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Strategies for preventing multi-micronutrient deficiencies: experiences with food-based approaches in developing countries

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ABSTRACT

The importance of multiple micronutrient deficiencies in developing countries (DCs) is gaining recognition, prompted by the often disappointing responses observed with single micronutrient supplementation programmes. Further, of concern, is the feasibility of supplementation as a mode of delivery in poor resource settings. As a result, there is increasing emphasis on food-based approaches. Several novel delivery approaches have been developed for home-based fortification, especially for complementary foods, in an effort to reduce risk of antagonistic micronutrient interactions. These involve using crushable or water-soluble tablets, and sprinkles, which are designed to supply micronutrients at the level of one or two recommended dietary allowances, without any changes in feeding practices, and irrespective of the amount of complementary food consumed. Alternatively, fortified spreads, designed as a ready-to-use therapeutic food for the treatment of malnourished children, can be used. In poor resource settings, improving dietary quality through household diversification/modification and nutrition education is being pursued. In the future, at the crop production level, biofortification, involving the application of soil or foliar fertilizers, plant breeding, or genetic modification will probably become the most sustainable approach to improve micronutrient adequacy, for the entire household and across generations in DCs. This review summarizes the new developments in food-based approaches, their advantages and limitations, and discusses some of the studies that have been carried out to examine their efficacy for alleviating multi-micronutrient deficiencies in poor resource settings.

INTRODUCTION

Muriel Bell completed her MD research on goiter. These findings contributed to the introduction of iodised salt in New Zealand and led to her life-time interest in public health and applied research. Indeed, during her scientific career, Muriel Bell supported many efforts to improve the nutritional quality of foods. Hence, a review focusing on food-based strategies to prevent multiple micronutrient deficiencies is an appropriate topic for the Muriel Bell lecture.

The existence of multiple micronutrient deficiencies in DCs is gaining increasing recognition (Ramakrishnan, 2002). Their etiology is multifactorial: both inadequate intakes, and genetic, parasitic and infectious diseases may all play a role (Stoltzfus, 2001; Fishman *et al*., 2000). Inadequate intakes of certain micronutrients such as iodine, selenium, and zinc, can also be exacerbated by environmental factors, because their content in plant-based foods are dependent on soil trace element levels (Gibson and Hotz, 2001). Micronutrient deficiencies can have major health consequences, contributing to impairments in growth, immune competence, mental and physical development, and poor reproductive outcomes (Viteri and Gonzalez, 2002; Ramakrishnan, 2002), which cannot always be reversed by nutrition interventions.

Clearly, there is an urgent need for programmes to alleviate micronutrient deficiencies in developing countries. Several efficacy trials employing multi-micronutrient supplements have been conducted on selected population groups in developing countries. Results have been mixed, depending on the combination of micronutrients included, age group, life-stage group, initial nutritional status of the subjects, (including HIV status), and the outcomes measured (Christian, 2003; Lind *et al.,* 2003; 2004). These findings have highlighted that a cautious approach is needed with regard to routine use of multi-micronutrients supplements. Further, in poor resource settings, the feasibility of supplementation as the mode of delivery is of concern. As a result, increasingly, food-based approaches involving fortification, improving dietary quality through diversification/modification and nutrition education, and biofortification are being pursued. Some of these new developments, designed especially for poor resource settings, are discussed below.

New approaches for fortifying complementary foods

Risk of direct antagonistic interactions between micronutrients is less when they are provided in fortified foods because of the presence of dietary ligands in the foods (Sandström *et al.,* 1985). As a result, several novel delivery approaches have been developed for supplying micronutrients in foods, especially during the complementary feeding period. At this time, inadequacies in several micronutrients, notably iron, zinc, and calcium, and sometimes vitamin B6, vitamin A and riboflavin, have been reported in complementary foods in developing countries (WHO, 1998; Dewey and Brown, 2003; Gibson *et al.,* 1998a). Such deficits arise because cereals or starchy roots and tubers are used as a basis for complementary foods in poor resource settings. These staples often contain high levels of phytic acid, polyphenols, and/or dietary fibre, all components known to inhibit absorption of certain micronutrients (e.g. iron, zinc, and calcium) (Gibson *et al.,* 1998a). Unfortunately, inclusion of animal-source foods, a rich source of absorbable iron and zinc, is often not feasible in complementary foods given to infants living in poor resource settings.

In an effort to reduce risk of these micronutrient inadequacies during the complementary feeding period, complementary food supplements (CFS) have been developed. At present, three types of CFS are available: crushable or water-soluble tablets—termed foodlets, sprinkles, and fortified spreads; they have been summarized in detail by Nestel *et al.* (2003). They have been designed to supply vitamins and minerals at the level of one or two recommended dietary allowances, without any changes in feeding practices, and irrespective of the amount of complementary food consumed. Ideally, the foodlets and sprinkles should be added to the complementary food after cooking, and consumed soon after to avoid destruction of both heat labile vitamins (e.g., vitamin C) and in sprinkles, the encapsulation system used to stabilize micro-and macronutrients.

Although antagonistic interactions between two or more micronutrients are less likely to occur when the foodlets or sprinkles are consumed with food, nevertheless, bioavailability of iron, zinc, and probably calcium may still be compromised when high phytate complementary foods are fed (Gibson *et al.,* 1998a). Household strategies can be used, however, to reduce the phytate content of such cereal and legume-based complementary foods; these strategies have been summarized elsewhere (Gibson *et al.,* 1998a; 1998b; Gibson and Hotz, 2001).

Unlike the foodlets or sprinkles, the fortified spreads are a ready-to-use therapeutic food (RUTF) designed to treat severely malnourished children; they are available in single serving sachets, or larger containers. The RUTFs are energy-dense pastes prepared from a mixture of dried milk products, powdered precooked soy flour, sugars, maltodextrin, vegetable fat, with added minerals and vitamins. They do not have to be cooked before consumption and have a low water content, so that risk of interactions among micronutrients, as well as bacterial contamination during home storage, is low (Ciliberto *et al*., 2005). RUTFs are commercially available, packed in oxygen-free foil sachets (Nutrieset, Malaunay, France), but they can also be produced locally at a lower cost. Indeed, a locally produced RUTF has been shown to be as effective as the imported RUFT in the home-based treatment of malnourished children in Malawi (Sandige *et al.,* 2004). In these studies, the malnourished children consumed the RUTF directly from the jar, without diluting it or mixing it with other foods. However, the RUTF can also be added to a traditional cereal-or legume-based porridge when used for feeding infants aged 6 to 12 mos, who may find the thick paste difficult to swallow. In the future, it may be possible to add commercial acid-resistant phytase enzymes to the CFS including RUTFs; these enzymes hydrolyze phytic acid during digestion in the stomach (Gibson and Hotz, 2001).

Several trials of the efficacy of CFS have been completed recently (Zlotkin *et al*., 2001; 2003; Smuts *et al.,* 2005; Ciliberto *et al.,* 2005). In at two-month efficacy trial in rural Ghana, Sprinkles containing 80 µg/d Fe as microencapsulated ferrous fumarate were shown to be as efficacious as ferrous sulphate drops in the treatment of anemic infants (n=560), with a mean recovering rate of about 60% in both groups (Table 1) (Zlotkin *et al.,* 2001).

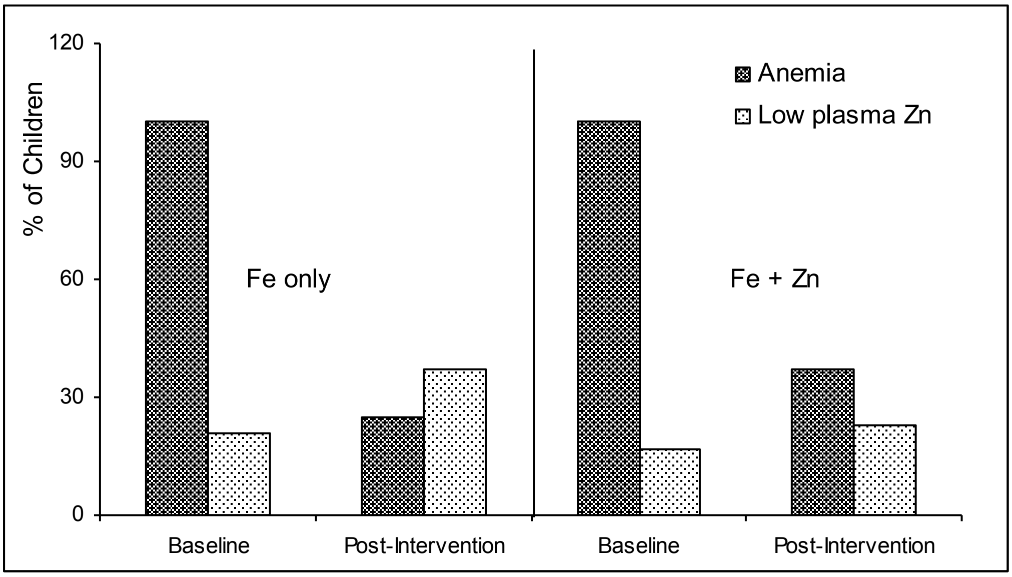
Table 1: Mean haemoglobin and percent anemic by treatment group at baseline and after two months of treatment (mean ± SD) (Zlotkin and Tondeur, 2004)

