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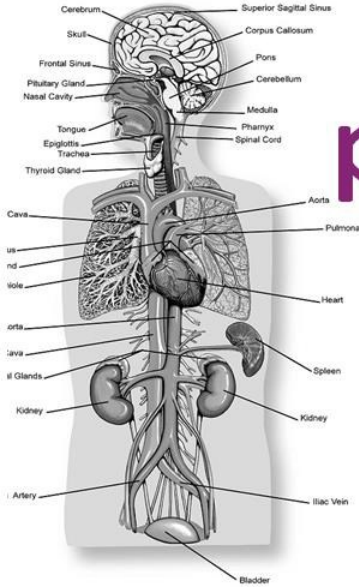
Beneficial effects of berry polyphenols in the gut: Food digestion and colon cancer



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7th World Congress on Polyphenols Applications
Bonn, *6th June 2013*

April 2011
MLURI and SCRI join forces to become
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The James Hutton Institute, Dundee

Dundee

Long-established breeding program for berries

JHI

Berry research at JHI

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We breed market-leading varieties

- *Blackcurrants – the "Ben" series*
- *Raspberries – the "Glen" series*
- *Blackberries – the "Loch" series*
- *Strawberries – "Symphony, Rhapsody…."*
- Research into Health Benefits of Berries
- Feedback to direct breeding of new varieties

Outline of talk

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Berry polyphenols and the gut

- MODEL *IN VITRO* SYSTEMS
- Polyphenol-enriched extracts
- Effects relevant to

- **Diabetes & Obesity**
- **Colon cancer**

Underlying thread of understanding bioavailability

Correlate bioactivities with polyphenol composition using LC-MS techniques

How can polyphenols affect human health?

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Antioxidant theory? Low serum bioavailability!

Majority of polyphenols remain in gut

Are these components inactive?

Possible roles

Modulating colonic microbiota?

In-gut antioxidants?

Benefit gut epithelia function / ***colon cancer***

Modulate digestive processes

Control of nutrient availability

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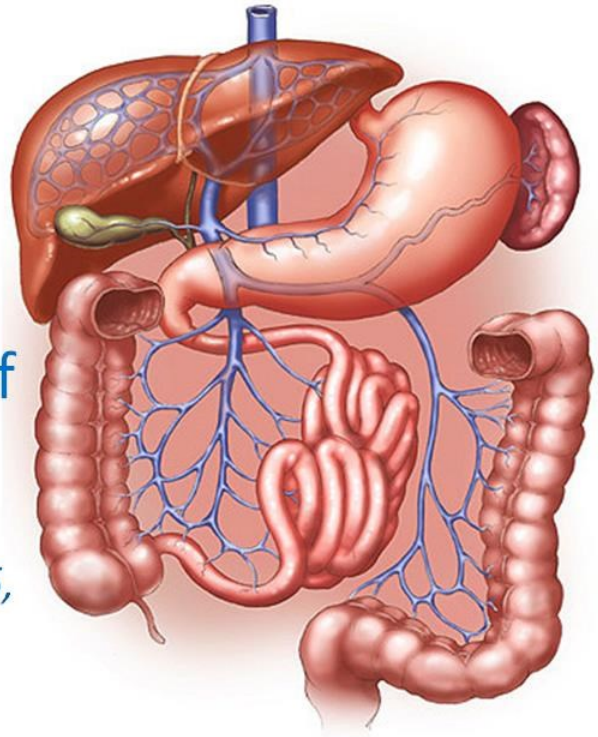
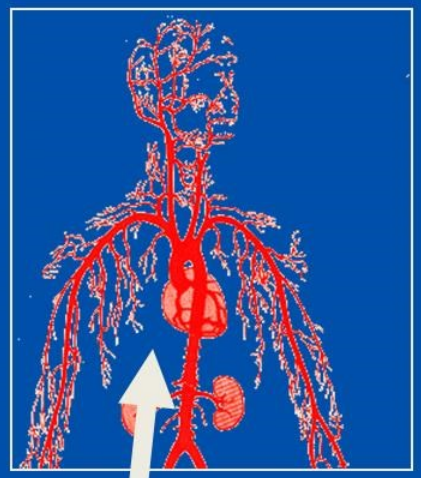
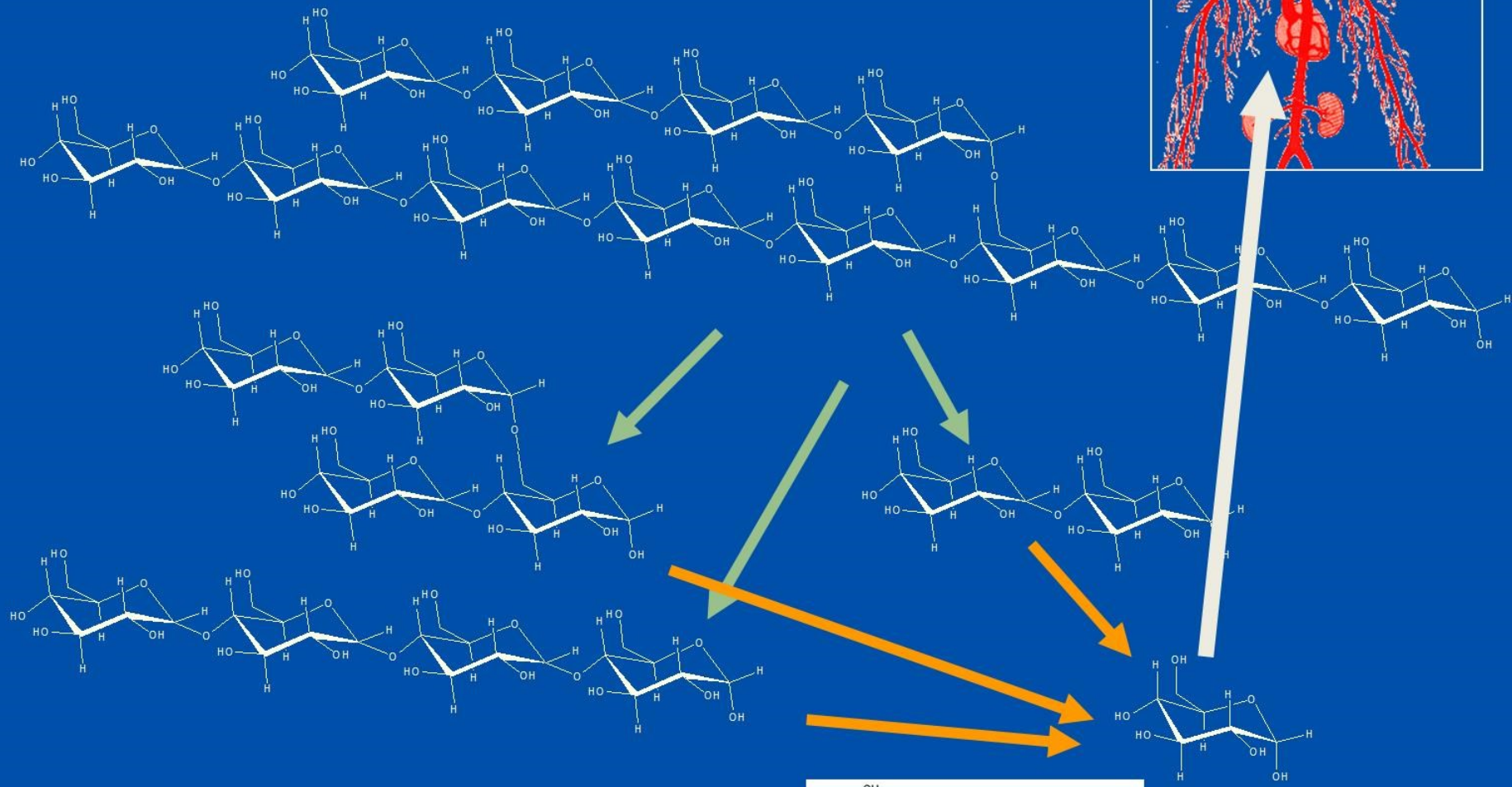
- Polyphenols can inhibit digestive processes and slow or modulate nutrient release from food



- Inhibition of lipid digestion – control of hyperlipidemia, CVD, diabetes and obesity (McDougall et al. (2009) *Food Chemistry 115, 93–9)*
- **Inhibition of starch digestion – blood glucose control and type 2 diabetes**

