Natural Food Colourings as Functional Ingredients

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Do fruits & veg contribute to health?

- Fruits and vegetables are known to contain carbohydrates, vitamins and minerals. They are usually very low in proteins and fat
- Of recent interests are phytochemicals and antioxidants
  - Phytochemicals – natural plant compounds that provide a variety of health benefits
  - Antioxidants – plant substances that protect the body by neutralising free radicals or unstable oxygen molecules which can damage cells and lead to poor health

Potential impact of pure fruit & vegetable juices (PFV) on cancer and CVD

Condition	Strength of Evidence	Volume of Evidence
Cancer	**Strong** – PFV juice unrelated to breast cancer link	3
	Weak – between PFV juice & increased risk of renal cell carcinoma	2
	Strong – that PFV juices sign decreases lymphocyte damage	
Ischemic stroke	**Weak** – association between PFV juice consumption and reduction in BP	3
Platelet aggregation	**Moderate** – tomato juice and purple grape juice have anti platelet effects (*in vitro* & human studies)	6
Antioxidant capacity	**Strong** – antioxidant effect particularly related to polyphenols content (*in vitro*)	6
	Strong – suggesting prevention of LDL oxidation in healthy subjects	12
	Weak – improved endothelial dependent vasodilation in subjects with coronary artery disease	2
Serum lipoprotein levels	**Moderate** – PFV can reduce plasma LDL levels in subjects with hypercholesterolaemia	4
Plasma homocysteine levels	**Weak** – suggestive of beneficial effects on plasma homocysteine levels	3

(Modified from Ruxton *et al.*, 2006)

Studies have suggested the following health benefits from fruits and vegetables

- Cancer
- Heart disease
- Immune system
- Neurological function
- Urinary tract health

(Beattie *et al.*, 2005)

Simple colour classification of fruits & veg

- Blue/purple
- Yellow/orange
- Red
- Green
- White/tan/brown

Colour classification of fruits & veg

- Blue/purple – help:
  - Lower risk of some cancers
  - Urinary tract health
  - Memory function
  - Healthy ageing

Blue/purple fruits and veg contain varying amounts of health promoting phenolics and anthocyanins

Examples of blue/purple fruits & veg

- Blueberries
- Black berries
- Black currants
- Elderberries
- Purple grapes
- Purple cabbage
- Aubergine
- Plums
- Raisins
- Purple peppers
- Purple figs



Colour classification of fruits & veg

- Yellow/orange – helps maintain:
  - Heart health
  - Vision health
  - A healthy immune system
  - A lower risk of some cancers

Yellow/orange fruits contain varying amounts of antioxidant such as vitamin C, carotenoids and bioflavanoids

Examples of yellow/orange fruits & veg

- Apricots
- Grapefruit
- Lemon
- Mangoes
- Nectarines
- Oranges
- Pineapple
- Carrots
- Yellow peppers
- Sweet corn
- Sweet potato



Colour classification of fruits & veg

- Red – helps maintain:
  - Heart health
  - Memory function
  - A lower risk of some cancers
  - Urinary tract health

The phytochemicals in the red food group include lycopene and anthocyanins

Examples of red fruits & veg

- Blood oranges
- Cherries
- Cranberries
- Pomegranates
- Redcurrants
- Raspberries
- Strawberries
- Watermelon
- Beetroot
- Red peppers
- Red onions
- Radishes




Coming Full Circle

Emerging evidence shows the added benefit of returning to natural colours

Colours & Nutraceuticals

2600 BC Earliest record of the use of natural dyes

700 BC Saffron mentioned in Homer's *Iliad*

1856 Sir William Henry Perkin discovered the first synthetic dye

1970's hyperactivity & food colours

2007 Research from Southampton University sparks concerns about the use of synthetic food colours

Colours extracted:

- Anthocyanins (red pigment)
- Betanins (red pigment)
- Carotenoids (yellow-orange pigment)

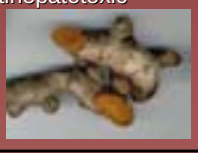
Food colours as Functional Ingredients?