	Sprinkles (n = 246)	Drops (n = 247)
Baseline		
Haemoglobin (g/L)	87 ± 8[a]	87 ± 9
Anaemic (%)	100[b]	100
Final		
Haemoglobin (g/L)	102 ± 16	100 ± 17
Anaemic (%)	42.3	43.7

[a] Values are baseline (p=0.63) and final visit (p=0.23)were not significantly different in both groups
[b] Values are percent anaemic where anemia is defined as haemoglobin values of <100g/L
[c] Mean haemoglobin values increased from baseline to the final visit in both groups (p<0.001)

Subsequent studies have confirmed the safety and efficaciousness of Sprinkles in both the treatment and prevention of anemia, and its acceptability to both infants and caregivers (Zlotkin and Tondeur, 2004). Moreover, results of a dose-response randomized controlled trial on anemic infants have indicated that lower doses of iron (ie 12.5 to 20 mg/d) from Sprinkles are efficacious in treating iron deficiency anemia in infants. This latter finding is important in view of the results of a second study in Ghana in which sprinkles containing zinc gluconate (10 mg Zn) and/or microencapsulated ferrous fumarate (80 mg Fe) were mixed with maize porridge and fed to anemic Ghanaian infants for two months. In this study, the rate of recovery from anemia was greater in the group receiving the iron alone compared with the Fe+Zn group (74.8 vs. 62.9 %; p=0.048). Further, the plasma zinc concentrations decreased in both groups (Figure 1), although there was a tendency for the decrease to be less in the Fe+Zn than in the Fe group. There was also a decline in height-for-age Z-score in the Fe+Zn group (p=0.0011), but no change in the Fe group (Zlotkin *et al.,* 2003).

Figure 1: Effect of Fe (80 mg) sprinkles with and without Zn (10mg) on the prevalence of anaemia and low plasma Zn in anaemic Ghanaian infants (Zlotkin et al., 2003).



Several other micronutrients, besides iron and zinc, can be incorporated into Sprinkles. In Mongolia, Sprinkles containing iron, ascorbic acid, folate, zinc, and vitamin D have been distributed to about 11,200 infants and young children over a 12 month period during a World Vision sponsored effectiveness programme (Zlotkin and Tondeur, 2004).

The efficacy of foodlets has recently been evaluated in a four-country (Peru, Indonesia, Vietnam, and South Africa) trial of full-term infants (birth weight $\geq$ 2500 g) (6-11 mos). Infants (n = 1134) were randomized to receive: (a) a weekly foodlet-based multiple micronutrient supplement (at twice dose of daily foodlet); daily foodlet-based multiple micronutrient supplement, daily foodlet containing iron alone (10 mg); or a daily placebo for six mos. Daily use of the multi-micronutrient foodlets for six months resulted in a greater reduction in anemia, biochemical iron, zinc, vitamin A and riboflavin deficiency, and a greater weight (but not height) gain compared to those infants receiving the placebo foodlet. However, among the infants receiving the foodlet containing iron alone, zinc deficiency increased by a third (based on plasma Zn < 10.7 µmol/L) compared to that of the placebo group (36.7 vs. 29.1 %) (Smuts *et al.,* 2005). These findings suggest the existence of an antagonistic interaction between iron and zinc, probably because three of the four countries in this trial administered the foodlets as a supplement alone (Sandström *et al.,* 1985; Troost *et al.,* 2003), rather than mixing them with the complementary food (Nestel *et al.,* 2003).

It is of interest that notwithstanding the improvement in biochemical micronutrient status and weight gain in this four-country study, growth faltering was not prevented in any group in the four-country study. Several factors may constrain the growth experienced by infants and young children living in poor resource settings. They include prenatal and/or intergenerational maternal malnutrition (Ramakrishnan *et al.,* 1999), infection (Filteau and Tomkins, 1994), child feeding practices (Engle and Zeitlin, 1996), and the consumption of complementary diets inadequate in energy and several micronutrients (WHO, 1998; Dewey and Brown, 2003). These findings emphasize the critical need for sustainable dietary strategies to enhance both energy and micronutrient adequacy of the plant-based diets across generations in developing countries; some of these strategies are outlined below.

Household dietary strategies

Details of dietary strategies that can be used in the household to enhance intakes of energy of infants and young children as well as the content and bioavailability of micronutrients have been summarized earlier (Gibson *et al.,* 1998a; Gibson and Hotz, 2001). These strategies involve: (a) increasing the energy density of the diets; (b) increasing the production and consumption of foods with a high content of micronutrients; (c) increasing production and consumption of foods known to enhance micronutrient bioavailability; and (d) reducing the content of absorption modifiers (eg. phytate and polyphenols) known to inhibit micronutrient bioavailability. They are discussed briefly below.

The energy (and micronutrient) density of porridges used for infant and young child feeding can be increased by using thicker porridges prepared with 20-28% dry matter, a practice that can be facilitated by the addition of small amounts of germinated cereal flours. The α-amylase in the germinated cereals hydrolyzes amylose and amylopectin to dextrins and maltose, reducing the viscosity of thick porridges to an easy-to-swallow semi-liquid consistency suitable for infant and child feeding, without dilution with water.

To increase the micronutrient content of household diets, small livestock production and aquaculture can be promoted, and consumption of meat, poultry, and fish encouraged to ensure they are not sold for cash but targeted to those household members at high risk of micronutrients. Incorporation of some flesh foods into predominately plant-based porridges used for infant and child feeding has several advantages. Flesh foods are good sources of readily available haem iron and zinc, as well as vitamin B12 and B2, also frequently limiting in plant-based diets. Incorporation of dried fish has the added advantage that it does not require refrigeration, and can be consumed in countries where religious and/or cultural beliefs prohibit the consumption of meat. When consumed as a flour, small whole dried soft-boned fish can be used to enrich cereal porridges for infant or young child feeding, providing a good source of protein, readily available calcium, zinc, and for certain oily fish (e.g. mackerel) preformed vitamin A.

An additional advantage of consuming sources of cellular animal protein is that they also enhance the absorption of non-haem iron and zinc from plant-based foods Sandström *et al.,* 1989*)*, even in the presence of dietary inhibitors such as phytic acid (Reddy *et al.,* 1996). However, the magnitude and mechanism of these effects in different types of meals remain uncertain (Sandström *et al.,* 1989; Reddy *et al.,* 1996). Other enhancing methods involve the addition of foods containing organic dietary components such as ascorbic acid, a well-recognized enhancer of non-haem iron absorption. Other organic acids (eg citric and lactic acid) produced during the fermentation may also enhance non-haem iron and zinc absorption to some degree, possibly by forming soluble ligands in the gastrointestinal tract, thus preventing the formation of insoluble compounds with phytate (Gibson and Hotz, 2001).

Finally, methods based on changes in food preparation and processing methods can be used to reduce the content of absorption inhibitors, specifically phytate. The methods involve inducing enzymatic hydrolysis of phytic acid by endogenous cereal and/or microbial phytases through germination and fermentation, respectively, or soaking to reduce the phytic acid content of some cereal and legume flours by passive diffusion because their phytic acid is stored in a relatively water-soluble form; some polyphenols that inhibit iron absorption may also be lost via soaking (Gibson and Hotz, 2001). Several *in vivo* isotope studies in adults have reported improvements in both iron (Hurrell *et al.,* 2003) and zinc (Egli *et al.,* 2003) absorption in foods prepared with cereals with a reduced phytate content.

Only a few efficacy trials have been undertaken on infants and young children to assess the impact of these household strategies on iron and zinc absorption (Manary *et al.,* 2000; Manary *et al.,* 2002a), nutrient adequacy (Gibson *et al.,* 2003; Hotz and Gibson, 2005), and biochemical and/or functional outcomes in infants and children (Manary *et al.,* 2002b; Yeudall *et al.,* 2002; Garcia *et al.,* 2003; Mamiro *et al.,* 2004). In a small hospital-based study in Malawi, phytate-reduction of a corn-plus-soy porridge via commercial phytase enzyme increased fractional and total zinc absorption in children recovering from tuberculosis but had no effect on zinc absorption in apparently well children (Manary *et al.,* 2000). It is also of interest that the phytate reduction reduced endogenous zinc losses in the recovering children but not the well children, presumably to provide sufficient retained zinc for the rapid catch-up growth and repletion of stores observed in the recovering children.

