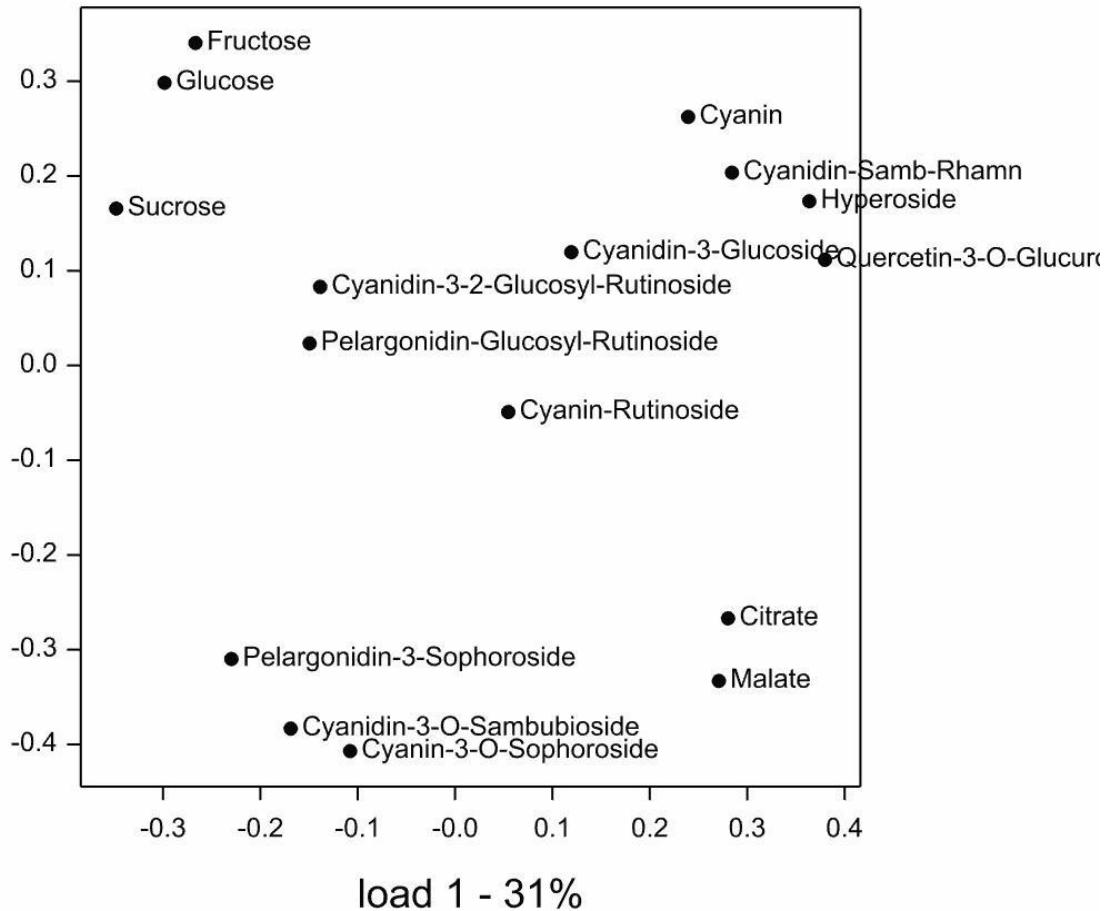
Separation of analysis between batches

- 5 batches
- All the samples of one variety analysed in one batch
 - Prioritize comparison of the same variety across different locations and different years
 - Comparison between varieties could be unpractical due to differences in the response of analytical method between different batches
- Addition of reference material will allow to estimate such effects

Autumn Treasure PCA



Autumn Treasure PCA

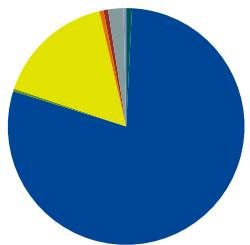


Autumn Treasure ANOVAs

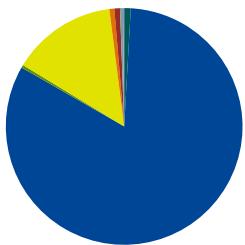
		Cyanin	Cyanidin-3-O-Sophoroside	Cyaninidin-Rutinoside	Cyanidin-3-Glucoside	Cyanidin-3-O-Sambubioside	Cyanidin-3-Glucosyl-Rutinoside	Cyanidin-Sambubioside-Rhamnoside	pelargonidin-3-Glucosyl-Rutinoside	Pelargonidin-3-Sophoroside	Quercetin-3-O-Glucuronide	Hyperoside	Citrate	Malate	Fructose	Glucose	Sucrose
	Autumn Treasure																
Germany	2011	67	3888	18.62	740.3	28.56	2.639	1.7453	0.00819	29.15	165.06	23.62	152.2	5.271	131.9	121.5	65.04
	2012	55.24	3362	18.33	720.5	23.84	2.722	0.419	0.00168	23.31	147.39	23.59	134.2	4.291	143.9	134.5	78.62
	mean	60.83	3612	18.47	729.9	26.08	2.683	1.049	0.00477	26.08	155.78	23.61	142.8	4.756	138.2	128.3	72.17
UK	2011	34.88	4468	21.87	688.6	32.25	3.361	0.0997	0.00912	72.09	60.17	11.57	119	3.791	147	144.1	156.9
	2012	40.97	4442	17.85	610.7	32.83	3.558	0.094	0.01049	46.01	15.46	5.88	126.8	3.588	155.2	146.6	129.1
	mean	38.64	4452	19.39	640.5	32.61	3.483	0.0962	0.00996	55.98	32.55	8.05	123.8	3.665	152.1	145.6	139.7
Norway	2011	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	2012	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	mean	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Sweden	2011	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	2012	45.12	4171	19.42	724.7	34.4	6.829	0.1388	0.07042	38.62	20.09	8.43	130.3	4.117	145.1	137.7	93.87
	mean	45.12	4171	19.42	724.7	34.4	6.829	0.1388	0.07042	38.62	20.09	8.43	130.3	4.117	145.1	137.7	93.87
Denmark	2011	71.57	3936	20.88	861.5	26.93	0.076	0.992	0.01004	25.84	126.93	22.04	135.3	4.963	123.7	110.2	99.59
	2012	36.17	3631	15.86	743.2	26.74	0.191	0.0293	0.02025	28.31	96.07	16.73	123.7	3.07	149.9	137	114.71
	mean	52.99	3776	18.25	799.4	26.83	0.136	0.4866	0.0154	27.14	110.73	19.25	129.2	3.969	137.5	124.3	107.53
Mean	2011	53.23	4167	20.64	744.4	29.89	2.381	0.812	0.00905	48.21	107.85	17.69	133	4.517	137	129.3	115.4
Mean	2012	44.46	3981	17.98	686.7	30.01	3.537	0.1696	0.02424	35.81	61.82	12.56	128.8	3.786	149.2	140	106.4
F pr.	location	<.001	<.001	0.976	0.037	<.001	0.103	<.001	0.224	<.001	<.001	<.001	<.001	0.007	0.441	0.12	<.001
	year	0.01	0.086	0.345	0.091	0.394	0.941	<.001	0.972	<.001	<.001	0.007	0.186	0.002	0.112	0.156	0.592
	location.year	<.001	0.3	0.84	0.656	0.269	1	<.001	0.976	0.001	0.337	0.179	0.008	0.035	0.689	0.476	0.107
	S.E.D.	5.586	236.5	5.573	68.38	2.443	3.307	0.1533	0.04767	5.154	13.42	2.307	5.911	0.42	14.22	13.42	16.38

Autumn Treasure polyphenol composition

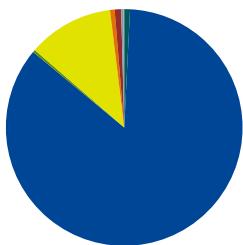
Denmark 2012



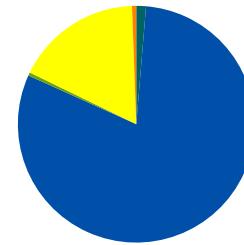
Sweden 2012



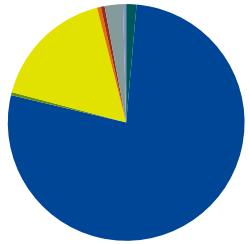
UK 2012



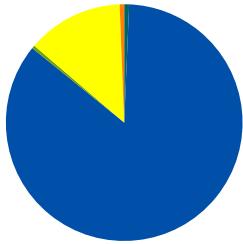
Germany 2012



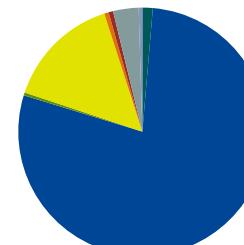
Denmark 2011



UK 2011



Germany 2011

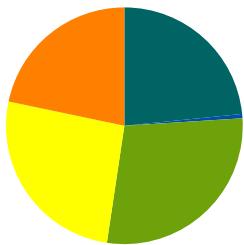


- Cyanin
- Cyanindin-3-O-Sophoroside
- Cyaninidin-Rutinoside
- Cyanidin-3-Glucoside
- Cyanidin-3-O-Sambubioside
- Pelargonidin-3-Sophoroside
- Quercetin-3-O-Glucuronide
- Hyperoside

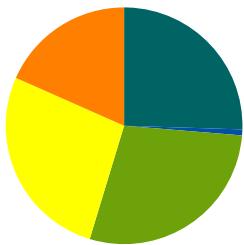
Note: No levels were detected for other bi-glycosilated anthocyanins

