Organic food authentication: potential and limitations

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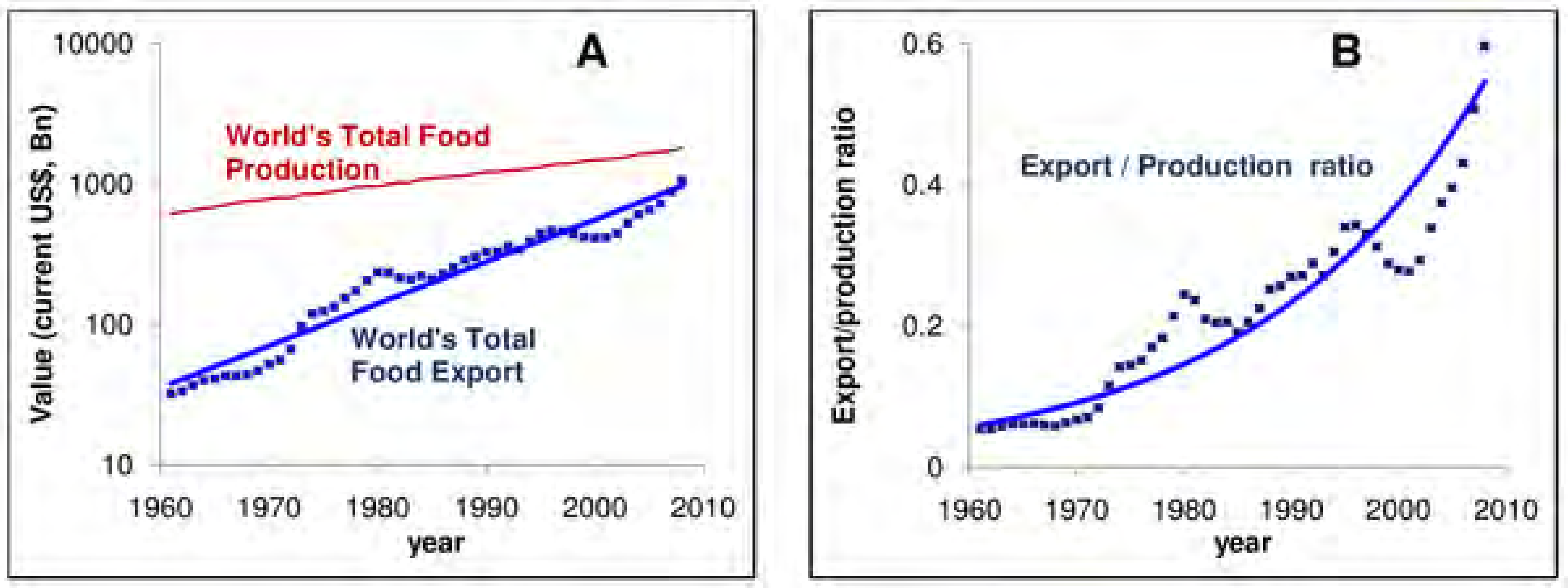
Souls for sale?

- What’s in it 4U?
- Food product adulteration and counterfeiting is a thriving multi-billion euro global industry. It is highly profitable and the risks of significant legal consequences are low.

The food supply network

- Retail demands shape global food market
- Price is the main governing feature
- Food and ingredients are sourced world-wide
- Extensive, fragile, vulnerable food supply chain

The world's food trade grows faster than the food production



Ercsey-Ravasz M, Toroczkai Z, Lakner Z, Baranyi J (2012) Complexity of the International Agro-Food Trade Network and Its Impact on Food Safety. PLoS ONE 7(5): e37810. doi:10.1371/journal.pone.0037810
http://www.plosone.org/article/info:doi/10.1371/journal.pone.0037810

Food fraud

- Food fraud differs from most food safety issues in that fraudsters **intentionally aim at deceiving targets by food adulteration or counterfeiting for their own economic gain**.

The crime triangle

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Food authenticity and safety

- Control systems are nowadays primarily aiming at food safety and defense
- Food authenticity and integrity has received less attention in the last decade
- Development of fraud risk assessment:
- Temptation ACCP: People factor, critical points, how to optimize detection

Detection

- Laboratory-based: checks of occasional samples
    - Single markers
    - Patterns
- Supply-chain: pro-active, red/green light, 100% check

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Single markers

Food Chemistry 119 (2010) 738–745

Contents lists available at ScienceDirect

Food Chemistry

journal homepage: www.elsevier.com/locate/foodchem

ELSEVIER

FOOD CHEMISTRY

Comparison of mineral concentrations in commercially grown organic and conventional crops – Tomatoes (*Lycopersicon esculentum*) and lettuces (*Lactuca sativa*)

Simon D. Kelly *, Alison S. Bateman

School of Environmental Sciences, University of East Anglia, Norwich NR4 7TJ, UK

Food Chemistry 119 (2010) 746–752

Contents lists available at ScienceDirect

Food Chemistry

journal homepage: www.elsevier.com/locate/foodchem

ELSEVIER

FOOD CHEMISTRY

Concentrations of phytanic acid and pristanic acid are higher in organic than in conventional dairy products from the German market

Walter Vetter *, Markus Schröder

University of Hohenheim, Institute of Food Chemistry (170b), Garbenstrasse 28, D-70599 Stuttgart, Germany

Sensory evaluation

Available online at www.sciencedirect.com

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Food Research International 38 (2005) 495–503