In a recent study in rural Mexico, no improvement in biochemical iron status was observed among iron-deficient women receiving 25 mg ascorbic acid from fresh lime juice twice a day, 6 days/week, for 8 months, compared to those receiving a placebo (Garcia *et al*., 2003), despite a two-fold increase in iron absorption, based on earlier stable isotope results (Diaz *et al.,* 2003). Similarly, after withholding coffee for 6 months, no positive effect on iron status was observed among iron-deficient Guatemalan toddlers, except among those taking iron supplements (Dewey *et al.,* 1997), attributed to the relatively small amount of coffee ingested. Likewise, in a large community-based double-blind randomized controlled trial in Tanzania in which a processed complementary food, based on soaked and germinated finger millet and kidney beans, with roasted peanuts and mango puree, and an identical unprocessed blend, were fed to six month-old infants (n = 309) for six months, there were no significant differences between the two groups at the end of the study in either anemia, iron status, as measured by hemoglobin and zinc protoporphrin, hair zinc concentrations, or growth. Failure to observe any positive response may be in part because there was only a 34% reduction in the phytate content of the processed complementary food (Mamiro *et al.,* 2004).

Results of these efficacy trials emphasize the importance of an integrated approach that combines a variety of the strategies discussed above, including the addition of even a small amount of animal source foods, is probably the best approach to improve the energy, micronutrient content, and bioavailability of diets based on plant foods. We have undertaken two such community-based efficacy trials among weanlings and young children in rural Malawi; details of the strategies used and their implementation have been published earlier (Gibson *et al.,* 1998b; 2003; Yeudall *et al*., 2002; Hotz and Gibson, 2005). The efficacy of these dietary strategies was evaluated by determining knowledge, trial and adoption of the new practices and comparing dietary quality and the adequacy of the energy and nutrient intakes of the intervention and control groups post-intervention (Gibson *et al*., 2003; Hotz and Gibson, 2005), and for the children only, changes in growth and body composition, morbidity, and hemoglobin and hair zinc concentrations (Yeudall *et al.,* 2000).

Biofortification

Future intervention strategies at the crop production level include biofortification to increase the content and/or bioavailability of micronutrients in staple food crops. Such strategies are especially appropriate for enhancing the micronutrient adequacy of plant-based diets across generations in developing country settings. They may include the application of soil or foliar fertilizers to improve the content of zinc, selenium, iodine, and/or iron in staple food crops (eg., wheat, maize, sorghum, beans), when grown in trace-element deficient soils, as practiced for zinc in Turkey (Yilmaz *et al.,* 1997), and for selenium in Finland (Varo *et al.,* 1994). Nevertheless, care is needed because too high amounts can have negative effects on plant growth and soil micro-organisms (Frossard *et al*., 2000).

Alternatively, plant-breeding can be used to increase iron and zinc concentrations in seeds of common beans (*Phaseolus vulgaris* L.), rice (especially aromatic varieties), and wheat, especially *Tritium dicoccum* Schrank species, with no negative correlations between grain yield and iron and zinc density in the seeds and grains. For maize, the expected increases in iron and zinc from plant breeding is less than those for rice and wheat, and some genetic modifications may be necessary to increase the concentration of iron and zinc in maize kernels (Welch and Graham, 2004). The effects of processing on the content and bioavailability of iron and zinc in these seeds have not yet been established.

Research is also underway to produce high β-carotene varieties of cassava roots, sweet potatoes, maize, and bananas. Genotypes containing the highest amount of beta-carotene have been found in the Amazonian regions of Brazil and Columbia. However, processing techniques influence the final β-carotene content of these foods, with some genotypes being more stable to various types of processing than others. Hence, any effects of processing must also be taken into account in any breeding programme.

For some crops (eg oilseed rape and rice), genetic engineering is the only way to enhance the content and in some cases the bioavailability of β-carotene (Shewmaker *et al.,* 1999; Ye *et al.,* 2000). Indeed, in the Philippines, 5000 hectares of a new variety of genetically modified "golden rice" containing a yellow daffodil gene that is rich in β-carotene were planted in 2004 (Chandrasekharan, 2000). Genetic modification can also be used to alter the amounts of absorption modifiers in plant foods. Possible approaches include producing new varieties of cereal grains with: (a) an increased content of methionine and cystine to promote zinc absorption in humans; (b) an enhanced ability to extract iron and/or zinc from soil (Reid *et al.,* 1996); and/or (c) a reduced phytic acid content (Raboy *et al.,* 1989). *In vivo* stable isotope studies have demonstrated increases in both iron (Mendoza *et al.,* 1998) and zinc (Adams *et al.,* 2002; Hambidge *et al*., 2004) absorption when adults were fed tortillas or polenta prepared from low-phytate hybrids of maize compared to those with their native phytate

Genetic engineering is also being used to introduce phytases from molds such as *Aspergillus niger* into cereal grains, although currently such phytases are almost completely deactivated during normal cooking procedures. Studies using the thermo-stable *Aspergillus fumigatus phytase* are in progress (Brinch-Pedersen *et al.,* 2002). Genetic engineering has also been used to introduce a gene that codes for a sulphur-rich metallothioneine-like protein into rice (*Oryza sativa),* a protein that increases the resorption-enhancing effect of iron from the small intestine.

CONCLUSIONS

More attention is urgently required to develop sustainable multi-micronutrient interventions suitable for poor resource settings. In such cases, deficits in both energy and micronutrients probably co-exist, especially in the complementary diets of infants (> 6 mos) and young children, so that provision of micronutrients alone is unlikely to prevent growth faltering during childhood. As a result, an integrated approach that combines a variety of dietary strategies, including, where feasible, the addition of even a small amount of animal source foods, is probably the best strategy to improve the energy and micronutrient density of plant-based complementary diets. In poor resource settings where inclusion of animal source foods is especially difficult, the addition of CFS such as foodlets or sprinkles to complementary foods should be explored, provided strategies are also introduced to simultaneously enhance their energy density. Alternatively, plant-based complementary foods can be fortified centrally, or at the village level, provided the fortificants selected are safe, stable, acceptable, bioavailable, and added at levels that do not induce any adverse nutrient–nutrient interactions or influence the organoleptic qualities and shelf-life of the complementary food. In the future, biofortification will probably be the most sustainable approach to improve micronutrient adequacy of plant-based diets across generations in developing countries.

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Antioxidant content of fermented products made from brassica waste

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ABSTRACT

Edible plant parts are a major source of dietary antioxidants required for health and well-being. The potential to utilise crop harvest residue and process waste by producing a fermented product is investigated. This novel fermented product can act as an additional source of antioxidants as well as adding value for the grower. In this study the content of vitamin C and total phenolic in broccoli and cauliflower stalks was measured before and after a fermentation process. Further, consumer acceptability for the processed product was determined by three groups from different cultural backgrounds.

The pith of fresh broccoli stalks had high vitamin C concentrations (mean ± SEM were 714.9 ± 7.1 and 633.5 ± 7.1 mg/100 g dry matter (DM), for large and small stalks, respectively). The outer-layers of fresh broccoli stalks had vitamin C concentrations of 269.9 ± 7.1 and 290.1 ± 7.1 mg/100 g DM, for large and small stalks, respectively. Large cauliflower stalks had significantly ($P<0.001$) lower vitamin C concentrations in the pith (481.0 ± 7.1 mg/100 g DM) and higher vitamin C concentrations in the outer-layers (355.8 ± 7.1 mg/100 g DM). Total phenolic concentration in the pith of fresh broccoli was 187.8 ± 3.3 and 188.4 ± 3.3 mg/100 g DM, for large and small stalks, respectively. The outer-layers of fresh broccoli stalks had total phenolic concentrations of 124.5 ± 3.3 and 116.6 ± 3.3, mg/100 g DM, for large and small stalks, respectively. Cauliflower had total phenolic concentrations of 205.5 ± 3.3 and 175.2 ± 3.3 mg/100 g DM, for pith and outer-layer, respectively. Fermentation decreased ($P<0.001$) vitamin C concentration to about 55% of that found in fresh stalks of broccoli and cauliflower (range 54.3-64%). Also, fermentation caused a reduction in total phenolic concentrations (about 28% and 15% for cauliflower and broccoli, respectively). The results from the taste panel indicated that the fermented broccoli and cauliflower could be acceptable condiments for consumers familiar with fermented products.