Autumn Treasure carbohydrate composition

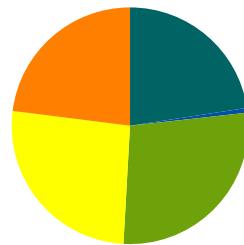
Denmark 2012



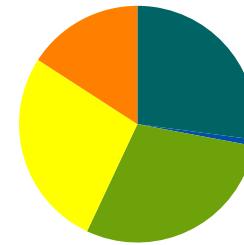
Sweden 2012



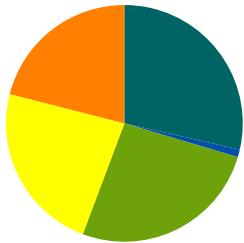
UK 2012



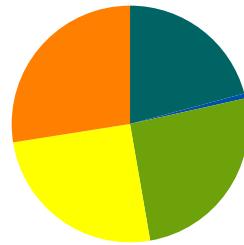
Germany 2012



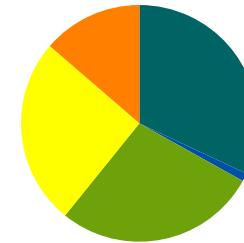
Denmark 2011



UK 2011

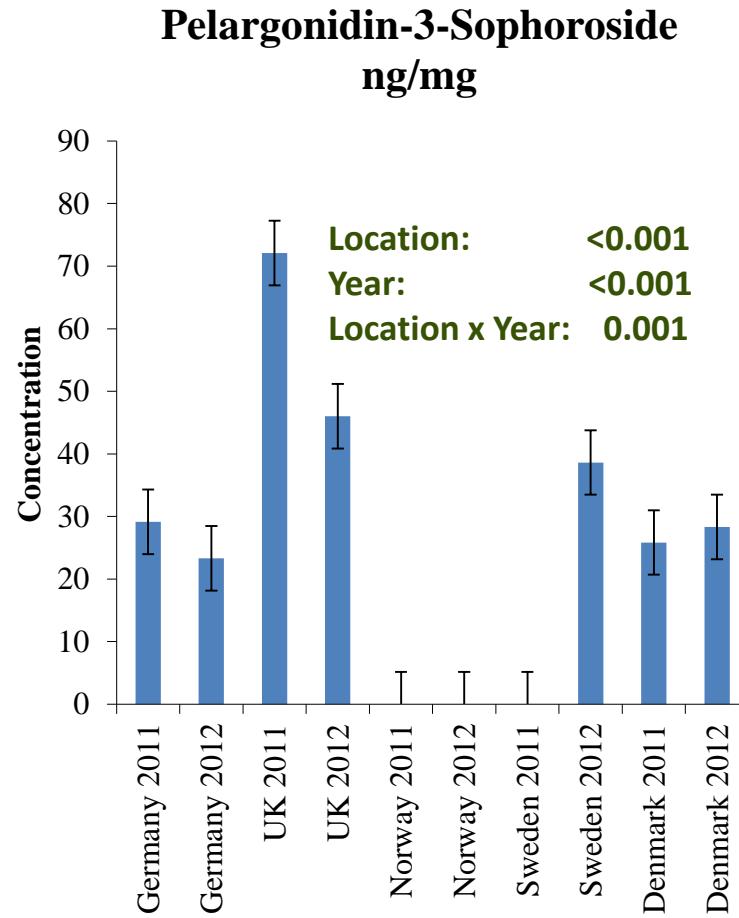
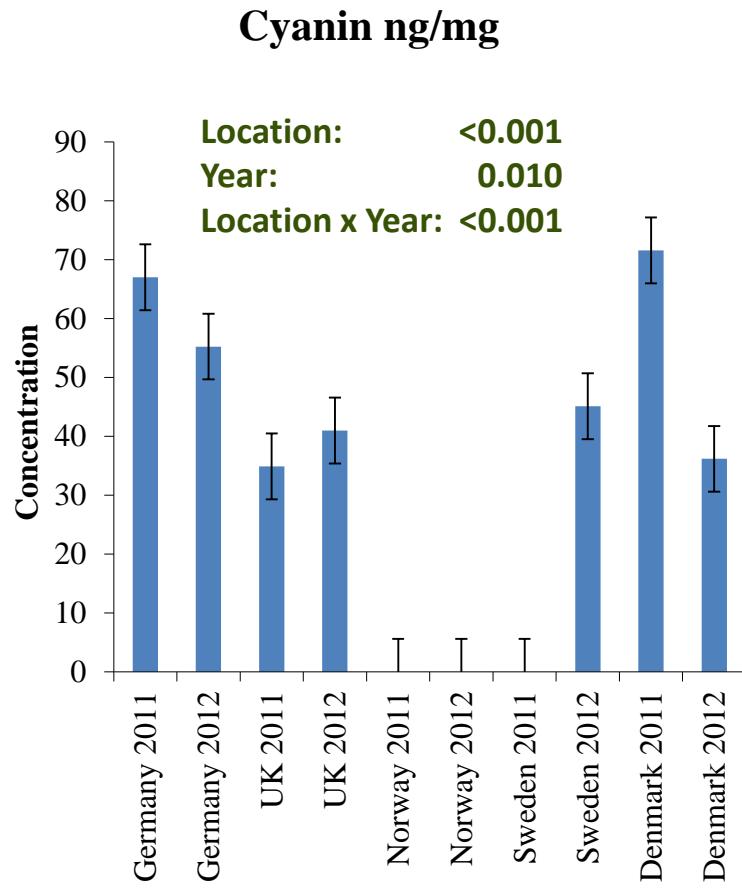


Germany 2011



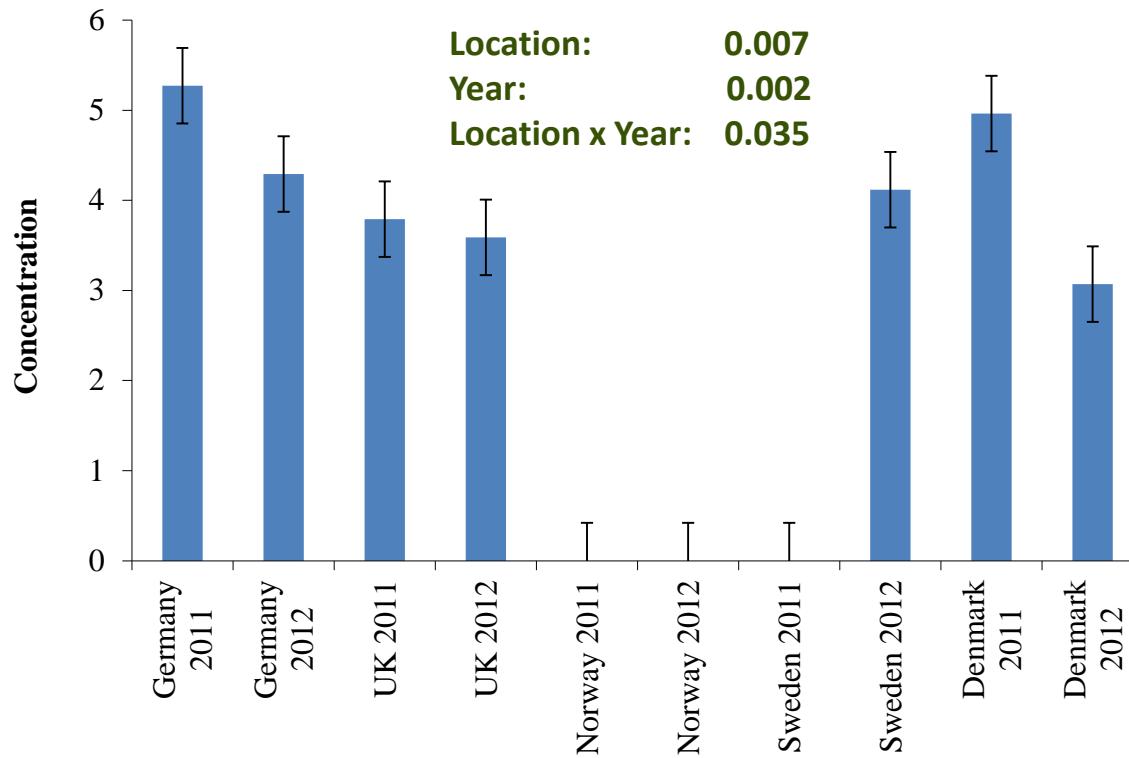
- Citrate
- Malate
- Fructose
- Glucose
- Sucrose

