Food and Health Research at JHI

Gordon J. McDougall
The James Hutton Institute
Invergowrie, Dundee
Scotland, UK
We breed new varieties of fruit and vegetables. Mainly focused on potato, barley and berries.
World class germplasm and genomic resources in potato, berries and barley
Overall Approach to HBCs

Breed New Varieties with elevated levels of health beneficial components (HBCs)

Confirm Mechanisms & Bioavailability

Establish Health Benefits

Germplasm

Bioactivities

QSARs

Define Phytochemistry (Metabolic profiling)
We work on HBCs in other foods
Translation of raw material composition to processed quality

- Methods for the early prediction of potato quality
- Mechanisms for quality generation: taste & texture
- Identification of key pathways/genes for organoleptic properties

Umami in potato
From field to fork

Health beneficial components are also affected by

• Shelf life, stability, processing
• Post-harvest treatments, packaging

Development of high throughput approaches to optimize the nutritional value of crops and crop-based foods

Developing a knowledge base that can aid food business
Accumulation of health-beneficial components and gene expression

- Measure changes in metabolic profiles using MS-based techniques
- Correlate accumulation of purple anthocyanin pigments with gene expression

Environmental/agronomic effects on health-beneficial components

- Reduced/increased water inputs/availability
- Climate change
- Health Beneficial Components
- Reduced pesticide and fertilizer inputs

E.g. Balruddery Field Experiment on Sustainable Practices
BarleyBread - Improving human health by modifying a staple food

β-glucan has been proven to influence cholesterol levels and has an approved health claim

- “Soluble fibre from barley foods that contain at least 4 % β-glucan may, as part of a diet low in saturated fat and cholesterol, reduce the risk of heart disease”

- This EU-supported research project identified which barley varieties had the best attributes – antioxidants and β-glucan content

Products = breads with added barley
Bread → Health(ier) Bread

• β-Glucan has an approved health claim.
• Preference surveys were done to assess public “likes and wants” for bread.
• Optimised milling process to retain nutrients and β-glucan (~75%).
• A baking process was developed to give a bread with ≤60% barley and ≤0.4% salt.
• Blind preference testing in Scotland: JHI Open day and Kingsway technical college (800 and 700 people respectively).
• Results showed a 80% preference for BarleyBread (25% barley).
• Being further developed.
EU-supported project to develop polyphenol-rich extracts from black currant (BC) juice waste for use against Alzheimer’s Disease (and other conditions)

Multi-Partner Collaboration between
MTT Agrifood, Finland
JHI
TTZ, Germany
Univ. Kuopio, Finland
& SME partners across Europe

**JHI role included**

Provide and characterize BC extracts
Characterize effective extracts and assess stability
Analyse blood and urine samples for bioavailability data
Advise on formulation of +BC products with SMEs
Human trial – modified glycemic response

Volunteers given sucrose-loaded black currant (BC) juice or sucrose-loaded BC juice supplemented with crowberry juice

The supplemented juice (●) caused a reduction in peak height of plasma glucose and extended the area under the curve

Törrönen et al. Functional Food in press
Effect of processing methods on herb quality

Flat parsley, basil and dill

Effects on antioxidant capacity, appearance, oil content, aroma.

The James Hutton Institute
Mild thermal treatments and shelf extension

Appearance

Texture

Nutritional quality

Microbial load

Antioxidant capacity (mg gDW$^{-1}$)

Microbial load (CFU gFW$^{-1}$)
Effect of different cooking regimes on rhubarb polyphenols

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ARTICLE INFO

Article history:
Received 16 March 2009
Received in revised form 8 May 2009
Accepted 14 July 2009

ABSTRACT

Polyphenolic components, such as anthraquinones and stilbenes, from species of the genus Rheum have been shown to have a range of bioactivities relevant to human health. This paper outlines the polyphenolic composition of edible petals of garden rhubarb (Rheum rhabarbarum) and describes the effects of common cooking methods on total polyphenolic content, anthocyanin content and total antioxidant capacity.

