Chapter 5

Other beneficial effects of cruciferous vegetables, isothiocyanates and indoles

Cardiovascular disease

The beneficial effects of fruit and vegetables in preventing coronary heart disease and stroke were summarized in Handbook 8 (IARC, 2003). This section covers only studies in which cruciferous vegetables were distinguished as a separate group or isothiocyanates or indoles were identified as distinct dietary constituents, and in which results were reported separately for these items (Table 60).

The relationship between coronary heart disease and cruciferous vegetable intake was examined by Joshipura *et al.* (2001) within a study of nurses' health and a follow-up study of health professionals. They studied non-fatal cases of myocardial infarct or fatal cases of coronary disease, confirmed by review of medical records by WHO criteria or designated 'probable' if confirmatory information was obtained by interview or letter. There were 1063 incident cases of coronary heart disease among men and 1127 among women. While total fruit intake and total vegetable intake were both inversely related to risk, inverse associations were also observed with high consumption of cruciferous vegetables. The results were similar for men and women. [The Working Group noted that confidence intervals were provided only for both sexes combined.]

Gaziano *et al.* (1995) obtained information on dietary intake of foods identified as having a high carotene content (including broccoli and Brussels sprouts) from 1273 residents of Massachusetts (USA), aged 66 years or more. The response rate was 96%. After an average of 4.75 years of follow-up, there were 270 confirmed deaths of known cause, of which 161 were attributed to cardiovascular disease. When people who ate one or more servings per day were compared with those who ate less, a nonsignificant inverse relationship was found between death from cardiovascular disease and intake of broccoli or Brussels sprouts. [The study was limited by the fact that only a small proportion of the population (1.4%) reported daily consumption of broccoli or Brussels sprouts, and the analysis was adjusted for only a few confounders.]

Joshipura *et al.* (1999) looked at the association between fruit and vegetable intake and incident stroke confirmed from medical records in the study of nurses' health and the follow-up study of health professionals. Cruciferous vegetable intake was inversely related to the risk for ischaemic stroke in men and women and in the combined analysis. The authors observed that biological evidence for a protective role of any single constituent of fruits and vegetables was inconclusive; the potentially beneficial constituents included potassium, folate and fibre.

Cataract

The relationship between cataract and cruciferous vegetable intake was examined within the follow-up study of health professionals (Brown *et al.*, 1999). Self-reported cataract extraction (of which 83% were confirmed from ophthalmologists' records) was used as the end-point. The primary hypothesis was for a protective effect of lutein and zeaxanthin, and an inverse relationship was found for intake of these nutrients. When intake of two cruciferous vegetables was assessed, broccoli showed the strongest inverse relationship with cataract; there was no significant association with kale.

Anti-bacterial activity

The anti-microbial properties of extracts of cruciferous plants were first reported in the early 1900s, but interest in their use as food preservatives has grown only during the past decade (Delaquis & Sholberg, 1997). Particular attention has been focused on allyl-ITC, which constitutes 90% of the volatile essential oils isolated from horseradish (*Amoracia lapathifolia*) and has consistently shown antimicrobial activity in both liquid and vapour forms (Kyung & Fleming, 1997; Shofran *et al.*, 1998; Ward *et al.*, 1998). This compound, which is poorly

Table 60. Cruciferous vegetable intake and risk for coronary heart disease, stroke and cataract

Author, year, country	Cases/cohort size, sex (years of follow-up)	Exposure measure (no. of items)	Range contrast (no. of categories)	Relative risk (95% CI)	Adjustment for confounding	Comments
Coronary heart disease						
Joshipura *et al.* (2001) USA	1127/84 251 (14 years) women and 1063 / 42 148 (8 years), men	Cumulative average daily intake of cruciferous vegetables from FFQ (131 in HPFS, 126 in NHS)	Highest versus lowest (5) Women Men Pooled	 0.80 0.93 0.86 (0.75–0.99)	Age, smoking, alcohol, family history of myocardial infarct, body mass index, vitamin supplement and vitamin E use, physical activity, aspirin use, hypertension, hypercholesterolaemia, total daily caloric intake, 2-year follow-up periods, postmenopausal hormone use	Prospective cohort (HPFS, NHS)
Gaziano *et al.* (1995) USA	161/1273 (4.75 years)	FFQ (43)	≥ 1 serving/day versus < 1 serving/day (2)	Broccoli and/or Brussels sprouts 0.29 (0.04–2.12)	Age, sex	Mortality Cohort study
Stroke						
Joshipura *et al.* (1999) USA	366/75 596 women (14 years) and 204/38 683 men (8 years)	Cumulative average daily intake of cruciferous vegetables from FFQ (131 in HPFS, 116 in NHS)	Highest versus lowest (5) Women Men Pooled	 0.77 (0.54–1.08) 0.64 (0.42–0.99) 0.71 (0.55–0.93)	Age, smoking, alcohol, family history of myocardial infarct, body mass index, vitamin supplement and vitamin E use, physical activity, aspirin use, hypertension, hypercholesterolaemia, total energy intake, time periods, postmenopausal hormone use	Incidence Prospective cohort (HPFS, NHS)
Cataract						
Brown *et al.* (1999) USA	840 cases/36 644 men (8 years)	Semi-quantitative FFQ (131)	> twice/week versus < once/month (4)	Broccoli 0.77 (0.61–0.97) $p_{trend} = 0.02$ Kale 0.85 (0.47-1.56) $p_{trend} = 0.86$	Age, time, diabetes, smoking, body mass index, area of residence, aspirin use, energy intake, physical activity, alcohol, routine eye examinations, profession	HPFS

FFQ, food frequency questionnaire; HPFS, Health Professionals Follow-up Study; NHS, Nurses' Health Study

soluble in water, is more potent against microorganisms in the gaseous state, as indicated by lower values for the 50% inhibitory concentration. The extent of inhibition appears to be species-specific and concentration-dependent. Interestingly, pathogenic bacteria are strongly inhibited, while lactic acid bacteria, which themselves inhibit undesirable bacterial growth, are largely unaffected (Ward *et al.*, 1998). When tested for bactericidal activities against a variety of bacteria, allyl-ITC appeared to be effective at all growth stages and not only on cells in the exponential growth phase (Lin *et al.*, 2000a). Its ability to inhibit stationary cells is relevant to its application in food preservation, as processing and temperature conditions generally reduce the metabolic activity of bacteria in food systems. Allyl-ITC has been reported to be an effective bacteriostatic and bactericidal agent in the preservation of lettuce and pre-cooked roast beef and is being investigated for use in controlling contamination of pre-packaged salads by pathogens, as these can still retain bacteria despite washing with chlorinated water (Ward *et al.*, 1998; Lin *et al.*, 2000b).

Another member of the isothiocyanate family with significant antibacterial activity is 6-methylsulfinylhexyl-ITC, extracted as a volatile fraction from wasabi (*Wasabia japonica* Matsum) stems and a variety of cruciferous vegetables (Ono *et al.*, 1998).

Fahey *et al.* (2002) reported that sulforaphane had a bactericidal effect against intracellular *Helicobacter pylori* in a human epithelial cell line (HEp-2).