Autumn treasure metabolites levels

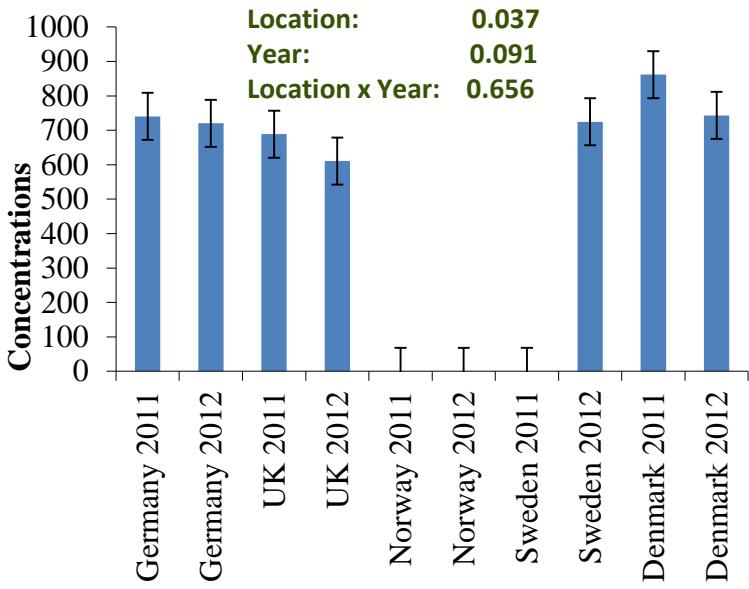


Autumn treasure metabolite levels

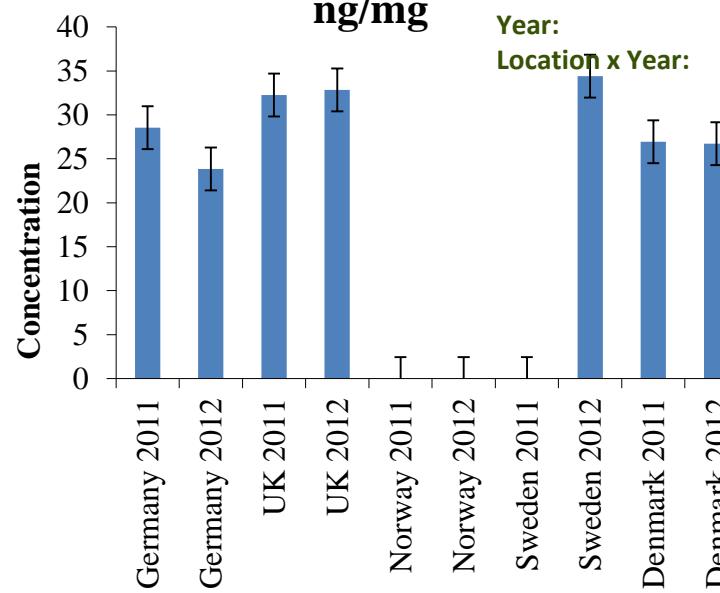
Malate $\mu\text{g}/\text{mg}$



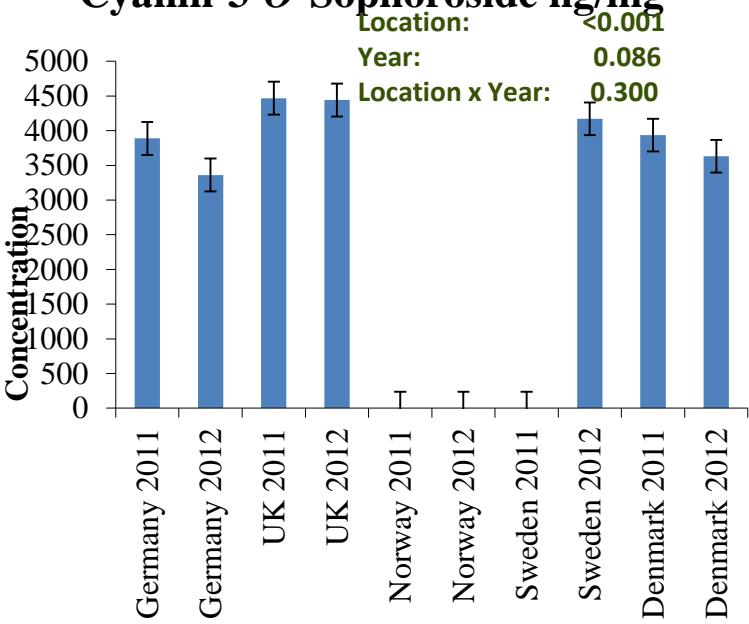
Cyanidin-3-Glucoside ng/mg



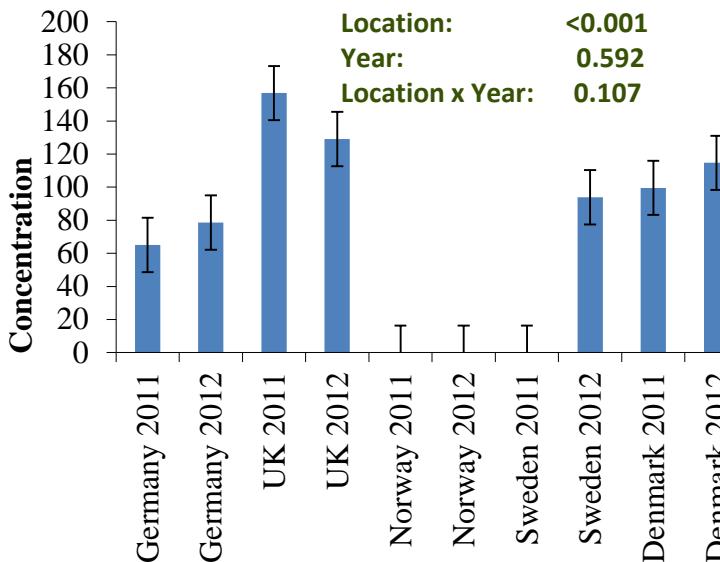
Cyanidin-3-O-Sambubioside ng/mg



Cyanin-3-O-Sophoroside ng/mg

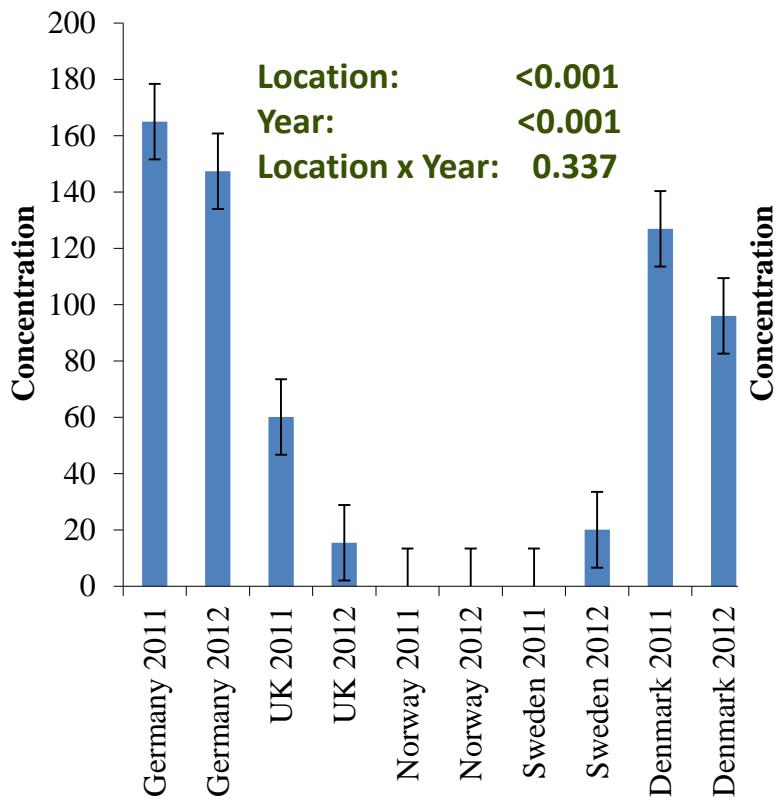


Sucrose µg/mg

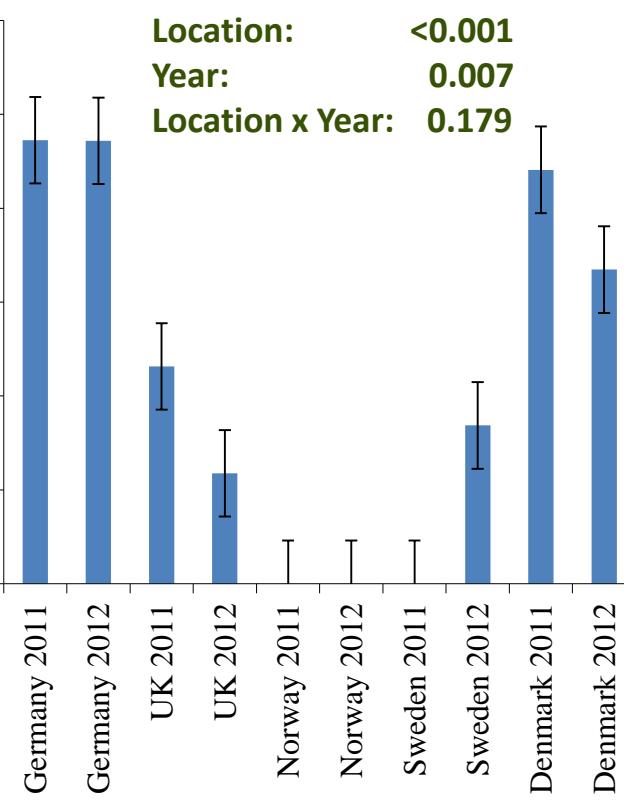


Autumn treasure metabolite levels

