



Phytochemical enhanced and standardised horticultural product, a change of emphasis for the plant industry

12/07/2005

Drivers for plant food consumption

- **Diversity in taste, aroma, texture**
- **Local availability (wide availability)**
- **Pride on local cultivars**
- **Essential components to food recipes
(Entrenched uses in local cuisines)**
- **Often they are the only food source available**
- **They contribute to health and well being**

Folate shown to cut child leukemia risk

Belinda Hickman

THE risk of children developing one of the most common forms of leukemia is reduced by almost two-thirds if their mothers take folate while pregnant, West Australian researchers have found.

The unexpected and internationally significant finding by epidemiologist Judith Thompson suggests many cases of acute lymphoblastic leukemia may be prevented if pregnant women maintain a healthy folate intake.

This form of leukemia strikes one in 2000 children before the age of 15. About 30 Australian children die from it each year.

The study, to be published today by the medical journal *The Lancet*, has already gained overseas interest. It will broaden researchers' understanding of how the cancer occurs and open up a new line of research.

"We have found that children whose mothers take folate during pregnancy have a 60 per cent lower risk of developing the most common type of childhood leukemia," Dr Thompson said yesterday.

"This is potentially very important ... if we could prevent any cases of cancer, particularly childhood cancer, it would be great."

Dr Thompson warned that the research was in its early stages, with many questions — such as how much folate is ideal and at which stages of pregnancy — still to be answered.

"If you are taking a reasonably good diet and a supplement, that should be

right — but it needs to be looked at in more detail," she said.

The benefits of folate in protecting fetuses from neural tube defects are well proven. Women are encouraged to take supplements of the nutrient, found in green leafy vegetables, bananas and wholegrain bread, in the month before pregnancy and its first 12 weeks.

Although folate is known to be important for cell growth and metabolism, Dr Thompson's research, involving 249 children and supported by the Cancer Foundation of Western Australia and Princess Margaret Children's Hospital, is the first to identify a link between it and the cancer.

"If you have a folate deficiency then maybe these things aren't ticking over as they should be. It could cause breaks in DNA and chromosome damage which leads to leukemia," Dr Thompson said.

Cancer Foundation president D'Arcy Holman said the results were "extraordinary" and of world importance.

"This is a very important area of cancer research dealing with childhood leukemia, and we have this light that gives us some hope of a major preventative possibility," he said.

Dr Thompson began the study in 1984 with the aim of discovering which factors might cause the disease.

Parents were asked a series of questions about their children's exposure to factors that might trigger the cancer, such as pesticides and x-rays. But to Dr Thompson's surprise, folate was the only factor to stand out.

Eat your broccoli

GOOD news for broccoli-lovers — a study shows there is up to 50 times more anti-cancer chemical in broccoli sprouts than in the mature vegetable, and the sprouts don't taste like broccoli.

Three-day-old broccoli sprouts, which are tender shoots topped with two baby leaves, are loaded with a concentrated form of sulforaphane, a powerful cancer fighter.

Dr Paul Talalay, head of a team that discovered sulforaphane five years ago, said: "If these are developed commercially, this could be a really easy way for people to get the benefits of chemoprotection against cancer".

Experts trumpet the value of vegies

By CLAIRE MILLER

It all seemed so easy when medical researchers first trumpeted the therapeutic value of anti-oxidants, the family of naturally occurring plant chemicals that zap the free radicals blamed for some common cancers. Good health and long life without a carrot in sight seemed no further away than a bottle of beta-carotene pills.

But with the latest Finnish research indicating that an excess of anti-oxidant pills can increase the risk of lung cancer, the best advice from cancer experts is to sweep the bathroom cabinet clean of all those "miracle" vitamin supplements and head for the greengrocer.

A visiting American cancer specialist, Dr Dan Nixon, said yesterday that more than 1000 anti-cancer chemicals had been identified in fruit and vegetables, but their



Health and well being from plant products (Convincing assessment of evidence)