FOOD RESEARCH INTERNATIONAL

www.elsevier.com/locate/foodres

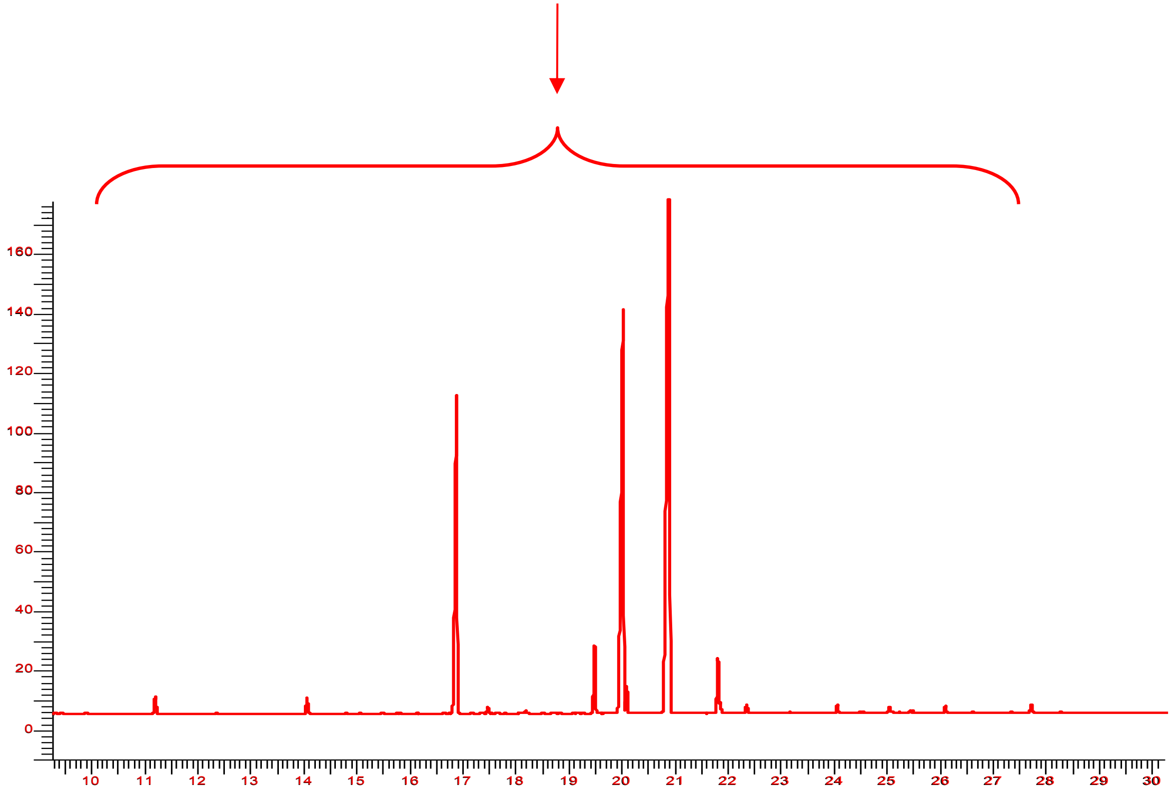
Sensory quality in retailed organic, free range and corn-fed chicken breast

Kishowar Jahan, Alistair Paterson *, John R. Piggott

Centre for Food Quality, Department of Bioscience, University of Strathclyde, 204 George Street, Glasgow G1 1XW, Scotland, UK

Received 22 July 2004; accepted 24 September 2004

Multiple markers: looking for patterns



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Multi marker fingerprints?

Fingerprints of target product group versus counterparts (e.g. genuine and adulterated products).

Method developments and confirmation

- Laboratory-based: finding the relevant markers:
- Combining analytical chemistry and chemometrics

AuthenticFood EU project

CORE organic II

AUTHENTIC FOOD

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Organic vs Conventional Tomatoes

- Tomato samples (n=24)

Region of origin in Italy	Botanical origin	Production method
Basilicata	2	Organic, Conventional
Emilia	2	Organic, Conventional

- Sample design was a full factorial 2x2x2 design
- Triplicate samples batches
- Duplicate analysis

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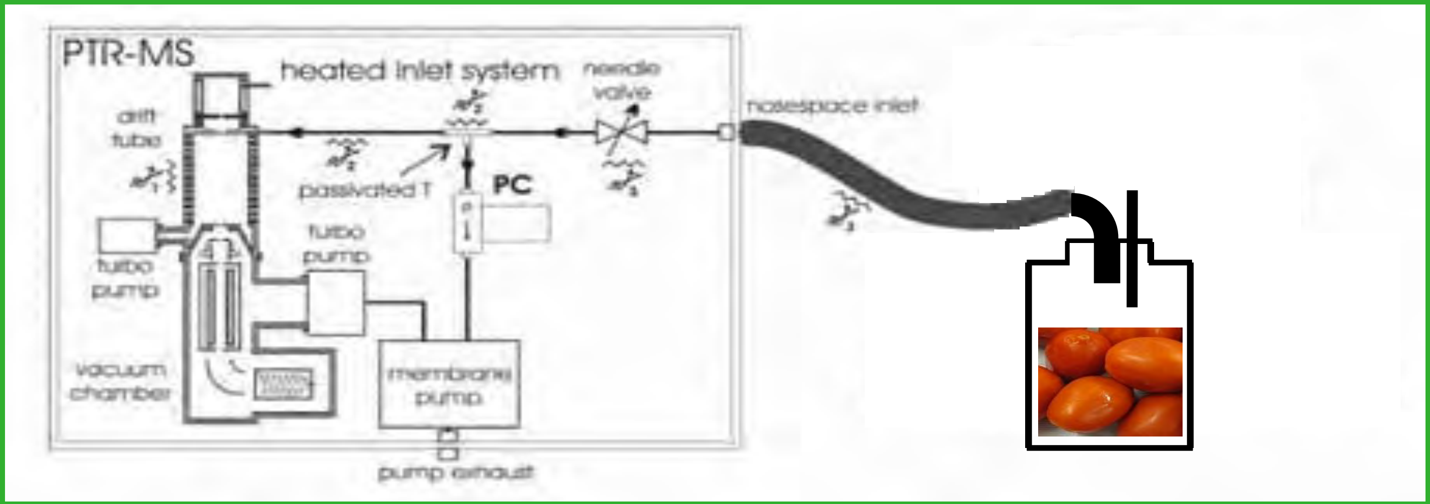
Italian tomatoes

- PTR-MS
- Sensory analysis



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Sensory profiling of the tomatoes

- Only 9 of the 12 samples from Emilia were assessed by sensory profiling due to early deterioration.
- Sensory analysis was performed by 13 expert assessors from the Flavour Research Team of Caroline Labrie and Petra Dorstijn at Wageningen UR Greenhouse Horticulture.
- A total of 17 sensory attributes comprised of aroma, taste and texture were used to evaluate the samples

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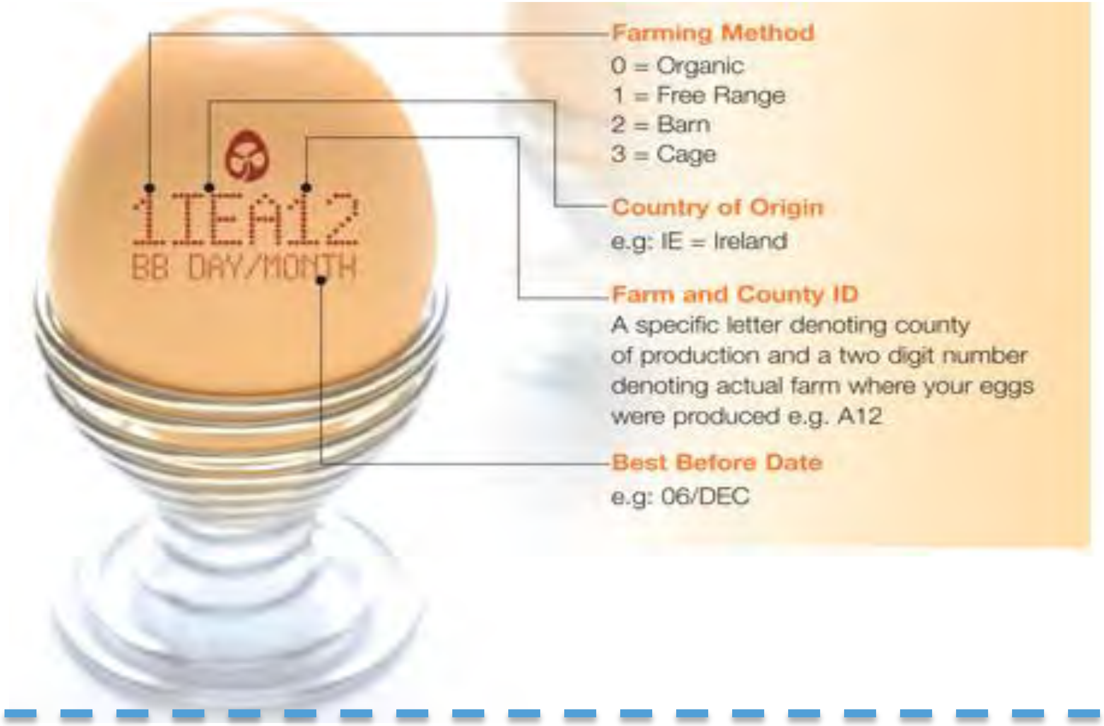
Method developments and confirmation