INTRODUCTION

Over the last few years there has been a plethora of biomedical research on antioxidants and active compounds derived from plants. Epidemiological studies have linked the increased consumption of plants products with reduced incidence of pathological diseases (Block *et al.,* 1992). Edible plant parts are the major source of dietary antioxidants required for health and well-being. Thus, the majority of published studies have been of the parts of plants considered edible. These edible parts in many cases represent a small fraction of the plant and the remainder is considered harvest residue or processing waste. These materials have an economic cost and disposal may cause environmental concern.

As a result of global environmental changes, urbanization and increased natural disasters, arable land is decreasing and food shortages are becoming chronic in many countries. Furthermore, in the light of increased populations, there is need to revise the current usage of raw material available for food and too utilize them to minimise waste. Many parts of plants have significant amounts of biologically active compounds (Peschel *et al.,* 2005). Crop harvest residue can be used as a dietary antioxidant source. This use may improve financial return, as well as reduce organic waste.

Of the many plants evaluated for their health benefits much attention has been focused on brassica vegetables. Biologically active compounds from brassica have been shown to prevent or interfere with progress of many diseases (for two good reviews see Beecher, 1994 and Podsędek, 2005). Therefore, the present study was undertaken to investigate the possible use of broccoli (*Brassica* *oleracea* var. Italica) and cauliflower (*Brassica oleracea* var. botrytis) stalks as a fermented condiment. The study also measured vitamin C and total phenolic changes in broccoli and cauliflower stalks before and after fermentation to measure the change in nutritional value.

MATERIALS AND METHODS

Samples

Standing harvest residue of broccoli was collected from a mid Canterbury commercial grower in April 2005, one week after saleable broccoli florets were harvested. Plants were cut about 5 cm from the soil surface and taken to the lab for preparation. The plants were divided into edible florets, leaves, stalks, flowered buds and woody parts and trimmings (Table 1). Broccoli stalks were grouped into large and small sized stalks based on their morphology (each plant had a large stem with branched small stalks).

Table 1: Composition of broccoli harvest remains and cauliflower processing waste.

	Broccoli harvest residue		Cauliflower	
	kg	%	kg	%
Edible Florets	1.49	9.57	11.84	62.55
Leaves	3.04	19.56	4.44	23.45
Stalks	3.38	21.75	2.25	11.89
Flowered buds	1.96	12.60	-	-
Woody parts and trimmings	5.67	36.51	0.40	2.11
Total	15.54	-	18.93	-

Ten whole cauliflowers (average weight ± SD was 1.58 ± 0.55 kg) were purchased from a Christchurch supermarket. Cauliflower has a large stem with no branching thus cauliflower stems were classed as large stalks. Cauliflowers were divided into different parts similar to broccoli harvest residue. Stalks from both plants were washed under warm running water (≅ 45°C), patted dried with paper towel and then fermented. Stalks from broccoli and cauliflower were placed in separate clean glass containers with other ingredients (herbs, spices and whole garlic cloves) and the mixture was topped with 6% brine solution at a stalk to brine ratio of 4:1 w/v. The mixture was left to ferment at room temperature (≅ 20°C) for 3 weeks.

Before analysis both fresh and fermented broccoli and cauliflower samples were peeled and divided into pith and outer-layer (contained epidermis, cortex and the vascular bundles tissues) reflecting the edible and non-edible parts, respectively (Table 2). This resulted in the following samples for broccoli: fresh large broccoli pith, fresh large broccoli outer layer, fresh small broccoli pith, fresh small broccoli outer layer, fermented large broccoli pith, fermented large broccoli outer layer, fermented small broccoli pith and fermented small broccoli outer layer. Cauliflower had the following samples: fresh large cauliflower pith, fresh large cauliflower outer layer, fermented large cauliflower pith and fermented large cauliflower outer layer. Fermented pith from large broccoli and cauliflower were sliced and used for the sensory evaluation. Samples for chemical analysis were frozen, freeze dried, pulverized, vacuum packed and stored at -20 °C until analysis.

Table 2: Processing yield and edible yield of fermented broccoli and cauliflower stalks as a percentage of original raw materials.

	Broccoli stalks (%)		Cauliflower (%)
	large	small	large
Fermented yield	97.26	95.50	97.60
Edible pith yield	43.10	41.23	53.85

Measurement of Vitamin C

The vitamin C content was determined by AOAC method (AOAC, 1990) using a 670 Titroprocessor (Metrohm, Switzerland). Vitamin C content was determined in triplicate and expressed as mg/100 g dry matter (DM).

Measurement of total phenolic compounds.

Total phenolic were determined in triplicates using Folin-Ciocalteu reagent method (Singleton and Rossi, 1965). A sample (200 mg) was extracted with 2 mL of 80% methanol containing 1% hydrochloric acid for 2 h at room temperature on an orbital shaker set at 200 rpm. The mixture was centrifuged at 2000 g for 15 min and the supernatant was transferred into 10 ml tube. The resultant pellet was extracted again as before and the combined supernatants were used for total phenolic assay. Extracts were appropriately diluted and then oxidized with 2.5 ml of freshly prepared 0.2 M Folin-Ciocalteau reagent. The reaction was neutralized by adding 2 mL of 7.5% w/v sodium carbonate and the samples were vortexed for 20 sec. The samples were incubated at 45°C for 15 min and then the absorbance was measured at 765 nm using a spectrophotometer (UV300, Unicam Ltd, UK). Total phenolic were corrected for the contribution of vitamin C and expressed as gallic acid equivalents (GAE) per 100 g DM (Toor *et al.*, 2006).

Consumer's perception of the fermented product

The fermented products were tested in a consumer type panel to determine the acceptability of the products. The panellists recorded their ethnicity and results were then split into three groups; New Zealander; Asian and others (Table 3). The panellists were asked to evaluate the physical and flavour characteristics as well as the overall acceptability of the products on a 1 (dislike very much) to 5 (like very much) scale. They were asked to rate, again on a 1-5 scale, their likelihood of purchase each fermented product. In addition, the panellists were asked directly which product they preferred most.

Table 3: Structure of panellists for consumer's perception of fermented broccoli and cauliflower stalks.

	New Zealanders	Asian	Others
Number of panellists	20	22	6
Males	5	13	4
Female	15	9	2
Age (average; range)	24 (18-56)	33 (20-48)	30 (21-37)

Statistical analysis

Data for vitamin C and total phenolic were analysed using analysis of variance (ANOVA) using PROC GLM in MINITAB (Release 14.1). Differences between means were determined using Fisher's least significant difference. Data for consumer's perception of the fermented products were analysed using the restricted maximum likelihood estimation (REML) routine in GenStat (Release 7, Lawes Agricultural Trust, VSN International Ltd., Rothamstead, U.K.), and the significance of model terms were determined by Wald tests. Means presented were those estimated by the REML routine.

RESULTS AND DISCUSSION

Raw material and processing

After the broccoli was harvested the residue still contained 9.5% of edible florets. About 22% of the residue was stalks that can be utilized as a raw material for further processing (e.g. fermentation). These materials are normally mulched into the soil as picking the secondary florets is not a financially viable practice and currently there is no economical use for harvest residues. Cauliflower had lower percentage of stalks (about 12%) because of the trimming process prior to retail sale (Table 1). This percentage would increase if the harvest remains were included. While broccoli and cauliflower stalks had similar processed yield after fermentation, the edible pith yield for cauliflower was at least 10% higher than that of broccoli (Table 2). This higher pith yield seems to have resulted from differences in the geometrical properties and the ratio of out-layer to pith for the two crops.