Most cooking regimes (fast stewing, slow stewing and baking) except blanching increased total polyphenol content and overall antioxidant capacity, compared to the raw material. The patterns of anthocyanin content and total polyphenol content between the different cooking regimes suggested a balance between two processes; cooking facilitated the release of polyphenol compounds from the rhubarb but also caused breakdown of the released compounds.

Baking and slow stewing offered the best maintenance of colour through preservation of anthocyanin and the highest antioxidant capacity. Baking for 20 min provided well-cooked rhubarb with the highest antioxidant capacity and the highest anthocyanin content, which is important for the aesthetic quality of the dish.

Liquid chromatography–mass spectrometric (LC–MS) analysis putatively identified over 40 polyphenol components in raw rhubarb, including anthraquinone, stilbene, anthocyanin and flavonol derivatives. Baking caused selective effects on the stability of the different polyphenol components. Initially, the yield of all components increased but there was a drastic decline in the relative stability of anthraquinone aglycones with increasing cooking time and initial evidence for the turnover of other anthraquinone derivatives was obtained.
RHUBARB is perhaps the most reviled of vegetables. Unloved and unlovely, it grows like a weed in some forgotten corner of the garden to be harvested only in the most straitened of times.

Marco Polo is widely blamed for bringing the stringy acidic plant to Europe from China in the 13th century, but it was not until the rationing of the Second World War that it became part of Britain's staple diet. Since then, stewed rhubarb and custard has been gradually edged off the nation's dinner tables in favour of far tastier fare.

But the vegetable's image was transformed last week thanks to Scottish-led research. Dr Gordon McDougall of the Scottish Crop Research Institute analysed ways of cooking rhubarb to produce the best combination of the plant's polyphenols and chemotherapy agents, which kill cancer cells. Baking gently for 20 minutes was found to be the most effective.

Where others saw an ugly and unappetising pudding, McDougall saw an unexplored avenue of science. Thanks to his work, millions of sufferers may benefit.
Other JHI areas

Analysis & validation of component content

Polyphenols in juices, tea & coffee, vitamin C, lipids, carotenoids in sea buckthorn & carrot products

Shelf-life assessment of berry juices/colour quality

Advice on reformulation for improved health (salt, fats, fibre, viscosity, product quality)

Advice on health claims and marketing approaches
Questions?

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

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

Future challenges

- Limited Water and Energy resources
- More Aged & Sicker Population
- Explosion in obesity, diabetes & Alzheimers
- Drive for healthier & more convenient foods
- Pressure on land use

Importance of Food Quality

Food Sustainability, Security & Climate Change

Food Processing & Novel Food Products

Food & Health
Polyphenols as insulin mimics

Previous work* showed that tea polyphenols could stimulate phosphorylation of the FOXO1a transcription factor – a crucial control in insulin sensing.

Current joint PhD has established that berry polyphenols share this ability.

Foxo1A phosphorylation

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Berry polyphenols and cancer

PhD on berry polyphenols and colon cancer
School of Biomedical Sciences
University of Ulster, Coleraine

Strawberry polyphenols in tumourigenic and non-tumourogenic cell lines
University of St. Andrews

Studies on polyphenol fractionation

Berry polyphenols and cancer

All berry extracts tested at 50 μg/ml

Inhibition not related to *in vitro* antioxidant capacity

McDougall et al. (2008) JAFC 56; 3016-3023
Human trial – insulin response

The insulin responses showed a similar pattern to the glucose response.

Possible role for inhibition of glucosidase/glucose transport?
Targeted analysis
Yield, flavour, aroma taste, texture, disease resistance, bioactivities, antioxidant capacity, polyphenol content, ascorbate, anthocyanins

Untargeted analysis: Hi-through-put metabolic profiling

Latham x Moy
Two environments, 5 seasons

MS spectra

Direct Infusion MS
No chromatography

SC-MS/uPLC

Hierarchical cluster analysis:

Understand inheritance of HBCs

Correlation Network: Interrelate metabolite changes.

Principal component analysis of MS data

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