Soft Fruit Health Benefits: State of the Art

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Why bother?

Prevalence of Obesity
Behavioral Risk Factor Surveillance System (BRFSS)
Data from U.S. Center for Disease Control

1985

weight.com

no data < 10% 10-14% 15-19% 20-24% 25-29% >30%
• Mortality ↓: Morbidity ↑
• Western population is living longer but is sicker.
• CVD, Diabetes, (some) cancers, neuro-degeneration and inflammation associated disorders
Anthocyanins

**GIT**
Implicated in cancer reduction, bacterial population modulation (prebiotic) either directly or via associated metabolites

**Cancer**

**Brain & Cognitive Function**

**Neural**
EU Capacities BrainHealthFood:improve neurological traits-neuphobia, avoidance time etc at low doses. See Claudia Santos talk

**Inflammation**
Modulation of exercise-induced oxidative stress. complement the ability of exercise to enhance immune responsiveness to potential pathogens

**Visual Acuity and Eye strain**
- Reduced eye strain. J. Eye, 23, 129-133; 25, 114-118.
- Reduced Asthenopia & Myopia and . Blackcurrant >>>Bilberry.
- Saccharide decoration
- Rut > Glc >>> Ara ≈ Gal
Porcine Artery model – Arterial relaxation

- DETCA 1mM + Delphinidin 100nM
- DETCA 1mM + SOD 150U/ml
- DETCA 1mM + Delphinidin 10μM

- DETCA induces oxidative stress in porcine artery model
- Delphinidin (acute phase) highly effective antioxidant in this model
Impact of soft fruit consumption on type II diabetes
Inhibition of starch digestion

- Anthocyanin-derived
- Ellagitannin-derived

Bar chart showing:
- % Inhibition for amylase and glucosidase
- Raspberry: LH bound and LH unbound

Graph depicts inhibition of starch digestion by soft fruit consumption, highlighting the role of anthocyanin- and ellagitannin-derived compounds from fruits like raspberries.
Impact of soft fruit consumption on diabetes; Inhibition of starch digestion

Anthocyanin-derived

Ellagitannin-derived

% Inhibition

Raspberry
LH bound
LH unbound

amylase

glucosidase

S07.021 (Wed. 1:30)
Modulation of Digestive Enzymes by Berry Polyphenols: Potential Health Benefits
Mcdougall et al.
Faecal metabolism of berry polyphenols

- Metabolomic Profiling of faecal water metabolites in 10 free-living students after intake of raspberry puree (200 g/d for 14 d) by gas-chromatography mass spectrometry (GC-MS [and LC-MS]): Metabolomics
- Substantial ingestion of anthocyanins, ellagitannins etc.
- Focus on major phenolic metabolites.
- Some common metabolic patterns noted.
Faecal metabolism of berry polyphenols

Phenylacetic acid increased in 7/10 subjects
4-Hydroxy phenylacetic acid increased in 6/10 subjects
3-Hydroxy phenylacetic acid increased in 5/10 subjects
3-Phenylpropionic acid increased in 6/10 subjects
3-(4-Hydroxy)-phenylpropionic acid increased in 5/10 subjects
3,4-Dihydroxy benzoic acid increased in 7/10 subjects
4-Hydroxy benzoic acid increased in 2/10 subjects

• Predominantly anthocyanin derived
• Fits evidence from model studies with faecal inocula but shows large inter-individual variation.
• Due to differences in diet or microflora?
• A proper confined study is required: defined diet, labelled fruit/anthos?
Measure serum antioxidant capacity in free-living students after intake of raspberry puree (200 g).
Blackcurrant anthocyanins cause a flow-dependent increase in blood perfusion in isolated human intracerebral arteries

- 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 type, in the prevention of TIA and stroke.

- Flow-dependent relaxation is almost identical to fluvistatin.
Nutrigenomic analysis: Blackcurrants anthocyanins in a rat model.

A
10% membrane concentrate
Young rat
25% Ethanol Extract

B
feed it to the rat every day

2 weeks
Liver

A
10% membrane concentrate
Old rat
25% Ethanol Extract

B
feed it to the rat every day
Nutrigenomic analysis: Blackcurrants anthocyanins in a rat.

Control (No feed)  Experiment (fed)

Specimen collection & storage

RNA isolation

Microarray experiment (Differential Gene Expression Profiling)

Rat Nutrigenomics array

Bioinformatics analysis

Targeted genes validation by Q-PCR
Blackcurrant anthocyanin intervention
Rat transcriptomic analysis

Liver Transcriptomic heat map

- Age: Old, Young
- Extract: Ethanol, Membrane
Blackcurrant anthocyanin intervention
Rat transcriptomic analysis

Venn Diagram

Old_Ethanol (208)
Young_Membrane (138)

Old_Membrane (237)
Young_Ethanol (114)
Pathway enrichment/regulation and ontology as a consequence of blackcurrant anthocyanin intervention

Database for Annotation, Visualization and Integrated Discovery (DAVID) - http://david.abcc.ncifcrf.gov/
QuickGO (http://www.ebi.ac.uk/QuickGO/)
Intervention trial – assess effects of six week ingestion of

- Blackcurrant berries with low vitamin C content
- Blackcurrant berries with high vitamin C content
- Blueberries (No vitamin C)
- Coloured flavoured water (control)

Effects on cardiovascular function

Assess Micro-circulation & macro-circulation, arterial stiffness, (SphygmoCor Pulsewave Analysis System) and carotid intima media thickness (Accuson Sequoia).
Relate to *In vivo* markers for endothelial cell function and oxidative stress. Assess bioavailability of fruit derived antioxidants.

- Blueberry group showed a modest reduction in carotid intima-media thickness
- Both blackcurrant groups showed reductions in isoprostanes.
Polyphenolic Diversity

Flavonols in Blackcurrant

- Isorham-3-Malonyl-Glu
- Isorham-3-Glu
- Kaem-3-Glu
- Kaem-3-Rut
- Qer-3-Malonyl-Glu
- Quer-3-Glu
- Quer-3-Rut
- Myr-3-Malonyl-Glu
- Myr-3-Glu
- Myr-3-Rut

Line
Genotoxic and anti-genotoxic effects of CARE (24 hr incubation) at different concentrations on DNA damage in HT29 cells
Impact of fruit polyphenolics of invasiveness of HT115 colon cancer cells *in vitro*: Cancer spread

90% reduction in invasiveness

Colon Available Raspberry Extract (mg.ml⁻¹ GAE)
Gene modulation in HT29 cell following exposure to Rubus extract

Modulation of:
- Tumour protein p53 - Transcription factor regulating cell cycle and thus functions as a tumor suppressor.
- G0/G1 switch gene 2 - control of cell growth phase shift.
Colon cancer cells efficacy

- All berry extracts tested at 50 μg/ml
- Inhibition not related to *in vitro* antioxidant capacity

McDougall et al. (2008) JAFC 56; 3016-3023
Conclusions

• Soft fruit are a viable source of nutrients and (proto) beneficial components.

• Regular intake may well reduce the risk/incidence of major degenerative disease.

• Many of the active components survive processing and hence intake can be multiple format.

• ‘Omics per se will be key to accelerating breeding and can lead to tailored fruit for fresh and processed markers.

• We must not lose sight of the fact that food also need to taste good so a detailed understanding of the crosstalk between biosynthetic pathways is crucial and will be exploited by metabolomics and genomic developments.