Vitamin C

Fresh large broccoli stalks had higher ($P<0.001$) concentrations of vitamin C compared with small ones (Table 4). Vitamin C concentrations in the pith of fresh broccoli (714.9 ± 7.1 and 633.5 ± 7.1 mg/100 g DM, for large and small stalks, respectively) were considerably higher ($P < 0.001$) than in outer layers. It is well known that broccoli florets contain high levels of vitamin C (Davey *et al.*, 2000; Podsędek, 2005). The reported values for vitamin C in the edible portion of broccoli ranged from 34-146 mg/100 g wet weight (WM). This variation was attributed to environmental (eg. climatic, geographical conditions) and agricultural practices (e.g. irrigation conditions; fertilization), (Podsędek, 2005). In the present study, the freeze dried pith of fresh broccoli stalks had 43 mg/ 100 g WM, which is slightly lower than the average reported for broccoli florets. There are two reasons for this; firstly, a 29% loss in vitamin C due to preparation and freeze drying was observed (fresh pith before freeze drying was 61.17 ± 3 mg/100 g WM). This is in agreement with results of Favell (1998) who reported a 20% loss of vitamin C in broccoli florets due to freezing. Secondly, cultivation in April meant that the plants were not exposed to light and temperature conditions that enhance vitamin C accumulation. Seasonal effects on vitamin C accumulation in plants are well documented (Davey *et al*., 2000; Podsędek, 2005). Large cauliflower stalks had significantly ($P<0.001$) lower vitamin C concentrations in the pith (481 mg/100 g DM) and higher vitamin C concentrations in the outer-layers (356 mg/100 g DM) than broccoli. Fermentation decreased ($P< 0.001$) vitamin C concentration in the edible portion (pith) to about 55% of that found in the pith of fresh stalks of broccoli. Also, there was about 44% loss in vitamin C content in cauliflower pith as a result of fermentation. Although almost 50% of the original vitamin C content in stalks was lost due to fermentation, this process is more efficient than storage at room temperature or partial chilling for longer periods. According to Favell (1998) broccoli florets lost 80% of its vitamin C during ambient or partial chilling/ambient storage for 3 weeks. Davey *et al*. (2000) listed vitamin C content in 63 fruits and vegetables in which broccoli ranked 7th on that list (after acerola, rosehip, guava, blackcurrant, kale and green pepper). In New Zealand, many of the high vitamin C sources (e.g. acerola, rosehip, guava and kale) are not available fresh to the average consumers. Thus, advice on the use of broccoli and cauliflower and their stalks as rich sources for vitamin C is important.

Table 4: Concentration of Vitamin C (mg/100 g DM) and total phenolic compounds (mg/100 g DM) in Brassica stalks before and after fermentation.

Brassica	Size	Treatment	Part	Mean vitamin C (mg/100 g DM)	Mean total phenolic compounds (mg/100 g DM)
Broccoli	small	fresh	pith	633.5b	188.4b
Broccoli	small	fresh	outer layer	290.1e	116.6e
Broccoli	large	fresh	pith	714.9a	187.8bc
Broccoli	large	fresh	outer-layer	269.9e	124.5e
Brocolli	large	fermented	pith	366.1d	161.0d
Cauliflower	-	fresh	pith	481.0c	205.5a
Cauliflower	-	fresh	outer-layer	355.8d	175.2c
Cauliflower	-	fermented	pith	268.7e	158.9d
Cauliflower	-	fermented	outer-layer	227.4f	111.0e
				SEM = 7.1 LSD = 29.1	SEM = 3.3 LSD = 13.5

Within a column for each factor, means that do not have a common letter are significantly different at the 1% level, SEM = standard error of mean, LSD = least significant difference (1%).

Total phenolic compounds

Size did not affect ($P>0.05$) the total phenolic content of fresh broccoli stalks (187.8 ± 3.3 and 188.4 ± 3.3 mg GAE/100 g DM, for large and small stalks, respectively, Table 4). Total phenolic content of broccoli florets was reported to be in the range of 34.5 to 337 mg of GAE/100 g WM (Podsędek, 2005). This wide variation was due to the use of different extraction methods. However, it seems that soil and environmental conditions (reflected in country of origin) played a role in this variation (Podsędek, 2005). Also, in most of the reported studies, the contribution of vitamin C to total phenolic content was not taken into account. Indeed, when harsh extraction conditions were used, total phenolic content in broccoli (florets and stem) was low (Zhang and Hamauzu; 2004). For instance, in the present study total phenolic content in the broccoli stalks was 11.3 mg GAE/100 g WM compared with 4.5 mg GAE/100 g WM broccoli stems reported by Zhang and Hamauzu (2004).

The pith of fresh cauliflower had similar total phenolic content (205.5 ± 3.3 mg GAE/100 g DM) to the pith of fresh broccoli, whereas the outer layer of the fresh cauliflower had higher ($P<0.001$) total phenolic content than the broccoli outer layer (Table 4). Fermentation caused a reduction in total phenolic concentrations (about 28% and 15% for cauliflower and broccoli, respectively). This was expected as polyphenols are known to degrade during fermentation (Svanberg and Lorri, 1997).

Consumer's perception of the fermented product

Forty eight people took part in the consumer panel. The panellists expressed their ethnicity and were then split into three groups: New Zealander, Asian, and other (Table 3). The majority (77%) of the Asian group were Chinese while those in the other group included those of Middle Eastern ethnicity and respondents who did not complete the ethnicity question.

There was a significant difference in the overall acceptability of the fermented products between groups of different ethnicity (Table 5). The Asian and others panellists found that the fermented products were acceptable or very acceptable, while 70% of the New Zealand panellists ranked the products with 1 (dislike very much) or 2 (dislike). This may reflect a cultural background difference in that the Asian and others groups were more familiar with fermented vegetables while in New Zealand the consumption of such products is low (Table 5). The fermented cauliflower ranked more highly in terms of saltiness, overall flavour, mouthfeel and hardness ($P<0.05$). Although the pale green colour of the broccoli product attracted comment, there was no significant difference in the acceptability of the colour of the products. Both products attracted scores at both end of the acceptability scale from dislike very much to like very much.

The overall acceptability of fermented products was not significantly different between males and females (Table 5). Female panellists reported higher scores for all the evaluation parameters, but significant differences were found in colour, smell and hardness. When the interaction of sex and type of fermented product was considered (data not shown) females gave a higher ranking to the cauliflower fermented product than the broccoli product. The panellists were also asked about their likelihood to purchase. There was again a significant difference ($P<0.001$) between the ethnic groups. Using scale of 1 (very unlikely) to 5 (very likely); with 3 the neutral position indicated as "maybe", the predicted means were 1.74, 3.51, 3.67 for New Zealanders, Asians and others respectively.

Table 5: Average taste panel scores for fermented broccoli and cauliflower stalks.

	Sweet -ness	Colour	Smell	Salt	Flavour	Hard-ness	Mouth-feel	Acceptance
Ethnicity								
NZ	2.13a	2.64a	2.33a	2.36a	2.14a	2.77a	2.46a	2.32a
Asian	3.11b	3.60b	3.57b	3.70b	3.54b	3.85b	3.55b	3.53b
Others	4.62b	4.27b	4.89b	4.08b	3.70b	4.80b	4.78b	4.17b
P	0.001	0.003	0.001	0.001	0.001	0.003	0.001	0.001
Broccoli	3.43	3.44	3.60	3.61	3.36a	3.86	3.87a	3.53a
Cauliflower	3.14	3.56	3.60	3.14	2.89b	3.75	3.20b	3.15b
P	NS	NS	NS	0.034	0.004	NS	0.001	0.002
Female	3.40	3.78a	3.99a	3.45	3.33	4.11a	3.87	3.50
Male	3.17	3.23b	3.21b	3.03	2.92	3.50b	3.32	3.17
P	NS	0.032	0.011	NS	NS	0.038	NS	NS

Within a column for each factor, means that do not have a common letter are significantly different at the stated P value.

There was no difference in the likelihood of purchase between the broccoli and cauliflower fermented products. This data indicate that these fermented products may have potential in markets with a high proportion of consumers who are familiar with fermented products. These markets could include Asian and Mediterranean countries as well as other countries where there are large populations of these consumers Fermented cauliflower stalks were perceived as more preferable than broccoli stalks.

CONCLUSIONS

The materials obtained from broccoli and cauliflower represents the material that can be recovered at the grower and processor levels, respectively. With the appropriate technology it is feasible to utilize these materials further. After appropriate processing, these materials can be used effectively as a dietary source of nutrients either directly as food or as an ingredient in a functional food product. In the present study, we reported relatively high vitamin C and total phenolics contents in broccoli and cauliflower stalks that were used to produce fermented products and in the fermented products themselves. The results from the taste panel indicated that the fermented broccoli and cauliflower could be a successful product as a condiment for consumers familiar with fermented products. The potential to use harvest residue and processing by-products and target overseas markets is promising.

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Oxalate content of raw and cooked silverbeet

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ABSTRACT

Silverbeet *(Beta vulgaris* var cicla) or Swiss chard is now available in shops in a range of colours. The original cultivars had white stems, now plants with stem colours ranging from red, pink, orange and yellow are commonly available. The leaves remain predominantly green with only a trace of additional colouration. Silverbeet leaves are known to contain moderate levels of oxalates which can be lost by leaching into the water when they are cooked.

In this study the oxalate content of the leaves of three different varieties of locally grown silverbeet with white, red and yellow stems were cooked in boiling tap water for 8 minutes. The total, soluble and insoluble oxalate contents were determined using HPLC chromatography.