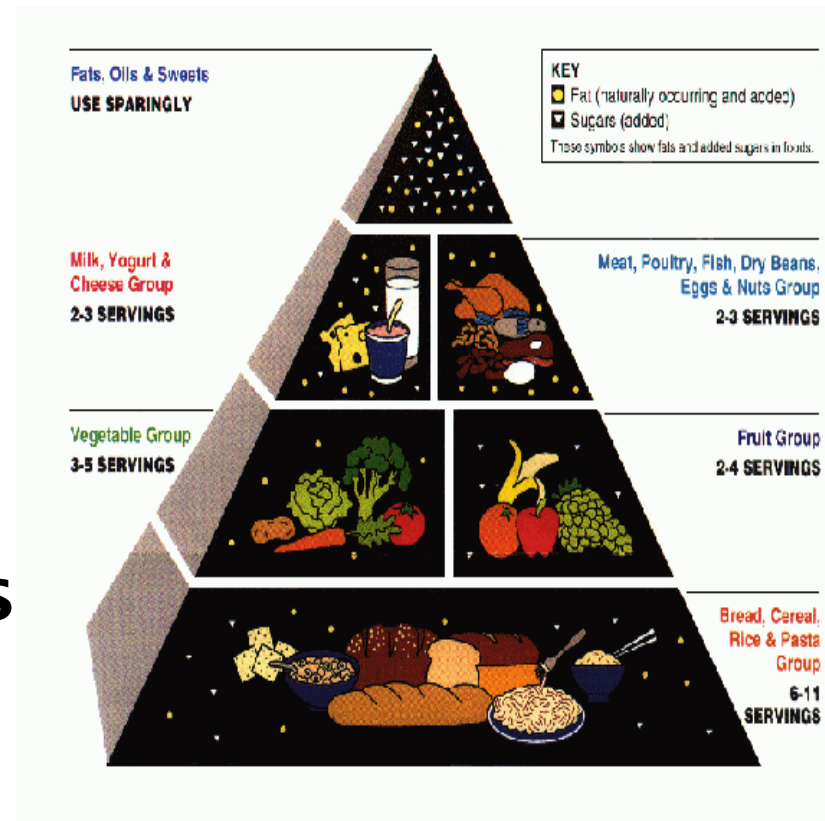
- **Coronary heart disease**
- **Diabetes**
- **High blood pressure**
- **Inflammation**
- **Infections**
- **Psychotic diseases**
- **Ulcers**
- **Macular degeneration**
- **Birth defects**

The anti-cancer benefit

- **In 1933 Stocks and Karn** showed that a high intake of fruit and vegetables had protective effects when 450 cancer patients were compared to an equal number of controls
- **In 1996 Steimetz and Potter** reviewed 206 human epidemiological studies and 22 animal studies to conclude that fruit and vegetables consumption protected against cancers of the stomach, esophagus, lung, oral cavity, endometrium, pancreas and colon

Plant foods and Dietary considerations

- Provide essential trace elements
- A good source of energy
- A good source of fibre
- A source of complex phytochemicals (vitamins antioxidants etc.)



Phytochemicals

- **Plant produced chemicals with discrete bio-activities towards animal biochemistry and metabolism**
- **There are over 250 identified phytochemicals in some Brassica vegetables**
- **some phytochemicals cannot be synthesized or if they can, do not show the same “in vivo” activities as their natural counterparts**

The three major classes of phytochemicals and the phytochemicals in each class

(adapted from Dillard and German 2000)

- **Phytochemical Class**
- Terpenoids
 - **Phytochemicals**
 - Monoterpenoids, iridoids, sesquiterpenoids, sesquiterpene lactones, diterpenoids, triterpenoid saponins, steroid saponins, cardenolides, bufadienolides, phytosterols, cucurbitacins, nortriterpenoids, triperpenoids and carotenoids, limonoids
 - Anthocyanins, anthochlors, benzofurans, chromones, coumarins, flavonoids, isoflavonoids, lignans, phenols, phenolic acid, phenolic ketones⁹, phenylpropanopids, quinoids, stilbenoids, tannins, xanthones
- Phenolic metabolites

The three major classes of phytochemicals and the phytochemicals in each class (cont)

- **Phytochemical Class**
- Alkaloids and other nitrogen containing constituents
- **Phytochemicals**
- Amaryllodacea, betalain, diterpenoid, indole, isoquinoline, lycopodium, monoterpene, sesquiterpene, peptide, pyrrolidine, piperidine, pyrrolizidine, quinoline, quinolizidine, steroidal, tropane compounds, non protein amino acids, amines, cyanogenic glycosides, glucosinilates, purines, pyrimines

Glucosinilates in Brassica

- Sinigrin is converted to allyl isothiocyanate. This causes cancers in the large intestine to self-destruct.
- Glucoraphanin, which breaks down into an isothiocyanate called sulphoraphane which by contrast stops or slows the genetic damage before it happens.
- (New Scientist 21/28 Dec 1996, 46)

Phytochemicals provide health benefits in many ways

- **substrates for biochemical reactions**
- **cofactors of enzymic reactions**
- **inhibitors of enzymatic reactions**
- **binders of undesirable constituents**
- **ligands to block cell reactions**
- **enhance adsorption and increase stability of nutrients**
- **interact with bacterial flora**

Modes of action of a range of phytochemicals in protecting humans against cancer

- **Mode of action**
- Reducing or blocking activation of carcinogen
- Increases activation of phase 2 enzymes
- Enhancing DNA repair
- **End result**
- Many carcinogens need to be activated through a system of enzymes in the body. Some phytochemicals reduce the activation of these phase 1 enzymes resulting in reduced or inactivation of carcinogen
- These enzymes can detoxify and eliminate carcinogens
- Reversing and preventing DNA damage

Modes of action of a range of phytochemicals in protecting humans against cancer (cont).