- Laboratory-based: finding the relevant markers AND (international) validation

The egg study continued



Organic

Cage

Barn

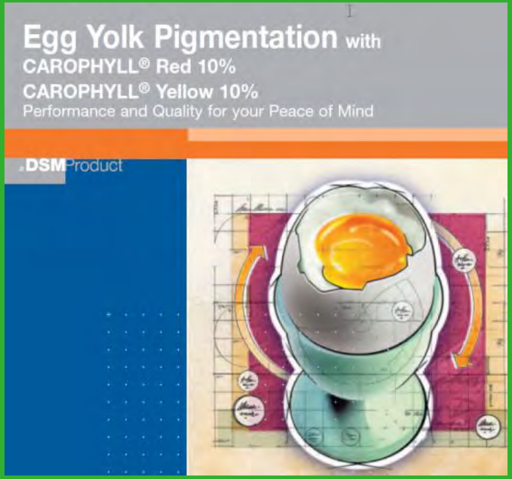
Free range

Instrumental method based on yellow pigments: carotenoids

Carotenoids in egg yolk

- Natural carotenoids
    - Lutein
    - Zeaxanthin

- Feed additives
    - Canthaxanthin
    - Apocarotenoic ester
    - Citranaxanthin



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~750 eggs

~200 pooled samples

~250 samples to be analysed

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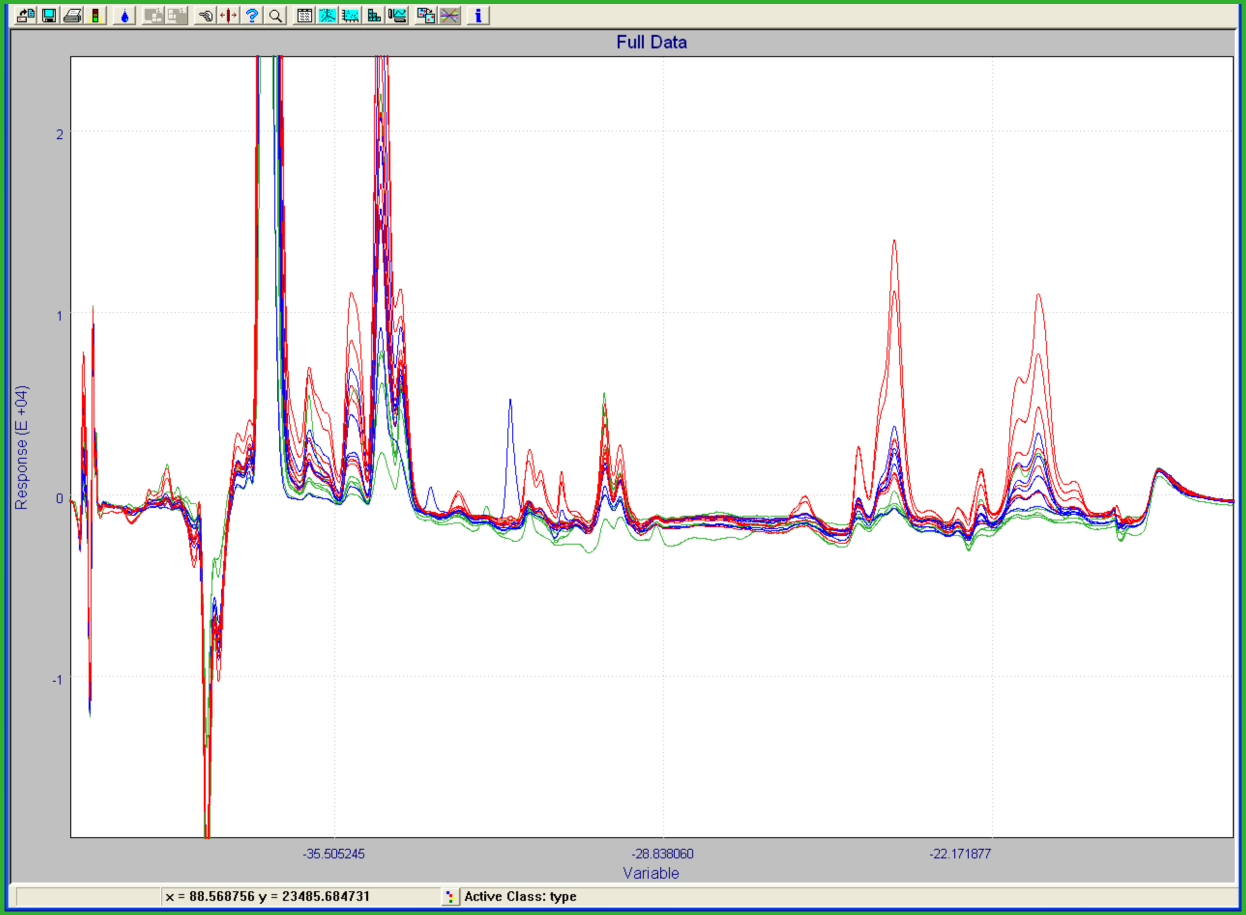
Chromatographic analysis of the yellow pigments