The mean total oxalate of the raw leaves of the three different coloured silverbeet was 792.7 ± 22.9 mg oxalate/100 g WM which fell to 659.9 ± 81.2 when the leaves were cooked. The mean soluble oxalate of the raw silverbeet leaves was 350.0 ± 24.1 mg oxalate/100g WM. The mean soluble oxalate fell to 298.2 ± 30.1 mg oxalate/100 g WM when the leaves were cooked. The different coloured silverbeet varieties did not have markedly different oxalate contents.

The consumption of a standard serving size of these cooked silverbeet leaves (a standard 250 ml cup contains 168 g of cooked tissue) would result the intake of 501 mg soluble oxalate in one meal, this is a significant intake of soluble oxalate People who have an increased risk of calcium oxalate stone formation should avoid eating silverbeet leaves.

INTRODUCTION

Silverbeet *(Beta vulgaris* var cicla) or Swiss chard as it is known in most places outside New Zealand is a native plant of the Mediterranean (Kiple and Kriemhild, 2000). There is some dispute over which part of silverbeet is most commonly eaten. Kiple and Kreimhild (2000) report that in the Mediterranean region the green leaves are eaten, while in northern Europe the creamy white stalks are viewed as the best part to eat. Silverbeet is a common autumn harvested vegetable in New Zealand. The leaves are boiled like spinach while the fleshy stems are often cooked separately and served in a white sauce. Until recently the commonly consumed cultivar of silverbeet had green leaves and creamy coloured stems. More recently coloured cultivars of silverbeet have become available in the shops. These are sometimes referred to as rainbow silverbeet; the stems are coloured red, pink, orange or yellow. The most commonly seen cultivars of these newer selections have stems with a pronounced yellow or red colour while the leaves remain predominantly green with traces of yellow or red colouration.

Plant species belonging to the Chenopodiaceae family (spinach, beetroot, Swiss chard) are known to have high levels of oxalates in the leaves (Santamaria *et al.,* 1999, Massey *et al.,* 2001; Noonan and Savage, 1999, Savage, 2002). Generally the oxalate levels in leafy plants are highest in the leaves and lowest in the stalk (Sanketkit *et al.,* 1999; Kawazu *et al.,* 2003). Earlier studies by Savage *et al.*, (2000) on New Zealand grown silverbeet have shown that the stems contain much lower levels of total oxalates compared to the leaves (127.0 vs 525.5 mg total oxalate/100 g wet matter (WM) stems and leaves respectively).

In this study the total, soluble and insoluble oxalate content of the leaves of three different coloured varieties (white, red and yellow stems) of silverbeet grown at the same location were determined. The analysis was carried out on both raw and cooked leaves as previous studies have shown that soluble oxalates are readily lost when boiled in water.

MATERIALS AND METHODS

Sample materials

Three varieties of silverbeet with white, red and yellow stems were grown without any applications of fertiliser in a Templeton silty loam soil at Lincoln University, Canterbury, New Zealand (172°29'E 43°39'S) 11m above sea level. The silverbeet were harvested on the 10th April 2004 and separated into two fractions, stems and leaves.

Cooking

Three hundred grams of leaves were added to 750 ml boiling tap water tap in a pan and boiled for 8 minutes until cooked. The cooked leaves were then allowed to drain for 2 minutes. Once cool the cooked leaves were packed into plastic bags and stored frozen at -20ºC until analysis could take place.

Dry matter analysis

Dry matter contents of the freshly harvested and cooked silverbeet were determined, in duplicate, by drying in an oven at 105°C for 24 h (AOAC, 2002, method 925.10).

Oxalate analysis

Duplicate 5 g samples of frozen raw and cooked silverbeet leaves were chopped into small pieces (5 × 5 mm) using a stainless steel knife and were homogenized with a household stick mixer (ZIP, New Zealand) with 50 ml nanopure water and placed in a water bath at 80°C for 15 minutes to extract soluble oxalates. Total oxalates were extracted using 0.2 M HCL at 80°C for 15 minutes. The extracts were allowed to cool and then transferred quantitatively into 100 mL volumetric flasks and made up to volume with nanopure water. Two extractions were carried out for each sample. The extracts were centrifuged at 3500 rpm for 15 min. The supernatant was filtered through a 0.45 μm cellulose nitrate filter. The chromatographic separation was carried out using a 300 × 7.8 mm ion exclusion column (Alltech Associates Inc., Deerfield, Illinois, USA) attached to a cation H+ guard column (Bio-Rad, Richmond, California, USA). The analytical column was held at 25°C. The equipment consisted of a ternary Spectra-Physics, SP 8800 HPLC pump (Spectra-Physics, San Jose, California, USA), a Waters, U6K injector (Waters Inc., Marlborough, Massachusetts, USA), a UV/VIS detector Spectra-Physics SP8450 (Spectra-Physics, San Jose, California, USA) set on 210 nm. Data capture and processing were carried out using Cromatopac C-R3A integrator (Shimadzu, Corporation, Kyoto, Japan). The mobile phase used was an aqueous solution of 25 mM sulphuric acid. Before use the mobile phase was filtered through a 0.45 μm membrane filter and degassed using a vacuum. Samples (20 μL) were injected onto the column and eluted at a flow rate of 0.6 mL/min. The oxalate content of the samples was calculated by comparison with standards of pure oxalate (BDH, Pool, UK) dissolved in either nanopure water for soluble oxalates or 0.2 M HCL for the total oxalate content. Insoluble oxalate = total oxalate – soluble oxalate (Hollaway *et al.,* 1989).

RESULTS

The leaf colour of the three different varieties of silverbeet analysed in this study were predominantly green but the veins of the leaves were the same colour as the stems. The hue of the leaves were subtly modified depending on the colour of the stem. The mean total oxalate of the raw leaves of the three different coloured silverbeet was 792.7 ± 22.9 mg oxalate/100 g WM which is higher than the value of 525.5 mg oxalate/100 g WM reported (Savage *et al.,* 2000) for a commercial sample of raw white stem silverbeet grown in New Zealand. The mean total oxalate content of the three varieties fell to 659.9 ± 81.2 when the leaves were cooked. In contrast, Savage *et al.*, (2000) reported a value of 291.1 mg total oxalate/100 g WM for commercially grown cooked silverbeet leaves

The mean soluble oxalate of the raw leaves of the three different coloured silverbeet was 350.0 ± 24.1 mg oxalate/100g WM which is higher than the value of 252.3 mg oxalate/100 g WM reported for a commercial sample of raw silverbeet grown in New Zealand by Savage *et al.,* (2000). The mean soluble oxalate content of the three cultivars fell to 298.2 ± 30.1 when the leaves were cooked. Savage *et al.*, (2000) reported a value of 117.7 mg soluble oxalate/100g WM for cooked silverbeet leaves.

Table 1: Oxalate content of raw and cooked silverbeet leaves (mg/100g WM).

[1] Insoluble oxalate = total oxalate – soluble oxalate (Hollaway *et al.,* 1989).

Analysis of the soluble/insoluble oxalate ratio of the three cultivars determined in this study shows that more soluble oxalate than insoluble oxalate can be found in the cooked tissue (mean 298.2 and 252.6, respectively). This is in contrast to the previous study where 68% of the oxalate in cooked tissue was insoluble oxalates. The differences in the soluble oxalates remaining in the cooked tissue probably occurred as a result of quite small differences in cooking time. Silverbeet and spinach leaves are notoriously difficult to cook successfully and considerable losses of oxalates and soluble sugars can occur over a very short time. Differences in the time allowed to drain the cooked tissue will also have a considerable bearing on the losses of soluble constituents from the cooked leaves.

DISCUSSION

This study confirms that there is no difference in the oxalate levels of the different coloured silverbeet leaves but it confirms that losses of oxalate do occur during boiling for 8 minutes and subsequent draining for 2 minutes. Overall, the dry matter contents of the cooked leaves fell 20% following cooking (mean dry matter 9.6 ± 0.44 and 7.7 ± 0.39 for the raw and cooked leaves respectively). The fall in dry matter of the cooked leaves results from leaching losses of oxalates and soluble materials such as carbohydrates and sugars into the cooking water. On a wet matter basis the mean loss of total oxalates from the silverbeet leaves was 30.4% which is comparable to the losses reported by Judprasong *et al.*, (2006) for leafy vegetables grown in Thailand. However, the apparent

Stem colour	Raw or cooked	Total oxalate	Soluble oxalate	Insoluble oxalate[1]
White	Raw	746.8	326.9	419.9
	Cooked	544.0	238.6	305.4
Red	Raw	815.1	405.5	409.6
	Cooked	619.3	335.5	283.8
Yellow	Raw	816.3	341.7	474.6
	Cooked	488.9	320.4	168.5

losses of oxalate as a resulting from boiling foods in water can lead to losses of other materials at the same time. This would lead to an overestimation of the oxalate losses (Murphy *et al.,* 1975).