- Public concern over some of the existing colourings used in foods
- Natural food colours may have a dual purpose, added health benefit
- Scientific studies have reported the potential of these natural pigments to improve human health
- Some pigments have been extensively studied but there is still relatively limited *in vivo* data on anthocyanins, betalains & saffron

Curcuma longa - Tumeric

Medicinal & biological properties of turmeric

- Antioxidant
- Antiarthritic
- Antimutagenic
- Antitumor
- Anti- tumor promotion
- Antithrombotic
- Antibacterial
- Antifungal
- Antiviral
- Nematocidal
- Choleretic
- Antihepatotoxic



Curcumin inhibits formation of amyloid beta oligomers & fibrils, binds plaque & reduces amyloid in vivo

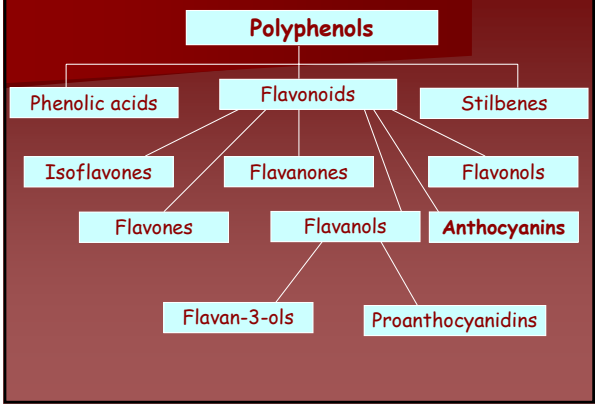
Curcumin is a naturally occurring phytochemical in turmeric. This earthy spice gives curry its intense yellow colour and may prevent, slow and even reverse the build up of neural plaque, which is implicated in Alzheimer's disease.

(Yang *et al*, 2005)

Turmeric

- Preliminary evidence to suggest that turmeric may slow down melanoma growth
- Phase I trials – curcumin demonstrated anti-cancer effects at virtually all stages of tumour development
- Recent studies have illustrated that people may take 10g/d for a few weeks without ill effects
- Phase II clinical trials – few to date however promising results. Turmeric capsules (600mg/d) were shown to have healing properties on peptic ulcer

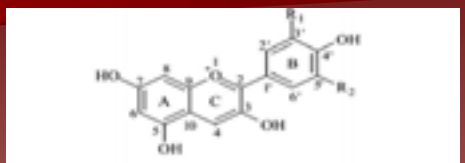
Anthocyanins



Anthocyanins

- Polyphenols found in plants in the glycosylated form
- Responsible for the red, purple & blue colours of many fruits, veg., cereal grains & flowers
- Over 300 structurally distinct anthocyanins have been identified
- Diverse range of physiological activities
- Potent antioxidant
- Physiological effects may be due to antioxidant activity, modulation of cellular biochemical processes or alteration of gene expression

Anthocyanins



Name	R1	R2
Delphinidin	OH	OH
Petunidin	OCH_3	H
Cyanidin	OH	H
Pelargonidin	H	H
Peonidin	OCH_3	H
Malvidin	OCH_3	OCH_3

Anthocyanins & Health

Beneficial effects on:

- Visual capacity
- Brain cognitive function
- Diabetes
- Obesity
- Cardiovascular risk
- Cancer prevention
- Inflammation
- Infection

Anthocyanins

- Numerous studies investigating the effects of anthocyanins at the cellular level
- Little information on the **dosage** of anthocyanins required to see similar effects in humans
- Few clinical trials to date
- Recent research from Norway found that supplementation of anthocyanins (300mg/d) for 3 weeks may have a role in the treatment/prevention of chronic inflammatory disease

Betalains

- Water soluble pigments, replace anthocyanins in most plants of the order *Caryophyllales* (also found in some fungi)
- Less well used in food processing than anthocyanins & carotenoids
- These pigments are stable between pH 3 7, suitable for use in low acid food
- Two main types, betacyanins & betaxanthins
- Many structural varieties & diverse activity related to structure

Betalains & Health

- Betacyanins are potent antioxidants and exhibit radical scavenging activity
- Betaxanthins are immonium conjugates of betalamic acid with an amine or amino acid group
- Through the use of the semi-synthesis technique, there is potential for betaxanthins to be used as a means for introducing essential amino acids into the diet
- In the future betalains could become 'the essential dietary colourant'