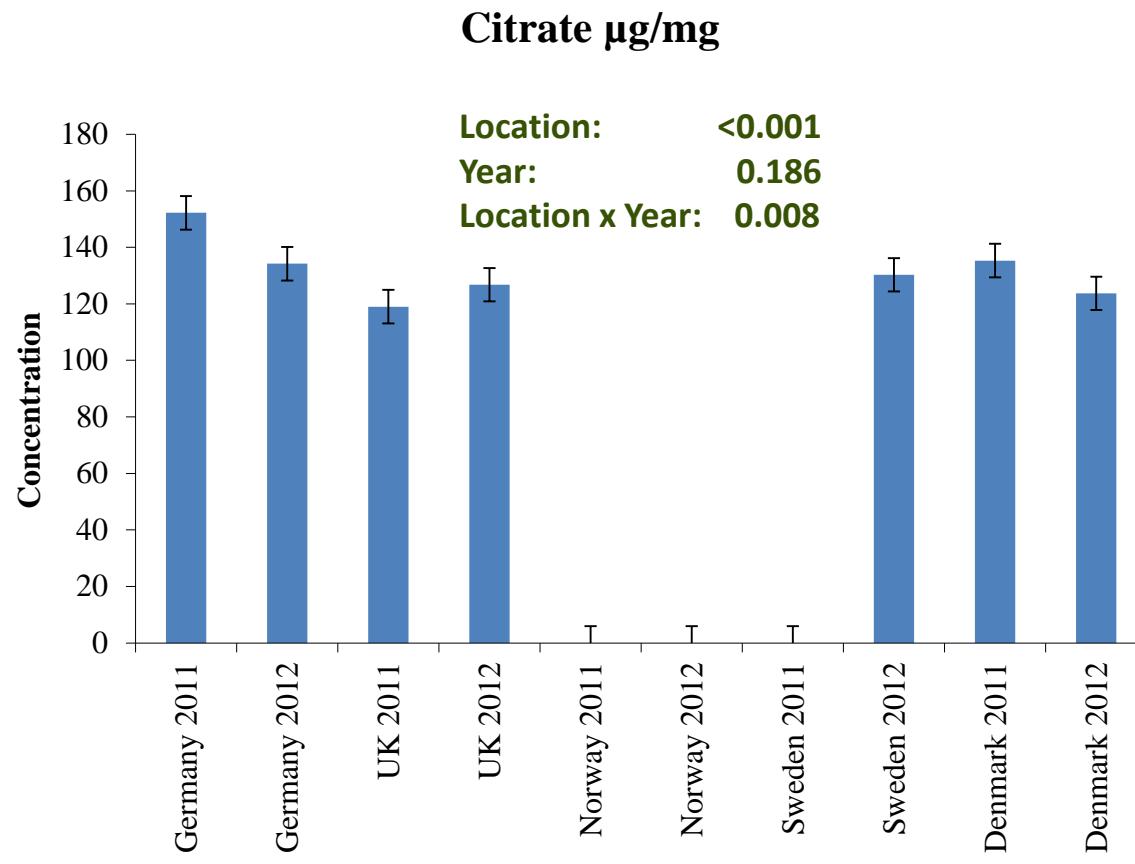
Quercetin-3-O-Glucuronide
ng/mg



Hyperoside ng/mg



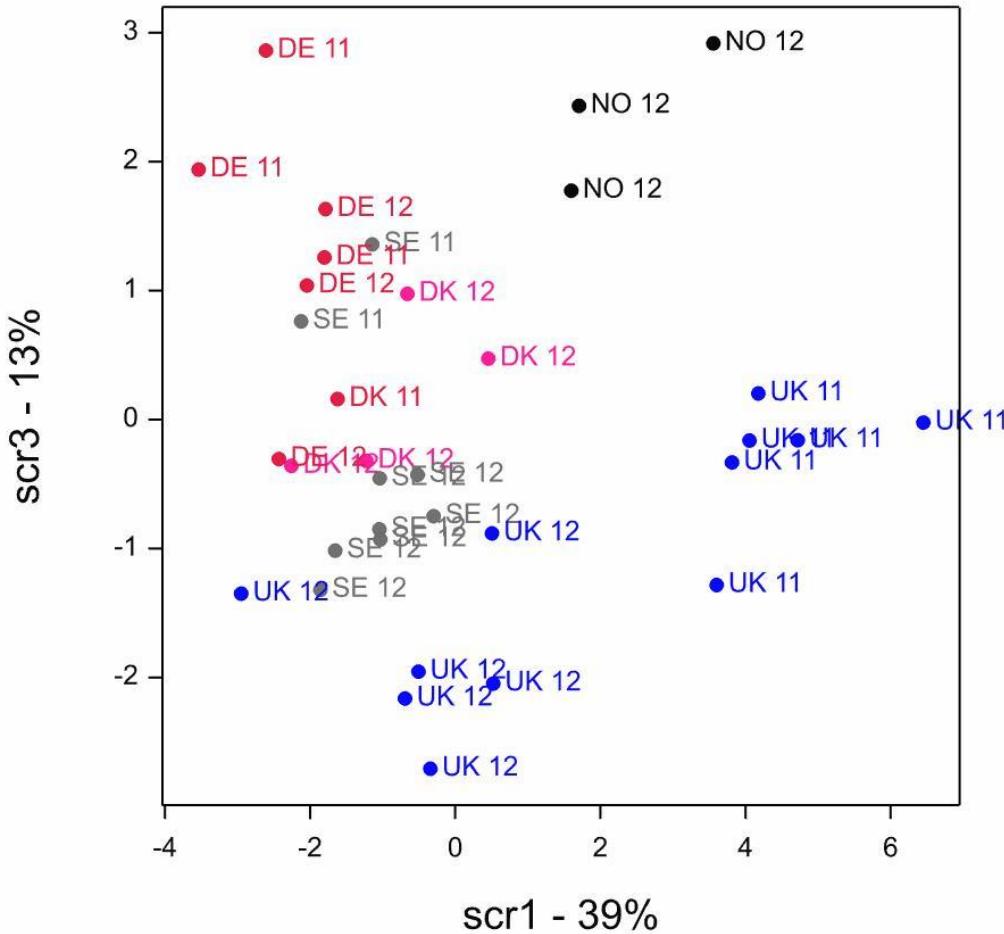
Autumn Treasure metabolite levels



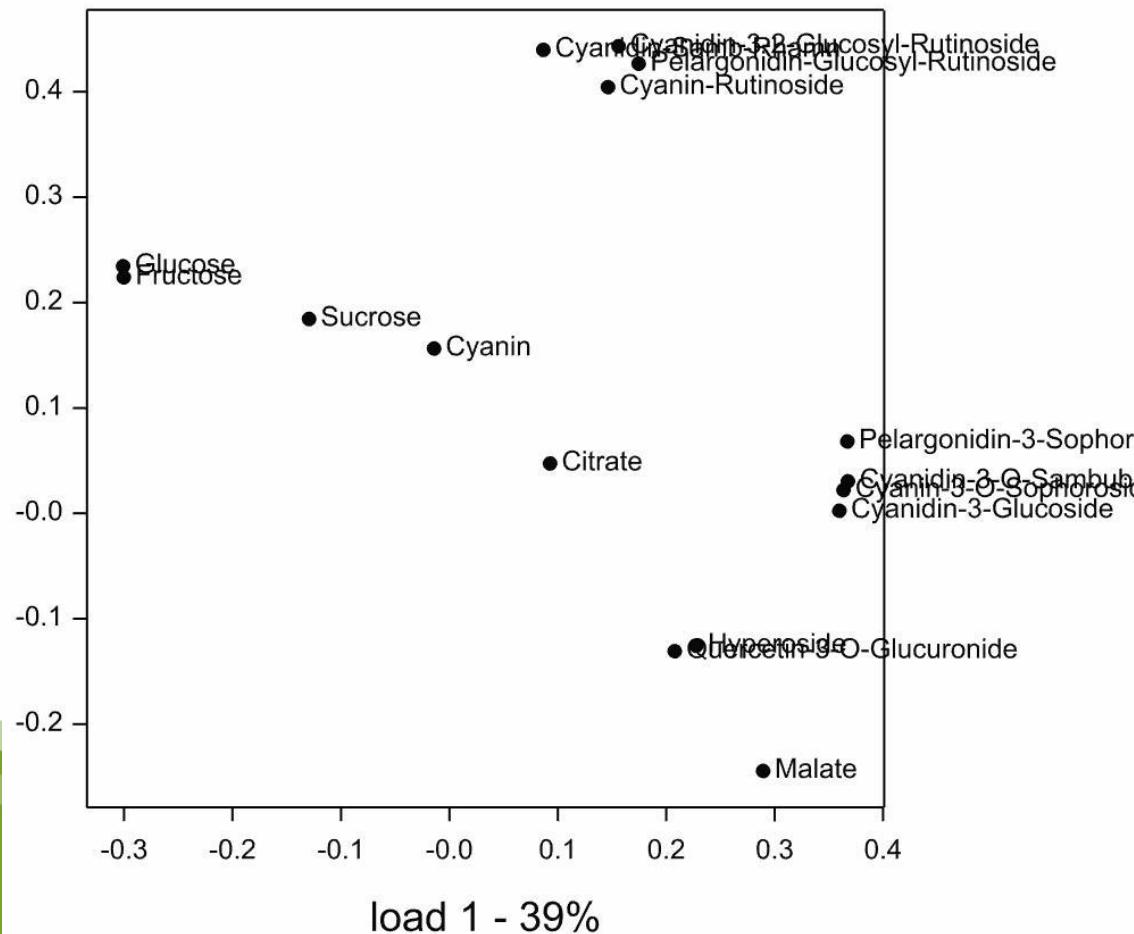
Autumn Treasure summary

- Cyanidin-3-O-Glucoside levels are highest in Denmark
- Flavonol levels are higher in Germany followed by Denmark and lowest in Sweden and UK (2012)
- Highest levels of organic acids found in samples from Germany
- Significantly higher levels of Sucrose in the UK

