'Hard Men Eat Blackcurrants'

Current research results on the health benefits of a diet rich in Blackcurrants

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Derek Stewart

Leader of Enhancing Crop Productivity and Utilisation

Overview

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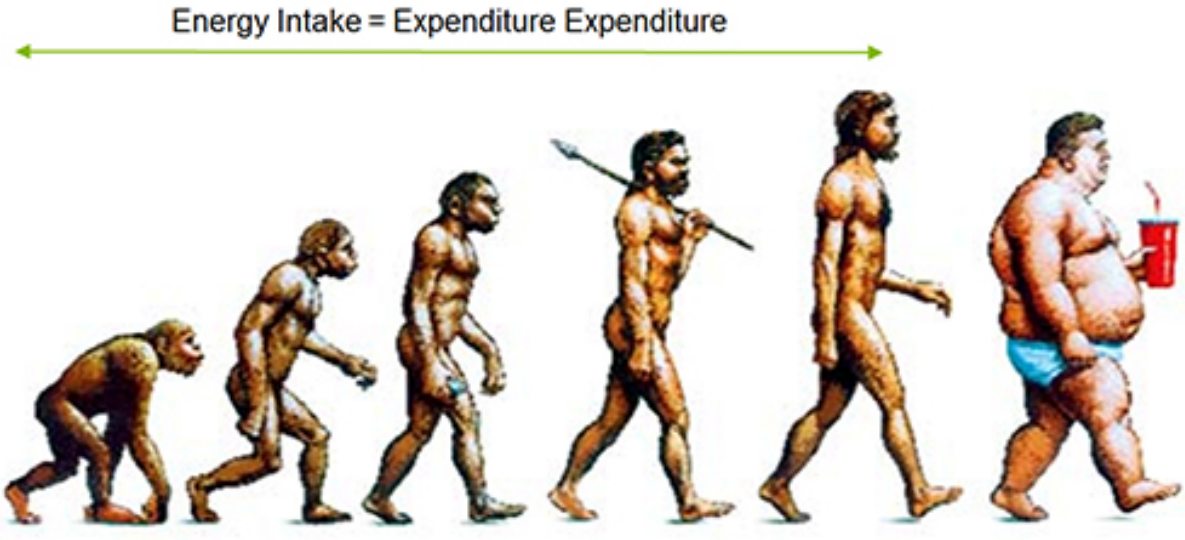
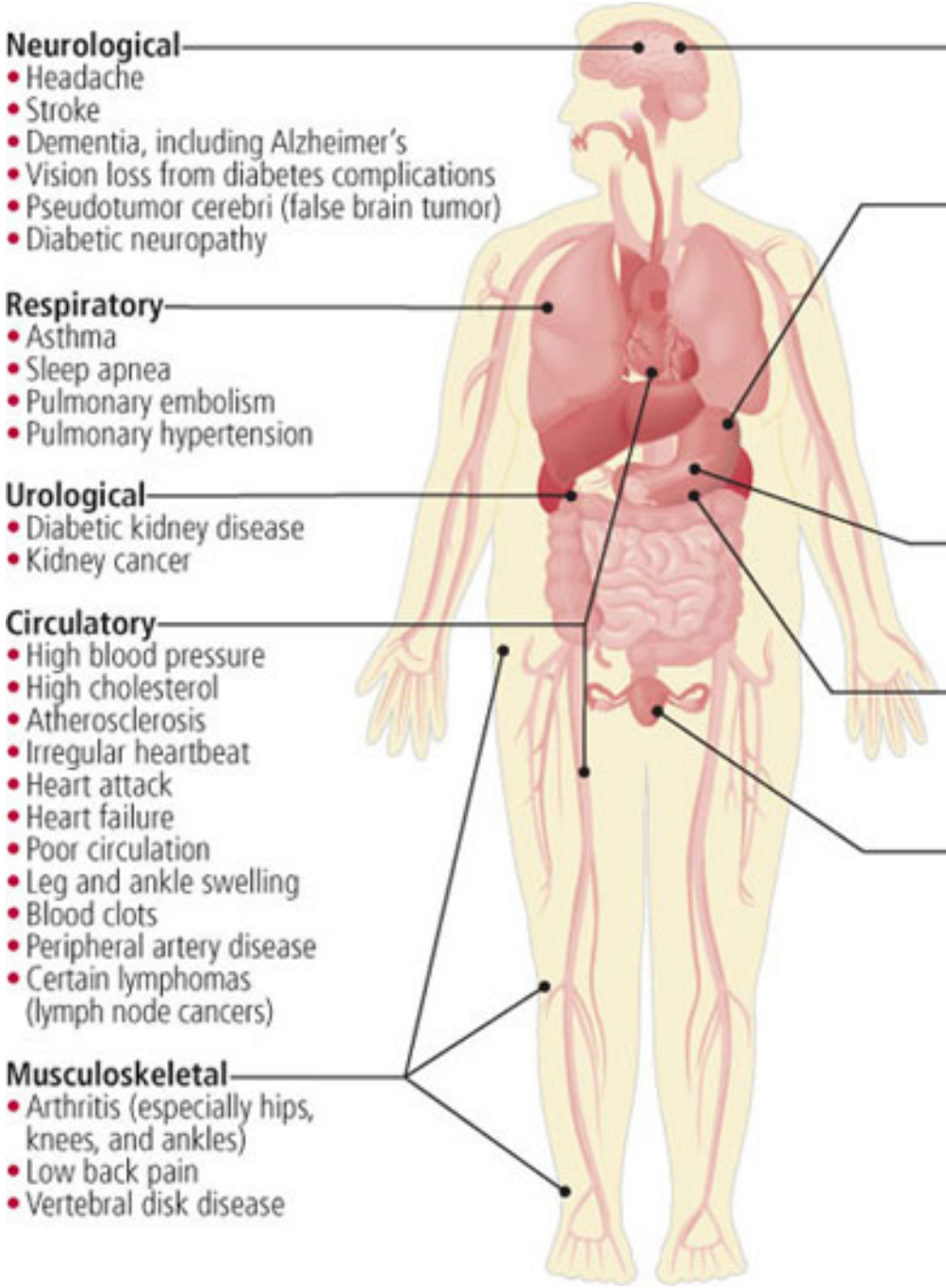
- Worldwide obesity has more than doubled since 1980.
- In 2014, more than 1.9 billion adults, 18 years and older, were overweight. Of these over 600 million were obese.
- 39% of adults aged 18 years and over were overweight in 2014, and 13% were obese.
- Most of the world's population live in countries where overweight and obesity kills more people than underweight.
- 42 million children under the age of 5 were overweight or obese in 2013.



Overview



Neurological
- Headache
- Stroke
- Dementia, including Alzheimer's
- Vision loss from diabetes complications
- Pseudotumor cerebri (false brain tumor)
- Diabetic neuropathy

Respiratory
- Asthma
- Sleep apnea
- Pulmonary embolism
- Pulmonary hypertension

Urological
- Diabetic kidney disease
- Kidney cancer

Circulatory
- High blood pressure
- High cholesterol
- Atherosclerosis
- Irregular heartbeat
- Heart attack
- Heart failure
- Poor circulation
- Leg and ankle swelling
- Blood clots
- Peripheral artery disease
- Certain lymphomas (lymph node cancers)

Musculoskeletal
- Arthritis (especially hips, knees, and ankles)
- Low back pain
- Vertebral disk disease

Psychological
- Depression
- Anxiety
- Eating disorders

Gastrointestinal
- Reflux disease
- Esophageal cancer
- Colon polyps
- Colon cancer
- Fatty liver disease
- Cirrhosis
- Liver cancer
- Gallstones
- Gallbladder cancer

Pancreas
- Diabetes (type 2)
- Pancreatitis
- Pancreatic cancer

Nutritional
- Vitamin D deficiency
- Other vitamin and mineral deficiencies

Reproductive

Women:
- Irregular menses
- Infertility
- Polycystic ovarian syndrome
- Ovarian cancer
- Endometrial cancer
- Cervical cancer
- Breast cancer