- **Mode of action**
 - Controlling oncogene expression
 - Modulating cell signalling
 - Promoting cell differentiation
 - Angiogenesis
 - Enhancing immune surveillance
- **End result**
 - Resulting in reduced expression of mutated genes
 - Increasing communication between damaged cells and cancerous cells
 - Reversing undifferentiated cancerous cells back to normally growing cells
 - Reducing the growth of cancer
 - Increasing the capacity to recognise and eliminate cancerous cells

The reality is that we are being increasingly exposed to smaller range of phytochemicals





Number of commercial vegetable product lines

- **32 grown commercially in Australia
Over 190 cultivars used**
- **Over 200 potential lines
Estimated total number of cultivars in
the world > 49,000**
- **Supermarket lines less than 22**

Number of commercial fruit product lines

- **31 grown commercially in Australia,
Over 100 cultivars used**
- **Over 150 potential lines
Estimated total number of cultivars in
the world > 27,000**
- **Supermarket lines 19**

Pressures to re-evaluate plant foods for economic reasons

- **Plant foods have the potential to be re-positioned in the market place by value adding to their existing attributes**
- **Intellectual property protection can turn old varieties into new marketing opportunities**
- **New and novel uses for old products**

Build on existing attributes

- **New flavours, new tastes**
- **New aromas, bring back old aromas**
- **New processing attributes, higher solids, new colours that resist processing**
- **New colours**
- **New or enhanced nutritional parameters**
- **New health specific compounds**

Changing horticultural foods for health and well being

- **Conventional breeding**
- **Hybrids**
- **Genetic modification**
- **Altered environment**
- **Harvest timing**
- **Storage conditions**
- **Packaging**

Conventional plant breeding

- **Increased shelf life of horticultural produce**
- **Produced high yield plants**
- **Produced uniform size (suitable for processing)**
- **Uniform maturing times**
- **Varieties suitable for harsh conditions**
- **Pest resistance**
- **Disease resistance**
- **New visual and flavor varieties**

Do we have a base line?

Variation in levels of sinigrin, a glucosinilate compound in brassica vegetables

• Crop	Level of sinigrin (mg/kg)
• Cabbage	0-480
• Brussels sprouts	110-1560
• Cauliflower	10-630
• Turnips	0-100

Commercial cultivars in Melbourne

- We know that cultivars vary: Concentration of sinigrin (mg/kg) in leaves from cultivars of *B.oleracea v. capitata* (cabbage)
- September 110 ± 4
- Hammer 9 ± 0.2
- Vorbote 480 ± 5

Commercial cultivars in Melbourne (apples) level of polyphenols

- **Fuji** 290-325 mg/100g
- **Royal gala** 122-165 “ “
- **Golden delicious** 78-87 “ “
- **Roma** 27-64 “ “

Hybrids

- **24th May 2000 - John Innes Centre (British Government funded). Richard Mithen has produced a type of broccoli by cross breeding a normal plant with a Sicilian species resulting in a cultivar that expresses 100 times more sulphoraphane than normal broccoli.**

Kalebrini: hybrid between broccoli and Chinese broccoli (kailan)



GRB-P1

(Broccoli)

298 $\mu\text{mol/g DW}$

X

98KL 32HS

(Kailan)

1.3 $\mu\text{mol/g DW}$



KLB-41

(Kalebrini)

(Henderson Seeds Pty.Ltd., Australia)



158 $\mu\text{mol/g DW}$

Genetic modification

- **31st May 2000 - Prof Peter Bramley, University of London and Zeneca Biotechnology inserted gene to increase β - Carotene 3.5 fold in tomato.**
- **1 May 2001- Unilever Research in Sharnbrook, Bedfordshire UK. Inserted a gene to boost production of an enzyme that controls synthesis of flavonols resulting in tomato with 78 times more flavonols**

Altered environment

- **Damage**
- **Soil type**
- **Fertilizers**
- **Soil supplementation**
- **Environmental stress - Irrigation regime - Light - Temperature**
- **Co-plantation**

Glucoraphanin content in broccoli heads as affected by sulphur application (mg/head)

	Control (No extra S)	High S application
Claudia	54.5	103.2
Marathon	78.6	98.0
TB-234	63.6	102.2