Tulameen PCA

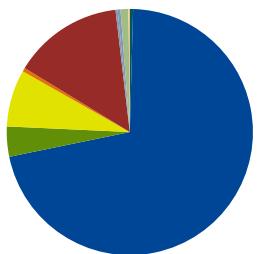


Tulameen PCA

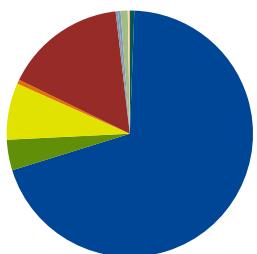


Tulameen Polyphenol composition

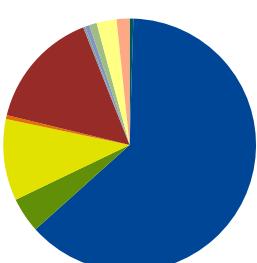
UK 2012



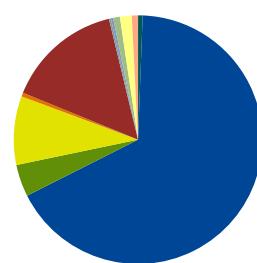
Sweden 2012



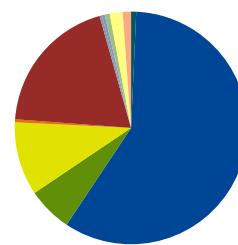
Norway 2012



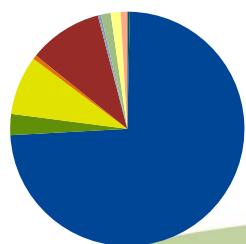
Denmark 2012



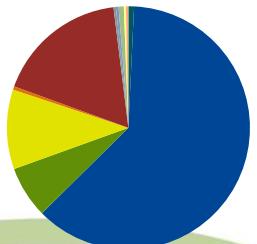
Germany 2012



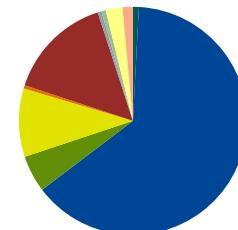
UK 2011



Sweden 2011

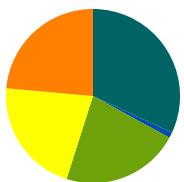


Germany 2011

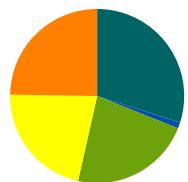


Tulameen Carbohydrate composition

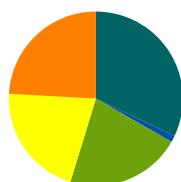
UK 2012



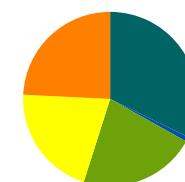
Sweden 2012



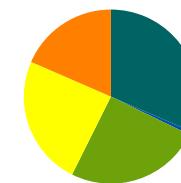
Norway 2012



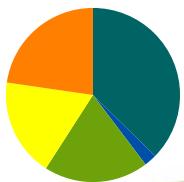
Denmark 2012



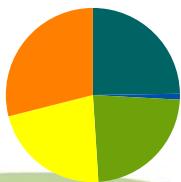
Germany 2012



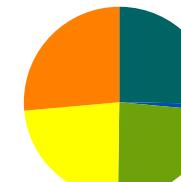
UK 2011



Sweden 2011



Germany 2011



- Citrate
- Malate
- Fructose
- Glucose
- Sucrose

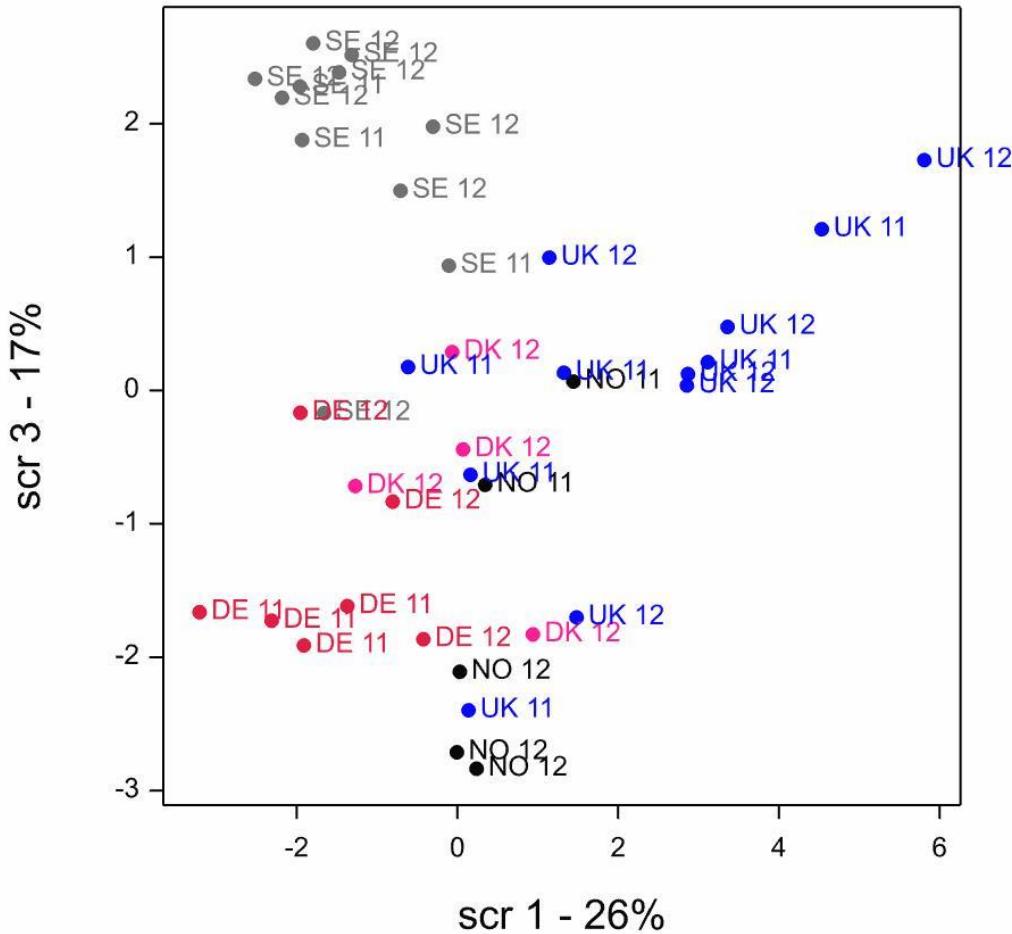
Tulameen ANOVAs

		Cyanin	Cyanidin-3-O-Sophoroside	Cyanidin-Rutinoside	Cyanidin-3-Glucoside	Cyanidin-3-O-Sambubioside	Cyanidin-3-Glucosyl-Rutinoside	Cyanidin-Sambubioside-Rhamnoside	pelargonidin-3-Glucosyl-Rutinoside	Pelargonidin-3-Sophoroside	Quercetin-3-O-Glucuronide	Hyperoside	Citrate	Malate	Fructose	Glucose	Sucrose
	<u>Tulameen</u>																
Germany	2011	23.54	1792	146.6	272.6	12.95	419.6	7.33	7.74	17.2	67.35	40.76	133.4	6.36	125.4	123.4	139.5
	2012	23.03	1897	200.7	330.2	13.36	628.9	10.7	12.52	22.65	58.24	37.11	181.6	3.897	145	139.3	106.4
	mean	23.2	1862	182.7	311	13.22	559.1	9.58	10.93	20.83	61.28	38.33	165.1	4.742	138.3	133.8	117.8
UK	2011	22.11	4678	184.5	516.9	36.38	644.9	10.78	16.81	84.88	87.26	57.38	176.3	11.098	91.6	86	107.2
	2012	19.72	3269	181.4	343.1	22.24	661.5	12.85	16.81	48.29	2.18	5.24	188.1	6.174	129.6	126.9	139
	mean	20.52	3739	182.5	401	26.95	656	12.16	16.81	60.49	30.54	22.62	184	7.862	116.6	112.9	128.1
Norway	2011	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	2012	23.71	3128	224.2	518.6	24.71	757.3	12.58	27.86	47.79	127.27	82.13	168.3	6.425	112.8	111	126.7
	mean	23.71	3128	224.2	518.6	24.71	757.3	12.58	27.86	47.79	127.27	82.13	168.3	6.425	112.8	111	126.7
Sweden	2011	24.34	2015	224.7	345.2	14.7	570.1	10.47	11.28	22.43	9.11	10.63	123.3	5.439	115.1	109.9	144.1
	2012	23.1	2720	157	290.8	21.56	623	11.8	13.27	36.53	3.68	6.67	163.4	6.196	122.8	118.7	135.2
	mean	23.51	2485	179.6	308.9	19.28	605.3	11.36	12.61	31.83	5.49	7.99	149.7	5.937	120.1	115.7	138.3
Denmark	2011	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	2012	23	2606	162.2	347.8	19.39	586.5	9.78	11.98	33.72	59.73	31.42	183.6	5.02	124.1	118.9	138
	mean	23	2606	162.2	347.8	19.39	586.5	9.78	11.98	33.72	59.73	31.42	183.6	5.02	124.1	118.9	138
mean	2011	23.12	2919	185.2	385	22.28	557.3	9.63	12.36	43.92	54.27	36.75	148.3	7.895	110.2	105.4	120.6
mean	2012	22	2784	178.8	341.7	20.38	642.9	11.75	15.36	38.68	30.36	20.99	178.3	5.646	128.3	124.4	131.2
F pr.	location	0.097	<.001	0.115	<.001	<.001	0.287	0.365	0.07	<.001	<.001	<.001	<.001	<.001	0.007	0.006	0.787
	year	0.098	0.007	0.764	<.001	0.004	0.269	0.132	0.622	0.008	<.001	<.001	<.001	<.001	<.001	<.001	0.734
	location.year	0.688	<.001	0.008	<.001	<.001	0.509	0.874	0.859	<.001	<.001	<.001	0.038	<.001	0.045	0.02	0.07
	S.E.D.	1.68	285.4	23.58	35.09	2.775	125.6	2.611	6.552	7.809	12.47	7.723	11.04	0.8638	8.764	8.725	21.08

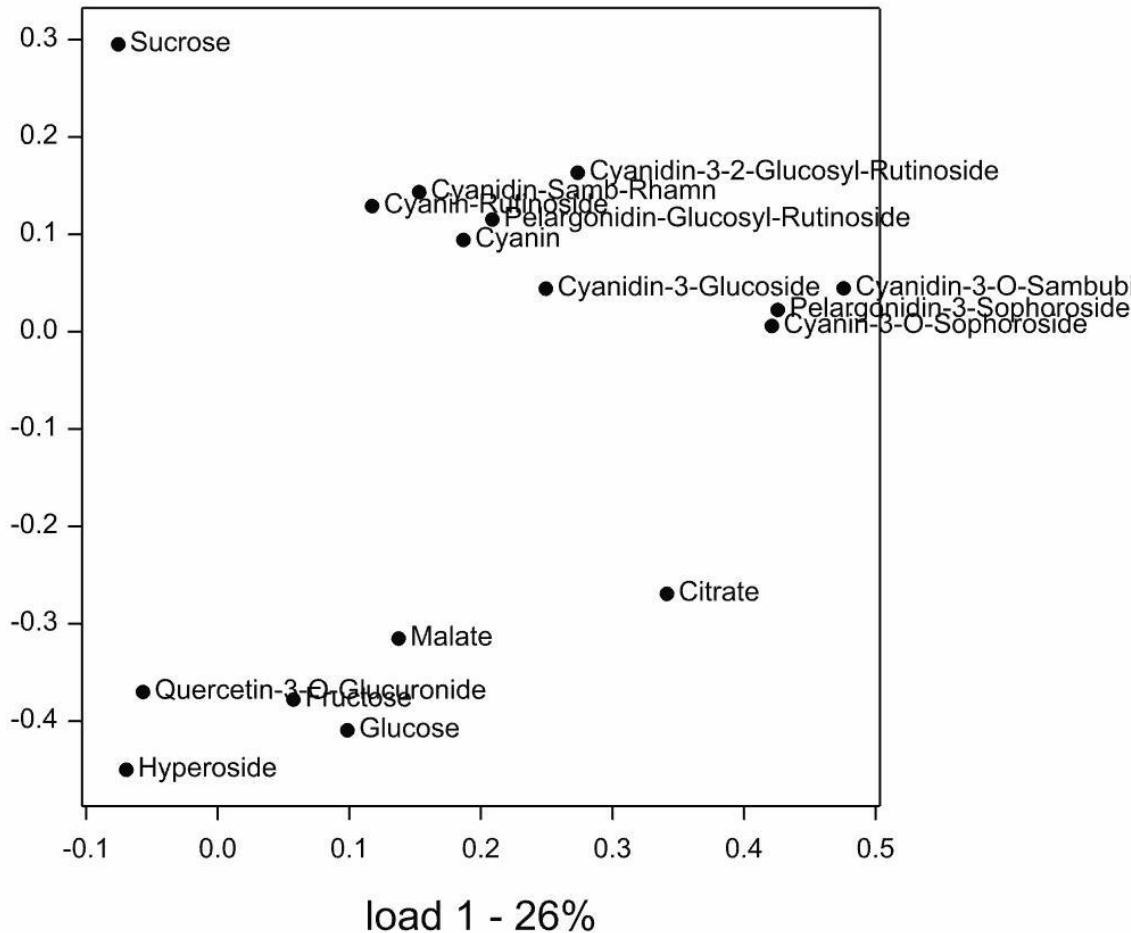
Tulameen summary

- Cyanidin-3-O-Sophoroside levels are highest in UK and lowest in Germany
- Flavonols are significantly higher in Norway but variable across years
- Citrate levels are the highest in Denmark followed by UK
- The levels of Malate are highest in UK
- Sugar levels highest in Germany and Denmark