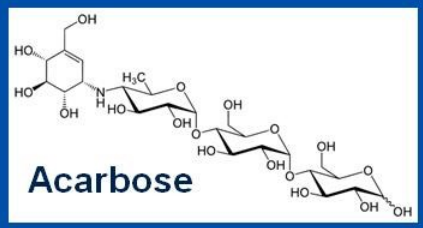
Inhibition of starch digestion



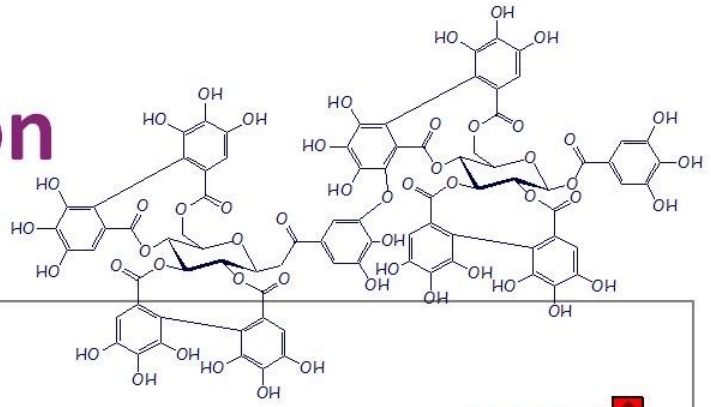


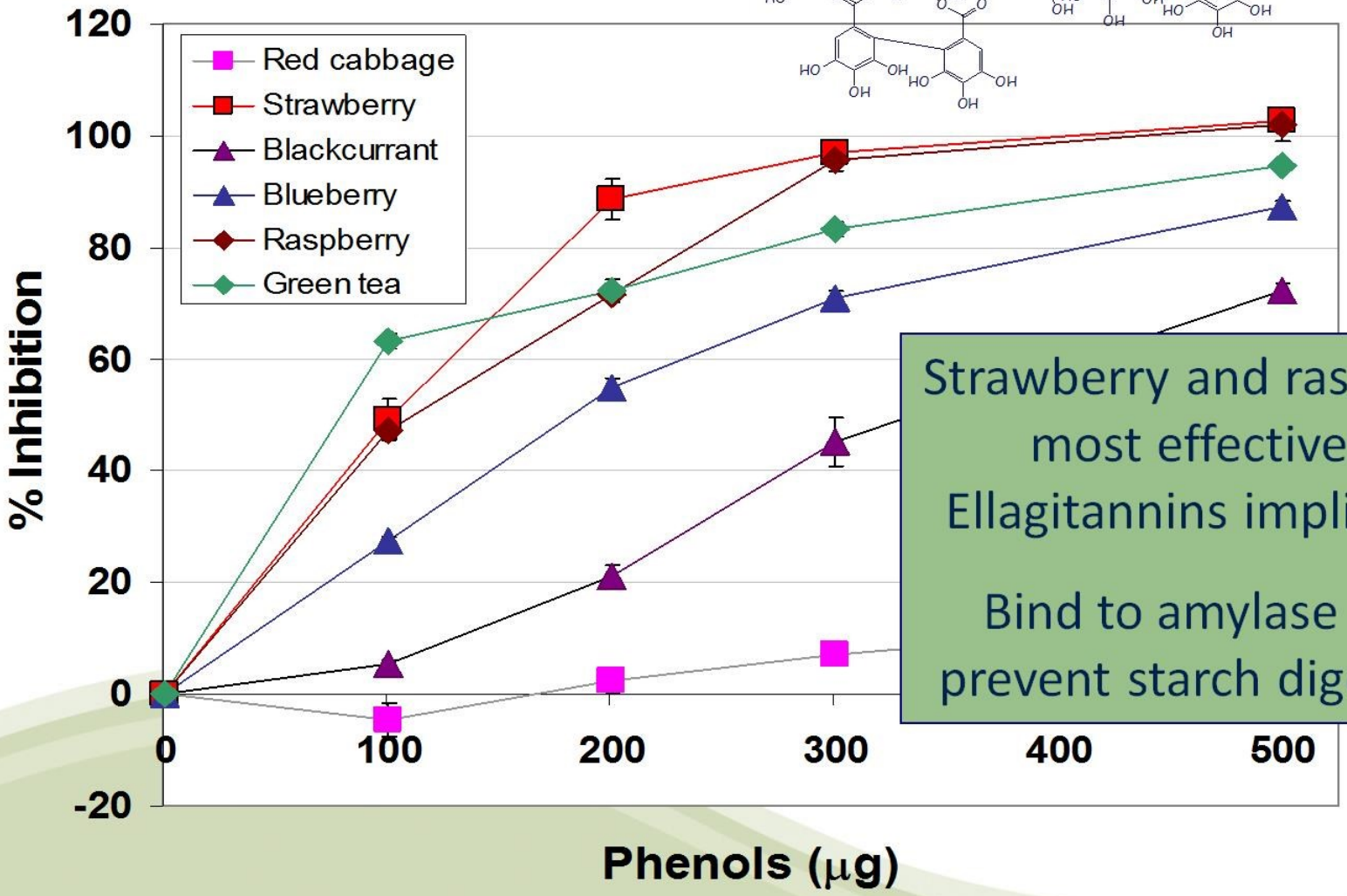
Amylase chops into fragments

Glucosidase nibbles off glucose



α-amylase inhibition



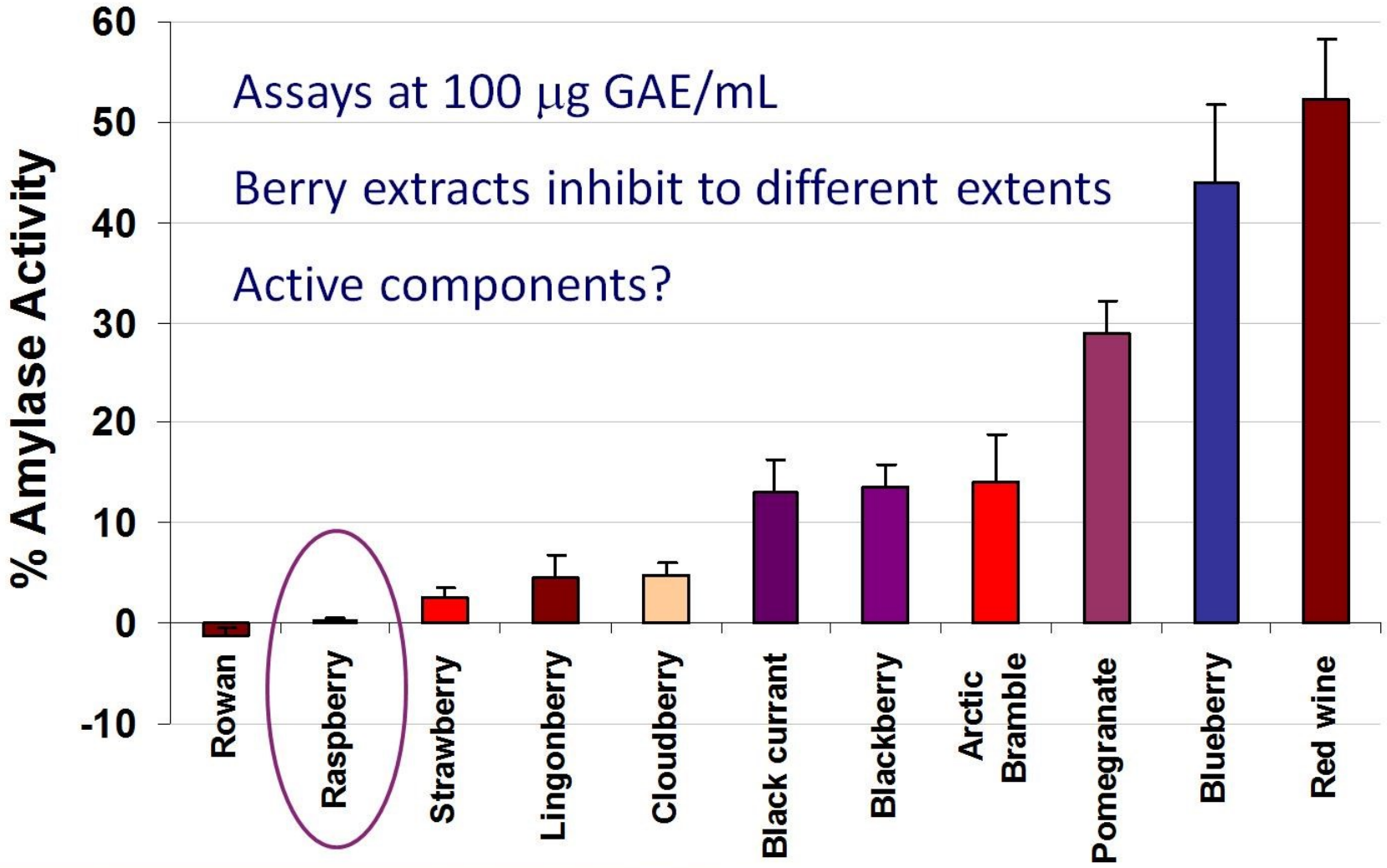


Strawberry and raspberry most effective – Ellagitannins implicated

Bind to amylase and prevent starch digestion

McDougall et al. (2005) *J. Agric. Food Chem. 53, 2760-6*

α-amylase inhibition



Grussu et al. (2010) *J. Agric. Food Chem. 53, 2760-6*

Yellow vs Red Raspberries

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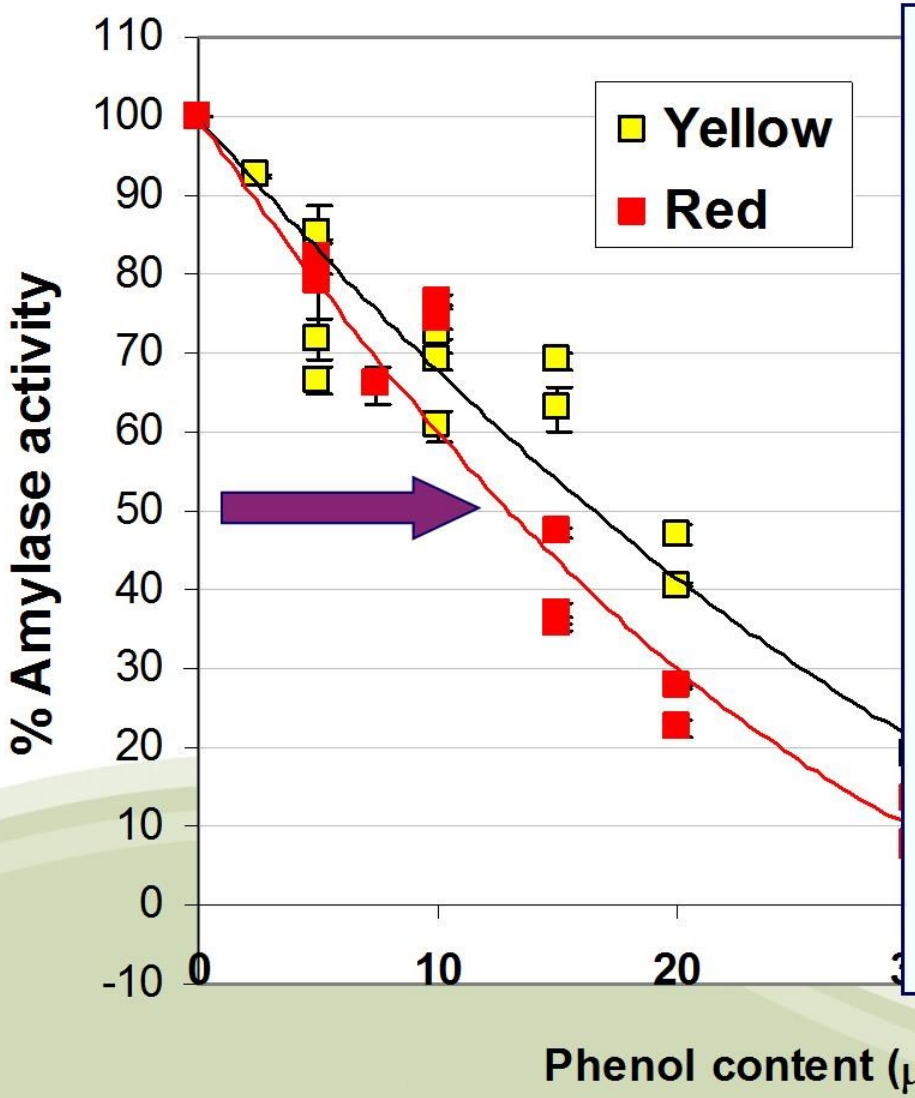
Re-examine inhibition by raspberry by comparing extracts of red raspberry (*Glen Ample*) with yellow raspberry (*selection 97134B1*)