Glucoraphanin content in broccoli seeds as affected by sulphur application (mg/seed head)

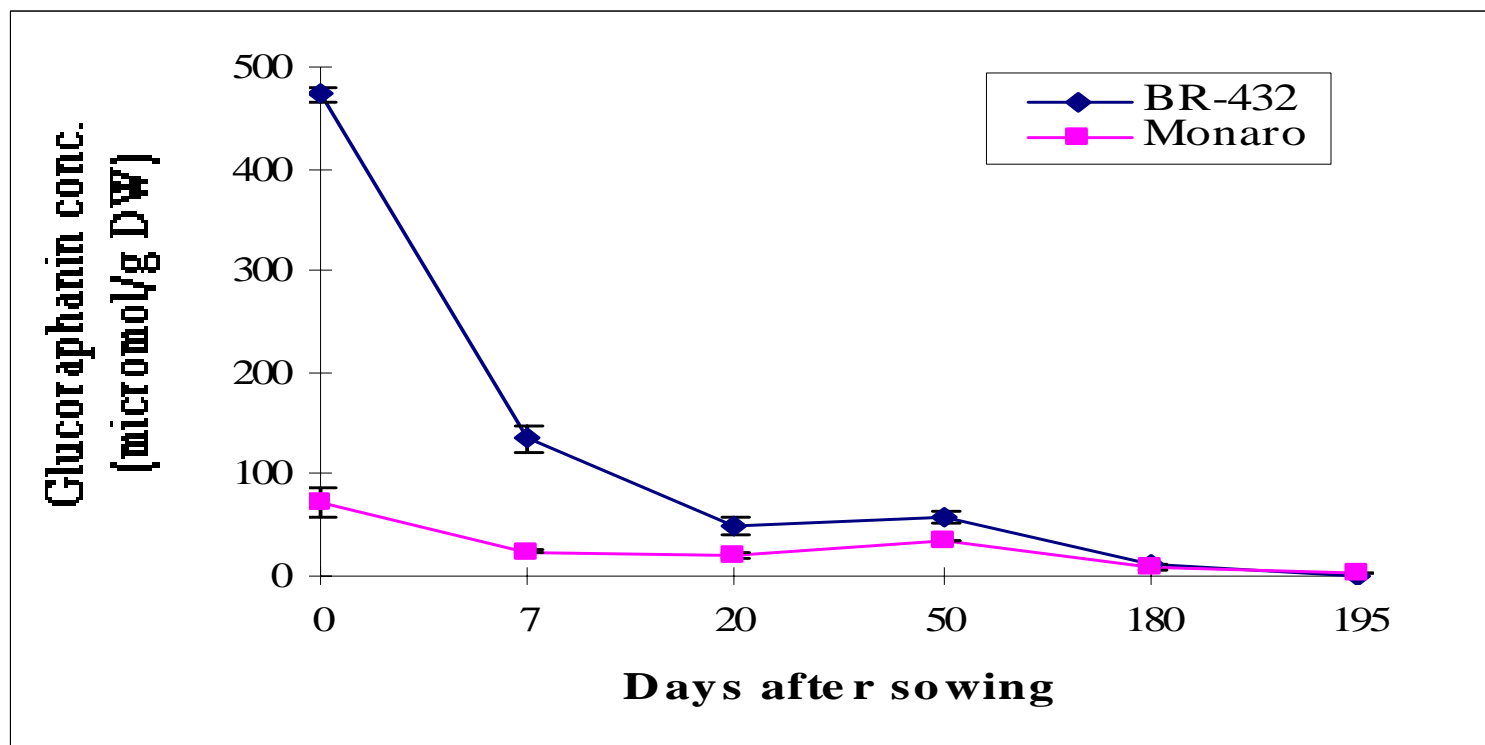
	Control (No extra S)	High S application
Claudia	171.1	427.6
Marathon	2141.3	2964.2
TB-234	849.4	1384.0

Conclusion:

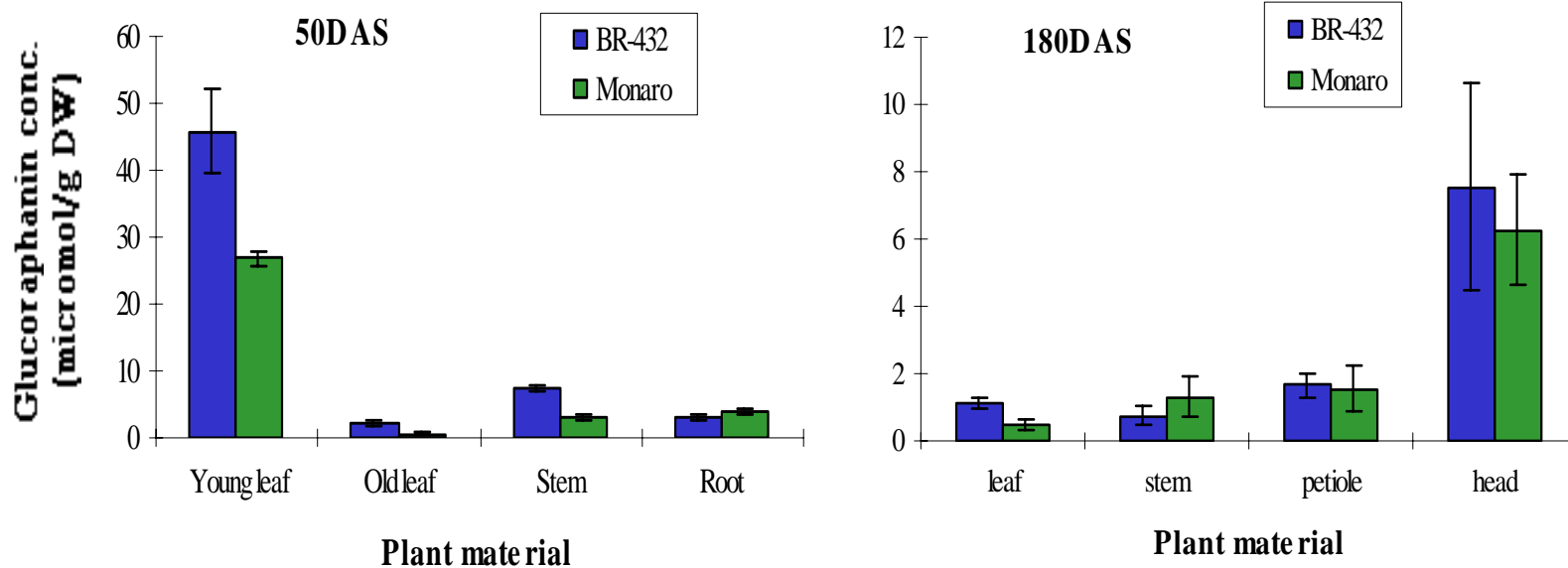
- **Increasing S content with S fertiliser application led to an increase in glucoraphanin content in all plant organs. A large increase was found in broccoli heads and mature seeds.**

Harvest timing

- Glucoraphanin concentration during plant development



Glucoraphanin in different parts of plant

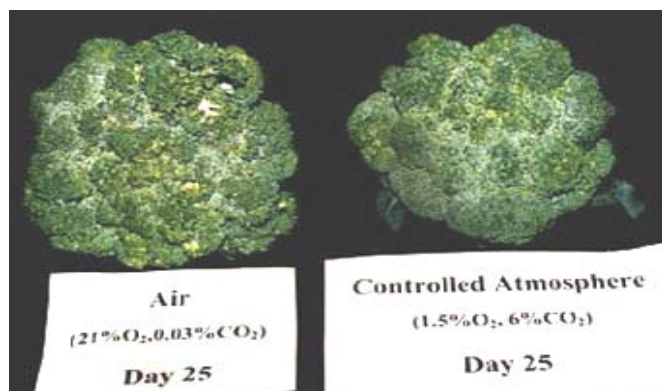


Packaging

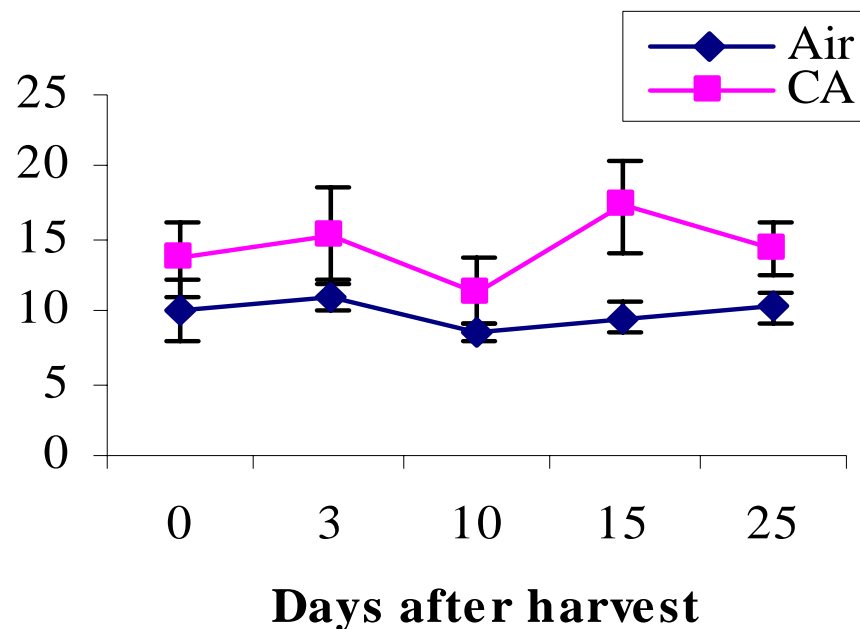
Changes of glucoraphanin concentration in different storage condition