Octavia PCA

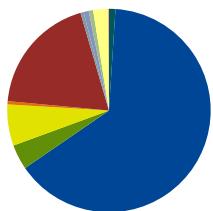


Octavia PCA

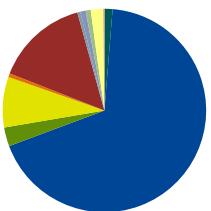


Octavia Polyphenol composition

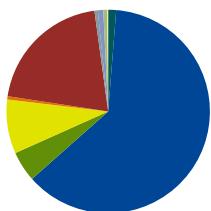
Denmark 2012



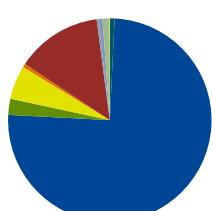
Norway 2012



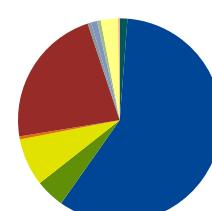
Sweden 2012



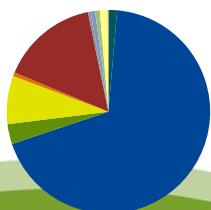
UK 2012



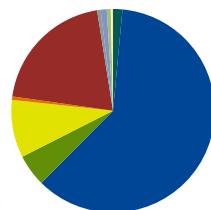
Germany 2012



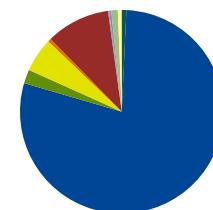
Norway 2011



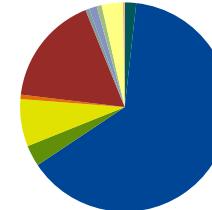
Sweden 2011



UK 2011

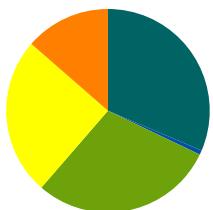


Germany 2011

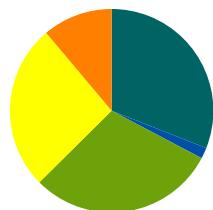


Octavia carbohydrate composition

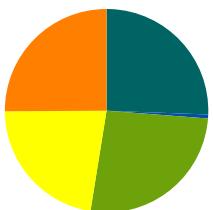
Denmark 2012



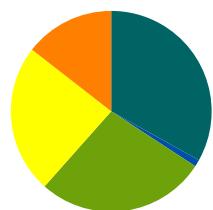
Norway 2012



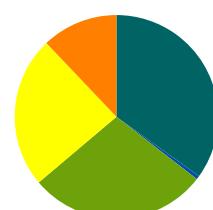
Sweden 2012



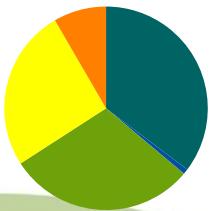
UK 2012



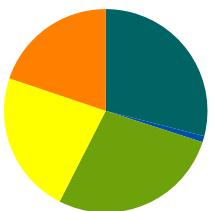
Germany 2012



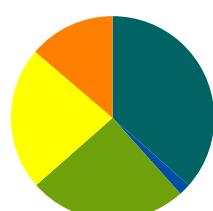
Norway 2011



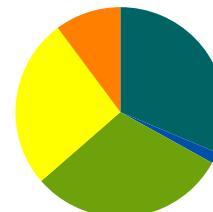
Sweden 2011



UK 2011



Germany 2011



- Citrate
- Malate
- Fructose
- Glucose
- Sucrose



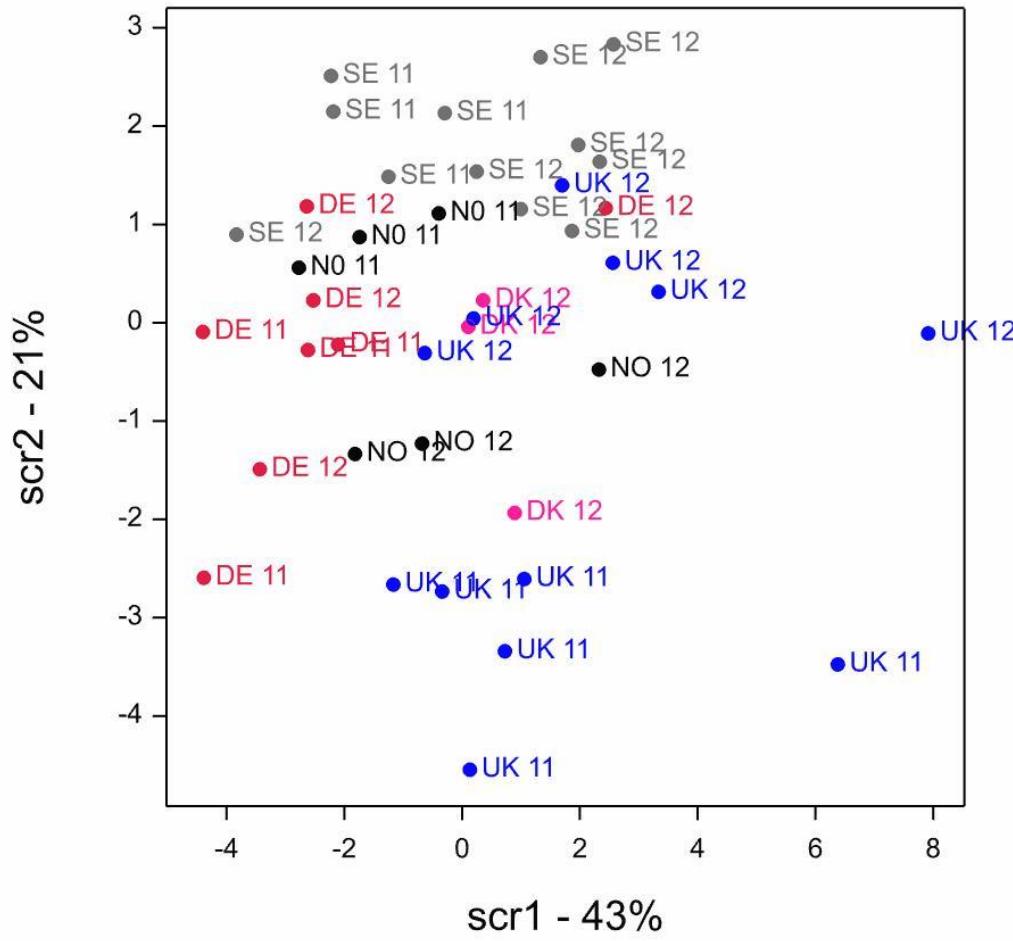
Octavia ANOVAs

		Octavia															
		Cyanin	Cyanindin-3-O-Sophoroside	Cyaninidin-Rutinoside	Cyanidin-3-Glucoside	Cyanidin-3-O-Sambubioside	Cyanidin-3-Glucosyl-Rutinoside	Cyanidin-Sambubioside-Rhamnoside	pelargonidin-3-Glucosyl-Rutinoside	Pelargonidin-3-Sophoroside	Quercetin-3-O-Glucuronide	Hyperoside	Citrate	Malate	Fructose	Glucose	Sucrose
Germany	2011	30.07	1085	55.47	124.2	11.45	288.5	10.07	20.32	12.99	55.76	4.677	152	8.318	148.2	127.3	49.38
	2012	29.16	1402	110.56	181.1	11.56	538	13.25	23.05	14.04	65.98	5.912	178.9	2.949	145.2	123.4	61.96
	mean	29.5	1283	89.9	159.7	11.52	444.4	12.06	22.03	13.64	62.14	5.449	168.5	5.014	146.3	124.8	57.24
UK	2011	30.11	3268	90.98	225.5	21.29	421.6	6.78	14.53	42.69	22.84	2.839	181.6	9.32	124.9	113.1	68.39
	2012	33.03	3281	111.96	234	24.37	595.6	13.43	27.37	47.05	1.96	0.974	187.4	6.315	154.8	135.7	81.96
	mean	31.94	3276	104.1	230.8	23.21	530.3	10.94	22.56	45.41	9.79	1.674	185.2	7.471	143.6	127.3	76.87
Norway	2011	43.12	2157	100.2	241.2	18.81	487	13.36	22.38	23.33	38.58	4.317	171	4.012	144.2	124.8	40.59
	2012	32.96	1746	77.09	206	15.19	379	12.16	22.22	20.3	50.04	5.508	175.8	9.831	169.3	149.2	63.1
	mean	36.77	1900	85.8	219.2	16.54	419.5	12.61	22.28	21.44	45.74	5.062	174	7.593	159.9	140.1	54.66
Sweden	2011	33.24	1365	113.98	205.4	12.34	453.2	12.7	21.52	14.16	6.86	0.989	137.5	4.661	130.4	107.6	93.97
	2012	30.09	1481	115.2	204.5	12.3	486.5	12.52	20.64	14.83	2.38	1.132	131.9	3.217	135.6	115.3	129.32
	mean	31.27	1438	114.7	204.8	12.31	474	12.59	20.97	14.58	4.06	1.079	134.1	3.772	133.7	112.4	116.06
Denmark	2011	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
	2012	31.21	1957	120.71	199.3	15.57	577.6	14.92	25.28	21.21	70.66	5.176	161.7	3.541	150.7	129	69.93
	mean	31.21	1957	120.7	199.3	15.57	577.6	14.92	25.28	21.21	70.66	5.176	161.7	3.541	150.7	129	69.93
mean	2011	33.23	2077	92.6	202.3	16.23	416.3	10.32	19.1	24.97	26.98	2.878	160.3	6.897	134.3	116.2	67.88
mean	2012	31.35	2094	108.3	208.9	16.55	521.2	13.11	23.78	25.82	27.36	2.982	166.1	5.003	149.6	129.3	87.45
F pr.	location	0.167	<.001	0.172	0.012	<.001	0.282	0.694	0.978	<.001	<.001	<.001	<.001	<.001	0.067	0.026	<.001
	year	0.353	0.788	0.213	0.569	0.642	0.052	0.192	0.255	0.614	0.646	0.703	0.269	0.006	0.018	0.02	0.025
	location.year	0.096	0.391	0.266	0.353	0.294	0.173	0.527	0.58	0.859	0.639	0.088	0.375	<.001	0.214	0.273	0.76
	S.E.D.	3.515	264.4	25.5	32.16	2.411	108.9	4.415	8.891	6.078	21.45	1.031	13.07	1.257	13.07	11.27	18.05

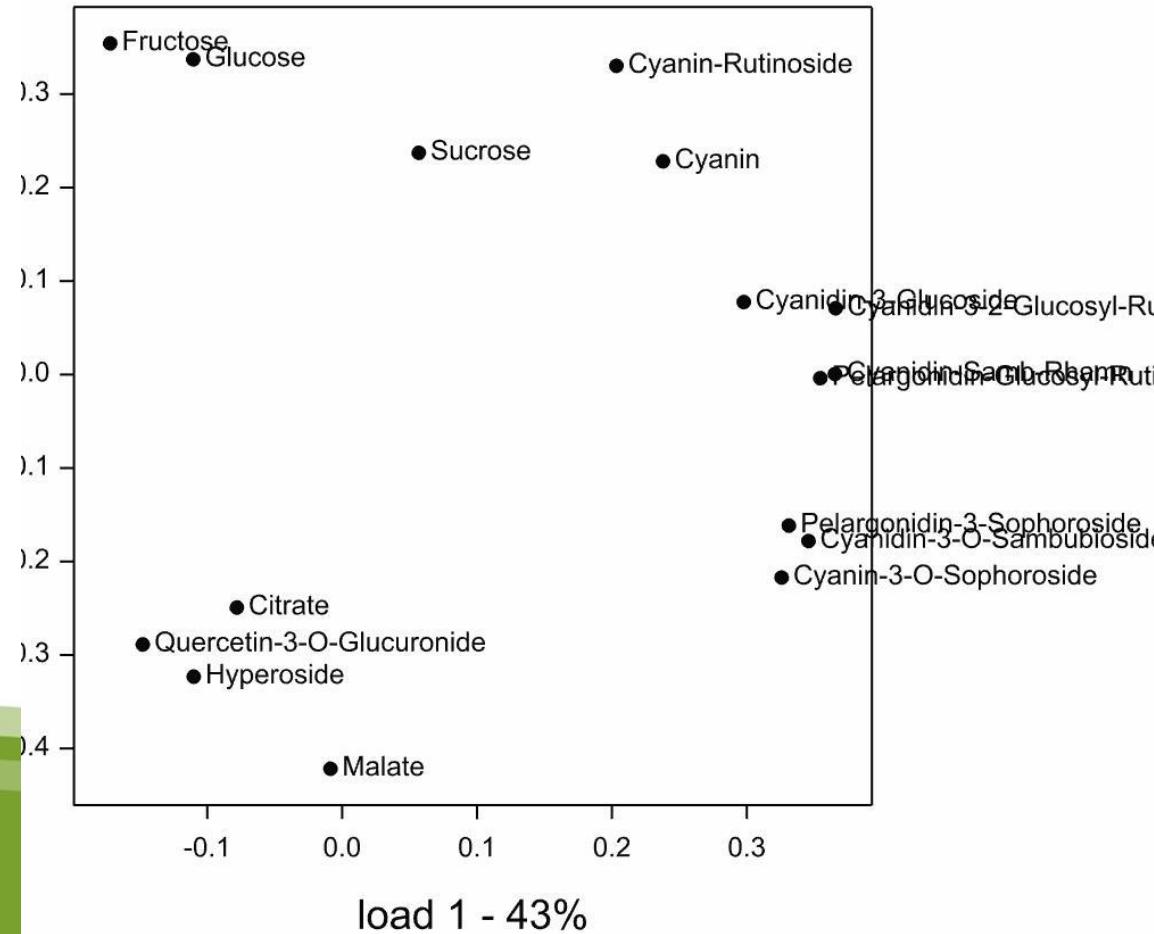
Octavia Summary

- Cyanidin-3-O-Sophoroside is highest in UK and lowest in Germany (~3-fold difference)
- Flavonols are highest in Denmark followed by Germany and lowest in Sweden and UK
- Organic acid levels higher in the UK
- Sucrose levels higher in Sweden