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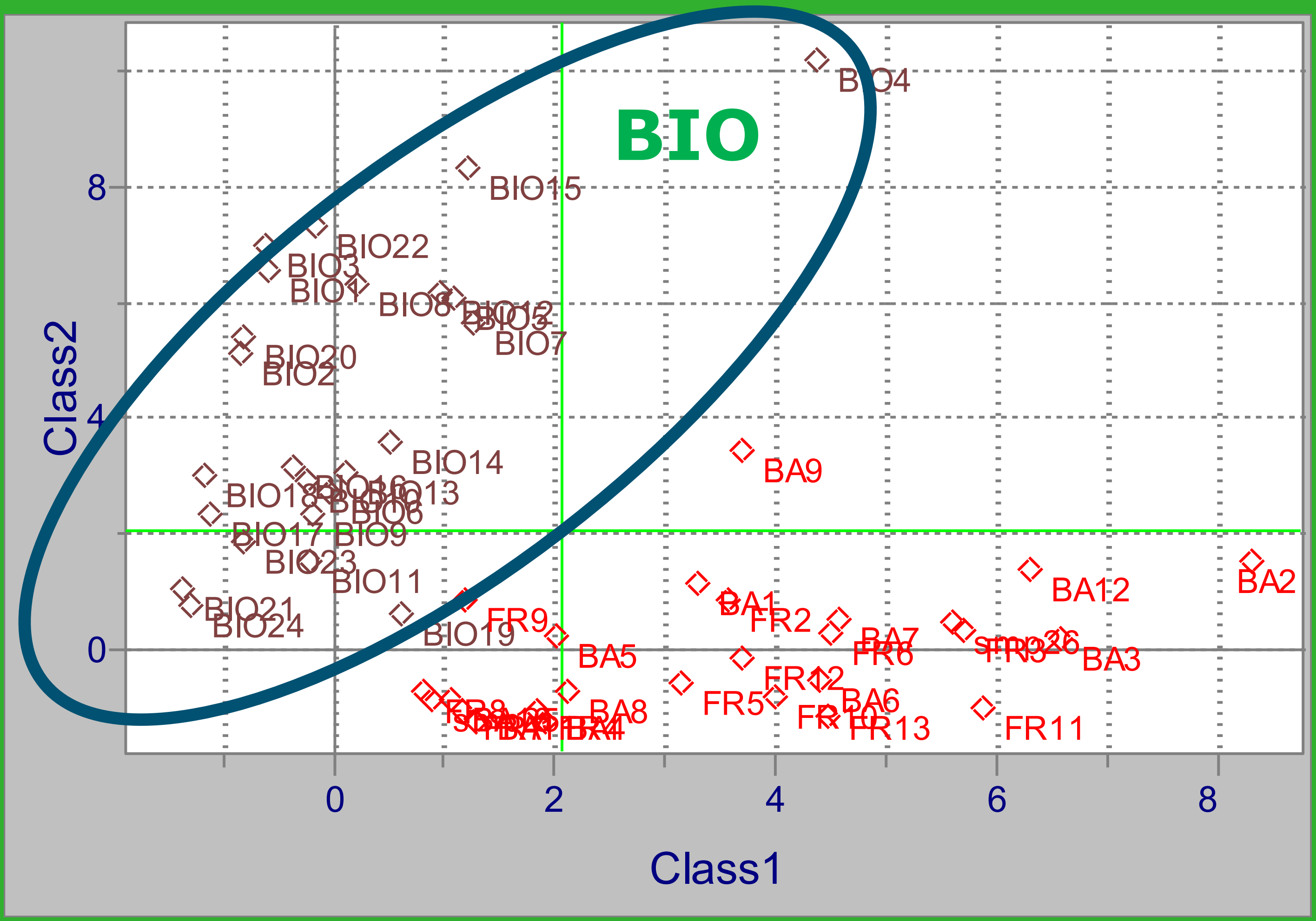
Lots of data