The total and soluble oxalate levels of the cooked silverbeet in this study are 51% and 39% higher than previously reported values for the raw leaf (Savage *et al.*, 2000). Savage (2002) commented on the enormous range in total oxalate levels reported in the literature for spinach, a similar leafy vegetable containing comparable oxalate levels in the leaves. For spinach the literature values range from 320 to 1260 mg total oxalate/100g WM. More recently the enormous range in varietal and seasonal differences in oxalate content of the leaves of spinach grown in Japan (range 760 to 1800 mg/100 g WM) have been reported by Kawazu *et al.*, (2003). They showed that there were significant differences depending on the seasons they were grown in (summer or winter) and the cultivar grown. Santamaria *et al.*, (1999), in a survey of nitrate and oxalate content of fresh silverbeet grown in Italy, showed that the total oxalate levels ranged from 167.8 to 603.1 mg total oxalate/100g WM (mean value 332.3 ±131.7). The mean results for total oxalate of the three cultivars of silverbeet in this study (792.7 ± 22.9 mg oxalate/100 g WM) are higher that the reported values for silverbeet grown in Italy but fall with the range of values reported for spinach by Kawazu *et al.*, (2003).

The standard serving size of cooked spinach and silverbeet is a cup full (250 ml) which is 168 g of cooked tissue (Burlingame *et al.*, 1993). Consumption of this amount of cooked silverbeet would mean that 501 mg soluble oxalate would be consumed in one meal. This is a significant intake of soluble oxalate and should be avoided by people who have an increased risk of calcium oxalate stone formation. This study confirms that boiled leaves silverbeet leaves should be included in the high oxalate food group (Noonan and Savage, 1999).

CONCLUSIONS

This study confirms that silverbeet leaves will supply a significant amount of oxalate in the diet if they are eaten regularly. This study shows that boiled leaves should be included in the high oxalate food group and should be avoided by people who have an increased risk of calcium oxalate stone formation, or low calcium intake.

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Making a healthy difference to menus: Evaluation of a catering programme in New Zealand

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ABSTRACT

This study was designed to determine the effect of the Heartbeat Catering Programme (HCP) on the provision of healthy menu items by measuring perceptions of caterers and dietitians involved in the programme. The study design used a multi methods approach involving a postal questionnaire and telephone interviews with caterers, and telephone interviews with dietitians involved in the programme. One hundred and sixty four caterers/food service managers and 15 Dietitians were surveyed. These people worked in food services in residential institutions (boarding schools, university hostels, prisons and rest homes), workplace cafeterias, cafes and lunch bars.

While not the sole source of information and motivation for menu development, it was clear that for most participants information learnt through contact with the Heart Foundation was incorporated into recipes and food preparation techniques. Programme resources and services of particular value to caterers were the mailed information packs and food demonstrations. Dietitians reported a high level of satisfaction with the programme and agreed that the programme was assisting caterers to offer nutritious menus to customers. Both groups recommended changes to the programme resources to improve their usefulness

INTRODUCTION

The National Heart Foundation of New Zealand used an external evaluation of the Heartbeat Catering Programme to plan and implement changes to move the catering programme forward. Heartbeat Catering Programme was first introduced to caterers in 1992. The programme provides nutrition information and education opportunities that encourage caterers to develop their skills in the provision of healthy food choices, for institutional residents and customers in food service outlets. Initially the programme targeted caterers in residential institutions such as rest homes, boarding schools, hostels and prisons. The programme aims was to encourage the provision of food and menus that meet the Heart Foundation Catering Guideline. The catering guideline was established to support the food environment within the food service industry where caterers make decisions about food selection. The programme activities involved nutrition education and information provision that encouraged caterers to make changes to menus. There was a series of resources – Heartbeat Catering Guidelines, a quantity recipe book and video. The Heartbeat Catering Guidelines contained a menu assessment checklist. The checklist helped caterers assess their menus and guides them to develop targets for change that are realistic and achievable. All of the resources follow the messages of the New Zealand Ministry of Health's Food and Nutrition Guidelines.

Initially the programme was piloted in 14 residential institutions in the central North Island and lower half of the South Island in New Zealand. Evaluation of the pilot indicated that the resources are useful. The programme and resources were modified to increase their relevance to caterers prior to national implementation. The programme resources were then extended to include mailed information packs which contained food product information, healthy food preparation techniques and food ideas. Nutrition newsletters were mailed out twice a year to a catering data base. Food demonstrations and trade shows where delivered nationally this provided us with opportunities to meet caterers face to face.

The target audience was expanded to incorporate, lunch bars, cafes, workplaces cafeterias and private caterers. The programme was predominately promoted to caterers by the Heart Foundation, although dietitians and other health professionals utilized the programme.

The Heartbeat Catering Programme was independently evaluated in 2000. Prior to this evaluation, evaluation was done, as the need arose and funds were available, it was used as a guide for programme development. Food demonstrations and trade shows were evaluated internally by the Foundation to see if they met the needs of the caterers. However the overall impact of the programme on food services has not been evaluated – it was considered timely.

Independent evaluation findings showed a positive view of Heartbeat Catering Programme and its services. The programme assisted caterers to provide healthier food choices on menus and prepare food in a more healthy way. Caterers perceived that their nutrition knowledge had increased as a result of involvement in the programme. However feedback from caterers, health professionals and dietitians indicated to improve the success of and expand the programme the following recommendations should be implemented. Review the current resources with the aim of; creating a clear brand identity for programme resources; continuing to provide mailed recipe ideas and food preparation information, but consider a recipe card system or similar design for recipes to be added over time, with more pictorial representation of completed dishes and limit the written information; developing menu assessment guidelines suitable for the different target groups in preference to the current "one size fits all" approach, for example, separate targets for young people in a hostel compared to older people in a rest home; Increasing the relevance of food information to specific food services, for example café style food, rest home meals; continue to offer food demonstrations, preferably more than currently delivered but tailored to the different catering settings; review and update content of stands at catering trade shows.

Based on the evaluation recommendations Heartbeat Catering Programme resources and services were up-dated, in consultation with caterers through a process of focus groups. The groups of caterers represented a cross section of food services and they were revisited several times during the resource development phase.

This process led to the development of:

- Newsletters with detachable recipe cards produced and distributed quarterly. The recipe cards offering serving sizes 10, 25 and 50. The recipes provided additional food ideas, ingredient and recipe variations so there is something for every caterer.

- A review and re-packaging of the Function Catering Guidelines which was developed to encourage healthy food choices at conferences and functions and Recipe Development Guidelines which provides a framework for food writers, home economist, food technologist and chefs.

- Heartbeat Catering Guidelines were reviewed in relation to the proposed target groups – hostels, rest homes, boarding schools and other residential institutions. From this review came the development of evidence-based guidelines for institutional caterers that include nutritional recommendations for Adolescents, Adults and Older People. This information is presented as practical workbooks that can be used by all caterers. They are the 'how to' so the food and nutrition guidelines can be incorporated into food services.

CONCLUSION

Caterers and dietitians perceived that the Heartbeat Catering Programme appeared to be improving the nutritional value of food served in food service outlets. However, the programme resources required updating in line with comments from caterers and dietitians. Overall, it was thought that it was important that the programme should be expanded to increase its influence as cooks and caterers are gatekeepers to good nutrition.

New nutrition: novel foods in nutrition and clinical practice, regulating health claims in Australia and New Zealand

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ABSTRACT

In late May 2004 the Australia New Zealand Food Regulation Ministerial Council (ANZFRMC) finalised its policy guidance on Nutrition, Health and Related Claims, opening the way for the development of a new food standard , applicable in both countries, which will contain permissions for nutrition and health claims and will set out the requirements which must be met. This is a marked departure from the current situation, where there is only one permitted health claim for foods, related to maternal folate consumption and reduced risk of fetal neural tube defects. This permission was introduced as a public health measure by the Health Ministers of all Australian states and territories, the Australian Government and New Zealand. The new standard will come into force in early 2006.

There will be two classes of claim allowed, general level claims and high level claims. Both will need to be substantiated before they can be included on labels or in advertisements. However, the general level claims will not require pre-approval by the regulator, although the manufacturer will be expected to hold the evidence in support of the claim and produce it at any time when requested to by the enforcement agency. General level claims could include content claims (eg. high in calcium), function claims (eg. calcium is good for strong bones and teeth), enhanced function claims and risk-reduction claims (with reference to non-serious disease).

High level claims, whether they refer to reducing the risk of serious disease or to maintaining or modifying biomarkers, will need pre-approval by the regulator following an evaluation of the scientific evidence provided by the manufacturer in support of the claim.