These have similar polyphenol profiles but yellow raspberries effectively lack anthocyanins

α-amylase inhibition



Yellow and red raspberry extracts are equally effective

This supports ellagitannins as active ingredients and suggests that anthocyanins are less important

However, ellagitannins are *proportionally increased* in yellow raspberry extracts

Possible interplay/protection from other polyphenols

Seaweed polyphenols also effective amylase inhibitors

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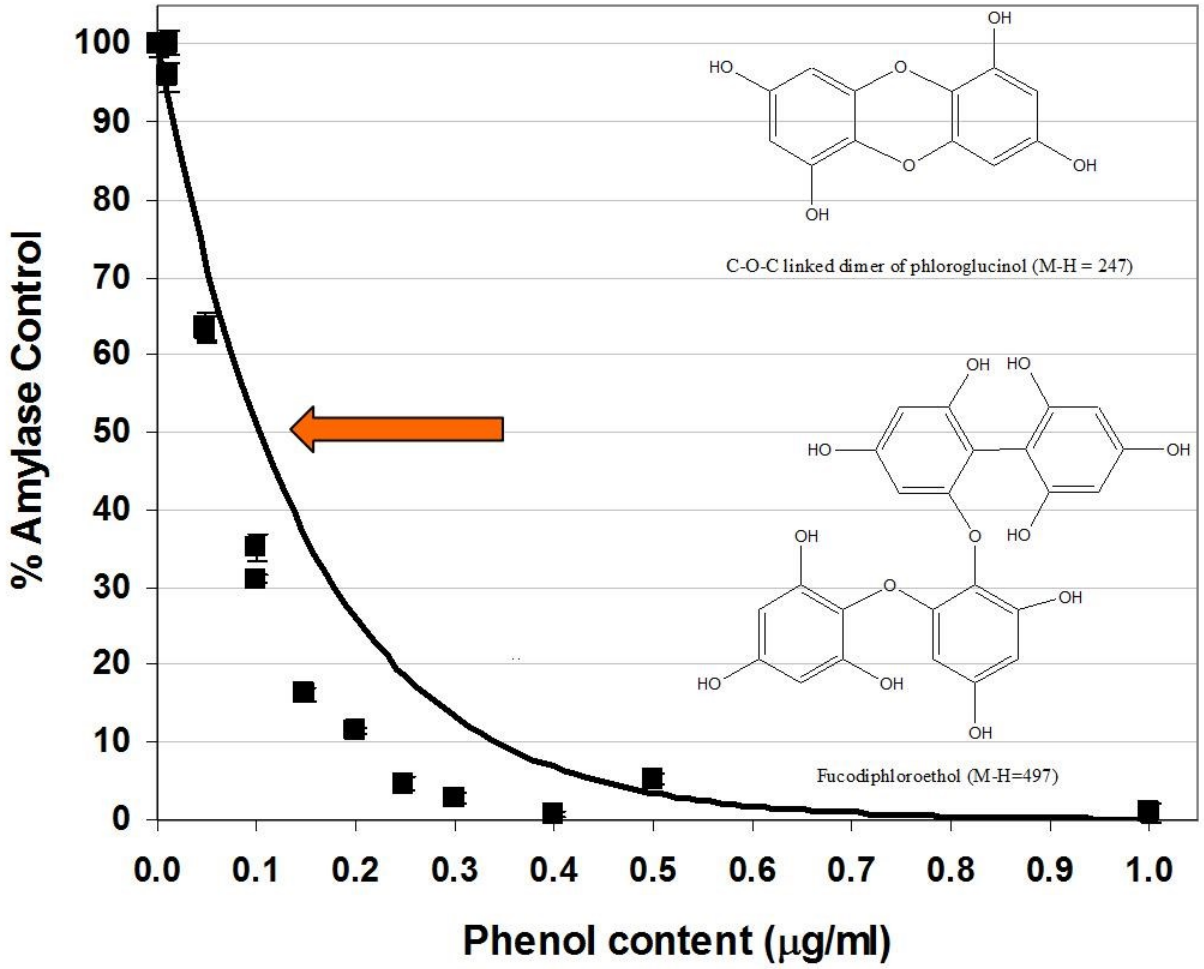
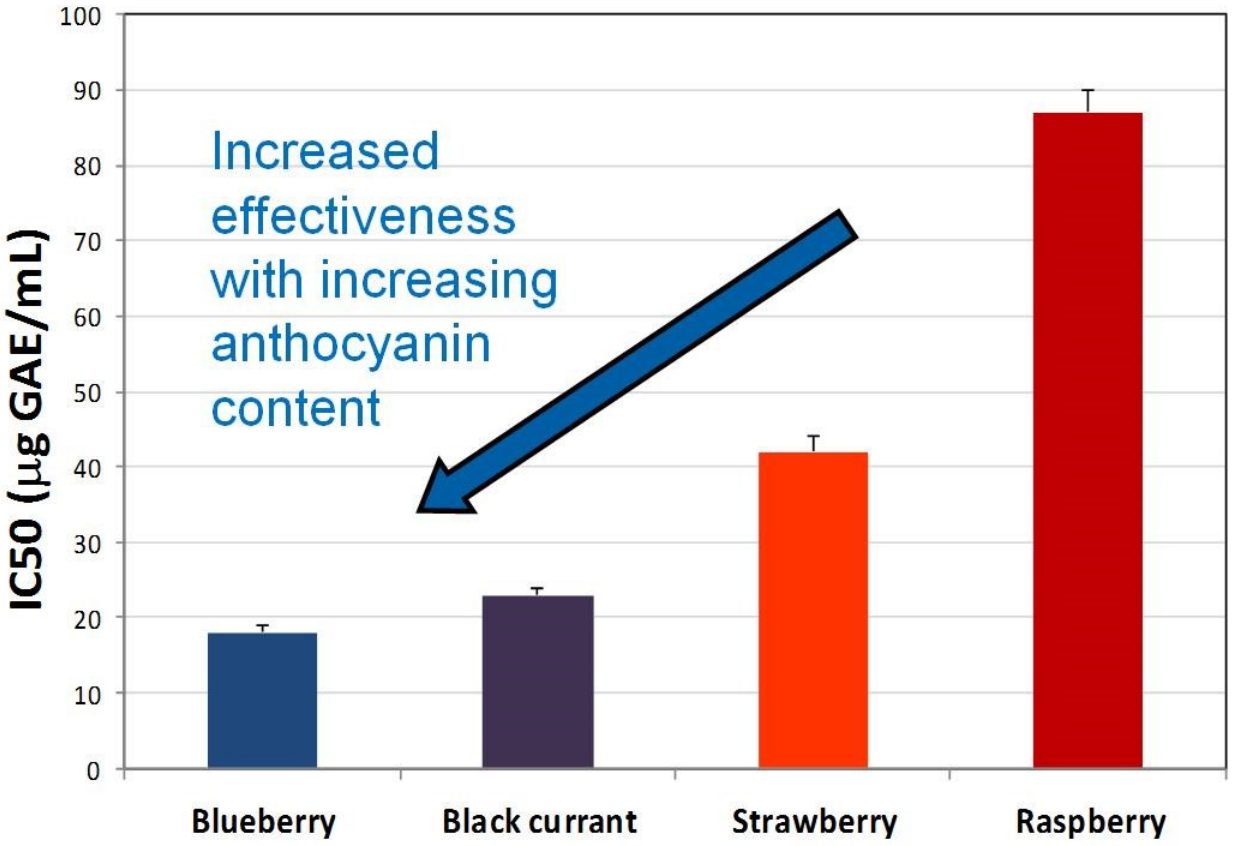


Phlorotannin-rich fractions from *Ascophyllum nodosum* are **very** effective amylase inhibitors

(IC_{50} ~ 0.1 μg/mL)

Nwosu et al. (2011) *Food Chem. 126, 1006–12*

α-glucosidase inhibition



Different berries inhibit to different extents

Anthocyanins implicated?

McDougall et al. (2005) *J. Agric. Food Chem. 53, 2760-6*

Whitson et al. (2010) *Funct. Plant Sci. & Biotech. 4, 34-8*

Inhibition by black currant

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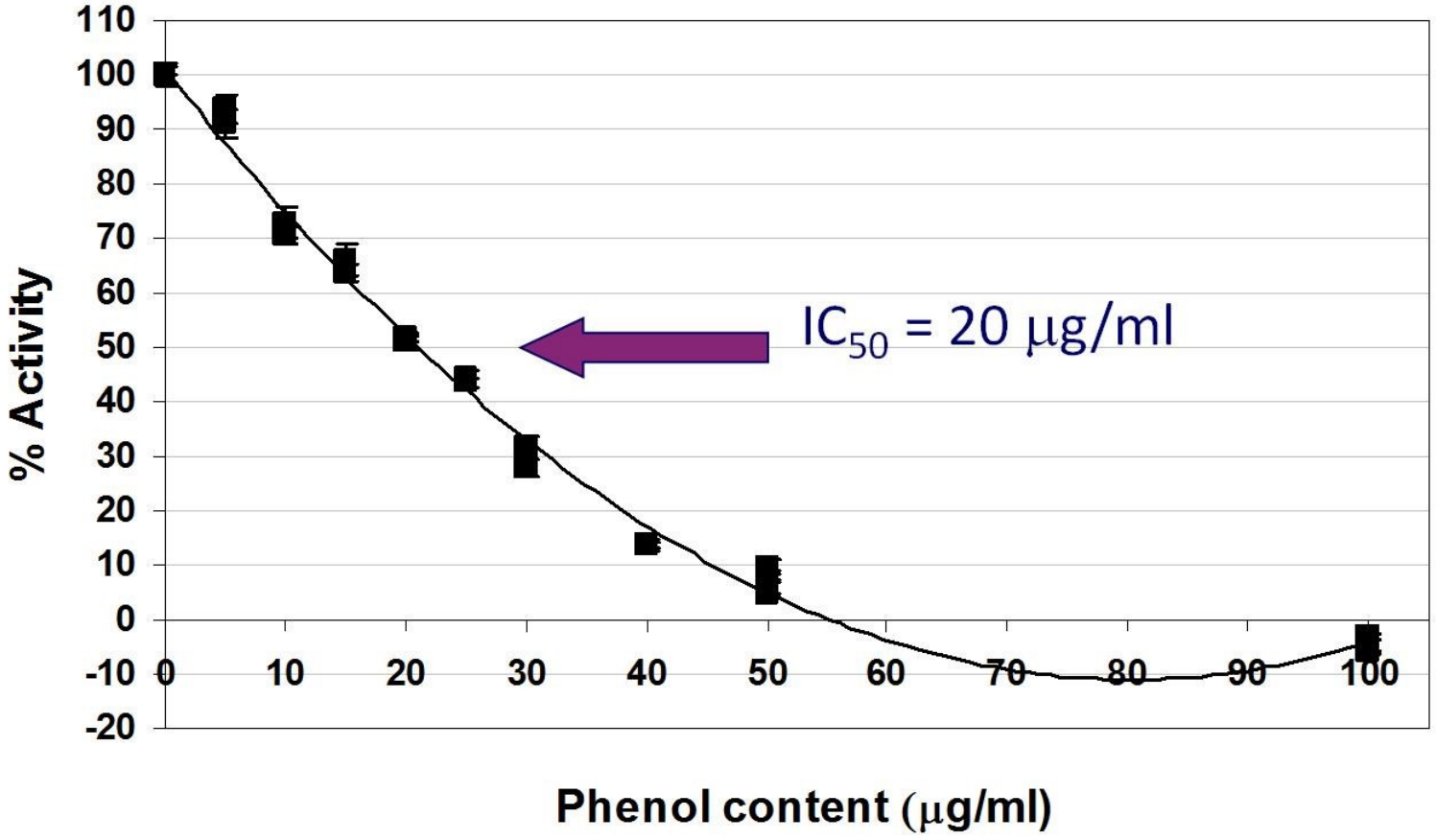