Men:
- Prostate cancer
- Infertility
- Erectile dysfunction

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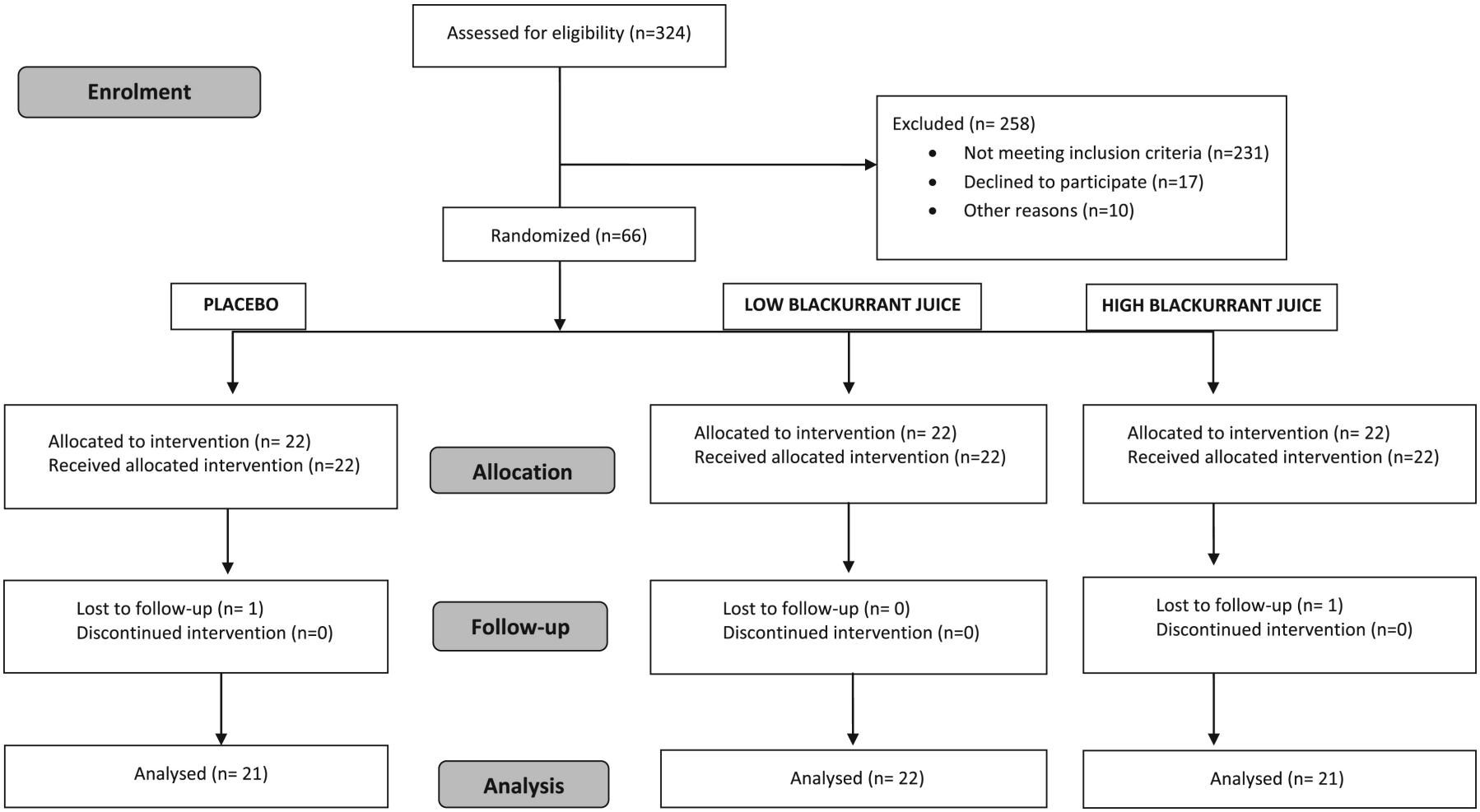
Blood Pressure



Khan et al (2014) Free Radical Biology and Medicine, 72, 232–237.

Blood Pressure

Markers of cardiovascular function, vitamins C and E, and oxidative stress at baseline and 6-week follow-up by group randomization.

	Placebo (*n*=21)	Low blackcurrant juice (*n*=22)	High blackcurrant juice (*n*=21)
Systolic blood pressure (mm Hg)			
Baseline	128±15	130±17	127±16
6 weeks	122±11	127±15	127±12
Diastolic blood pressure (mm Hg)			
Baseline	81±15	82±15	79±15
6 weeks	78±15	80±15	80±15
Flow-mediated dilation (%)			
Baseline	6.0±2.2	5.8±2.7	5.8±3.1
6 weeks[a]	5.1±2.4	6.5±2.8	6.9±3.1[b]
GTN-mediated vasodilation (%)			
Baseline	14.9±3.9	14.3±5.2	13.6±5.4
6 weeks	14.6±4.9	13.2±5.0	14.4±6.3
Total cholesterol (mmol/L)			
Baseline	5.2±0.9	5.5±0.9	4.9±0.9
6 weeks	5.0±0.6	5.3±0.9	4.8±0.9
Vitamin C (µmol/L)			
Baseline	38.1±21.0	38.6±17.6	34.6±20.4
6 weeks[c]	29.0±17.6[d]	49.4±21.0[d]	73.8±23.3[d]
Vitamin E (µmol/L)			
Baseline	5.8±1.7	5.5±1.6	4.7±1.5
6 weeks	5.1±1.6	5.5±1.6	5.1±1.4
F_2-isoprostanes (pg/ml)			
Baseline	264±61	271±59	288±76
6 weeks[c]	254±59	257±69[e]	225±64[f]

⇧ **Endothelium-dependent process facilitating the relaxation of an artery in response to increased shear stress**

⇧

⇩ **Markers of oxidative stress in vivo**

Khan et al (2014) Free Radical Biology and Medicine, 72, 232–237.

Blood Pressure

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- Inadequate fruit and vegetable intake might contribute to increased cardiovascular disease risk.
- Oxidative stress decreases after intake of blackcurrant juice drink rich in vitamin C and polyphenols.
- Endothelial function improves after intake of blackcurrant juice drink.
- Changes in vitamin C correlate with improvement in endothelial function.
- Consumption of blackcurrant juice drink high in vitamin C and polyphenols improves vascular health.

Khan et al (2014) Free Radical Biology and Medicine, 72, 232–237.

Blackcurrants Attenuate Weight Gain

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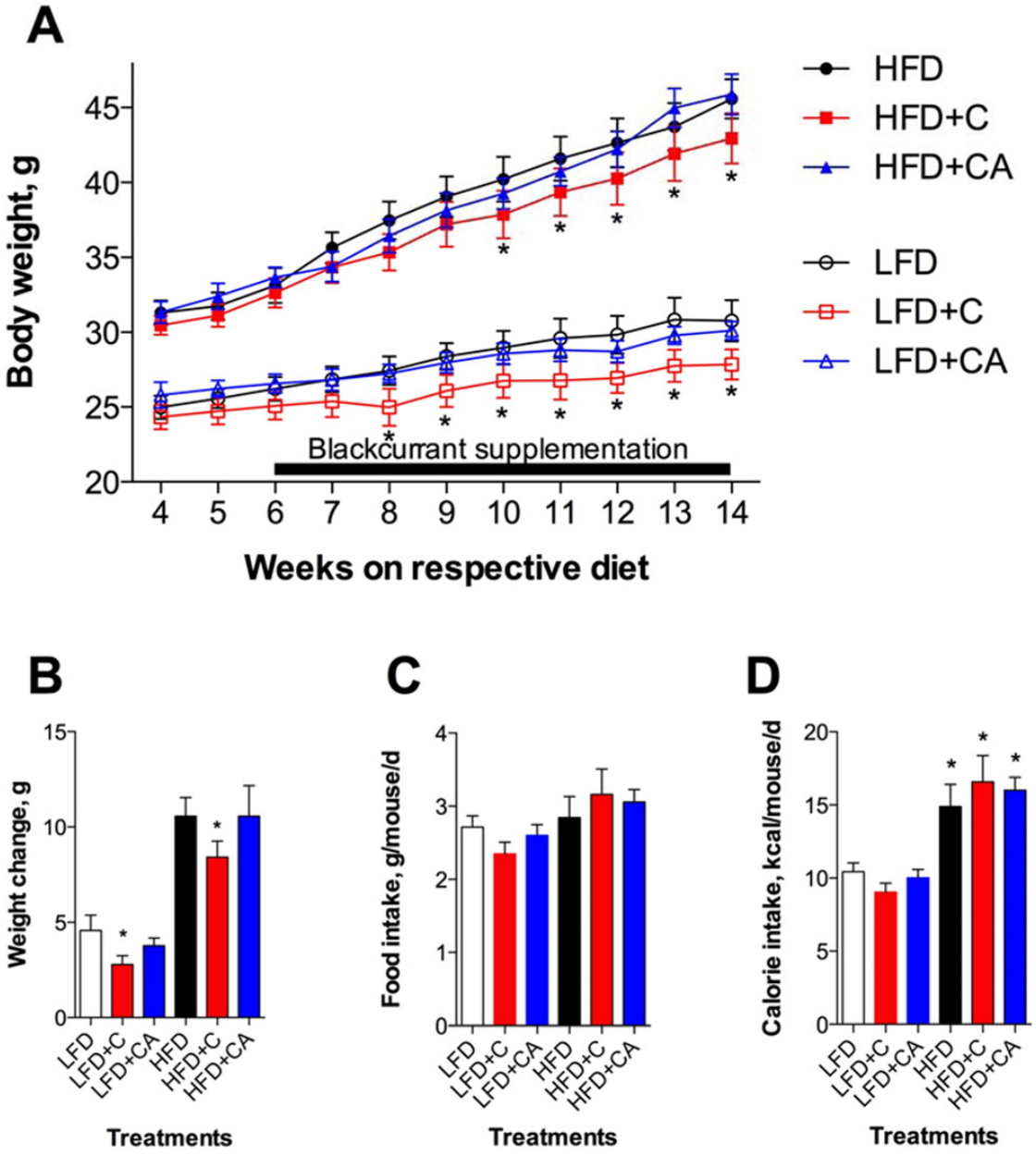

Effects of black currant and gut microbiome on body weight (A), body weight gain (B), food intake (C), and calorie intake (D) in the C57BL/6J mice. Six-week-old male mice were fed a low- or high-fat diet for 6 weeks. Lean and obese mice were further randomized to control low-fat diet (LFD), control high-fat diet (HFD), and the respective low-fat (LFD+C) and high-fat (HFD+C) black currant-supplemented treatment groups (1% black currant powdered extract incorporated in LFD or HFD) and kept on the same diet for an additional 8 weeks. An antibiotic cocktail was administered in drinking water ad libitum to half of the animals on black currant-supplemented treatment groups (LFD+CA and HFD+CA groups, respectively) for the entire duration of the black currant feeding study (weeks 7–14). Animal weight and food intake were recorded weekly for the duration of the study. Results are expressed as means ± SEM, $n = 8$. Body weight gain was analyzed by two-factor repeated-measures ANOVA, with time and treatment as independent variables. (*) $P < 0.05$ versus respective LFD or HFD control. One-way ANOVA, Dunnett's post hoc test. Body weight gain was analyzed by two-factor, repeated-measures ANOVA, with time and treatment as independent variables.