Sample	Region	of anal	Class	g/non-r	Sample	Unknown 1	Canthaxanthin	Unknown 2	Unknown 3	Unknown 4	Unknown 5	β-apo-carotena	Unknown 6	Unknown 7	Unknown 8	B-Carotene	known at RT 1	S
Barn3S	3	1	2	2	1A	665.6	45.7	27.4	0.00	0.00	0.00	0.00	11.81	9.98	0.00	0.0	414.3	11
FR2S	3	1	1	2	2A	624.9	294.5	16.2	0.00	0.00	0.00	0.00	14.61	12.27	0.00	0.0	0.0	96
FR2W	4	1	1	2	3A	624.3	64.0	34.4	8.03	0.00	0.00	0.00	10.31	13.09	0.00	0.0	230.9	98
FR2E	1	1	1	2	4A	668.9	364.2	25.1	0.00	0.00	0.00	0.00	15.63	16.01	148.10	0.0	0.0	12
Cage2N	2	1	3	2	5A	361.9	27.9	14.4	0.00	0.00	0.00	0.00	9.38	6.56	0.00	0.0	0.0	42
FR1E	1	1	1	2	6A	838.1	347.9	25.2	0.00	0.00	0.00	0.00	22.76	15.60	0.00	0.0	0.0	12
Bio2E	1	1	0	1	7A	1818.6	117.9	106.6	0.00	16.56	15.73	0.00	46.92	31.71	0.00	0.0	0.0	21
Bio1E	1	1	0	1	8A	981.7	63.9	57.5	0.00	0.00	0.00	0.00	24.58	22.15	0.00	0.0	0.0	11
FR2N	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	368.2	18.7	0.00	0.00	0.00	0.00	19.12	17.32	225.07	0.0	0.0	12
Barn3N	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	330.7	24.9	0.00	0.00	0.00	0.00	21.15	9.15	0.00	0.0	0.0	11
Barn3N	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	335.4	28.0	0.00	0.00	0.00	0.00	24.00	16.01	0.00	0.0	0.0	10
Barn1N	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	71.2	41.7	0.00	0.00	0.00	0.00	27.49	19.81	0.00	0.0	224.5	13
Bio3N	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	104.3	101.7	0.00	12.91	10.29	0.00	46.32	32.09	0.00	0.0	0.0	20
Cage2E	1	1	3	2	13A	932.1	68.6	42.6	0.00	0.00	0.00	0.00	23.07	21.37	0.00	0.0	280.7	13
Bio3W	4	1	0	1	14A	2625.1	174.0	161.8	0.00	15.15	16.42	0.00	55.31	47.53	0.00	0.0	0.0	30
FR3E	1	1	1	2	15A	1335.1	91.5	93.3	0.00	15.51	10.82	0.00	50.12	32.23	0.00	0.0	0.0	16
Bio2S	3	1	0	1	16A	990.3	59.7	60.5	0.00	0.00	0.00	0.00	18.50	31.13	0.00	0.0	0.0	11
Barn3S	3	2	2	2	1B	635.4	55.2	27.2	0.00	0.00	0.00	0.00	18.02	17.61	0.00	0.0	489.4	12
FR2S	3	2	1	2	2B	536.8	386.6	20.8	0.00	0.00	0.00	0.00	14.13	7.96	0.00	0.0	0.0	96
FR2W	4	2	1	2	3B	634.4	25.8	33.4	13.53	0.00	0.00	0.00	34.67	32.19	0.00	0.0	621.9	13
FR2E	1	2	1	2	4B1	808.9	470.4	29.2	0.00	0.00	0.00	0.00	23.28	14.64	209.25	0.0	0.0	15
FR2E	1	2	1	2	4B2	572.4	813.0	41.0	0.00	0.00	0.00	0.00	62.03	35.77	579.06	0.0	0.0	21
Cage2N	2	2	3	2	5B	441.2	33.4	22.6	0.00	0.00	0.00	0.00	13.79	6.39	0.00	0.0	0.0	51
FR1E	1	2	1	2	6B	980.9	425.4	29.7	0.00	0.00	0.00	0.00	25.77	14.33	0.00	0.0	0.0	14
Bio2E	1	2	0	1	7B	2109.3	126.8	131.1	0.00	20.07	8.38	0.00	43.58	26.90	0.00	0.0	0.0	24
Bio1E	1	2	0	1	8B	1280.8	73.7	67.7	0.00	0.00	0.00	0.00	36.46	36.35	0.00	0.0	0.0	14
FR2N	2	2	1	2	9B	701.3	341.4	23.4	0.00	0.00	0.00	0.00	21.26	17.15	170.56	0.0	0.0	12
Barn3N	2	2	2	2	10B	787.1	416.7	31.6	0.00	0.00	0.00	0.00	18.34	12.82	0.00	0.0	0.0	12
Barn1N	2	2	2	2	11B	1264.4	99.0	60.5	0.00	0.00	0.00	0.00	32.01	24.55	0.00	0.0	325.4	18
Bio3N	2	2	0	1	12B	1900.3	108.7	107.9	0.00	17.67	9.34	0.00	55.86	41.01	0.00	0.0	0.0	22
Cage2E	1	2	3	2	13B	1047.2	82.5	47.8	0.00	0.00	0.00	0.00	33.49	27.04	0.00	0.0	308.3	15
Bio3W	4	2	0	1	14B1	1445.5	93.3	103.9	0.00	27.08	14.06	0.00	120.60	113.38	0.00	0.0	0.0	19
Bio3W	4	2	0	1	14B2	1744.6	112.3	128.9	0.00	18.88	11.21	0.00	88.53	71.51	0.00	0.0	0.0	21
FR3E	1	2	1	2	15B	1811.8	94.4	100.9	0.00	18.10	6.93	0.00	68.75	38.66	0.00	0.0	0.0	21
Bio2S	3	2	0	1	16B	1386.4	79.4	80.6	0.00	17.53	11.23	0.00	48.41	30.66	0.00	0.0	0.0	16
Barn3S	3	8	2	2	1C	1076.1	92.6	50.6	0.00	0.00	0.00	0.00	34.73	27.45	0.00	0.0	468.3	17
FR2S	3	8	1	2	2C	753.3	443.0	18.5	0.00	0.00	0.00	0.00	19.78	12.64	0.00	0.0	0.0	12
FR2W	4	8	1	2	3C	1165.3	55.7	125.5	15.77	0.00	0.00	0.00	24.78	25.89	0.00	0.0	459.5	18
FR2E	1	8	1	2	4C	839.2	456.2	30.0	0.00	0.00	0.00	0.00	30.15	24.67	239.66	0.0	0.0	16
Cage2N	2	8	3	2	5C	498.1	32.5	23.4	0.00	0.00	0.00	0.00	16.17	10.92	0.00	0.0	0.0	58
FR1E	1	8	1	2	6C	1170.7	282.4	27.6	0.00	0.00	0.00	0.00	43.32	23.71	0.00	0.0	0.0	15
Bio2E	1	8	0	1	7C	2581.2	161.4	146.6	0.00	24.37	17.06	0.00	71.77	44.02	0.00	0.0	0.0	30
Bio1E	1	8	0	1	8C1	1542.9	81.1	74.1	0.00	0.00	0.00	0.00	44.78	41.35	0.00	0.0	0.0	17
Bio1E	1	8	0	1	8C2	1506.2	75.3	65.9	0.00	0.00	0.00	0.00	52.57	41.21	0.00	0.0	0.0	17
FR2N	2	8	1	2	9C	789.7	516.9	23.3	0.00	0.00	0.00	0.00	22.03	19.46	356.77	0.0	0.0	17
Barn3N	2	8	2	2	10C	919.3	426.6	27.7	0.00	0.00	0.00	0.00	23.64	12.23	0.00	0.0	0.0	14
Barn1N	2	8	2	2	11C	1384.7	74.4	100.1	0.00	0.00	0.00	0.00	32.55	23.91	0.00	0.0	329.4	19
Bio3N	2	8	0	1	12C	1948.9	99.5	112.7	0.00	17.72	10.58	0.00	75.67	57.49	0.00	0.0	0.0	23
Cage2E	1	8	3	2	13C	1109.1	56.0	79.7	0.00	0.00	0.00	0.00	47.67	35.99	0.00	0.0	401.5	17
Bio3W	4	8	0	1	14C	1574.4	81.5	97.6	0.00	27.40	12.63	0.00	143.71	124.76	0.00	0.0	0.0	20
FR3E	1	8	1	2	15C	1664.4	95.0	100.1	0.00	24.98	28.92	0.00	80.86	57.44	0.00	0.0	0.0	20
Bio2S	3	8	0	1	16C	1624.2	81.9	92.8	0.00	0.00	0.00	0.00	36.76	30.33	0.00	0.0	0.0	18
Bio3S	[illegible]	[illegible]	0	1	17A	1493.8	81.9	81.7	0.00	25.47	13.22	0.00	75.85	71.28	0.00	0.0	0.0	18
Cage2S	3	9	3	2	18A1	799.7	319.2	23.6	0.00	0.00	0.00	0.00	16.62	13.34	543.78	0.0	0.0	17
Cage2S	3	9	3	2	18A2	827.7	291.5	27.1	0.00	0.00	0.00	0.00	17.24	14.48	406.87	0.0	0.0	15