Boath et al. (2012) *Food Chem.* 135, 929-936

Inhibition by rowanberry

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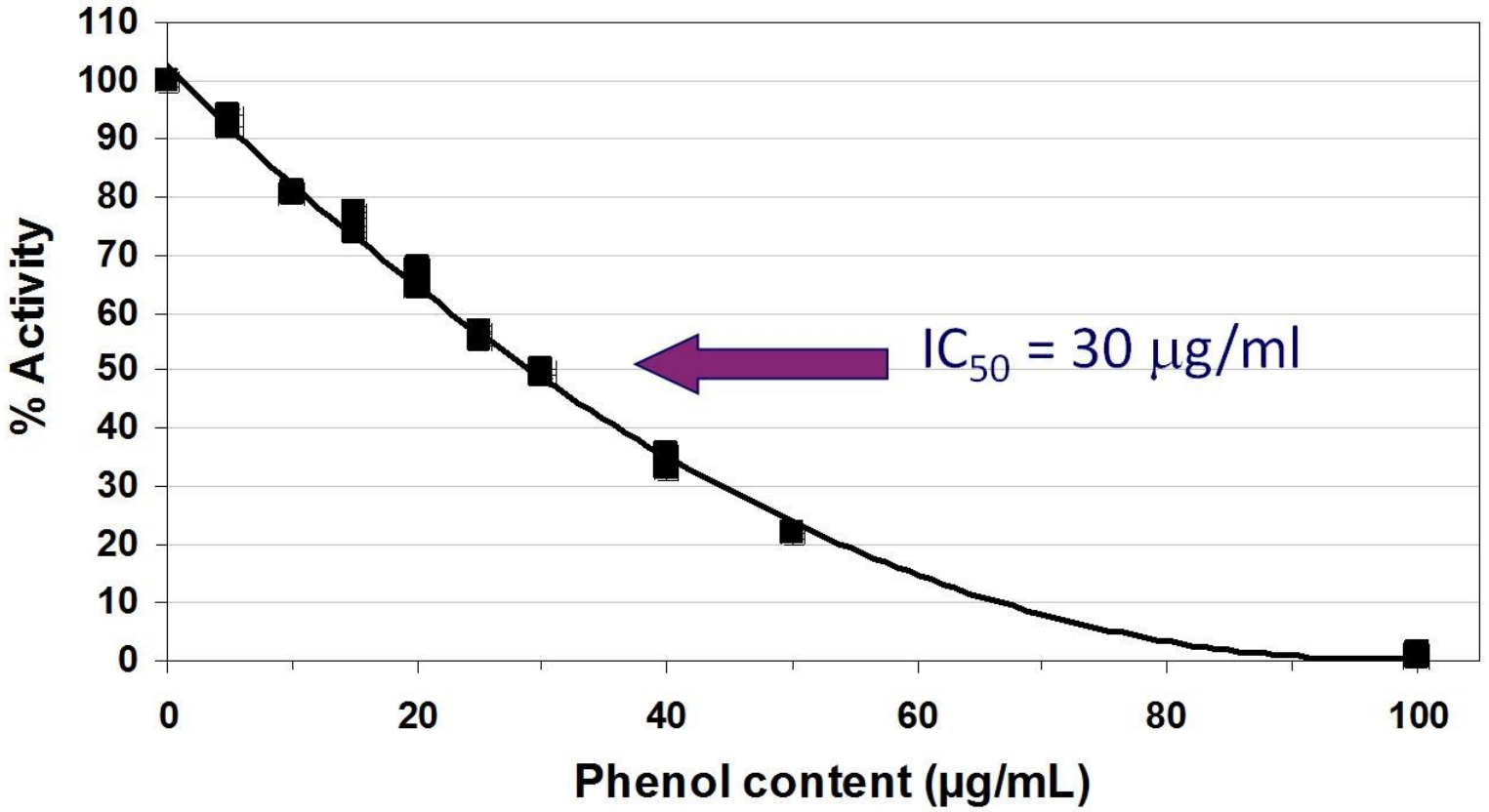
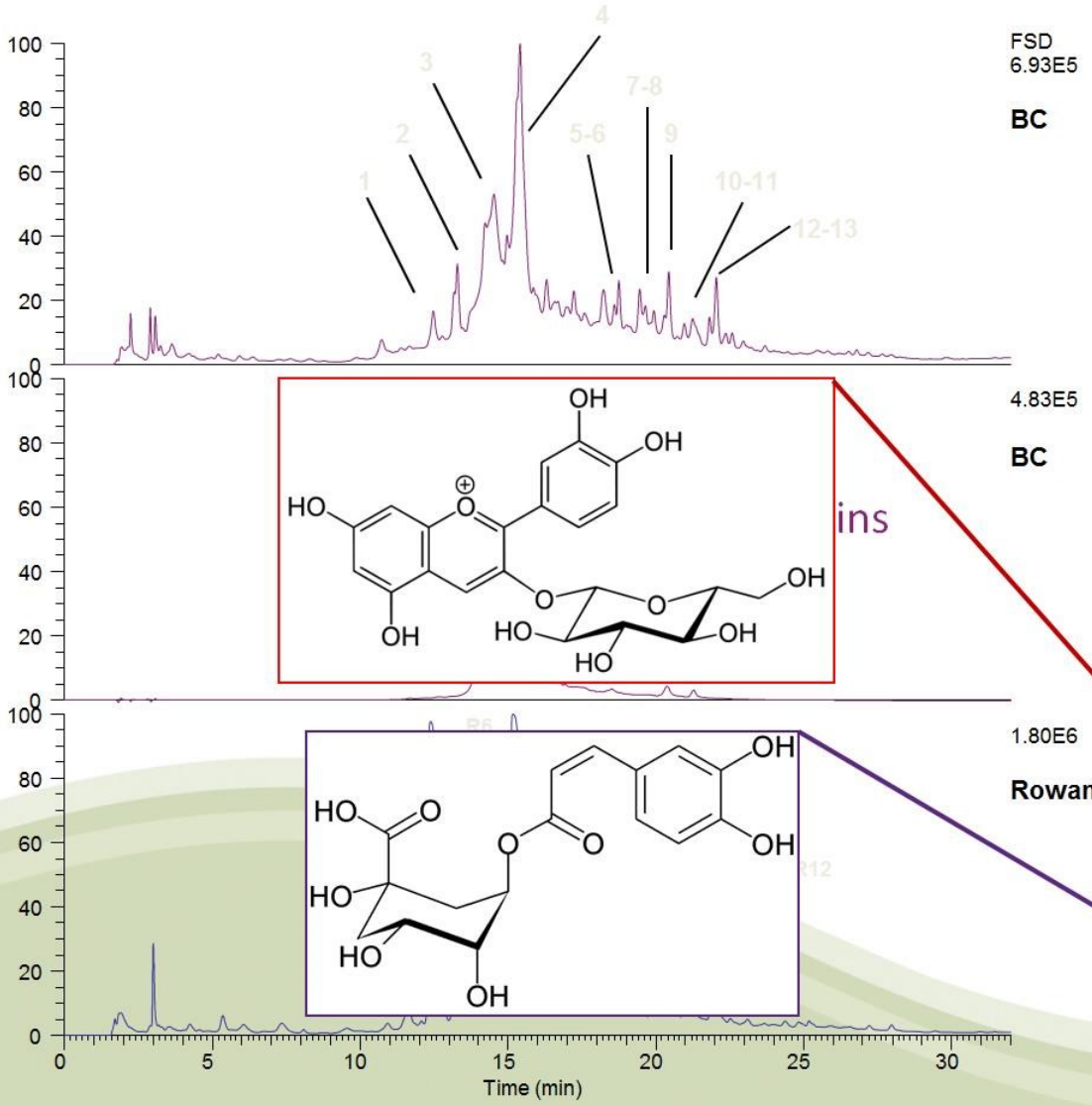


Active Polyphenol Components?