Esposito et al. J. Agric. Food Chem., 2015, 63, 6172–6180

Blackcurrants and feed efficiency

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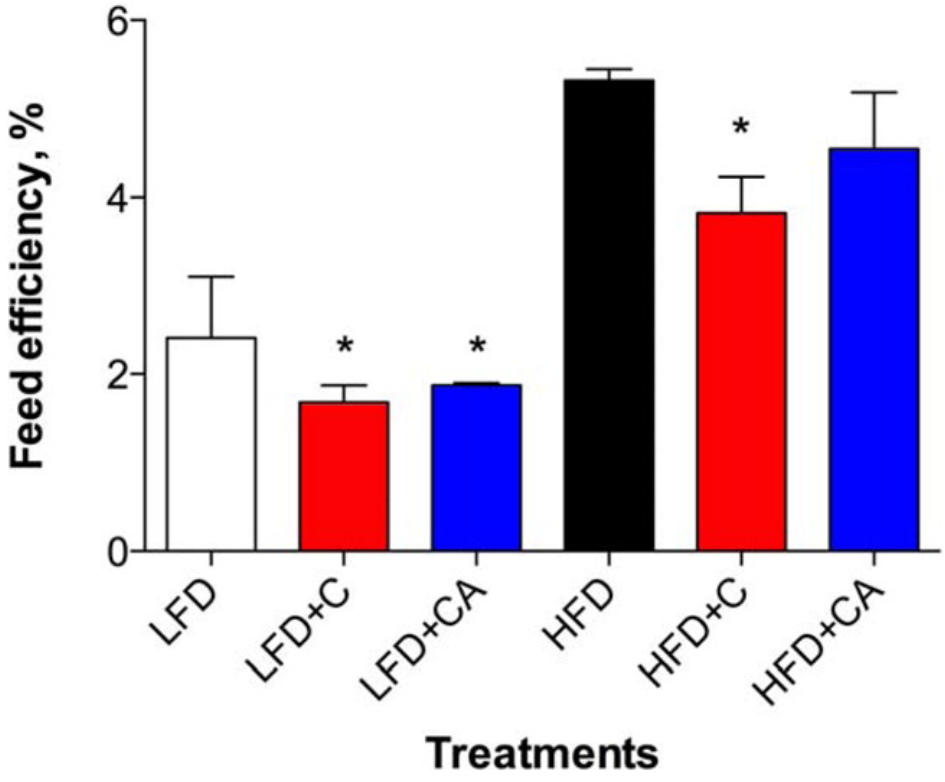

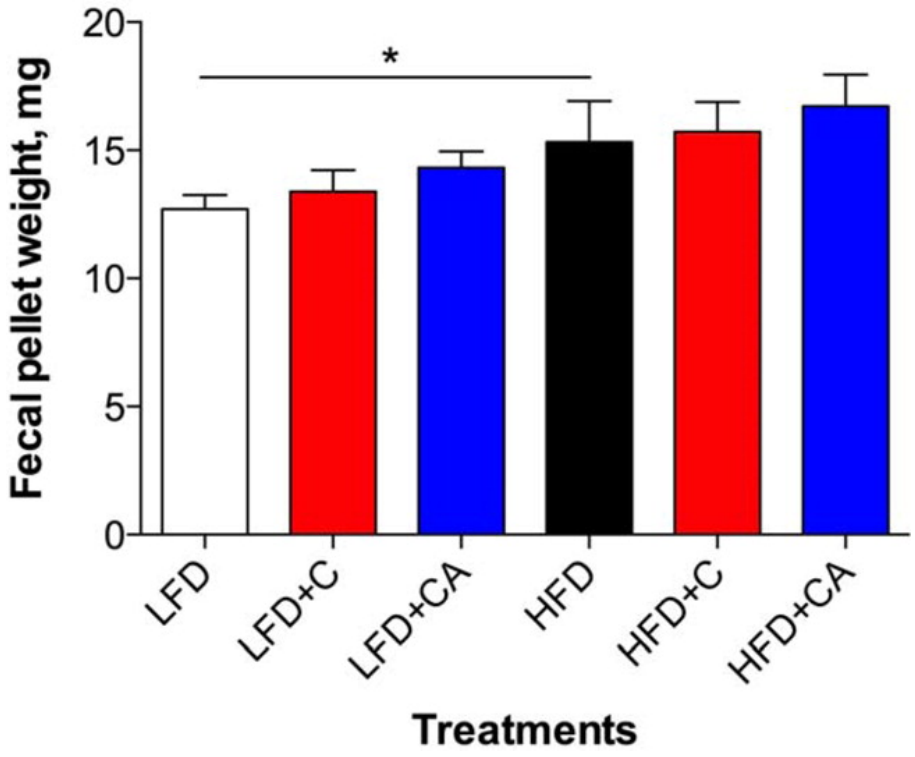

Effects of black currant and gut microbiome on feed efficiency in the C57BL/6J mice fed low- and high-fat diets. Animals received low-fat diet (LFD) or high-fat diet (HFD) or black currant-supplemented treatment groups (1% black currant extract) LFD+C or HFD+C for 8 weeks. Feed efficiency was calculated as (body weight gain/food intake) × 100 ratio. (*) $P < 0.05$ versus respective LFD or HFD control. One-way ANOVA, Dunnett's post hoc test.

Effects of black currant and gut microbiome on fecal excretion in the C57BL/6J mice fed low- and high-fat diets. Animals received low-fat diet (LFD) or high-fat diet (HFD) or black currant-supplemented treatment groups (1% black currant extract incorporated in LFD or HFD; LFD+C or HFD+C) for 8 weeks. Results are expressed as means ± SEM. (*) $P < 0.05$ versus respective LFD or HFD control. One-way ANOVA, Dunnett's post hoc test.

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Blackcurrants and Glucose/Insulin Tolerance

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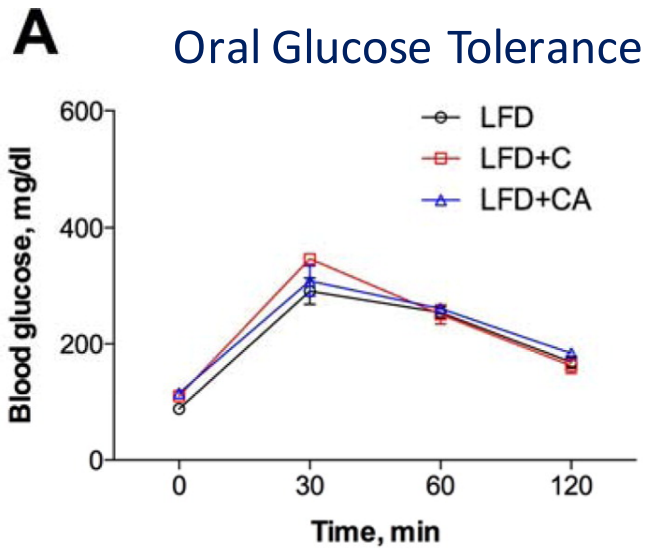

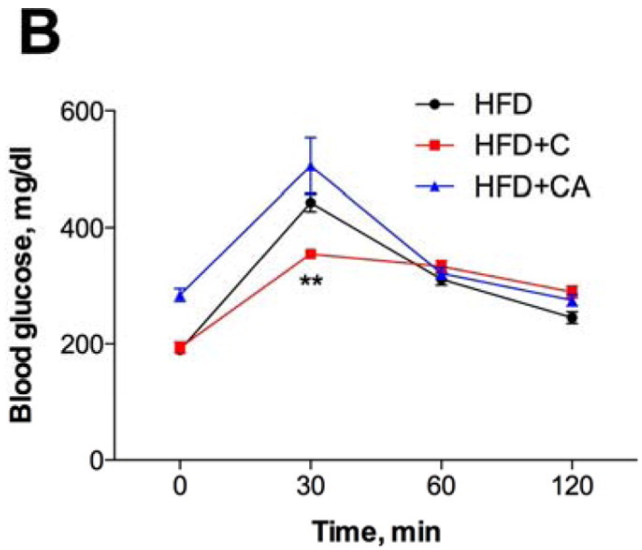

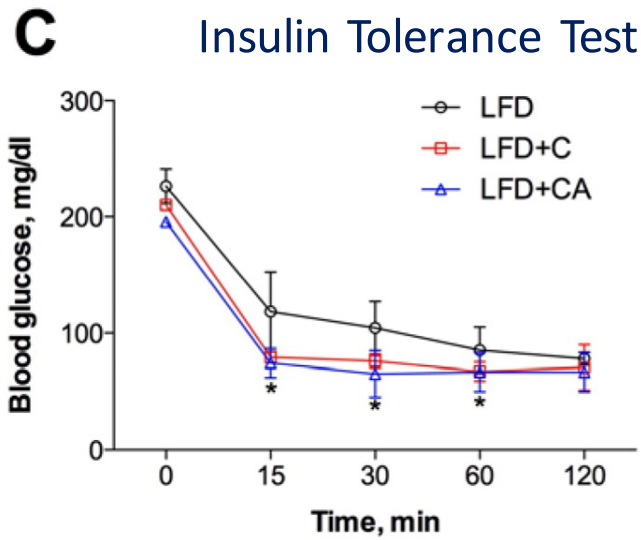

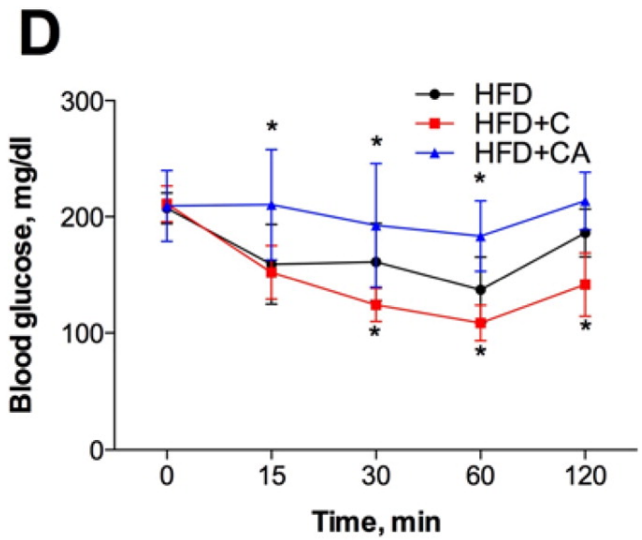

Chronic insulin-sensitizing effect of black currant supplementation on oral glucose tolerance test on low-fat diets (A) and high-fat diets (B) and insulin tolerance test on low-fat diets (C) and high-fat diets (D) in the C57BL/6J mice. Eight-week-old male mice were fed a low- or high-fat diet for 6 weeks. Lean and obese mice were further randomized to control low-fat diet (LFD), control high-fat diet (HFD), and the respective low-fat (LFD+C) and high-fat (HFD+C) black currant-supplemented treatment groups (1% black currant extract incorporated in LFD or HFD diet) and kept on the same diet for an additional 8 weeks. An antibiotic cocktail was administered in drinking water ad libitum to half of the animals on black currant-supplemented treatment groups (LFD+CA and HFD+CA groups, respectively) for the entire duration of the black currant feeding study (weeks 7–14). For oral glucose tolerance test, mice were fasted overnight (16 h) and received oral gavage of d-glucose (1.5 g/kg body weight). For insulin tolerance test, mice were fasted for 4 h and received intraperitoneal injection of insulin (0.75 U/kg body weight). Blood glucose concentrations were measured at 0, 15, 30, 60, and 120 min after glucose or insulin challenge in blood samples obtained from tail-tip bleedings, using a glucometer