Glen Ample PCA

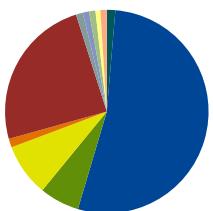


Glen Ample PCA

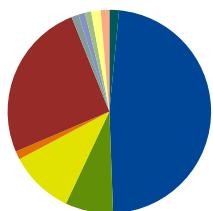


Glen Ample polyphenol composition

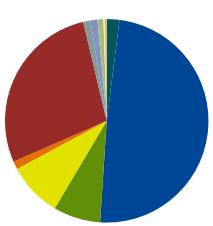
Denmark 2012



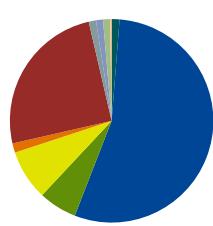
Norway 2012



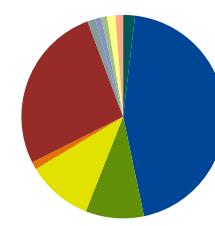
Sweden 2012



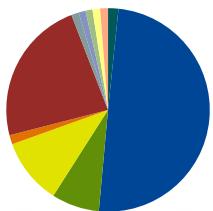
UK 2012



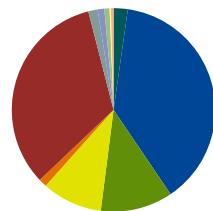
Germany 2012



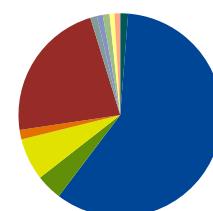
Norway 2011



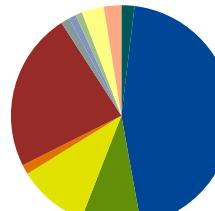
Sweden 2011



UK 2011



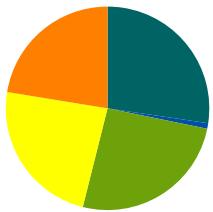
Germany 2011



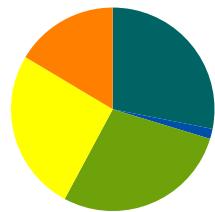
- Cyanin
- Cyanindin-3-O-Sophoroside
- Cyaninidin-Rutinoside
- Cyanidin-3-Glucoside
- Cyanidin-3-O-Sambubioside
- Cyanidin-3-Glucosyl-Rutinoside
- Cyanidin-Sambubioside-Rhamnoside
- pelargonidin-3-Glucosyl-Rutinoside
- Pelargonidin-3-Sophoroside
- Quercetin-3-O-Glucuronide
- Hyperoside

Glen Ample carbohydrate composition

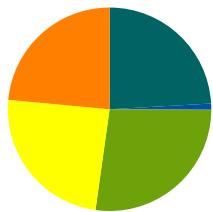
Denmark 2012



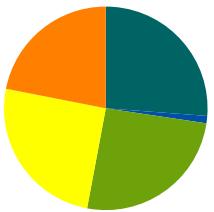
Norway 2012



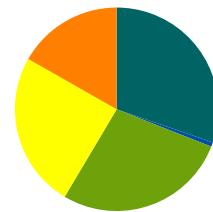
Sweden 2012



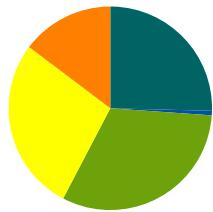
UK 2012



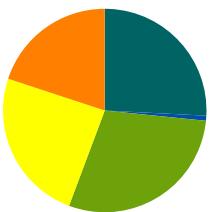
Germany 2012



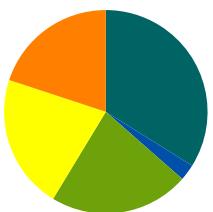
Norway 2011



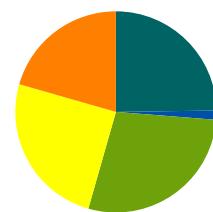
Sweden 2011



UK 2011



Germany 2011



- Citrate
- Malate
- Fructose
- Glucose
- Sucrose

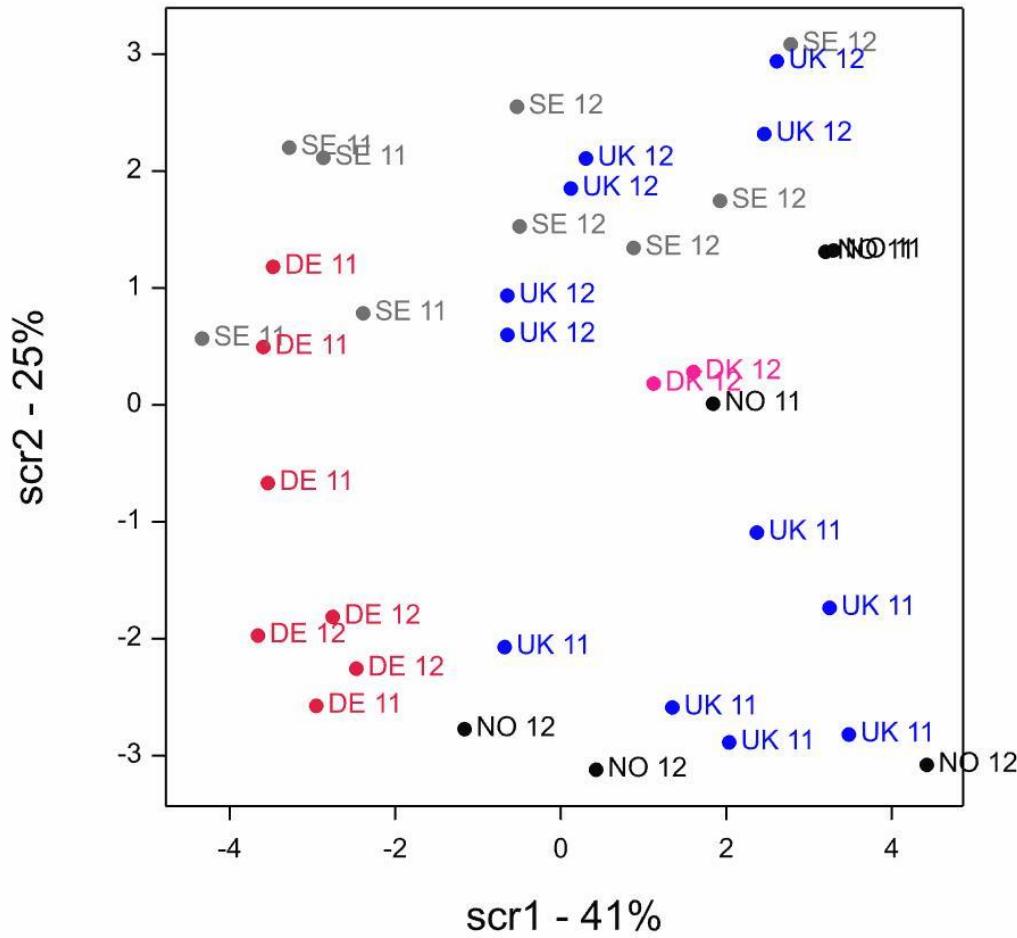
Glen Ample ANOVAs

<u>Glen Ample</u>		Cyanin	Cyanindin-3-O-Sophoroside	Cyanindin-Rutinoside	Cyanindin-3-Glucoside	Cyanindin-3-O-Sambubioside	Cyanindin-3-Glucosyl-Rutinoside	Cyanindin-Sambubioside-Rhamnoside	Pelargonidin-3-Glucosyl-Rutinoside	Pelargonidin-3-Sophoroside	Quercetin-3-O-Glucuronide	Hyperoside	Citrate	Malate	Fructose	Glucose	Sucrose
Germany	2011	60.76	1439	278.1	327.2	44.7	740	40.86	33.26	31.42	103.18	81.6	142.7	8.473	162.2	144.1	118.4
	2012	74.31	1770	365.9	411	47.39	1055	49.43	38.47	36.37	52.67	47.89	169.7	3.988	154.4	138.4	94
	mean	68.69	1632	329.5	376.2	46.27	924	45.87	36.31	34.32	73.62	61.87	158.5	5.848	157.7	140.8	104.2
UK	2011	72.1	3414	238.9	386.6	87.01	1306	61.57	53.85	61.53	45.74	52.12	178.7	13.648	117.1	112.8	105.2
	2012	73.26	3200	355.5	467.1	86.66	1461	67.76	64.81	66.79	2.57	10.13	142	6.302	138.7	136.3	118.8
	mean	72.78	3288	307.1	433.7	86.8	1397	65.19	60.26	64.61	20.47	27.54	157.3	9.348	129.7	126.6	113.1
Norway	2011	66.69	2015	307.1	424.5	59.04	937	47.73	44.83	44.84	48.92	50.54	153.4	4.309	190.6	166.8	88.9
	2012	72.6	2282	362.4	487.5	63.12	1209	53.91	50.47	46.94	71.87	65.36	139.7	7.978	139.9	128	81.7
	mean	70.15	2172	339.5	461.4	61.43	1097	51.35	48.13	46.07	62.35	59.22	145.4	6.457	160.9	144.1	84.7
Sweden	2011	78.99	1343	402.8	337.4	45.1	1161	51.68	37.58	29.19	6.95	14.76	151.7	4.728	171	143.1	117.2
	2012	99.78	2440	373	429	63.39	1386	57.24	54.89	47.59	9.19	16.17	141.2	5.692	159	142.2	137.8
	mean	91.16	1985	385.4	391	55.81	1293	54.94	47.72	39.96	8.26	15.58	145.6	5.292	164	142.6	129.3
Denmark	2011	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	2012	68.56	2702	321.4	424.9	70.14	1240	54.67	51.34	51.38	39.8	51.21	137.7	4.434	129.4	119.1	113
	mean	68.56	2702	321.4	424.9	70.14	1240	54.67	51.34	51.38	39.8	51.21	137.7	4.434	129.4	119.1	113
mean	2011	71.04	2123	309.7	364.5	60.45	1083	51.9	42.95	42.35	46.09	46.28	158.6	8.267	155.2	137.5	109.2
mean	2012	80.79	2528	361.2	444.9	67.53	1307	58.12	53.68	51.2	27.15	30.35	146.5	5.78	147.2	136	113.7
F pr.	location	0.034	<.001	0.21	0.493	<.001	0.02	0.031	0.011	<.001	<.001	<.001	0.1	<.001	<.001	0.002	0.007
	year	0.117	0.079	0.052	0.014	0.202	0.036	0.134	0.019	0.053	<.001	<.001	0.047	0.001	0.291	0.976	0.603
	location.year	0.67	0.107	0.247	0.993	0.497	0.952	0.995	0.741	0.52	<.001	<.001	0.003	<.001	0.004	<.001	0.166
	S.E.D.	13.57	424.3	60.34	66.53	10.46	221.8	8.941	9.123	8.936	7.441	6.786	11.67	1.494	12.6	9.417	15.89

