Plant natural products and health: from evidence to implementation

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Institute of Food Research
Food and health - the two global challenges

- Malnutrition
- Micronutrient deficiencies

≈ 1 - 2 billion

- High calorific diets
- Reduced physical activity
- Non communicable disease

≈ 1 billion

• Food security
• Iron and Zinc deficiency
• Vitamin A deficiency

• Plant-based diets
• Fruit and vegetable rich diets
• Complex carbohydrates
• ‘Food bioactives’

Is there a role for biofortified and functional foods?
What is the evidence that these products could enhance health?
What are the implementation strategies
Vitamin A deficiency

Leafy vegetables

Golden rice?

Orange flesh sweet potatoes
• An estimated 32% of Africa’s population is vitamin A deficient
• Average consumption of sweet potato is 200g/day
• Estimated biofortification contribution: 50% of the mean daily vitamin A requirement
• HarvestPlus biofortified sweet potato varieties were released in 2007
• In 2022, 10 million people will be consuming provitamin A sweet potato in Uganda and 1 million in Mozambique.
• Spillover Countries: Burundi, Rwanda, Ethiopia, Ghana, Kenya, Malawi, Mali, Nigeria, South Africa, Tanzania, Zambia, Zimbabwe

Food bioactives and chronic non communicable disease

*What is the evidence that specific or mixtures of plant secondary metabolites may reduce risk of chronic disease such as cardiovascular disease and cancer?*

- Epidemiological evidence
- Cell and animal models
- Human intervention studies

*How can we use this evidence to enhance health?*

- Dietary advice and behavioural changes
- Functional and biofortified foods -
  - Processed foods
  - Agronomic practices and food chain
  - New cultivars
The Panel notes that 1.5 - 1.9 g and 2.0 - 2.4 g plant sterols/plant stanols per day was observed to lower blood LDL-cholesterol by an average of 8.5 % and 8.9 %, respectively. The Panel concludes that for an intake of 1.5 - 2.4 g/d an average reduction of between 7 and 10.5 % can be expected. The Panel considers that such a reduction is of biological significance in terms of reduced risk of coronary heart disease.

Benecol & Flora pro active - £7.60/kg
Sunflower spreads – £2.00-4.00/kg
Butter spreads - £5.60/kg
Evidence that diet rich in fruits and vegetables reduced risk of CVD and cancer – underpinned ‘5-a-day’ dietary advice

Evidence that fruit and vegetables reduces risk of CVD, but, in general, less support for reduction in cancer risk.

Evidence for health promoting effect of certain classes of F&V and dietary components

- Leafy green vegetables - Type II diabetes
- Cruciferous vegetables and glucosinolates – certain cancers and CVD
- Flavonoids – hypertension and CVD
Flavonoids and health

Analysed total flavonoid and subclasses intakes from semi-quantitative food frequency questionnaires and food compositional databases in three cohort studies.
Human intervention studies – acute effects of chocolate or cocoa on flow mediated dilation


<table>
<thead>
<tr>
<th>Study or subcategory</th>
<th>Treatment</th>
<th>Control</th>
<th>% FMD (random) (95% CI)</th>
<th>% FMD (random) (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low dose (1-100 mg/d epicatechin)</td>
<td>n</td>
<td>n</td>
<td>3.30 (1.75, 4.85)</td>
<td>3.30 (1.75, 4.85)</td>
</tr>
<tr>
<td>Heiss et al (40)</td>
<td>20</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subtotal (95% CI)</td>
<td>20</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test for heterogeneity: not applicable</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test for overall effect: z = 4.17 (P &lt; 0.0001)</td>
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<tr>
<td>Moderate dose (101-200 mg/d epicatechin)</td>
<td></td>
<td></td>
<td>4.65 (-0.40, 10.10)</td>
<td>5.90 (3.68, 8.12)</td>
</tr>
<tr>
<td>Farouque et al (42)</td>
<td>19</td>
<td>19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schroeter et al A (39)</td>
<td>10</td>
<td>10</td>
<td>2.40 (1.14, 3.66)</td>
<td></td>
</tr>
<tr>
<td>Schroeter et al B (39)</td>
<td>3</td>
<td>3</td>
<td>6.50 (3.46, 9.54)</td>
<td></td>
</tr>
<tr>
<td>Heiss et al (38)</td>
<td>5</td>
<td>5</td>
<td>4.71 (2.26, 7.16)</td>
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</tr>
<tr>
<td>Subtotal (95% CI)</td>
<td>37</td>
<td>37</td>
<td></td>
<td></td>
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<tr>
<td>Test for heterogeneity: Chi² = 11.30, df = 3 (P = 0.01), I² = 73.5%</td>
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<tr>
<td>Test for overall effect: z = 3.77 (P = 0.0002)</td>
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<tr>
<td>High dose (≥201 mg/d epicatechin)</td>
<td></td>
<td></td>
<td>2.80 (1.82, 3.78)</td>
<td>2.60 (1.82, 3.78)</td>
</tr>
<tr>
<td>Schroeter et al B (39)</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subtotal (95% CI)</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test for heterogeneity: not applicable</td>
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</tr>
<tr>
<td>Test for overall effect: z = 5.60 (P &lt; 0.00001)</td>
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<tr>
<td>Total (95% CI)</td>
<td>60</td>
<td>60</td>
<td>3.75 (2.56, 4.94)</td>
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</tr>
<tr>
<td>Test for heterogeneity: Chi² = 12.76, df = 5 (P = 0.03), I² = 60.9%</td>
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<tr>
<td>Test for overall effect: z = 6.17 (P &lt; 0.00001)</td>
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</tr>
</tbody>
</table>