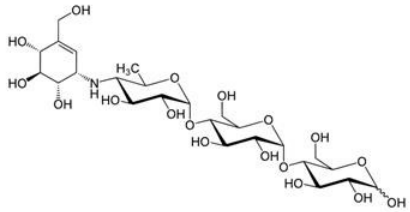


Black currant and rowanberry extracts differ greatly in their composition but both are effective inhibitors

Black currant is rich in **anthocyanins**

Rowan is rich in **chlorogenic acids**

Co-incubation with acarbose



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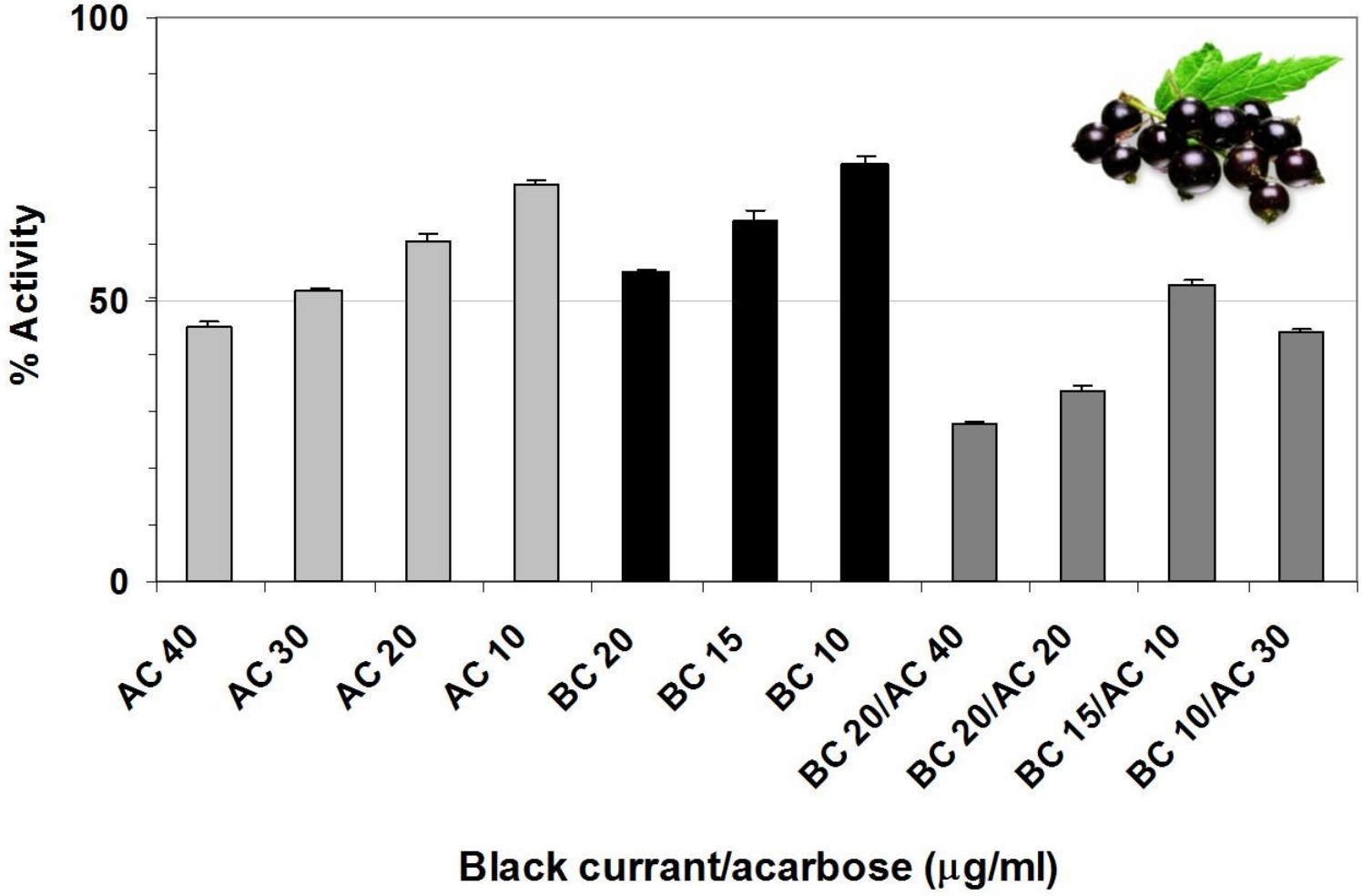
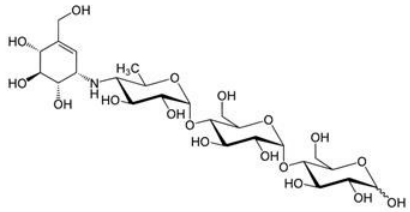


Co-incubation with acarbose



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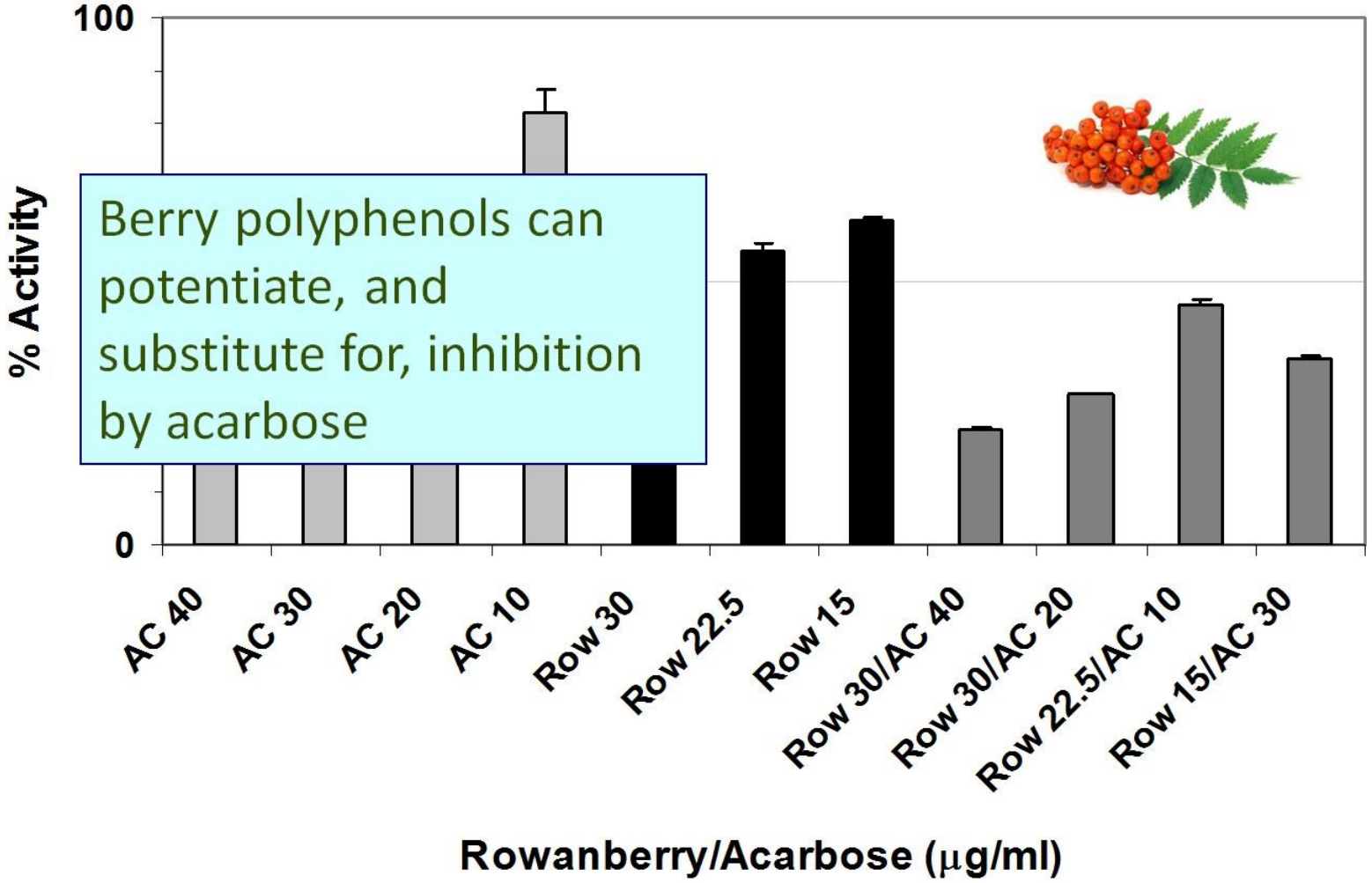
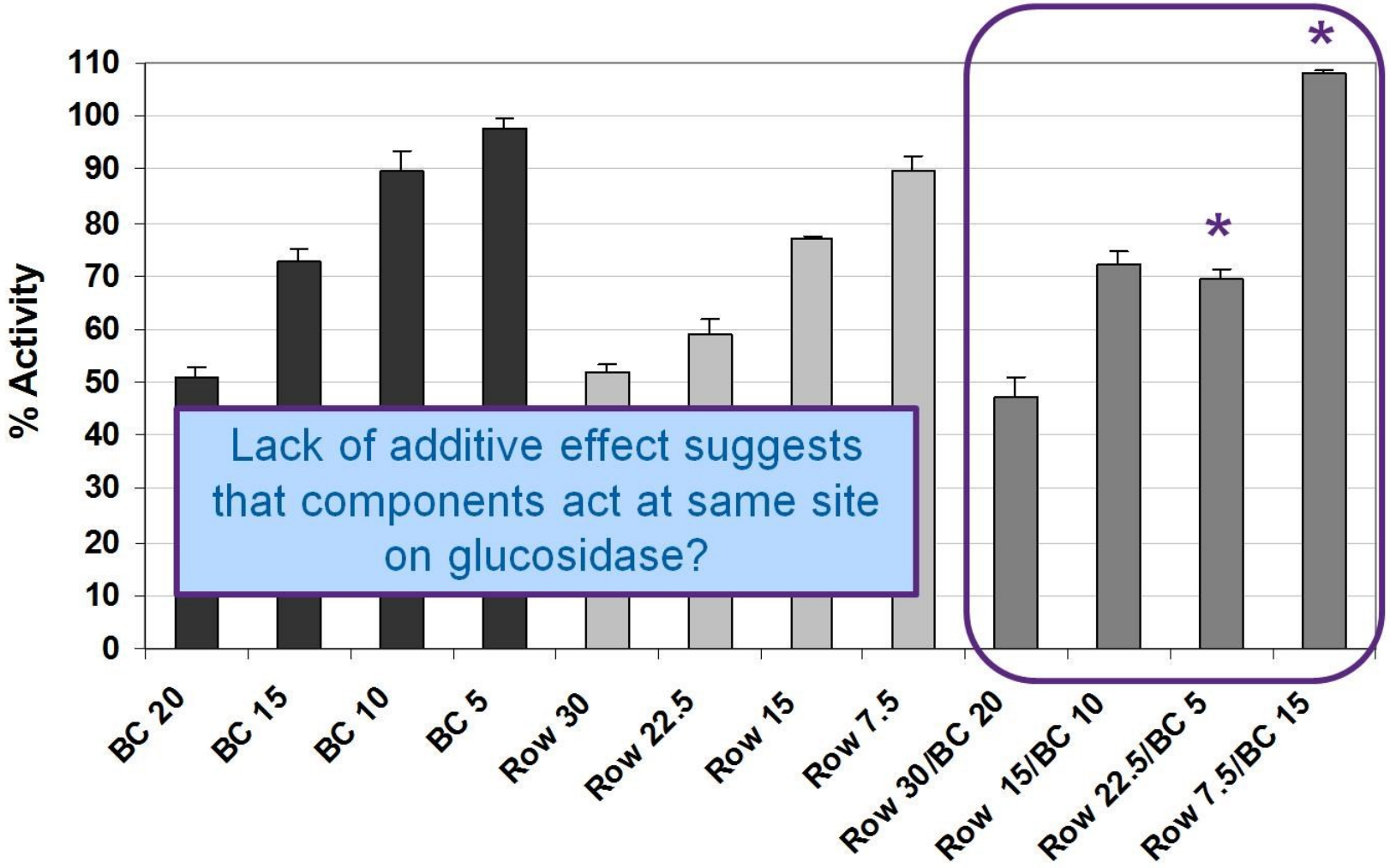
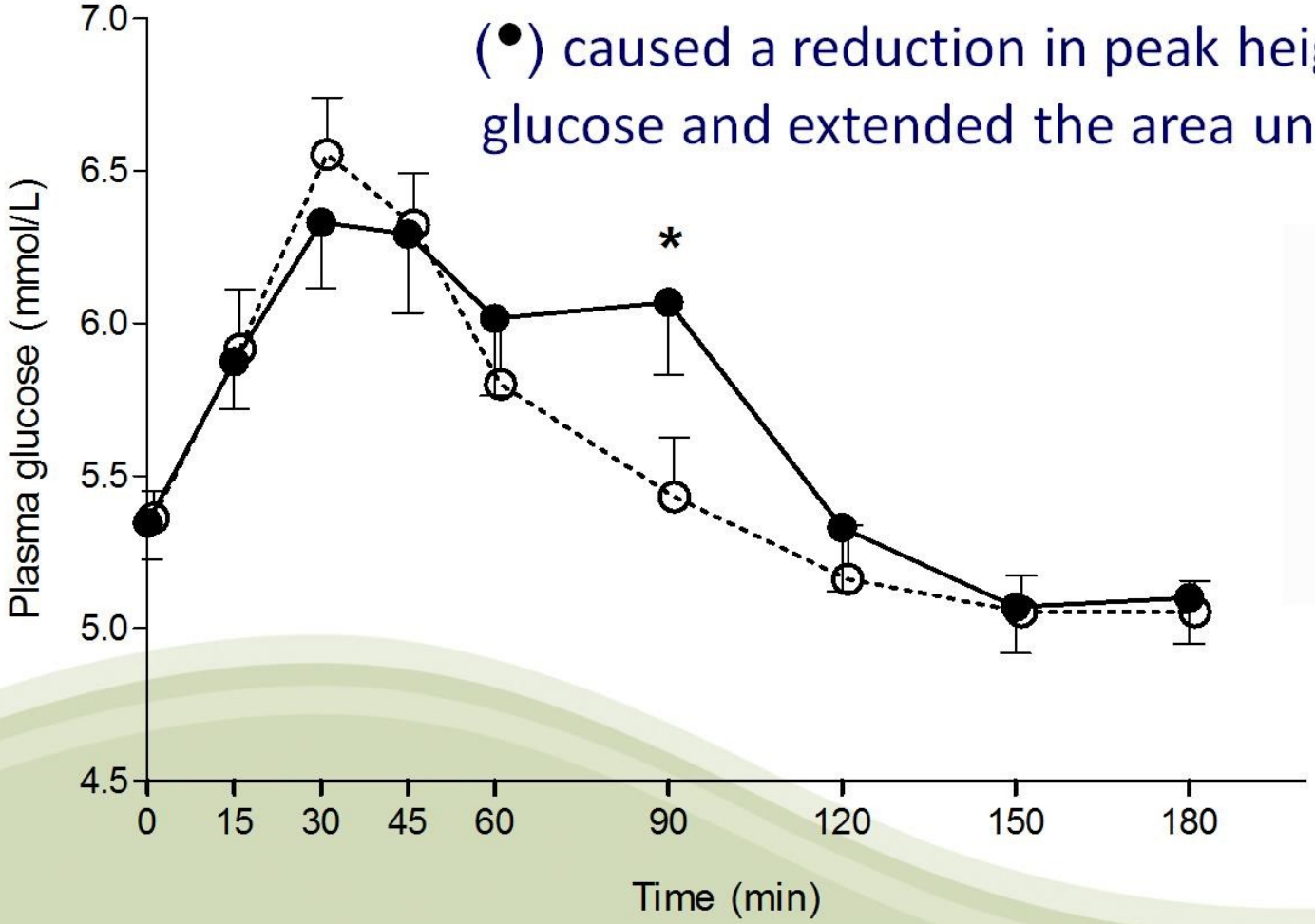