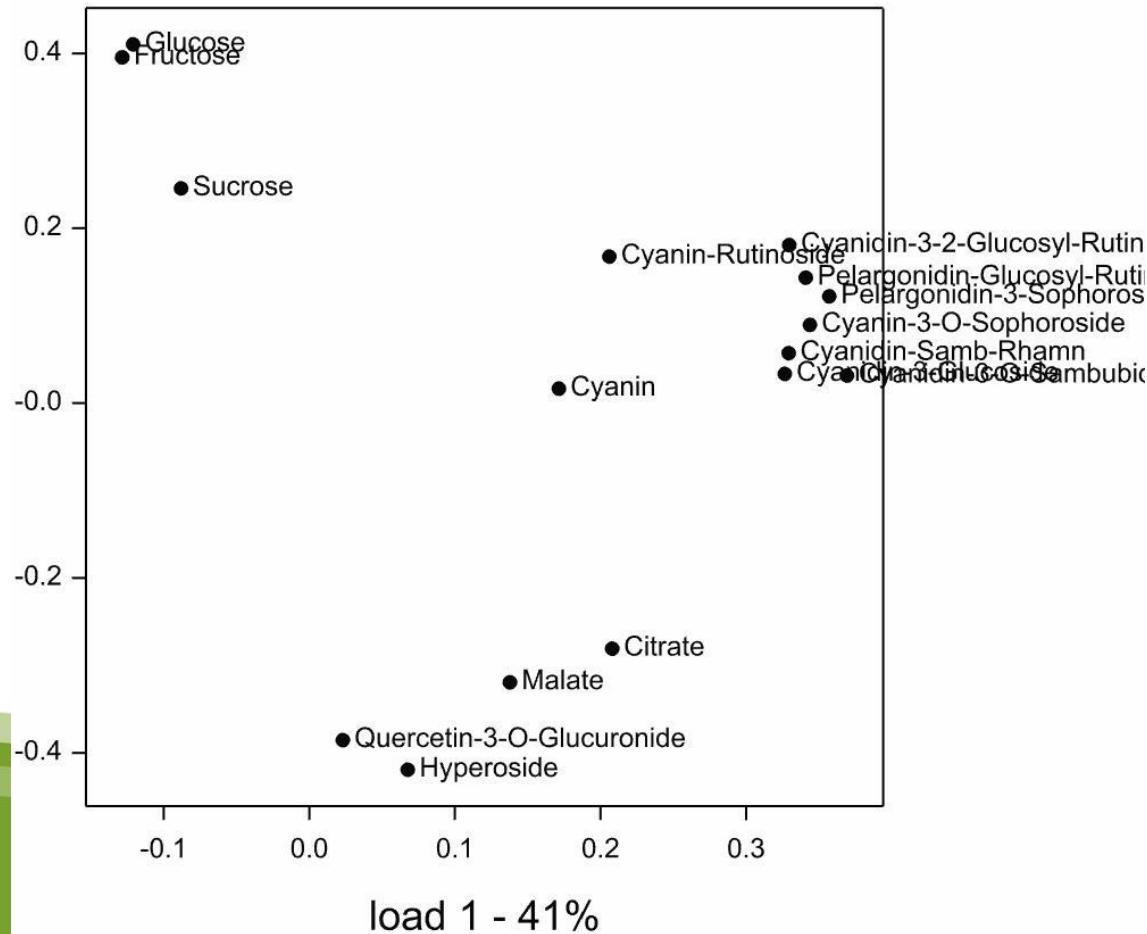
Glen Ample Summary

- Highest levels of Cyanidin-3-O-Sophoroside in the UK and the lowest are found in samples from Germany
- Flavonols are highest in Germany and Norway and Lowest in Sweden and UK 2012
- Organic acid levels tend to be highest in the UK
- Samples from Norway have the lowest levels of Sucrose, but they also contain the highest levels of Fructose and Glucose

Glen Fyne PCA

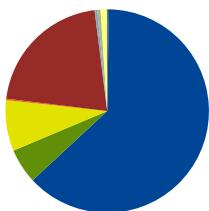


Glen Fyne PCA

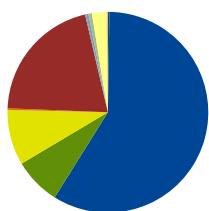


Glen Fyne Polyphenol composition

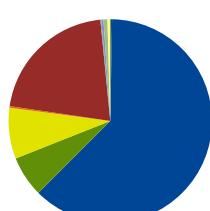
Denmark 2012



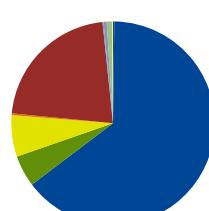
Norway 2012



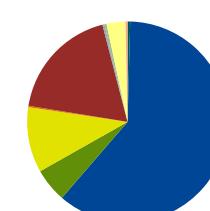
Sweden 2012



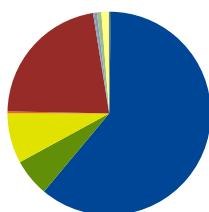
UK 2012



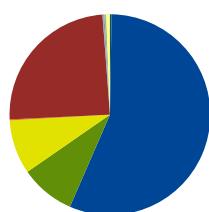
Germany 2012



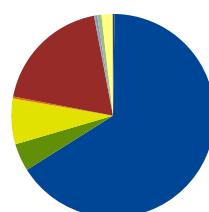
Norway 2011



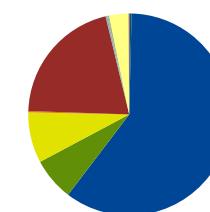
Sweden 2011



UK 2011



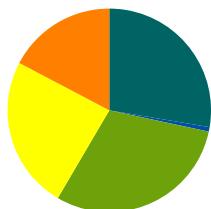
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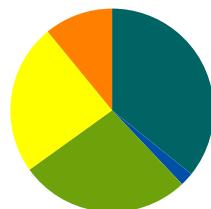
- Cyanin
- Cyanindin-3-O-Sophoroside
- Cyaninidin-Rutinoside
- Cyanidin-3-Glucoside
- Cyanidin-3-O-Sambubioside
- Cyanidin-3-Glucosyl-Rutinoside
- Cyanidin-Sambubioside-Rhamnoside
- pelargonidin-3-Glucosyl-Rutinoside
- Pelargonidin-3-Sophoroside
- Quercetin-3-O-Glucuronide
- Hyperoside

Glen Fyne Carbohydrate composition

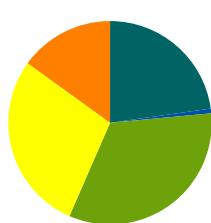
Denmark 2012



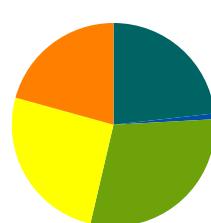
Norway 2012



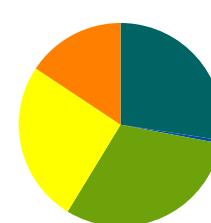
Sweden 2012



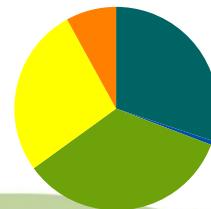
UK 2012



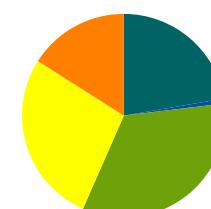
Germany 2012



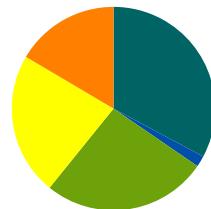
Norway 2011



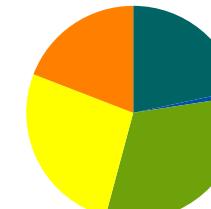
Sweden 2011



UK 2011



Germany 2011



- Citrate
- Malate
- Fructose
- Glucose
- Sucrose

Glen Fyne ANOVAs

Glen Fyne		Cyanin	Cyanindin-3-O-Sophoroside	Cyanidin-Rutinoside	Cyanidin-3-Glucoside	Cyanidin-3-O-Sambubioside	Cyanidin-3-Glucosyl-Rutinoside	Cyanidin-Sambubioside-Rhamnoside	Pelargonidin-3-Glucosyl-Rutinoside	Pelargonidin-3-Sophoroside	Quercetin-3-O-Glucuronide	Hyperoside	Citrate	Malate	Fructose	Glucose	Sucrose
Germany	2011	22.22	3544	405.9	479.6	11.61	1223	4.86	10.37	19.1	177.6	10.881	125.3	5.053	182.8	154.3	110.57
	2012	22.99	3311	297.7	572.2	11.96	1000	7.74	8.65	19.66	166	17.35	133	2.583	149	124.2	76.01
	mean	22.64	3418	347.4	529.6	11.8	1102	6.38	9.46	19.4	171.3	14.378	129.6	3.688	164.1	137.7	91.47
UK	2011	24.35	6457	431.6	711.9	30.21	1862	14.14	34.33	67.06	163.7	14.615	167.7	9.012	134.2	115.9	84.4
	2012	19.68	5985	463.5	611.5	26.5	2024	14.9	46.51	75.87	12.2	3.568	130.5	5.129	165.9	144.1	116.38
	mean	21.83	6202	448.8	657.7	28.21	1950	14.54	40.76	71.82	81.8	8.644	147.1	6.866	151.8	131.5	102.07
Norway	2011	26.36	6294	618.4	824.4	32.15	2289	19.34	43.92	72.63	119.6	8.553	167.6	3.674	190.3	150	44.51
	2012	21.37	4879	629.4	741.8	22.05	1724	13.27	31.08	46.44	198.2	14.532	157	9.444	119.2	105.4	47.88
	mean	23.66	5529	624.3	779.7	26.69	1984	16.13	37.14	58.47	162.1	11.785	161.8	6.863	151	125.4	46.37
Sweden	2011	16.25	3427	537.6	531.8	9.6	1496	6.4	12.48	17.59	33.9	2.324	130.1	4.443	195.3	159.9	93.26
	2012	27.34	5967	623.1	775.6	25.21	2024	13.38	33.45	59.57	38.7	4.533	124.2	4.05	180.2	155	82.05
	mean	22.24	4800	583.8	663.6	18.04	1782	10.08	23.55	40.28	36.5	3.518	126.9	4.226	186.9	157.2	87.07
Denmark	2011	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	2012	27	6405	565	822.6	24.68	2148	12.31	28.65	54.23	98.1	8.927	139.6	3.619	151.9	122.5	87.33
	mean	27	6405	565	822.6	24.68	2148	12.31	28.65	54.23	98.1	8.927	139.6	3.619	151.9	122.5	87.33
mean	2011	22.13	4984	485	631.8	20.99	1695	11.1	25.31	44.33	125.9	9.562	147.8	5.973	171.3	142.4	86.03
mean	2012	22.93	5246	498.9	675.5	22.22	1761	12.71	32.32	53.81	86.7	8.851	134	4.911	158	135.5	86.5
F pr.	location	0.577	<.001	<.001	<.001	<.001	<.001	0.027	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	0.005
	year	0.707	0.325	0.76	0.186	0.597	0.691	0.437	0.112	0.077	0.008	0.465	<.001	0.018	0.02	0.156	0.949
	location.year	0.001	<.001	0.217	<.001	<.001	0.011	0.241	0.079	0.002	<.001	<.001	0.001	<.001	<.001	<.001	0.052
	S.E.D.	3.056	406.5	69.14	55.25	4.212	225.3	4.432	9.52	11.02	30.13	2.117	8.323	0.8606	11.42	9.157	18.72

Glen Fyne Summary

- Norway, Denmark and UK have high levels of Cyanidin-3-O-Sophoroside
- The levels of most anthocyanins are high in samples from Norway and Denmark
- There are high levels of flavonols in Germany and UK (2011) whereas in Sweden there are low levels
- High levels of organic acids in UK and Norway
- High levels of sugars in Sweden, Norway (2011) and Germany (2011)

General trends found

- Samples from UK tend to have higher levels of Cyanidin-3-O-Sophoroside and organic acids
- Samples from Germany tend to have the highest levels of Flavonols
- Samples from Sweden tend to have the least levels of flavonols

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