Raw results

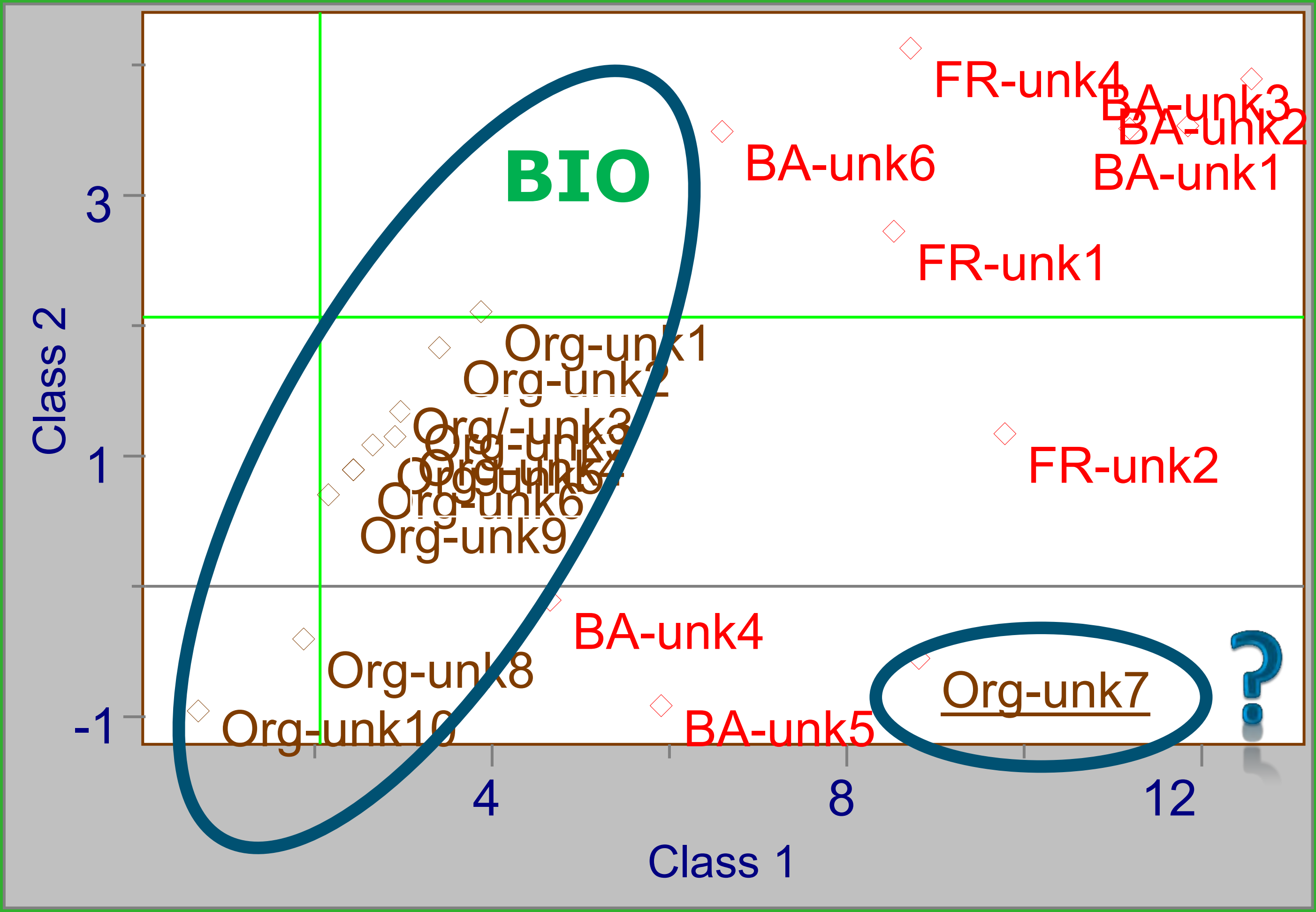
Statistical analysis

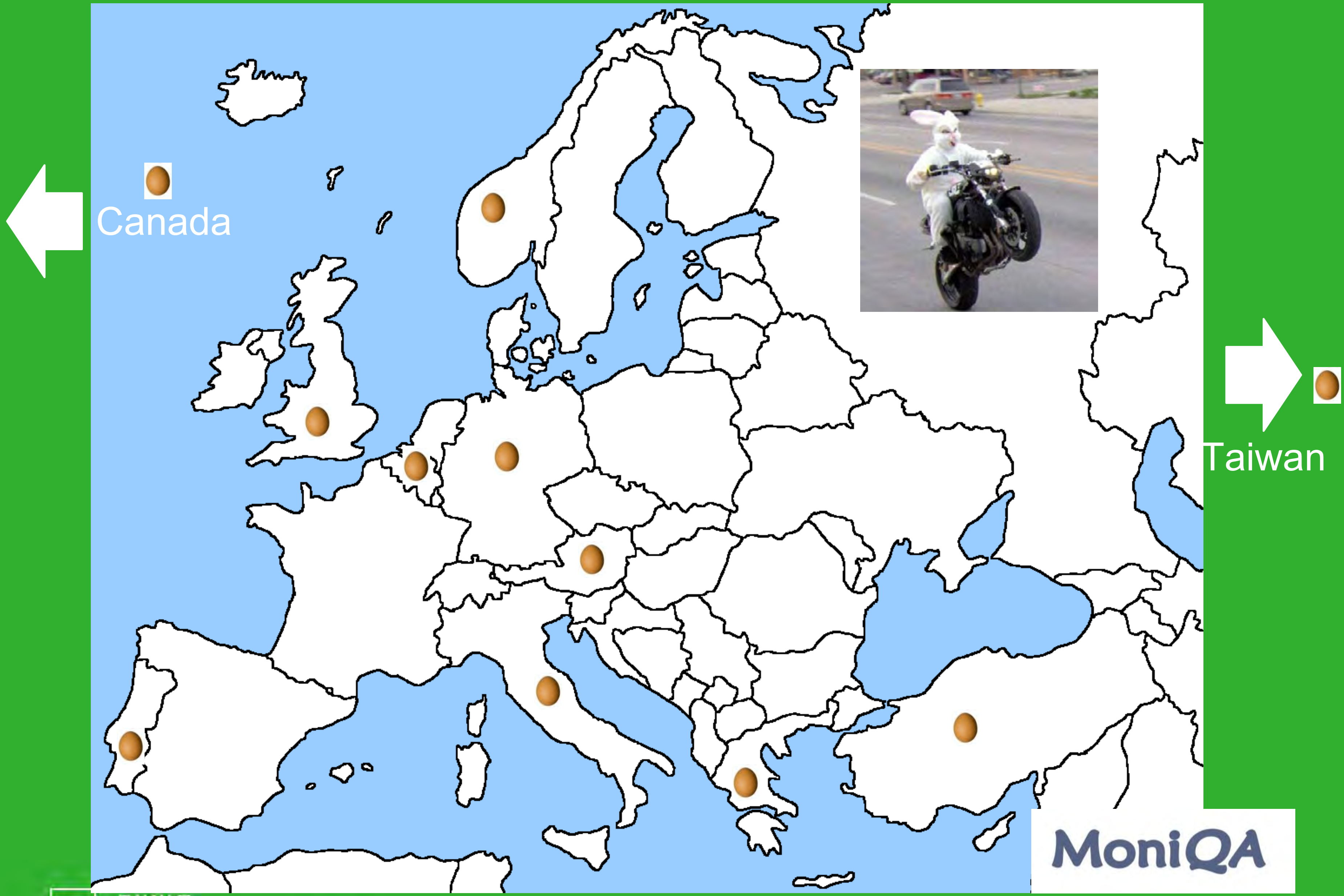


Scientific validation

- Cross-validation with training set: all organic and 24 out of 26 non-organic egg samples were correctly classified
- Validation with new eggs from 12 organic and 12 conventional farms from
    - The Netherlands
    - New Zealand