Mixing of berry extracts?



Human trial – modified glycemic response

Patients given sucrose-loaded black currant (BC) juice and BC juice supplemented with crowberry juice. The BC + juice (●) caused a reduction in peak height of plasma glucose and extended the area under the curve



UNIVERSITY OF EASTERN FINLAND

Törrönen et al. (2012) *J. Functional Foods.* 4, 746-756.

Summary

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- Berry polyphenols can inhibit the main enzymes involved in starch digestion
- The inhibition occurs at concentrations easily reached in the gut
- The active polyphenols are not fully defined but different components in the same berry can inhibit different enzymes = potential synergistic effects on digestion
- Berry polyphenols can potentiate inhibition by acarbose
- Initial human studies show promise

Berry polyphenols & colon cancer

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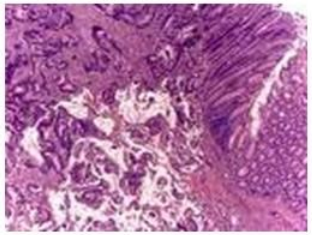
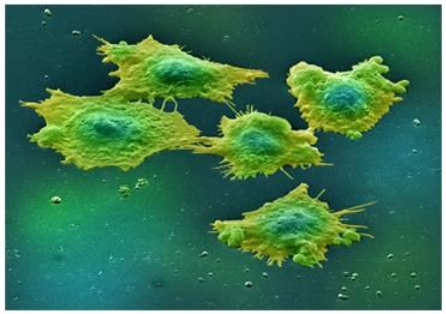


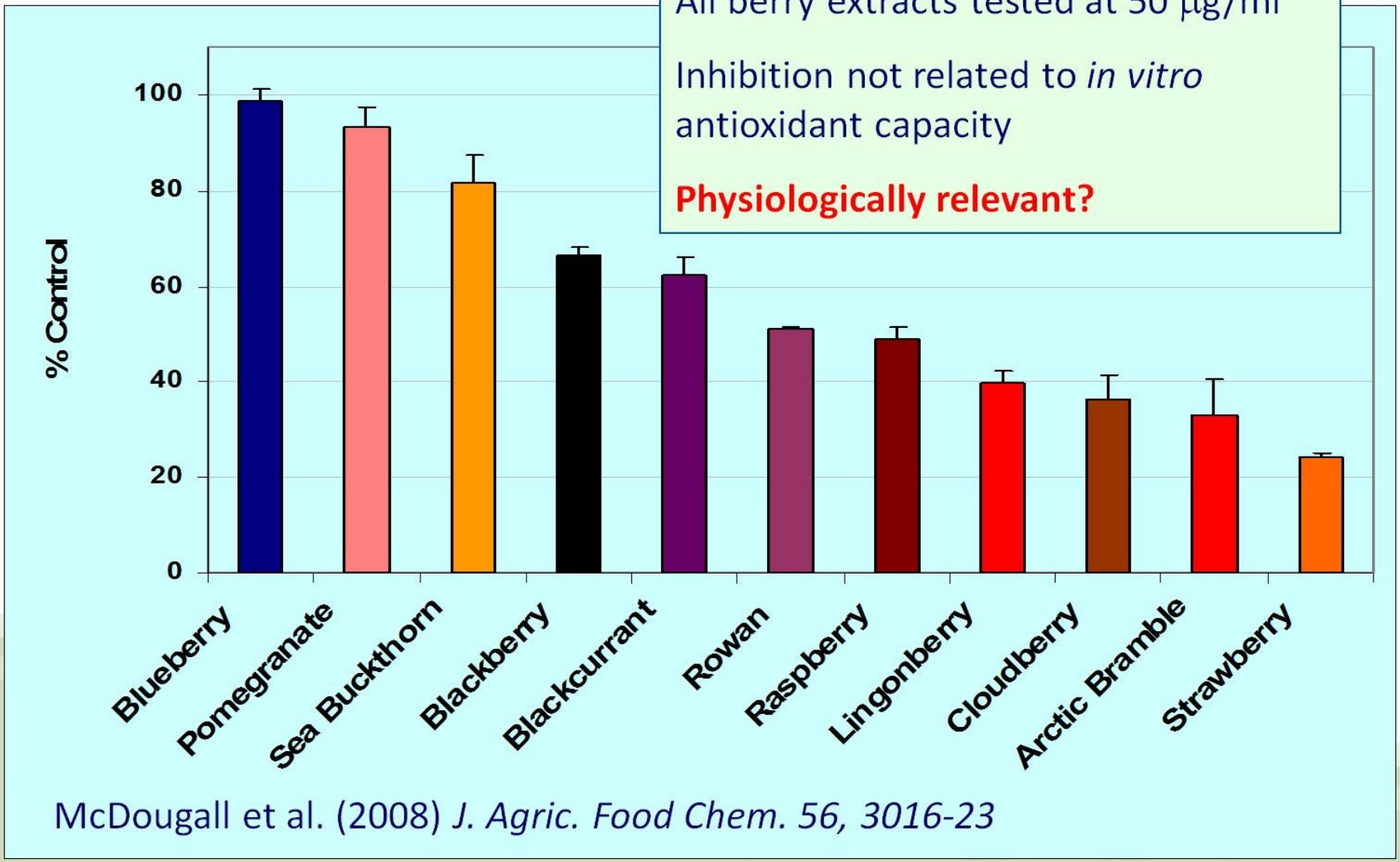


Emma Brown and Dr Chris Gill, School of Biomedical Sciences, University of Ulster, Coleraine