Air (21%O₂:0.03%CO₂) at 4°C

Controlled Atmosphere (1.5%O₂:6%CO₂) at 4°C



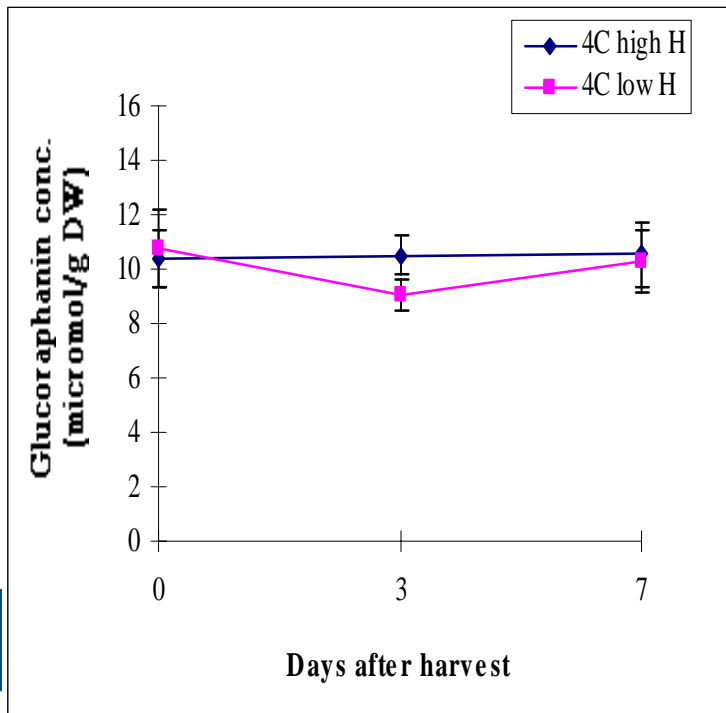
Glucoraphanin conc.
(micromol/g DW)