Esposito et al. J. Agric. Food Chem., 2015, 63, 6172–6180

Blackcurrant
Impact on glucose and insulin management

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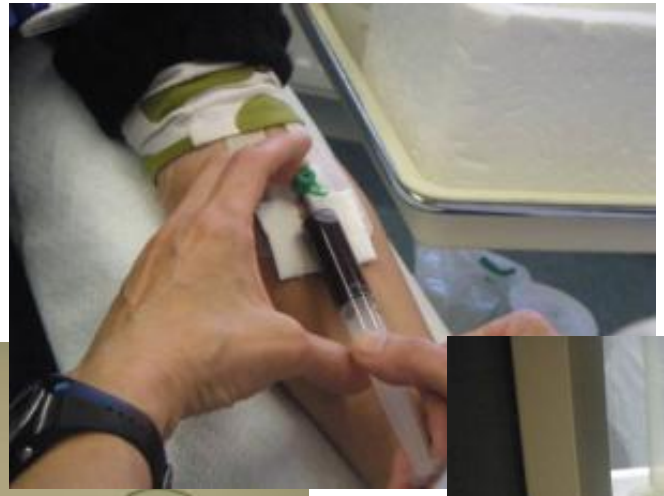
- Bioavailability of anthocyanins and other polyphenols from the two blackcurrant juices with different polyphenol contents (a control juice and a polyphenol-enriched juice)
- Randomized, controlled, double-blind cross-over study.
- Each subject in two 8-h postprandial tests, on separate days, at least 5 days apart.
- Control (pre consumption bloods taken).
- Blood taken at samples 15, 30, 45, 60, 90, 120, 150 and 180 min for plasma polyphenol, glucose and insulin measurements.
- Blood also taken at 4, 6 and 8 h for polyphenol measurements only.
- Control and trial urine taken at 0-2, 2-4, 4-6 and 6-8 hr.



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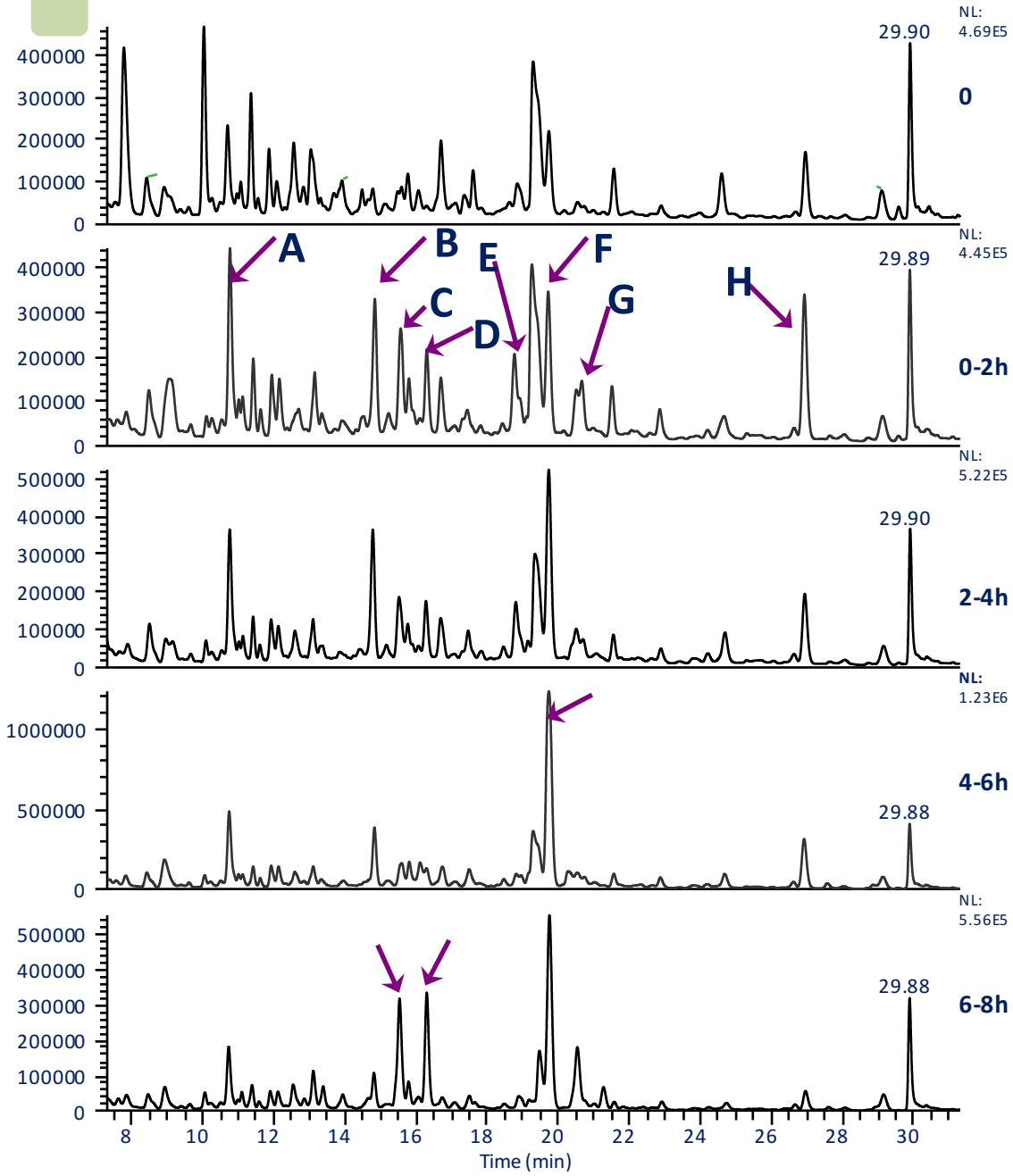
Blackcurrant
Impact on glucose and insulin management



- As metabolism progresses BC-related compounds start to become present in the urine. These are polyphenolic & anthocyanin derived.
- At 4-6 hrs the main peak has increased by 10-fold.
- The later peaks are probably a result of colonic bacterial breakdown processes followed by reabsorption and excretion

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Blackcurrant
Impact on glucose and insulin management

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Plasma glucose and insulin concentrations (mean ± SEM) after consumption of 300 mL of sucrose-sweetened basic (○) and fortified (●) blackcurrant juices in 13 healthy subjects.

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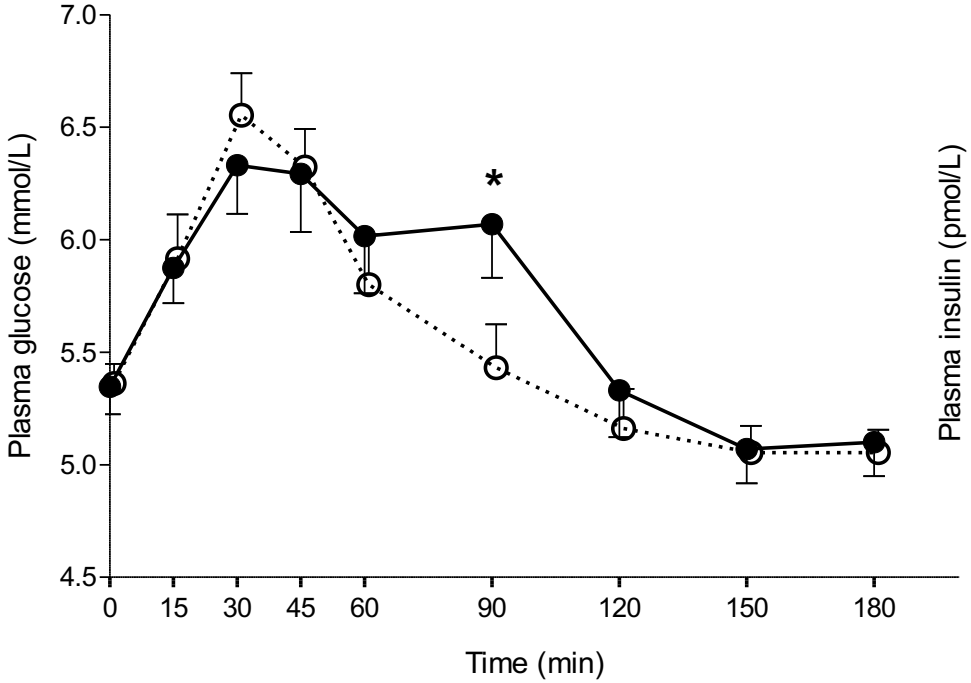