Strack, D., Vogt, T. and Schliemann, W. (2003). Recent advances in betalain research. *Phytochemistry* 62, 247-249

Saffron

- Dry stigmas of the plant *Crocus sativus L.*
- Used as a spice & food colourant
- Traditionally used in Chinese traditional medicine
- A rich source of carotenoids, particularly crocins (water soluble carotenoid)
- Relatively limited scientific data available
- Many proposed health benefits, claims need to be substantiated

Saffron & Health

Preliminary scientific research has shown that effects of saffron may include:

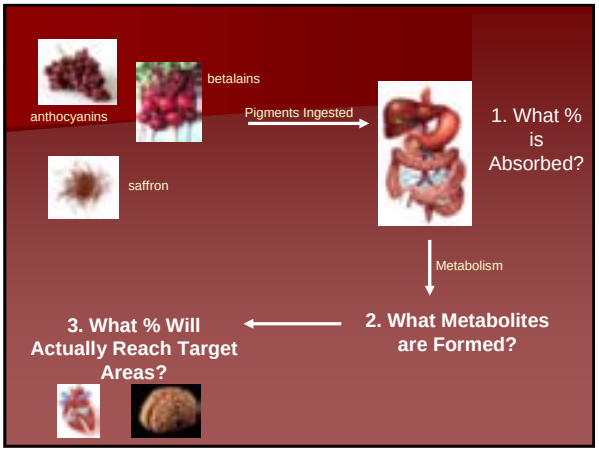
- Anticonvulsant
- Antidepressant
- Anti inflammatory
- Antitumour
- Antioxidant, radical scavenger,
- Neuroprotective
- Chemopreventative
- Aphrodisiac*

Saffron

- Information from animal and *in vitro* studies indicate that saffron may possess anticancer and antitumour properties
- Potential caution as toxicity of saffron has been found to be quite low (oral LD_{50} 20.7g/kg administered as a decoction)
- Clinical trial evidence is lacking
- Positive claims from preliminary research need further investigation via clinical trials in humans

Caution!

Even though the food industry is very quick to accept the benefits of these pigments ….To date, we have more question than answers



Potential Difficulties

- Limited data on the physiological effects of these compounds *in vivo*
- Limited data on the amount of these compounds that would need to be in the diet to produce the desired effects
- Limited information on the bioavailability and metabolism of these pigments *in vivo*
- Preliminary research on healthy human volunteers suggests that there is very poor availability of these compounds when ingested

Can dietary beta-carotene materially reduce human cancer rates?

R. Peto, R. Doll, J. D. Buckley & M. B. Sporn, Nature 290: 201 - 208 (19 March 1981)

"Human cancer risks are inversely correlated with blood retinol and dietary carotene… If dietary β-carotene is truly protective—which could be tested by controlled trials—there are a number of theoretical mechanisms whereby it might act, some of which do not directly involve its 'provitamin A' activity"

Alpha-Tocopherol, Beta-Carotene Cancer Prevention (ATBC) Trial

Virtamo *et al.*, JAMA, 290: 476-485 (23rd July 2003)

- A cancer prevention trial conducted by the U.S. National Cancer Institute (NCI) and the National Public Health Institute of Finland from 1985 to 1993.
- The purpose of the study was to determine whether certain vitamin supplements would prevent lung cancer and other cancers in a group of 29,133 male smokers in Finland.
- The 50- to 69-year-old participants took a pill daily for five to eight years that contained one of the following: 50 milligrams (mg) alpha-tocopherol 20 mg of beta-carotene (a precursor of vitamin A), both, or a placebo (inactive pill that looked like the vitamin).
- In the eight-year follow-up period, the participants taking beta-carotene experienced 7 percent higher overall mortality than men on the placebo

Carotenoid Bioavailability

- Studies to date show very different levels of bioavailability of various carotenoids
- Processing can have a significant impact
- Overall diet composition may either increase or decrease bioavailability
- *In vitro* studies have provided some insights

The future…

- Much remains to be discovered
- Necessary to determine the full *in vivo* effects of these compounds
- Preliminary studies promising much, but confirmation can only come from human trials
- If these compounds hold up to scrutiny, there is potential for the natural food colours to provide sensory stimulation and also act as nutraceuticals

Functional Food Centre

Thank you for your kind attention.
We would be delighted to hear from you!

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