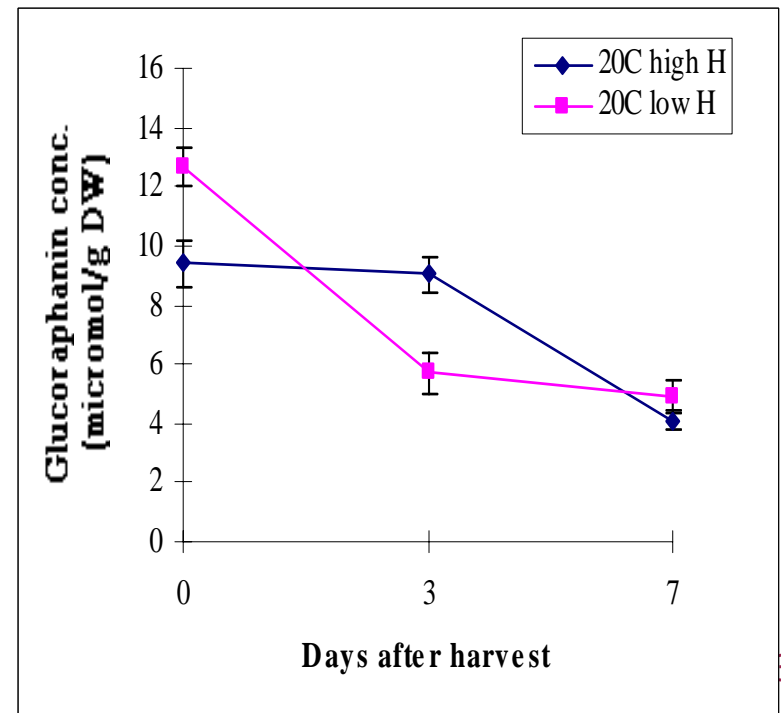
Storage Conditions

Changes of glucoraphanin concentration at different temperatures and humidity

4°C



20°C



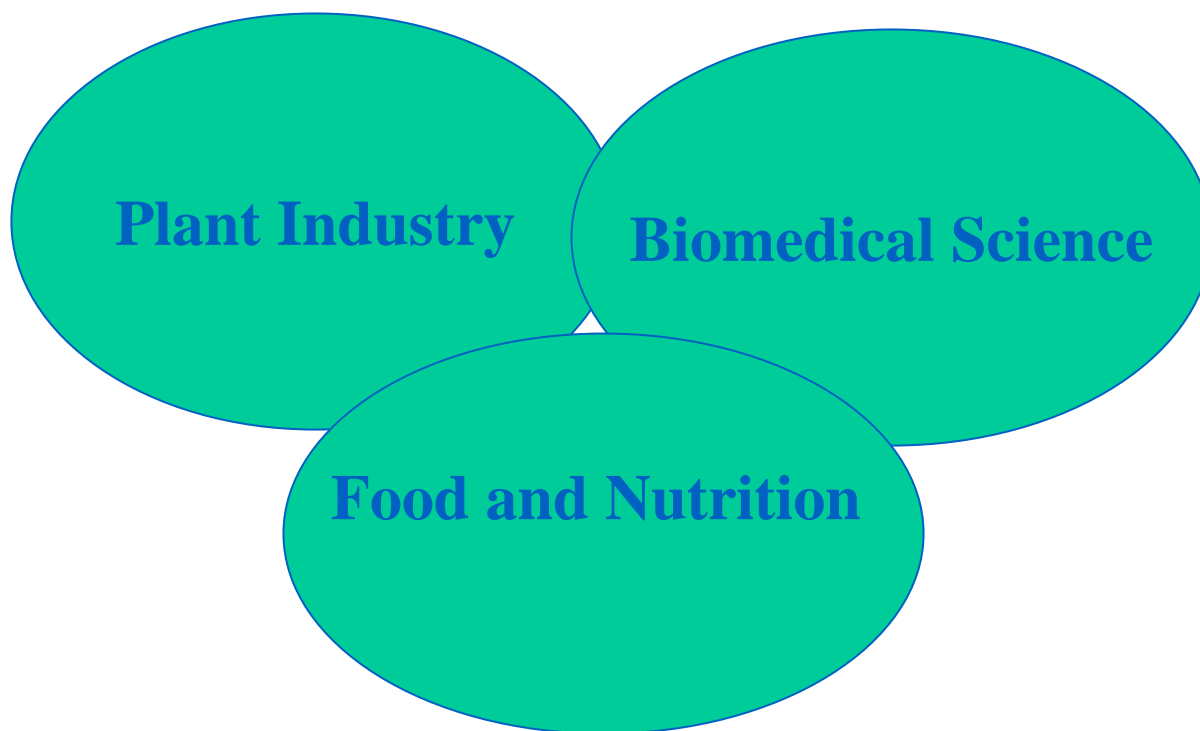
The future?

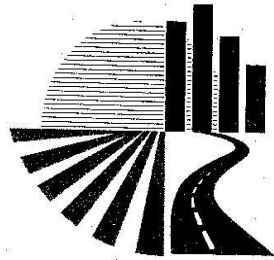
- **Specific purpose designed phytochemical enhanced and standardized horticultural products will be with us in the next 5 years, initially as curiosity foods in economically advantaged communities but will extend to all horticultural product users within a decade.**

We must evaluate their benefits, risks, nutritional characteristics and acceptability

- **We need clinical data to support the product**
- **We need toxicological data**
- **We need to know when we have too much phytochemical (levels of intake, guidelines)**
- **We need information on these new products and co-nutrition (other micro and macro nutrients) products**
- **More medical research especially on safety levels**

Phytochemicals and Health





National MARKETPLACE NEWS

The paddock-to-plate newspaper for the
fresh & processed produce industry



The horticulture industry's most widely read publication
- CAB audited circulation 13,000 - estimated readership 35,000.

Volume 18, Number 189
Registered by Australia Post, Publication No. VAC 5931.

MARCH, 2001.

\$2.75* (incl. GST)

LOST MILLIONS

Anti-Cold Oranges, Diet Avocado, Anti-Cancer Tomatoes, Healthy Heart Garlic...these are just some of the marketing opportunities that horticulture could be overlooking.



Millions of dollars foregone as the industry is slow to take up new technology that would see a proliferation of horticultural lines and the opening of new markets.

It is a failure to exploit the internal attributes of fresh



by Fiona Douglas

National

shandy, full cream, extra cream, extra calcium, long life UHT, soy, no fat, ultra filtered and the original plain (albeit homogenised).