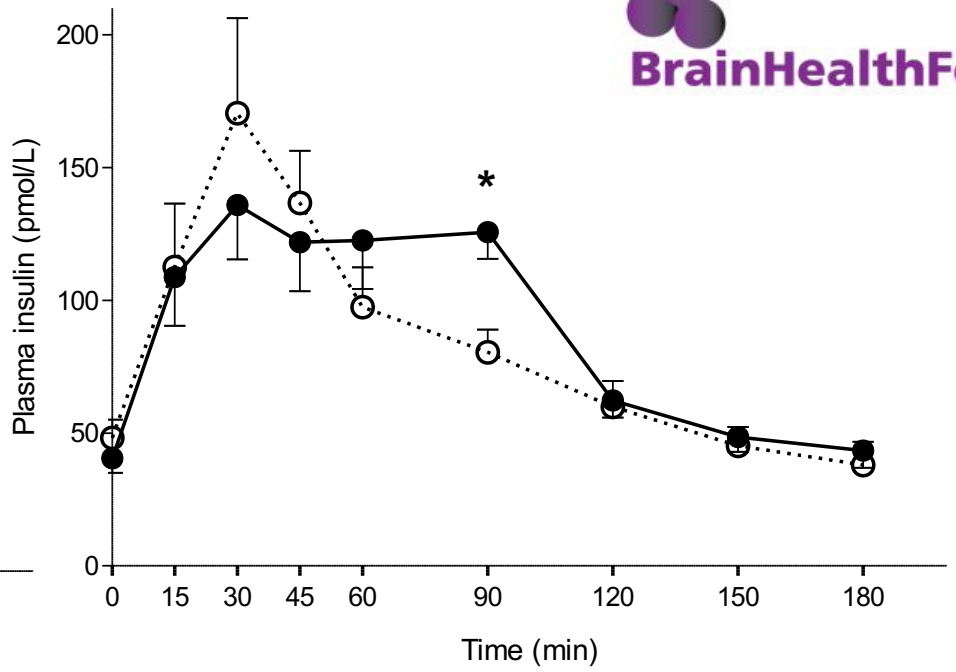

The polyphenol rich (fortified) juice attenuated both glucose and insulin levels:
An amelioration of the sugar rush and potentially a reduction in the inflammation triggers. The long term consequence would be a reduction in the risk of CVD.

Dietary Natural Products
What is the active component?

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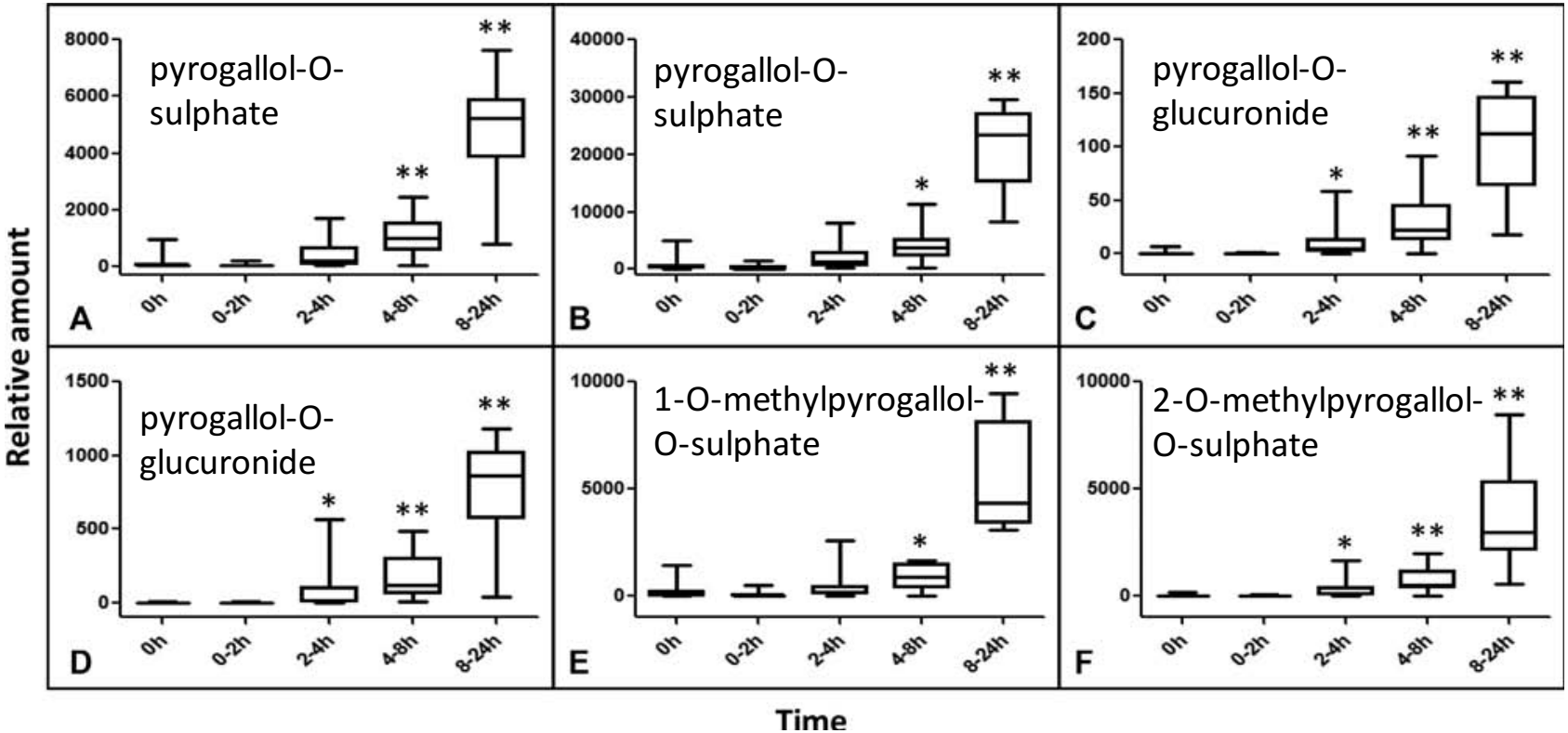
Human digestion and metabolism

Colonic bacteria fermentation



Dementia and Alzheimer's

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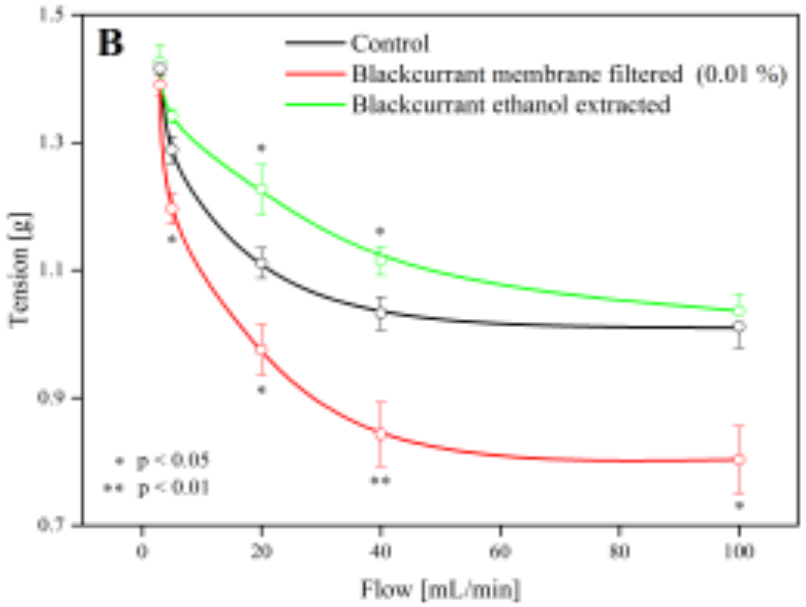
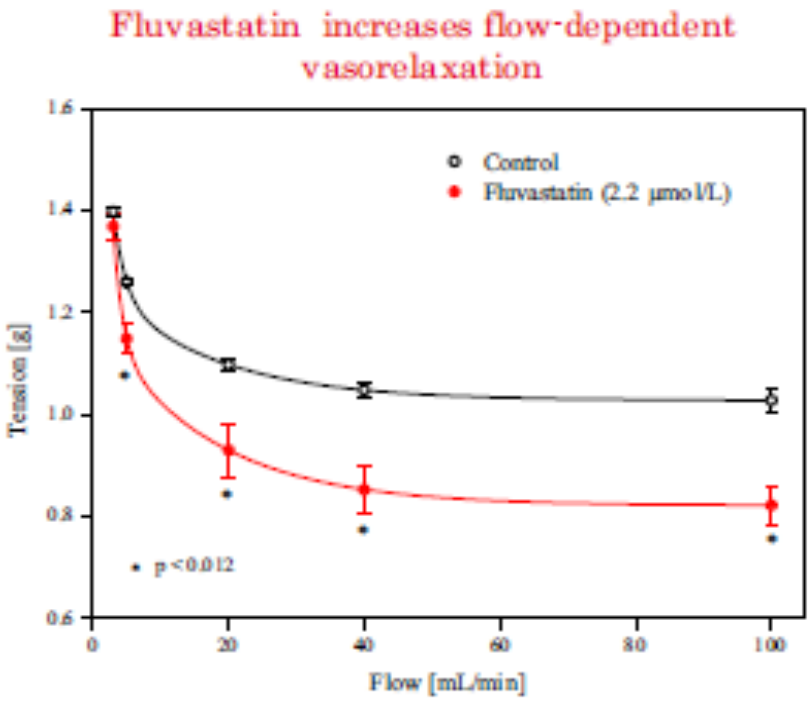
- Every 3.2 s, an individual falls ill with dementia, the number of persons concerned will almost be trebled by 2050, scientists communicated in London at the World Alzheimer Report 2015: 46.8 million people live with a dential disease worldwide.
- 850,000 people living with dementia in the UK in 2015
- Costs - £26 billion a year.
  - £4.3 billion of healthcare costs
  - £10.3 billion of social care of which:
    - £4.5 billion spent on publically-funded social care
    - £5.8 billion spent on privately-funded social care
  - £11.6 billion of ***unpaid*** care
  - £111 million on other dementia costs

- This represents £32,250 person/annum

Dementia and Alzheimer's

- Flow-dependent isometric tension was measured in segments of isolated human intracerebral arteries from consciousness areas: derived from brain surgery.
- The anthocyanin driven vasodilatation may have a beneficial effect on the cognitive functions in dementia of the Alzheimer's type, in the prevention of TIA and stroke
- Flow-dependent relaxation is almost identical to fluvistatin: used to treat hypercholesterolemia and to prevent cardiovascular disease.