- Favor control
- Favor flavanol
Flavonoid–rich foods may provide health benefits

Plenty of options, and easy to incorporate into processed foods
### Minerals
- Calcium
- Potassium
- Magnesium
- Iron
- Manganese
- Zinc
- Selenium

### Vitamins
- C, A, E, K, B1, B2
- Folates

### Polyphenols
- Quercetin glycosides
- Kaempferol glycosides
- Chlorogenic acid
- Sinapic acid

### Organo-sulphur compounds
- S-methyl cysteine sulphoxide
- Glucosinolates
sulphate $\rightarrow$ APS $\rightarrow$ sulphite $\rightarrow$ sulphide $\rightarrow$ cysteine $\rightarrow$ methionine $\rightarrow$ Protein

Acetyl Co-A $\rightarrow$ elongated methionine

PAPS $\rightarrow$ Glutathione

Glutathione $\rightarrow$ S-methyl cysteine sulfoxide

Methionine-derived glucosinolates

\[
\begin{align*}
\text{S-methyl cysteine sulfoxide:} & \quad \text{S} & \quad \text{O} & \quad \text{NH}_2 \\
\text{cooking:} & \quad \text{S} & \quad \text{O} & \quad \text{S} & \quad \text{OH} & \quad \text{NH}_2 \\
\end{align*}
\]

\[
\begin{align*}
\text{sulforaphane:} & \quad \text{S} & \quad \text{N=C=S} & \quad \text{O} \\
\end{align*}
\]
Germplasm collection

B. villosa x broccoli

Marker-assisted backcrossing

Human dietary studies

Functional analyses

1984

1995

2010

US launch of Beneforte broccoli

2011

UK launch of Beneforte broccoli

2012
The superlative super food.

Why Beneforte

Broccoli is one of the most nutrient-dense foods known: it offers an incredibly high level of nutrition for a very low caloric cost. Beneforte broccoli is even more of a good thing...

Learn about the Beneforte story

In the early 1990s, scientists from the UK's Institute of Food Research traveled to Italy where the earliest broccoli plants first appeared hundreds of years ago.

Beneforte Recipes

Beneforte broccoli is an even more healthful variety of regular broccoli. Use as a colorful and nutritious addition to quiche, stir fries or vegetable platters. Try roasting Beneforte as a simple method to bring out its natural sweetness.
Plant and microbial myrosinases

Gut lumen

Conjugation with glutathione

Dissociation

GSTM1 polymorphism

Mercapturic acid metabolism and excretion
Mechanistic studies

Perturbation of cell signalling pathways by food bioactives – integration of cell and animal models with human studies.
## Cardiovascular Risk Calculator For Primary Prevention

This calculator should not be used if patient has known CVD or Diabetes (already known to be at high risk)

<table>
<thead>
<tr>
<th>Age (30-74)</th>
<th>Smoking Status</th>
<th>Sex</th>
<th>Glucose</th>
<th>Systolic BP</th>
<th>LVH</th>
<th>Diastolic BP</th>
<th>Central Obesity</th>
<th>Total Cholesterol</th>
<th>South Asian Origin</th>
<th>HDL Cholesterol</th>
<th>Family History of CVD</th>
<th>Total /HDL Ratio</th>
<th>Serum TG mmol/l</th>
<th>Using Systolic BP prediction, the 10 year risk of</th>
<th>The equivalent risk calculation with diastolic BP is</th>
</tr>
</thead>
<tbody>
<tr>
<td>57</td>
<td>Non Smoker</td>
<td>Male</td>
<td>Normal</td>
<td>141</td>
<td>No LVH</td>
<td>92</td>
<td>No</td>
<td>6.7</td>
<td>No</td>
<td>1.55</td>
<td>No FH</td>
<td>4.32</td>
<td>2.05</td>
<td>JBS CVD Risk is 19%</td>
<td>20%</td>
</tr>
</tbody>
</table>

**Calculate** | **Clear Fields**
Nutrition and Health claims

EFSA’s work includes providing scientific advice on:

- General function health claims under Article 13.1 of the EU regulations
  
  4637 applications, 263 opinions

- New function health claims under Article 13.5
  
  48 applications (13 withdrawn) 27 opinions

- Claims regarding disease risk reduction and child development or health under Article 14
  
  264 applications (103 withdrawn) 75 opinions
New function health claims under Article 13.5

Scientific opinions give on:

• Lactobacillus or Bifidobacter containing products – 8
• Plant extracts – 8
• Products involving fish oils – 2
• Others - 4

“Helps maintain normal platelet aggregation, which contributes to healthy blood flow.”

“Frequent consumption of typical juice drinks and sugar-containing, acidic, non-alcoholic beverages may contribute to tooth demineralisation; consumption of 'toothkind' juice drinks in replacement of typical juice drinks and sugar-containing, non-alcoholic beverages may help to reduce tooth demineralisation.”