Chapter 7

# Toxic effects

## Human studies

Potential adverse effects of fruit and vegetable consumption have been investigated in relation to nitrates (Steinmetz & Potter, 1991), pickled vegetables, as prepared traditionally in Asia (IARC, 1993), goitrogens in cruciferous vegetables (Steinmetz & Potter, 1991), aflatoxins in dietary staples including dried fruit particularly in Africa, south-west Asia, southern China and episodically in the USA (IARC, 1993), other contaminants, e.g. cyclosporiasis (Osterholm, 1997), pesticides and herbicides (Steinmetz & Potter, 1991) and Alar, a growth regulator used to treat apples (Steinmetz & Potter, 1991). There appears to be little evidence that exposure to these factors as a result of dietary intake of fruit and vegetables leads to adverse effects.

Undesirable effects from consumption of fruit and vegetables that can occur range from bloating, flatulence and cramps to immunoallergic reactions. Allergic reactions have been associated with tomatoes, kiwi fruit, bananas and other fruit (Wagner & Breiteneder, 2002). A vegetable which may cause allergic reactions is celery. Celery root is often consumed in a processed form as a cooked vegetable or as a spice. Ballmer-Weber *et al.* (2002) studied the allergenicity of processed celery in celery-allergic patients. In 12 patients with a history of allergic reactivity to raw or cooked celery, double-blind placebo-controlled food challenges with raw celery, cooked celery and celery spice were performed. Six patients showed a positive reaction to cooked celery. The conclusion was that celery remains allergenic even after extended thermal treatment.

## Animal studies

Many toxicants occur in plants consumed by humans, but the majority of these do not occur in cultivated fruits or vegetables. A few animal studies have been conducted to test for toxic effects due to feeding of fruit or vegetables, as summarized below.

### Cruciferous crops (goitre)

Glucosinolates predominantly occur in the family of the *Cruciferae*, in particular in the *Brassica* species. These include cabbage species, radish, cress and rapeseed. Thioglucosidases hydrolyse the glucosinolate into glucose, sulfate ions and the aglycone (organic isothiocyanates or mustard oil). The aglycones inhibit thyroid function and therefore are also called goitrogens.

The first harmful effect in animals fed *Brassica* vegetables was reported 75 years ago, when relatively large amounts of cabbage fed to rabbits caused goitre development (Chesney *et al.*, 1928). Fifteen years later, it was shown that the thiocyanate product of the indolyl glucosinolate (GS) caused goitre in animals with a dietary iodine deficiency (Astwood, 1943). Growth retardation, liver lesions or necrosis and thyroid hypertrophy or hyperplasia occur in most animals when the diet contains approximately 2–5 mg GS/g diet (Fenwick *et al.*, 1989). Mink have been adversely affected by diets containing GS levels of only 0.5 mg/g diet (Belzile *et al.*, 1974). Cattle fed large quantities of kale developed severe haemolytic anaemia (Rosenberger, 1939). After 1–3 weeks of kale feeding, most ruminant animals produced the first signs of the disease: the appearance of stainable granules within the red blood cells known as Heinz–Ehrlich bodies. These bodies are formed by dimethyl disulfide, a product of *S*-methylcysteine sulfoxide (SMCSO). SMCSO intake in goats at 15–19 g/100 g bw elicits this haemolytic response (Smith, 1978). Rats fed SMCSO at 2% in the diet showed growth depression, anaemia and splenic hypertrophy (Uchino & Itokawa, 1972; Uchino & Otokami, 1972). SMCSO occurs in plant tissue in variable amounts up to 4%. Besides *Brassica* vegetables, SMCSO has been shown to be present in various beans, *Allium* (onion, garlic, chives), radish and cowpea. It is obtained by conversion of *S*-methylcysteine formed by methylation of cysteine by methionine (Stoewsand, 1995).

### Umbelliferous crops (phototoxicity)

Furocoumarins present in certain food plants may give rise to phototoxicity. In particular, umbelliferous crop plants, such as the parsnip (*Pastinaca sativa* L.) elaborate enhanced levels of furocoumarins, including psoralens, when subjected to biotic or abiotic stress. Young male mice were fed for 30 days diets containing 32.5% dried healthy, 32.5% apparently healthy or 32.5% fungicide-treated and 8, 16 or 32.5% dried diseased (*Phoma complanata*-infected) parsnip root tissue (Mongeau *et al.*, 1994). Dried healthy parsnip, compared with controls, did not significantly affect cellular proliferation or histopathological parameters. No histopathological changes were observed in the oesophagus and forestomach with any of the diets. In the liver, only the highest level of dried diseased parsnip led to swelling of cells in hepatic lobules. Using [$^3$H]thymidine, a dose-related increase in cell labelling with the level of diseased parsnip was seen in the liver; a slight, not significant, increase was noted with fungicide-treated parsnip. Increased [$^3$H]-thymidine labelling with feeding diseased parsnip was also found in the forestomach but not in the oesophagus.

## Celery (allergenic compounds)

Although for humans some fruit and vegetables are known to be allergenic, almost no animal studies have been performed in which fruit or vegetables have been tested for allergenicity.

Celery, which is allergic for humans, has been tested for allergenicity in mice (Ballmer-Weber *et al.*, 2002). Intraperitoneal immunization of mice followed by a rat basophil leukaemia cell mediator release assay was used to assess the allergenicity of processed celery. The murine model reflected the allergenicity observed in humans.

## Bitter gourd (general toxicity)

*Momordica charantia* (bitter gourd) 5% aqueous extracts were tested orally in mice at doses of 50 and 100 μL/mouse per day for three months (Ganguly *et al.*, 2000). The dose of 50 μL was well tolerated but, at the higher dose, food intake was severely reduced and the animals had rapid loss in body weight, fall in blood glucose level and high mortality.