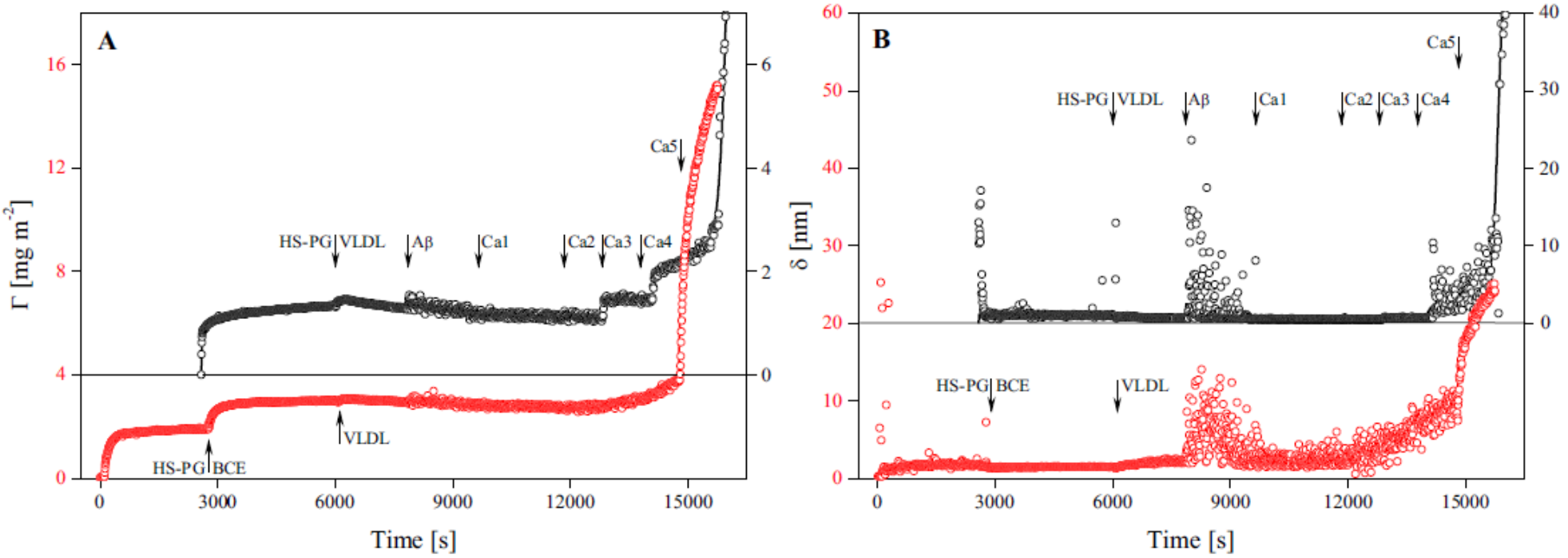
Materials and methods: Flow-dependent isometric tension was measured in segments of isolated human intracerebral arteries from consciousness areas, coming from brain surgery. The blood vessel segments were stretched by 1.5 g pretension. The flow of the blood substitute solution (Krebs) was varied in the steps 3, 5, 20, 40, and 100 mL/min. Krebs solution without and with addition of 0.01% blackcurrant liquid extract (BC ACL-1.5, BerryPharma AG, Leichlingen, Germany) was used as superfusate. **Results:** In the controls (n = 14), the smooth muscle cells of the brain arteries relaxed from 1.416 ± 0.009 g to 1.011 ± 0.033 g ($p < 0.001$) corresponding to 28.6% of their initial tone. Under blackcurrant liquid extract (n = 5), the decrease in wall tension was much more distinct. Vascular tone decreased from 1.454 ± 0.010 g (flow 3 mL/min) to 0.867 ± 0.052 g (flow 100 mL/min) ($p < 0.001$; against the control $p < 0.0354$). This is equivalent to a 40.4% reduction in tension, a 45.2% increase in flow-dependent relaxation, and an estimated 50.7% rise in blood perfusion under blackcurrant. Flow-dependent relaxation is practically the same as measured under fluvastatin (47.8% increase) in human intracerebral arteries of identical vessel provinces [6]. **Conclusion:** These experiments impressively show that blackcurrant extract clearly improves endothelial function. This vasodilatation, detected here for the first time as a novel pleiotropic action of blackcurrant, may have a beneficial effect on the cognitive functions in dementiae of the Alzheimer type, in the prevention of TIA and stroke.

Circulation: Cardiovascular Quality and Outcomes. 2016; 9: A135

Dementia and Alzheimer's

Preincubation with Blackcurrant extract reduces the plaque protein "docking" and plaque formation by ~30%.

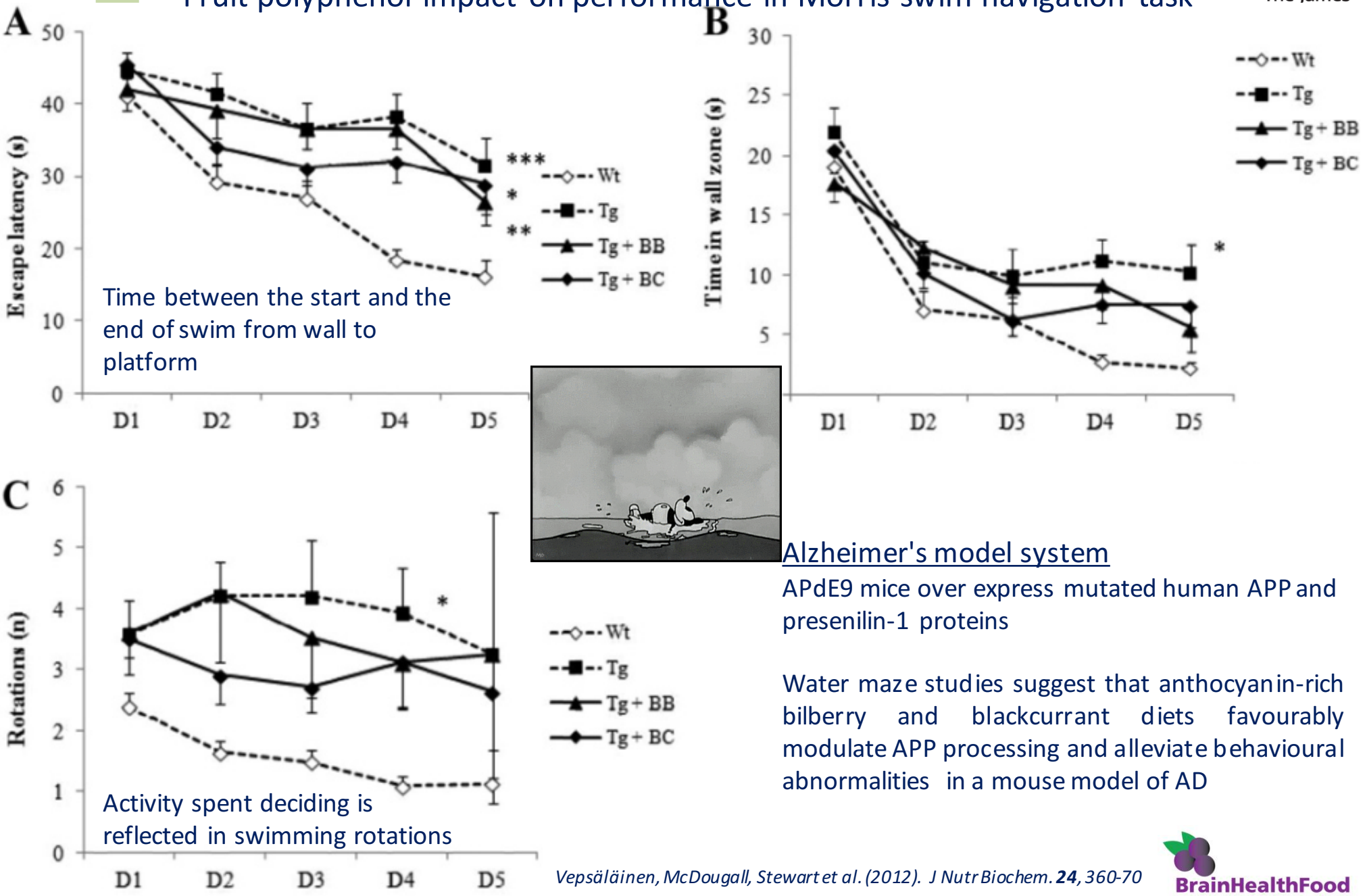
Nanoplaque formation and size upon Aβ-42 addition without and with blackcurrant extract



Circulation: Cardiovascular Quality and Outcomes. 2016; 9: A135

Dementia and Alzheimer's

Fruit polyphenol impact on performance in Morris swim navigation task



Time between the start and the end of swim from wall to platform

Activity spent deciding is reflected in swimming rotations

Alzheimer's model system

APdE9 mice over express mutated human APP and presenilin-1 proteins

Water maze studies suggest that anthocyanin-rich bilberry and blackcurrant diets favourably modulate APP processing and alleviate behavioural abnormalities in a mouse model of AD

Vepsäläinen, McDougall, Stewart et al. (2012). J Nutr Biochem. ***24****, 360-70*

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Erectile Dysfunction

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- Erectile dysfunction (ED) affects 322 million men globally and as well as being distressing at the personal level it is often an early indicator of poor vascular function, a precursor of cardiovascular disease.
- Consequently, changing lifestyle factor to impact on CVD can impact on ED also since its basis is in vascular function.
- The study used the 25,096 men from the Health Professionals Follow-Up Study* and as a 10 year follow up 365.6% reported incidence of ED.
- Statistical analysis revealed that several polyphenols were associated with reduced risk of ED: flavones, flavanones and anthocyanins.
- Analyses suggest that the greatest benefit from an increased intake of flavononones, flavones, and anthocyanins is observed in the younger overweight and obese men

Aedín Cassidy et al (2016) Dietary flavonoid intake and incidence of erectile dysfunction. Am J Clin Nutr. 103(2), 534-41.
The Health Professionals Follow-Up Study (HPFS) is a prospective cohort study that commenced in 1986 with the recruitment of 51,529 middle-aged male dentists, pharmacists, optometrists, osteopath physicians, podiatrists, and veterinarians (aged 40–75 y). Approximately 97% of participants were of white European descent.