Professor Ian Rowland, University of Reading

Professor Alan Crozier, University of Glasgow

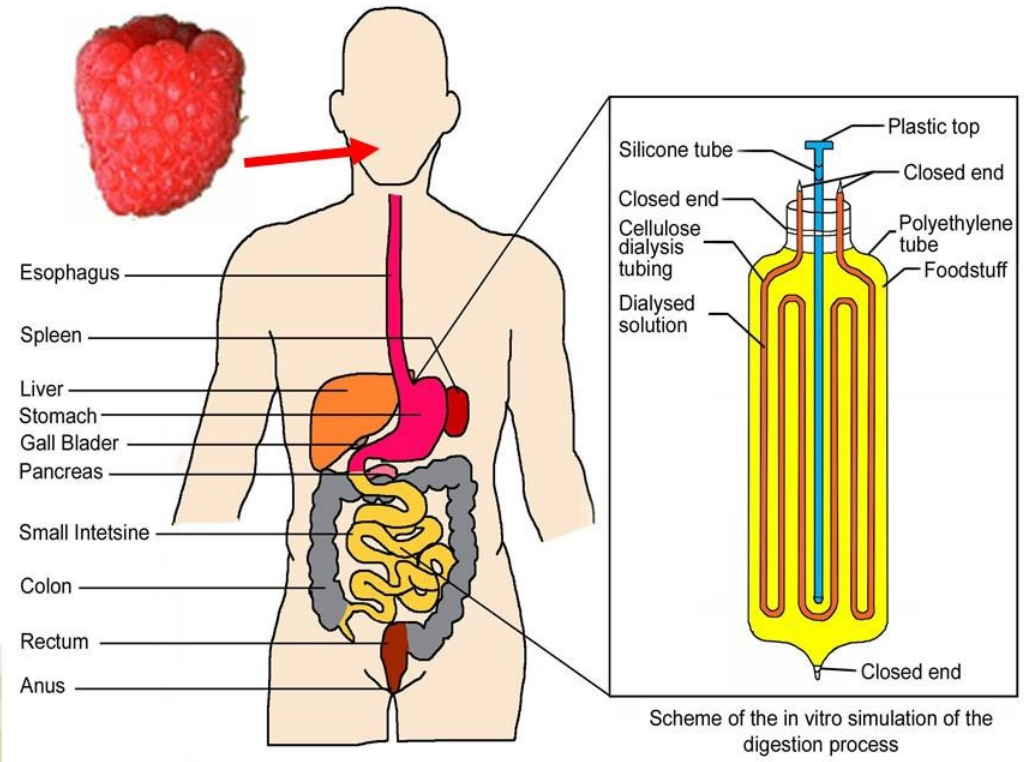
Effects on colon cancer cells *in vitro*



McDougall et al. (2008) *J. Agric. Food Chem. 56, 3016-23*

In vitro digestion

Model which polyphenols survive in gut?



Scheme of the in vitro simulation of the digestion process

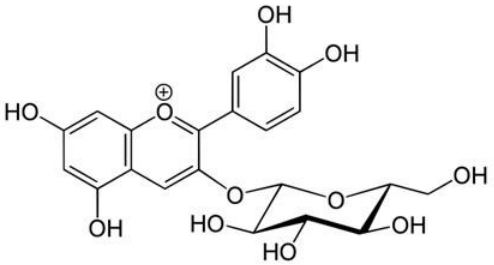
Simulation of human digestive system

1. Gastric digestion – 2 h at 37° C at pH 1.7 with pepsin

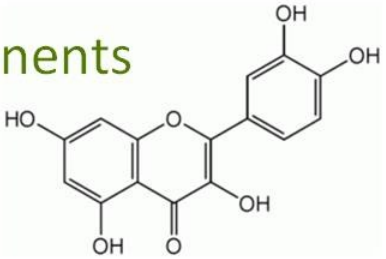
2. Pancreatic digestion – 2 h at 37° C with digestive enzymes and bile salts

Analyse recovery of polyphenol components

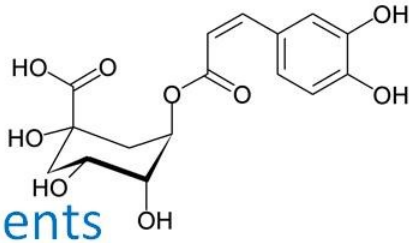
General effects of IVD



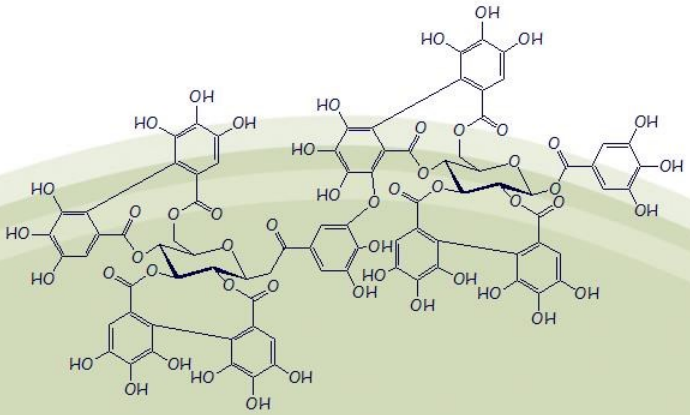
- Anthocyanins less stable

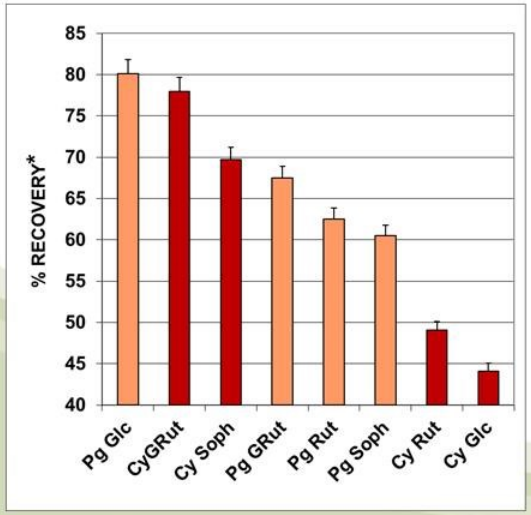


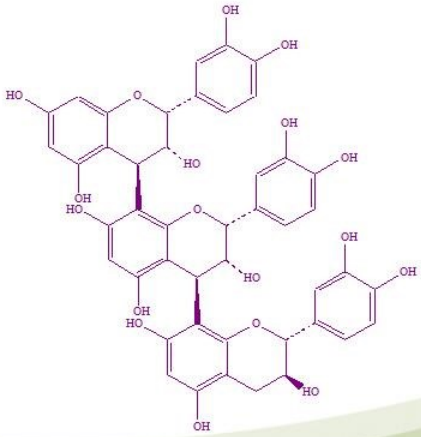
- Ellagitannins/PACs break down to smaller components
- Flavonols more stable



- Hydroxycinnamates stability dependent on linkages
- Stability not absolute but influenced by other components







IVD berry extracts and colon cancer

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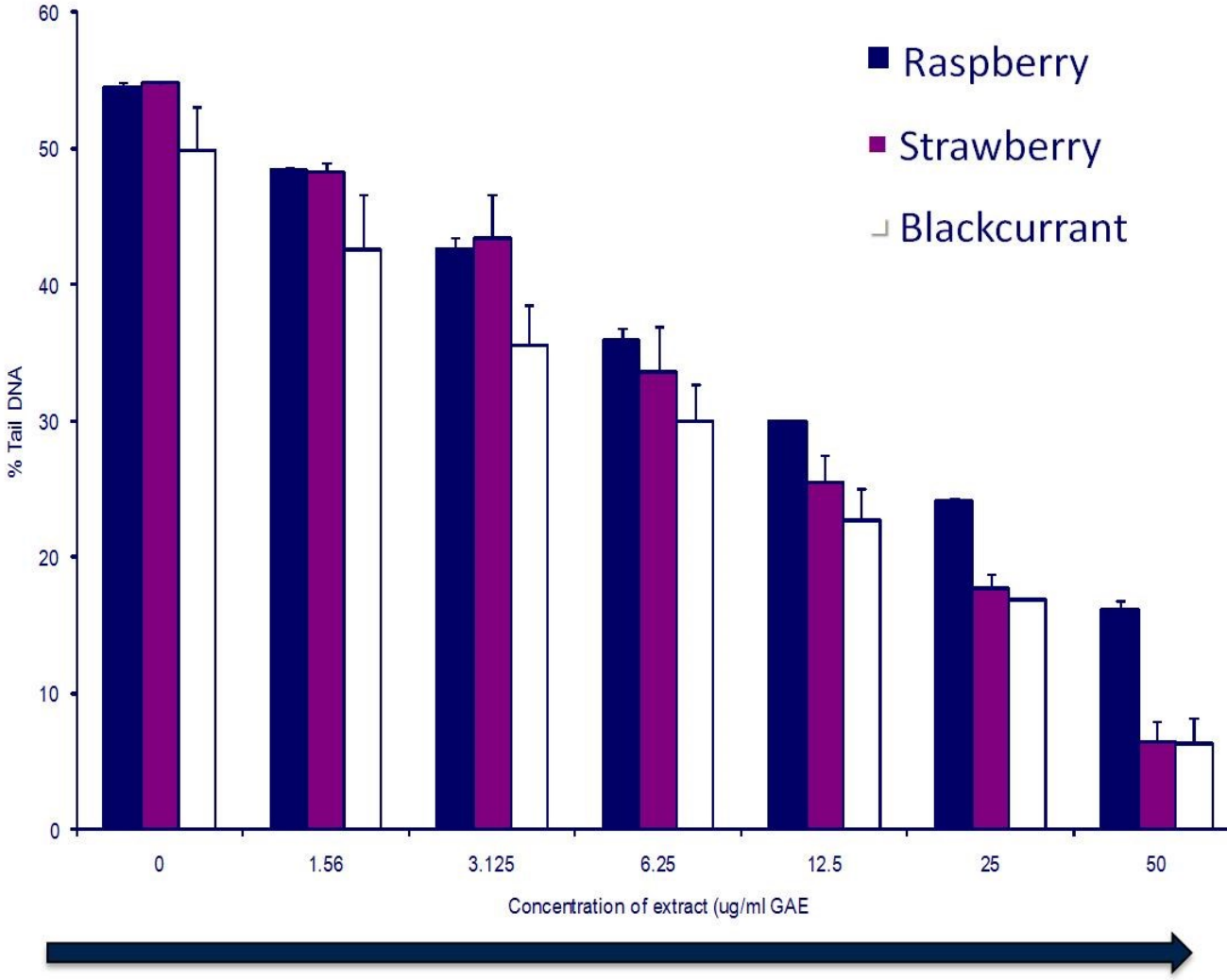