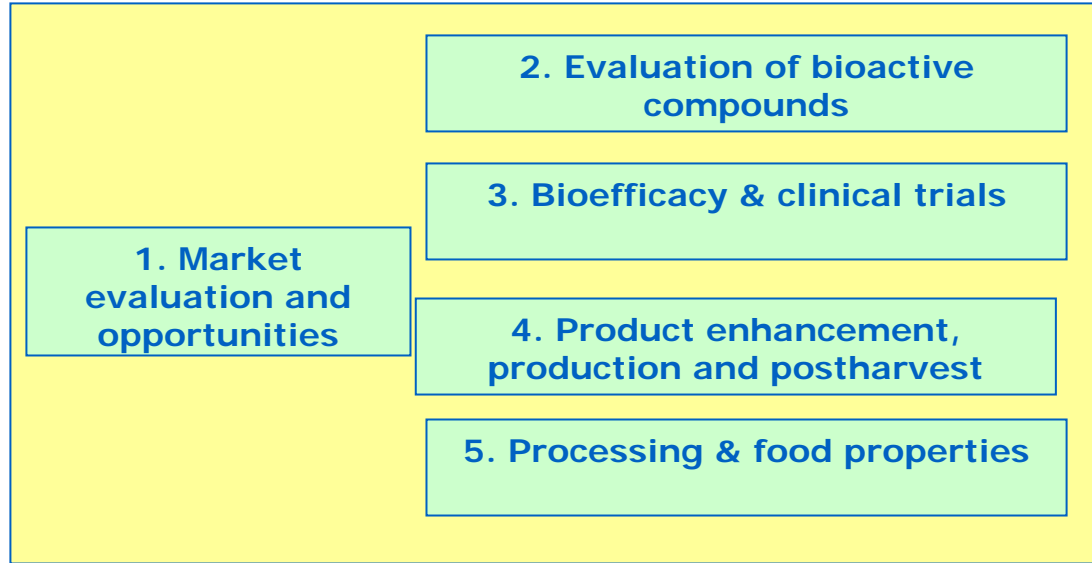
It comes as different brands, pack sizes and in-

Vital Vegetables - a trans-Tasman collaboration
to produce the complete vegetable; fresh,
flavoursome and functional





R&D Program



Market Research

- **Consumer focus groups** - Twelve focus groups comprised 8 to 10 participants drawn from Melbourne (3 groups), Sydney, Brisbane and Auckland (2 each), Adelaide, Wellington and Christchurch (1 each).
- **Quantitative research by questionnaire** - A telephone survey comprised 601 respondents in total: 450 in Australia and 151 in New Zealand.
- **Opinion leader research** - interviews with some key public figures participating in the food, health and retail sectors in both Australia and New Zealand.

Results

- **75% support research to enhance functional properties of fruit and vegetables**
- **63% claim they would probably or definitely buy new horticultural products if they had proven functional benefits**
- **43% would pay up to 30% more**
- **84% would prefer to consume functional foods as fresh fruit or vegetables**
- **85% prefer conventional plant breeding**
- **70% would not buy if it was created by genetic engineering**
- **58% would prefer taste over functional benefit**

3 strong market segments were identified

- **Older people (50+ age group)** - the highest current users of vegetables and functional food together with a high propensity to buy functionally-enhanced vegetables.
- **Mothers of young children** - highly motivated to establish good eating habits in their children., with obesity in children at adolescence being a key issue.
- **Consumers touched by disease** - those with a family history of the most common life threatening diseases, including various forms of cancer, heart disease, diabetes and obesity.

Thanks

- *Rangkadilok N., Nicolas M., Bennett R., Premier R., Eagling D. and P Taylor (2002) Developmental changes of sinigrin in brassica nigra/brassica juncea and glucoraphanin in brassica oleracea var. Scientia Horticulturuae 96:11-26*
- *Rangkadilok N., Nicolas M., Bennett R., Premier R., Eagling D. and P Taylor (2002) Determination of Sinigrin and glucoraphanin in Brassica species using a simple extraction method combined with ion-pair HPLC analysis. Scientia Horticulturuae 96: 27-41*
- *Rangkadilok N., Tomkins B., Nicolas M., Premier R., Bennett R., Eagling D. and P Taylor (2002) The effect of post-harvest and packaging treatment on glucoraphanin concentration in Broccoli (Brassica oleracea var. Italica). Journal of Agricultural and Food Chemistry 50: 7386-7391*
- *Rangkadilok N., Nicolas M., Bennett R., Premier R., Eagling D. and P Taylor (2004) The effects of sulphur fertilizer on glucoraphanin levels in broccoli at different growth stages. Journal of Agricultural and food chemistry V 52(11) 2632-2639*
- *Premier R. (2002) Phytochemical Composition: A paradigm shift for food health consideration. Asia Pacific Journal of Clinical Nutrition. 11 (S6): S197-S201*