Erectile Dysfunction

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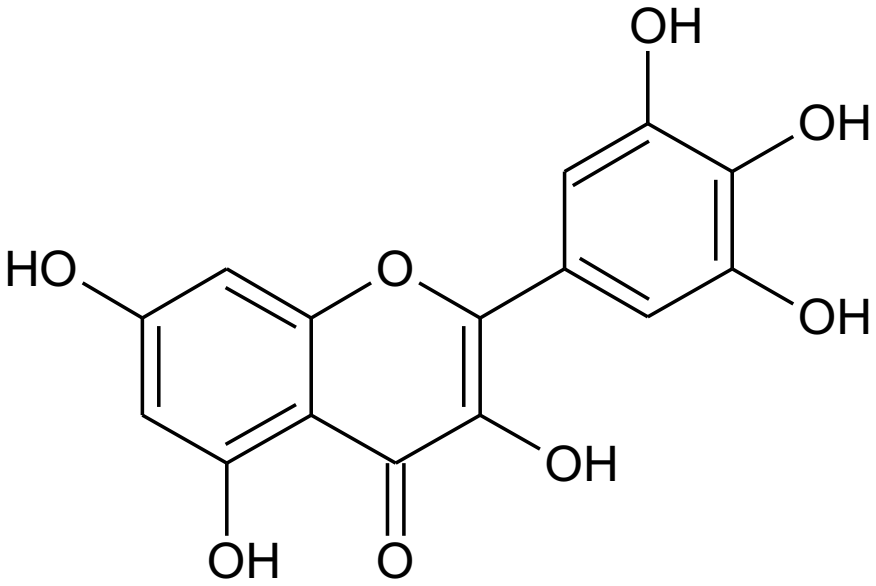
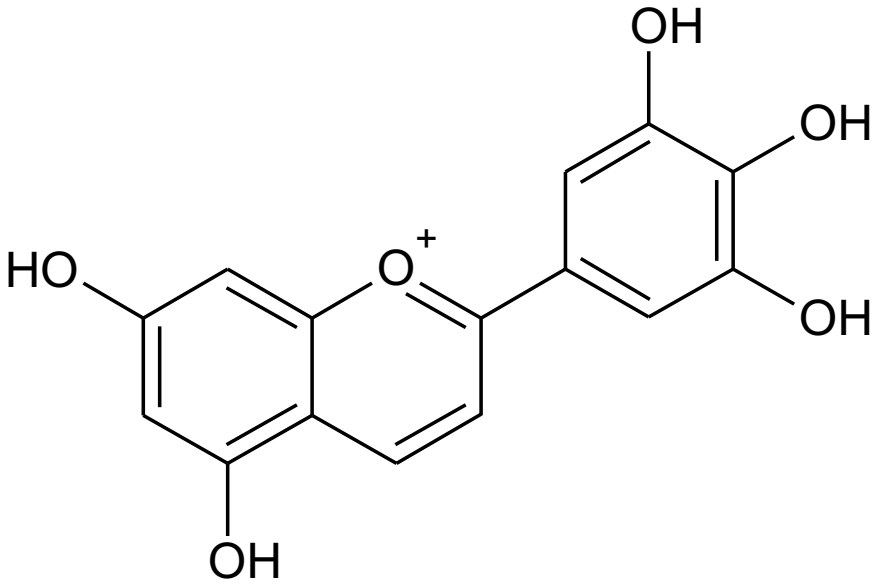
Flavonol - Myricetin



Anthocyanin - Delphinidin



Erectile Dysfunction

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TABLE 3
Associations of anthocyanin, flavanone, and flavone intake with risk of erectile dysfunction across strata of risk factors for participants from the Health Professionals Follow-Up Study[1]

	Q5 vs. Q1								
	Flavones			Flavanones			Anthocyanins		
	RR (95% CI)	*P*-trend	*P*-interaction	RR (95% CI)	*P*-trend	*P*-interaction	RR (95% CI)	*P*-trend	*P*-interaction
Age, y									
<70	0.89 (0.81, 0.98)	0.002	0.002	0.87 (0.79, 0.96)	0.007	0.03	0.84 (0.77, 0.93)	<0.0001	0.007
≥70	1.06 (0.96, 1.16)	0.35		1.01 (0.91, 1.11)	0.99		1.04 (0.94, 1.14)	0.63	
BMI, kg/m^2									
<25	1.06 (0.94, 1.18)	0.82	0.14	1.01 (0.90, 1.13)	0.99	0.009	1.04 (0.92, 1.16)	0.88	0.48
25–29.9	0.84 (0.76, 0.93)	0.004		0.87 (0.79, 0.96)	0.003		0.83 (0.75, 0.92)	0.0007	
≥30	0.78 (0.65, 0.94)	0.005		0.69 (0.57, 0.83)	0.0002		0.89 (0.74, 1.07)	0.08	
Smoking									
Never	0.86 (0.78, 0.95)	0.005	0.26	0.87 (0.79, 0.96)	0.005	0.73	0.90 (0.81, 1.00)	0.03	0.80
Ever	0.94 (0.85, 1.03)	0.70		0.90 (0.82, 1.00)	0.04		0.91 (0.82, 1.00)	0.01	
Physical activity									
Q1 and Q2	0.94 (0.85, 1.05)	0.20	0.84	0.92 (0.83, 1.03)	0.04	0.55	0.95 (0.85, 1.06)	0.14	0.78
Q3	0.89 (0.80, 1.00)	0.07		0.86 (0.77, 0.96)	0.01		0.89 (0.80, 1.01)	0.03	
Q4 and Q5	0.92 (0.78, 1.08)	0.23		0.93 (0.80, 1.09)	0.68		0.88 (0.75, 1.04)	0.21	
Prevalent hypertension									
No	0.97 (0.90, 1.05)	0.28	0.72	0.94 (0.87, 1.01)	0.06	0.86	0.93 (0.87, 1.01)	0.04	0.80
Yes	0.92 (0.79, 1.07)	0.14		0.91 (0.79, 1.06)	0.25		0.92 (0.79, 1.06)	0.19	
Statin use									
No	0.90 (0.83, 0.98)	0.02	0.71	0.89 (0.82, 0.96)	0.002	0.79	0.92 (0.84, 1.00)	0.01	0.78
Yes	0.90 (0.79, 1.03)	0.13		0.89 (0.78, 1.01)	0.09		0.91 (0.79, 1.04)	0.12	

[1]Multivariate model adjusted for age, physical activity, smoking, BMI, alcohol, energy, marital status, use of multivitamins, history of cardiovascular disease, history of hypercholesterolemia, history of hypertension, and history of diabetes. Q, quintile.