Validation with new eggs





MoniQA

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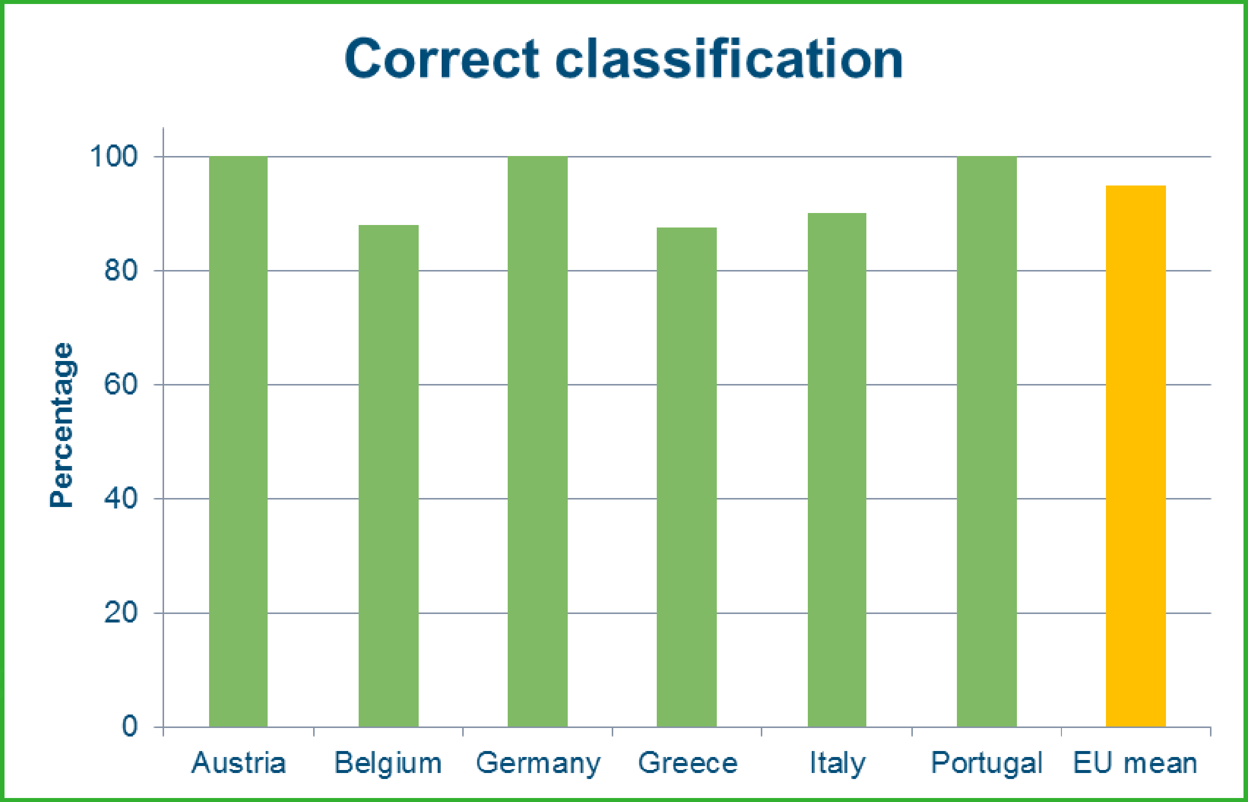
Organic egg classification based on model for Dutch eggs



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MoniQA

Quality Assurance and Safety of crops & foods, March 2013; 5 (1): 7-14

Wageningen Academic Publishers

Eggspectation: organic egg authentication method challenged with produce from ten different countries

S.M. van Ruth[1], A.H. Koot[1], S.E. Brouwer[1], N. Boivin[2], M. Carcea[3], C.N. Zerva[4], J.-E. Haugen[5], A. Höhl[6], D. Köroglu[7], I. Mafra[8] and S. Rom[9]

Application

- For certifiers
- For farmers/trade
- For NGO's
- For research
- For the press

Supply-chain: pro-active, red/green light, 100% check

- In industry
- 100% check
- Anomaly testing (red/green light)
- Rapid, low-cost, in-/at-line detection

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Multiple markers: wine

Food Chemistry 116 (2009) 761–765

Contents lists available at ScienceDirect

Food Chemistry

journal homepage: www.elsevier.com/locate/foodchem

Analytical Methods

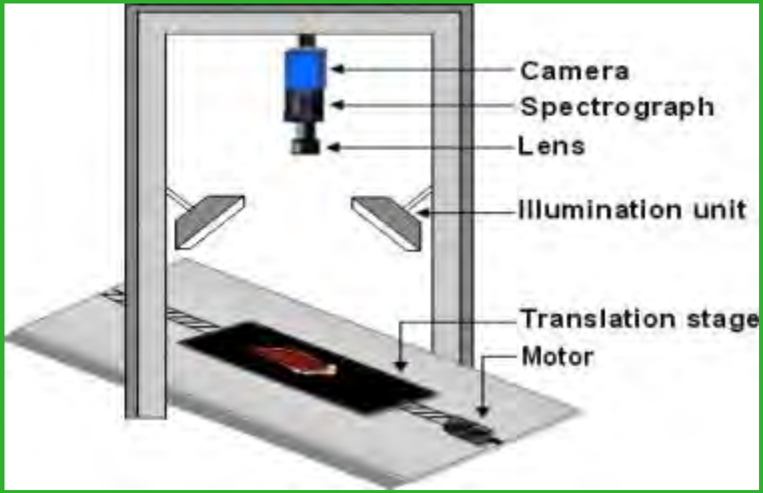
Mid infrared spectroscopy and multivariate analysis: A tool to discriminate between organic and non-organic wines grown in Australia

Daniel Cozzolino *, Matt Holdstock, Robert G. Dambergs, Wies U. Cynkar, Paul A. Smith