IVD berry extracts protect against DNA damage in colon cancer cells; **SB = BC > RB**

Colonic metabolism of berry polyphenols

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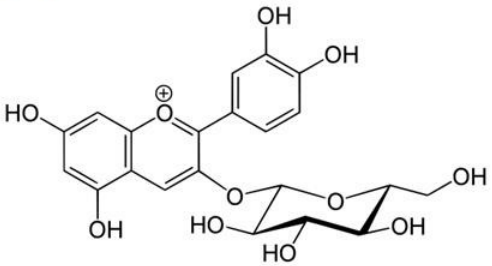
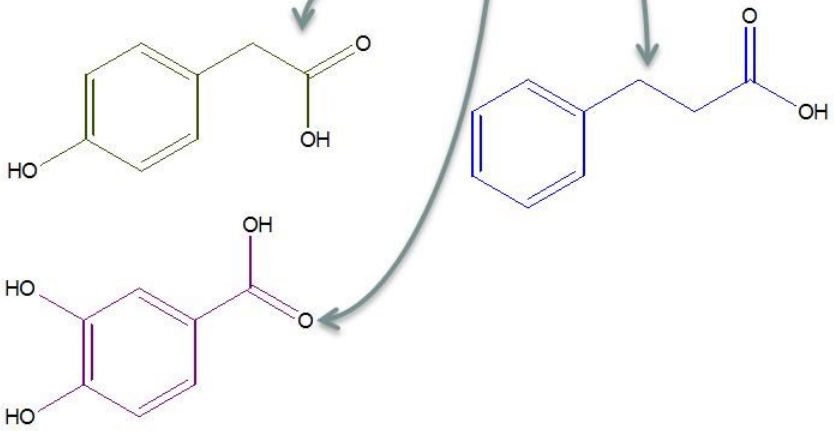
Colonic bacteria degrade polyphenols



Studies with humans fed berries show increases in

- Phenylacetic acid derivatives
- Phenylpropionic acid derivatives
- Hydroxybenzoic acid derivatives



Similar products formed in laboratory fermentations but large inter-person variability in amounts

Use berry IVD digests as substrates for lab fermentation studies

Gill et al. (2010) *J. Agric. Food Chem. 58, 10389–95*

Fermentation products as effective as IVD extracts

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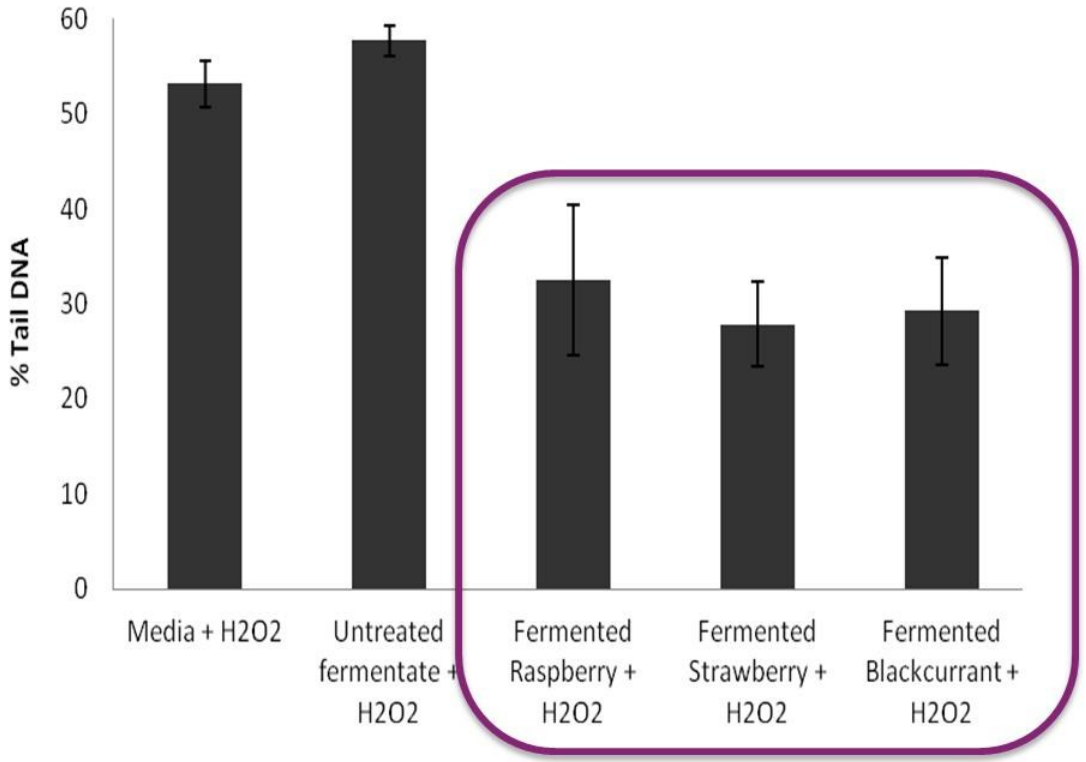
Berry polyphenols retain effectiveness as they undergo metabolism in the colon



Berry polyphenols contribute anti-cancer activity as they pass through the colon

Brown et al. (2012). *PLoS ONE 7: e49740. doi:10.1371/journal.pone.0049740*

Equally effective but compositionally different

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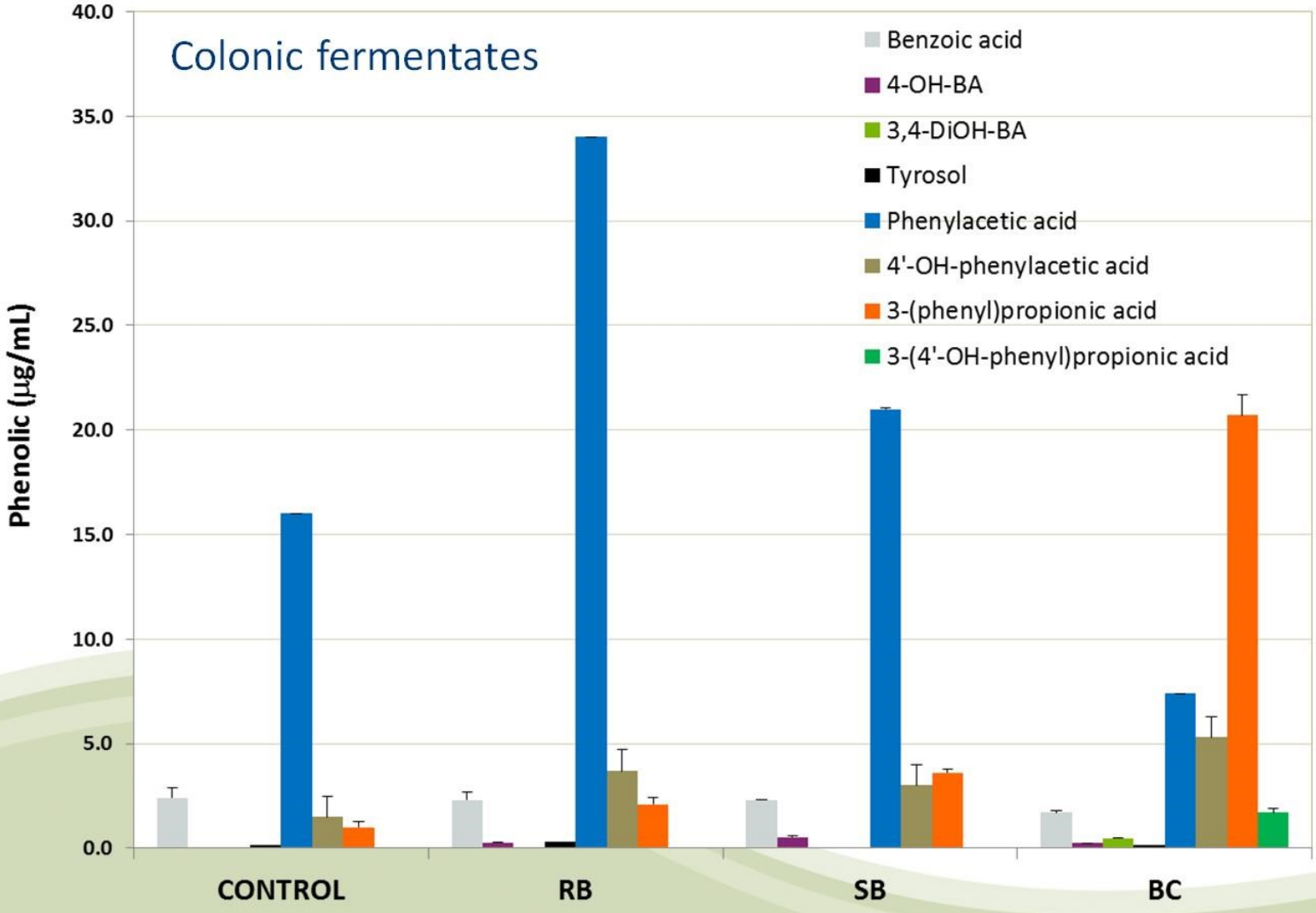

Summary/Future work

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- Berry polyphenols characteristic of intestinal digestion and colonic fermentation have beneficial effects on models of colon cancer
- The differences in effectiveness between different berry samples are less apparent after fermentation to simpler components in the colon?
- Extend work on phenolic degradation products using human ileostomy studies
- Examine effect of berry polyphenols on functional response of microbiota

Acknowledgements

healthier scotland
SCOTTISH GOVERNMENT

The James Hutton Institute

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Ian Rowland

University of Reading

UNIVERSITY OF EASTERN FINLAND

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All staff in CPU, JHI

Questions?

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JHI Dundee is located in Invergowrie on the north bank of the River Tay

Visit http://www.hutton.ac.uk

Berries and Health: A review of the evidence. McDougall and Stewart
http://www.foodhealthinnovation.com/media/5637/berries_august_2012.pdf

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