Aedín Cassidy et al (2016) Dietary flavonoid intake and incidence of erectile dysfunction. Am J Clin Nutr. 103(2), 534-41.
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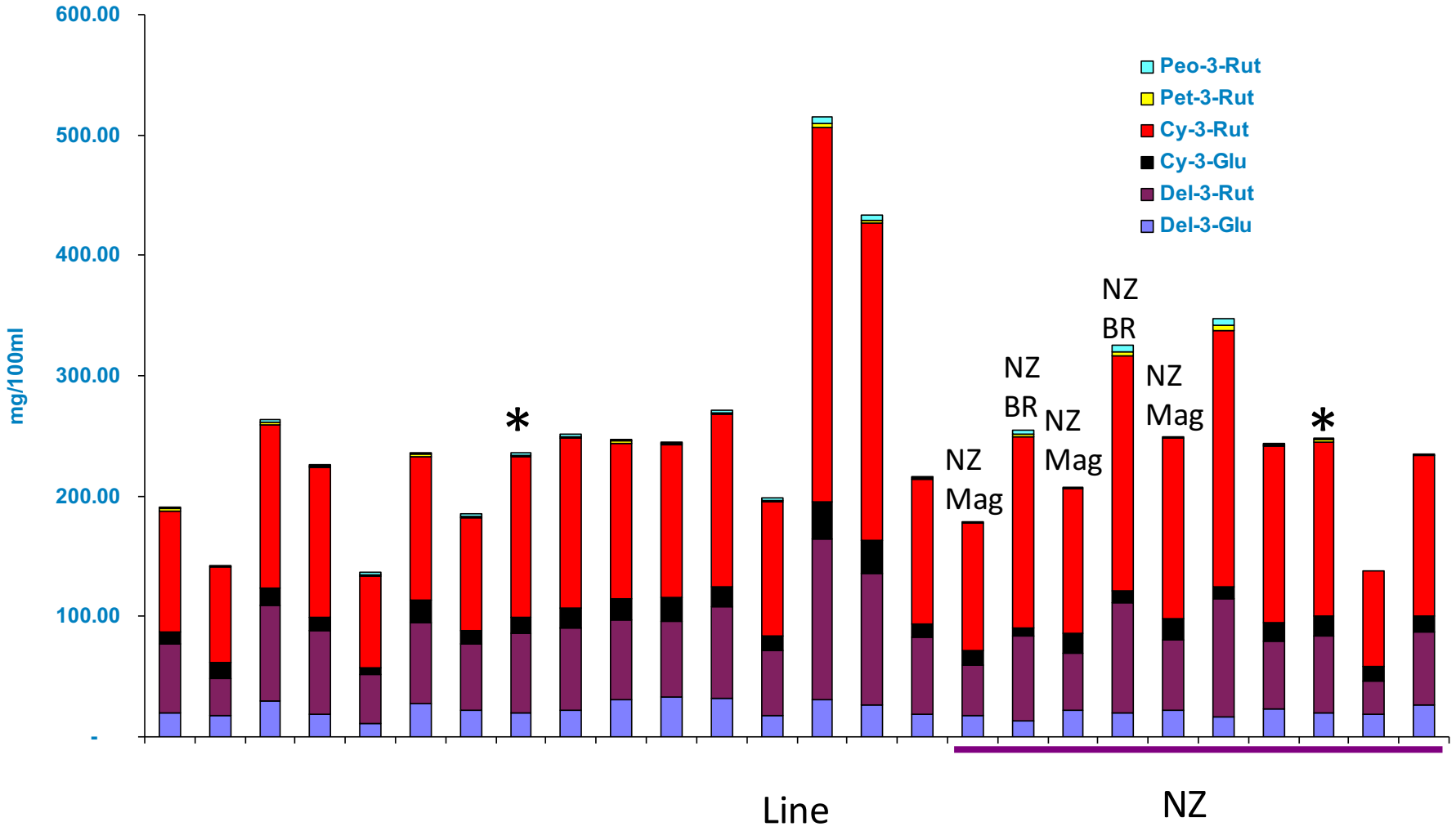
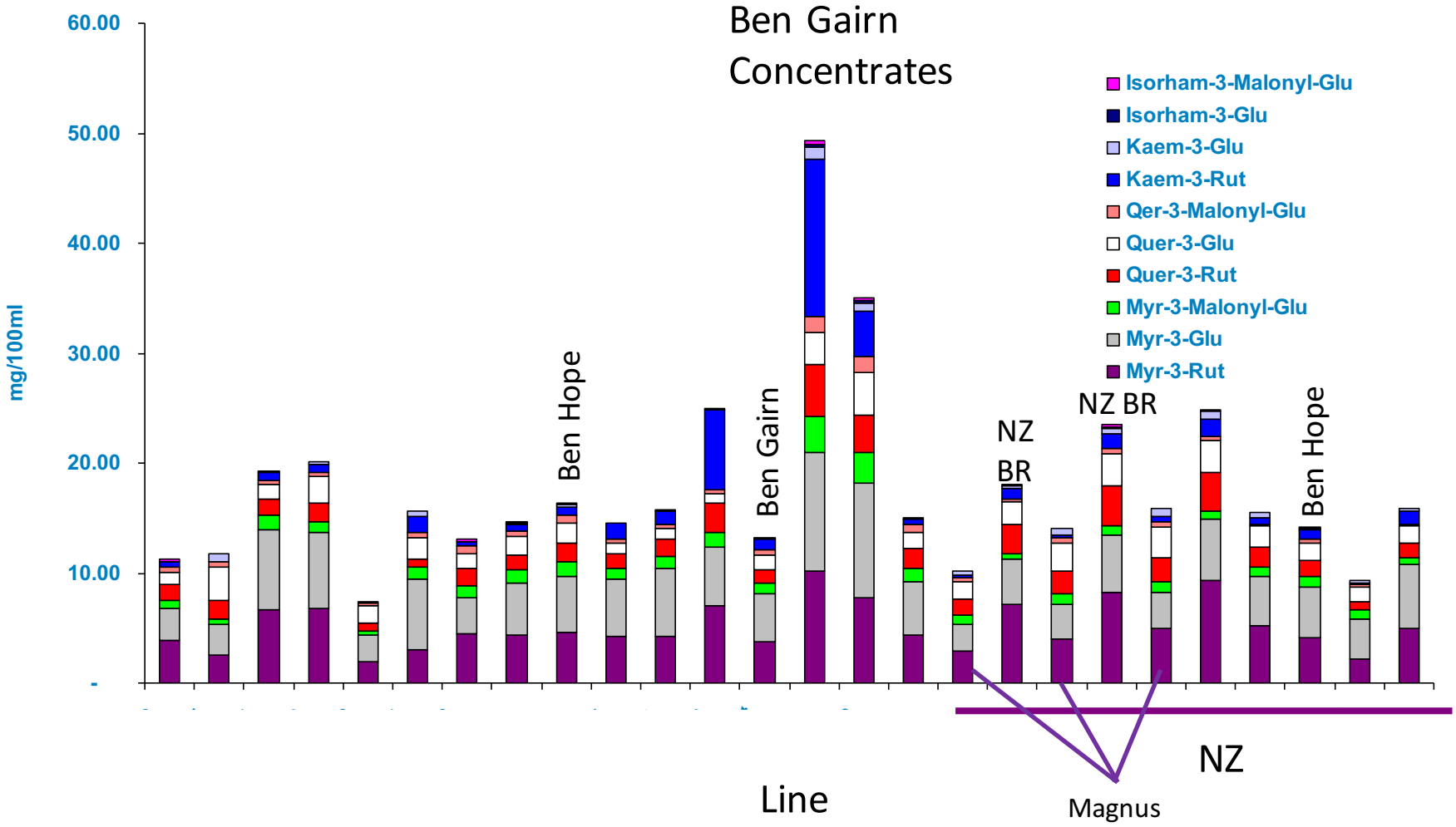
Anthocyanin contents and composition



Flavonol contents and composition



JHI Fruit Translational Pipeline: Rubus & Ribes

JHI has bred 95% of all blackcurrant varieties used in UK and 75% in global use.

Genomes
Rubus & Ribes
Watch this space…

• Markers

Yield, Pathogen resistance/tolerance
Taste, Colour, Texture, Nutrition etc.

Breeding → **Phenotyping Genotyping** → **Varietal Selection** → **Variety**

Fresh

• Firmness
• Decay

U S P

• Soil
• Water
• Inputs
• Reduced Biocides
• Under cover
• Organic/Conv.

Environment

• Reduced processing energy,
• Vit C level
• Aroma & Taste
• Bioactives

Processing

LUCOZADE RIBENA SUNTORY

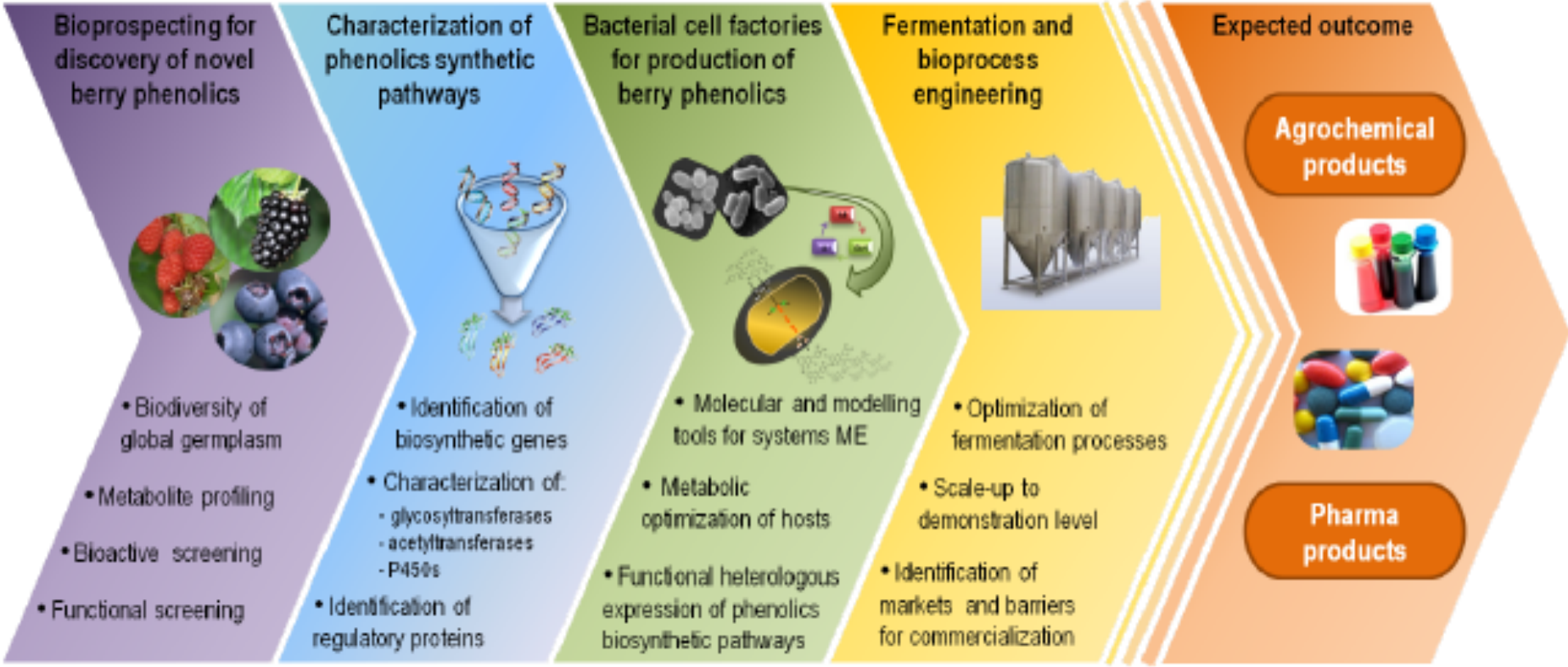
Winterwood ……growing together

angus SOFT FRUITS

Ben Gairn

Ben Tirran

BACterial Hosts for production of Bioactive phenolics from BERRY fruits: BacHBerry. EU FP7 http://www.bachberry.eu/



Thanks go to

The James Hutton Institute

IBA International Blackcurrant Association

BacHBERRY

UNIVERSITY of ULSTER

ITQB UNIVERSIDADE NOVA DE LISBOA

The Blackcurrant Foundation

BrainHealthFood

University of the Highlands and Islands
Oilthigh na Gàidhealtachd agus nan Eilean

The Scottish Government

Future-proofing berryfruit
CLIMAFRUIT

NIBIO
NORSK INSTITUTT FOR BIOØKONOMI

EUBerry

LUCOZADE RIBENA SUNTORY

UNIVERSITY OF EASTERN FINLAND

AARHUS UNIVERSITY