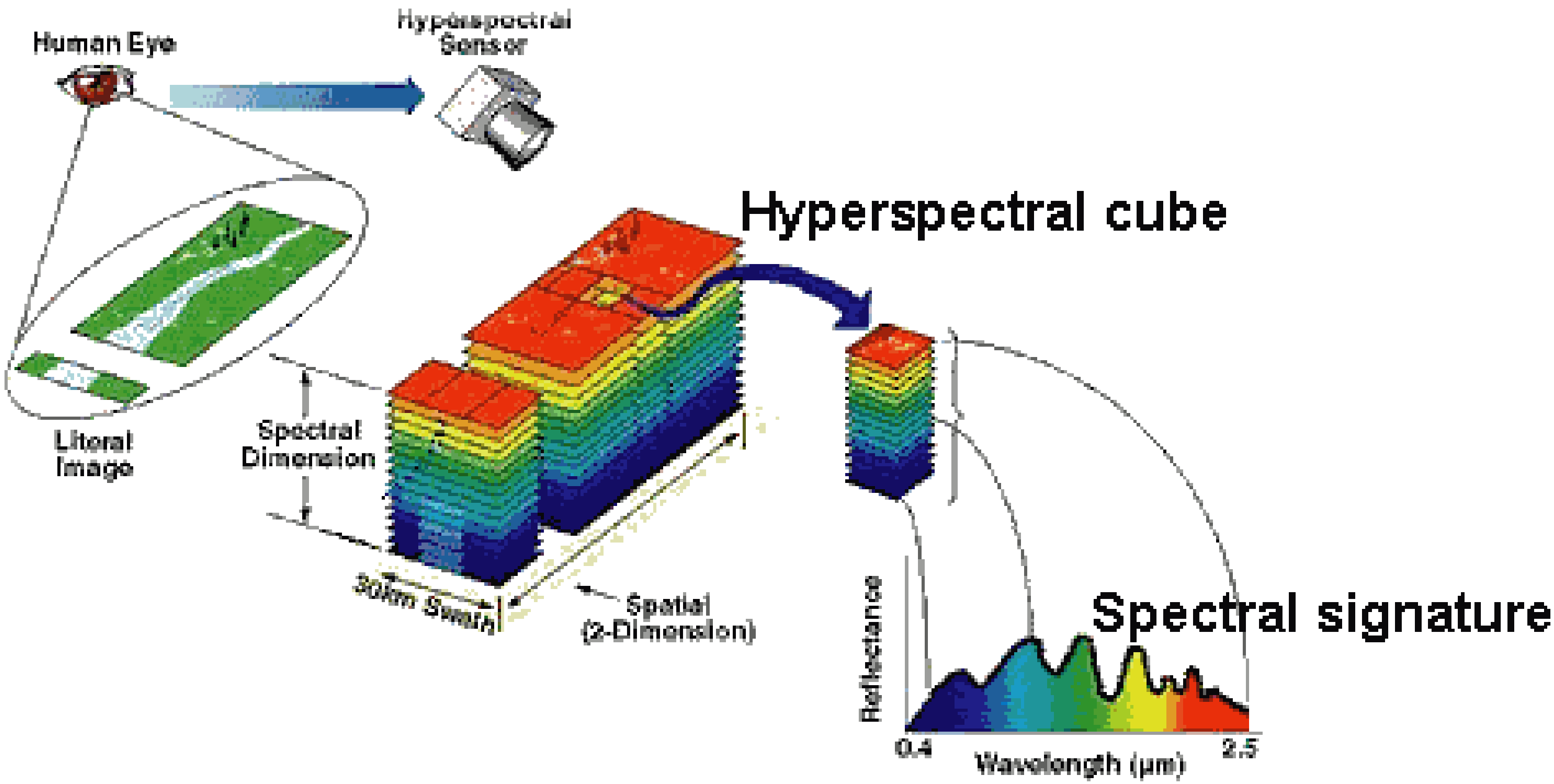
The Australian Wine Research Institute, P.O. Box 197, Adelaide, Glen Osmond, SA 5064, Australia

Meat testing

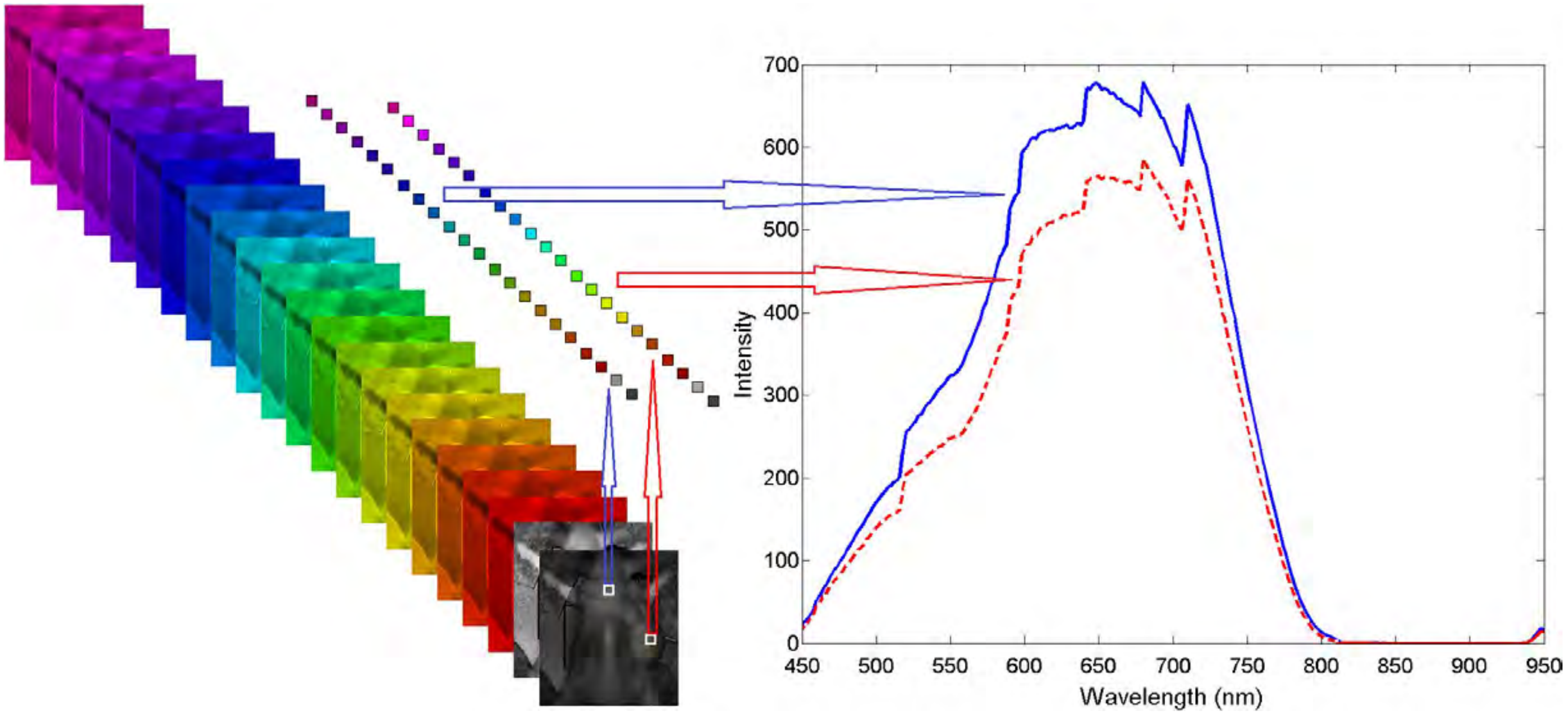
- Hyperspectral measurements



Principles hyperspectral imaging



Principles hyperspectral imaging 2



Comparison organic/conventional beef

Potentials and limitations

- Interdisciplinary developments: social sciences/food science/chemistry/physics/statistics/economics/financial world
- Technology allowing more detailed evaluations

- Limitations: one can only find differences if they are present (consistently)....

Outlook food authentication

- Interaction with social sciences required to understand what would be perceived as a fraud opportunity which will allow eventually science-based determination of critical temptation points
- Developments in authentication in confirmatory laboratory testing, especially with regard to fingerprinting
- New opportunities to measure in industrial environment

Thanks

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