During the early phases of developing the new standard, the role of scientific nutrition has centered on developing a draft framework for substantiating these high level claims. The primary challenge is to produce a framework incorporating a systematic approach to the totality of the evidence, which grades the quality of the scientific studies provided, demonstrates a causal relationship between consumption and claimed effect, and which has little risk of being invalidated by new emerging science in the subject. A secondary objective is to develop the framework so that it can used by manufacturers as a guide to the collecting and interpreting the strength of the evidence they will need to hold in support of their general level claims.

This presentation introduces a proposed 5-step process for substantiating claims, which will be the subject of public consultation from August to October 2004 and which will be available on the, FSANZ website: www. *foodstandards.gov au.*

The use of dietary supplements in a group of potentially elite secondary school athletes

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ABSTRACT

Athletes, concerned with goals of maximising performance and fearful of losing their competitive edge, have been targeted as a significant consumer group for vitamin and mineral supplements. The reasons for athletes supplement use fall into three areas: to compensate for less than adequate diets or lifestyles; to meet unusual nutrient demands induced by heavy exercise; and to produce an ergogenic effect. The objective was to investigate the use of dietary supplements taken by elite secondary school sports students.

One hundred year 9 and 10 students, identified as having potential in their respective sports by their school administrators, were recruited from two decile 10 North Shore secondary schools, Rangitoto College and Takapuna Grammar to complete a questionnaire. Twenty-eight female athletes (84.8%) and 42 male athletes (62.6%) took dietary supplements. Energy products were taken by 43.1% of the athletes, vitamins by 28.7% and recovery products by 7.1%. Many athletes (52.8%) took more than one product. Multi-vitamins, B-group vitamins and vitamin C were the most commonly consumed vitamins. Parents, coaches and friends (74.8%) were the most important sources of information about dietary supplements and were also the most likely to suggest taking supplements (77.5%). There was a very high rate of supplement use by athletes in this study. Adolescent athletes are encouraged to consume supplements by parents and coaches. Both parents and the athletes themselves need to be better informed as to the important role good nutrition has in assisting adolescent athletes to achieve their sporting goals.

How achievable are recommended dietary allowances for 12-24 month old New Zealand children?

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ABSTRACT

Reported nutrient intakes of 12-24 month old New Zealand (NZ) children arc often below the USA/Canadian recommended dietary allowances (RDAs).The objective of the study was to investigate whether RDAs are achievable with modest changes to NZ toddler diets. Dietary data (weighed records) collected from 12-24 month old NZ children (n=188) were analysed using linear programming analysis. In this analysis, the minimum dietary modifications required to achieve the RDAs for 13 nutrients, when feasible, were examined while allowing (1) modifications in the food portion sizes, (2) increases in red meat and (3) replacement of cows' milk with fortified toddler milk. All models minimised the difference between each child's actual and modelled food intakes while meeting constraints on dietary energy (child's reported intakes), nutrients (RDAs), and on the food portion sizes (up to twice the reported amounts). Unfeasible modelled diets did not meet at least one constraint. Before modelling, only 7% of the reported toddler diets achieved all RDAs. Iron was the most difficult RDA to achieve (15% achieved it) followed by Ca (71%). Only 39%, 46% and 78% of modelled diets were feasible after allowing changes in the food portion sizes, red meat intakes and the type of milk, respectively. The most common changes (expressed as a % of diets in which they were present),were increased amounts of fortified breakfast cereals or Milo (9-75%), meat/fish/legumes (4-30%) and milk (20-26%) with corresponding decreased amounts of milk (8-59%), other beverages (1-18%) and cakes/biscuits (1-15%), depending on the model run. Achievement of the RDAs in toddler diets, especially for iron, is difficult given their small appetites relative to high nutrient requirements. Implications for nutrition planning and promotion become important, if achievement of the USA/Canadian RDAs in NZ toddler diets is our desired aim.

Serum 25-hydroxyvitamin D status New Zealand children

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ABSTRACT

New Zealand children may be at risk for poor vitamin D status due to low vitamin D intakes, decreased sun exposure, and the country's location (35-46°S). Further, Maori and Pacific Children may be at greater risk because of their darker skin. The objective of this study was to determine 25-hydroxyvitamin vitamin D concentrations in New Zealand children (5-14 y) who participated in the 2002 National Children's Nutrition Survey. The survey aimed to recruit 3000 participants with 1000 children each of Maori, Pacific, and New Zealand European and other (NZEO) ethnicity. The nationally representative sample was recruited using a two-stage process involving random selection of schools followed by random selection of children within each school. Serum 25-hydroxyvitamin D concentrations were measured using a radioimmunoassay kit (DiaSorin, MN).

Serum 25-hydroxyvitamin D concentration (mean 95%Cl) in Maori children (n=485) was 44 (39 to 48) nmol/L; in Pacific children (n = 675) it was 37 (32 to 42); and in NZEO (n=499) it was 53 (48 to 58). Pacific females 11-14 y (n=160) were the group with the lowest serum 25-hydroxyvitamin D concentrations, 32 (26 to 38) nmol/L. The prevalence of serum 25-hydroxyvitamin D deficiency (<17.5 nmol/L) was 5% (3 to 10) amongst Maori children, 8% (6 to 12) amongst Pacific children, and 3% (1 to 5) amongst NZEO children. The prevalence of insufficiency (<37.5 nmol/L) was 41% (32 to 50) amongst Maori children, 59% (46 to 70) amongst Pacific children, and 25% (18 to 33) amongst NZEO children. Multiple regression analysis revealed that vitamin D concentration was lower in the winter [38 (35, 41) nmol/L)] than summer [53 (49, 57) nmol/L)], lower in females [42 (39, 44) nmol/L)] than males [47 (44, 49) nmol/L)], was highest in NZEO [53 (50, 57) nmol/L)] followed by Maori [44 (41, 48) nmol/L)] and lowest in Pacific Children [37 (35, 40) nmol/L)].

Ethnicity and season are major determinants of scrum vitamin D status in New Zealand children. Scrum 25-hydroxyvitamin D concentrations in New Zealand children are lower than in countries of similar latitude where vitamin D fortified foods are consumed. The potential consequences of this lower vitamin D status, particularly amongst Pacific children, are not clear but should be investigated.

A randomised trial of three non-dieting programs for overweight women

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ABSTRACT

Since traditional treatments for overweight/obesity that focus on energy restriction show poor long-term maintenance of weight loss, `non-dieting' approaches are increasingly advocated. Non-dieting approaches encourage the adoption of eating in response to physiological hunger and satiety cues, rather than cognitive control of eating. Few randomised trials of non-dieting programs have been reported. The objective of this study was to evaluate the effects of non-dieting programs in overweight and obese women at high risk of coronary heart disease. 225 obese/overweight women (BMI >28; 25-65 years) with at least one other cardiovascular risk factor took part in a randomised trial of three different non-dieting programs (P1, P2, P3). P1: ten weeks of weekly group intervention focusing on training in eliciting the relaxation response and cognitive restructuring. The other two programs (P2: ten week group intervention; P3: mail-delivered intervention) focused on healthy eating and activity patterns. Measures were obtained at baseline, 10 weeks and 4 months. For participants in all three non-dieting programs, depression, anxiety and other psychological distress, perceived barriers to physical activity and to reducing dietary fat, self-reported medical symptoms, and diastolic blood pressure showed significant reductions at 10 weeks and 4 months; while stage of readiness for regular exercise, eating self-efficacy, dietary quality scores and "Health-Promoting Lifestyle Profile" scores all improved significantly ($P<0.01$). At four months, 44% of all participants had lost weight, 22% had maintained weight and 34% had gained weight. P1 participants showed significantly greater improvements in stress management ($P<0.0001$). The findings of this study suggest that non-dieting interventions can enhance psychological wellbeing and lifestyle habits for overweight/obese women.

Multiple micronutrients may lead to improved cognitive function in NE Thai schoolchildren

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ABSTRACT

Deficiencies of iron, iodine and zinc can affect the learning abilities and cognitive function of children. In a study in rural NE Thai school children, 31% were anaemic, 44% had moderate iodine deficiency, based on urinary iodine <0.40 µmol/L, and 57% had serum zinc levels indicative of zinc deficiency. The objective of this study was to determine the efficacy of a seasoning powder fortified with iron, iodine, vitamin A and zinc served with noodles or rice consumed for school lunch on biochemical status and cognitive function in 567 rural NE Thai children. The design of the experiment was a randomized controlled trial of children 6-12 yr recruited from ten rural schools in Ubon Ratchanthani province in Thailand. Children were stratified by age and gender, and then randomly assigned to receive either the placebo or a fortified seasoning powder containing 1/3 of the Thai RDA for iron, iodine, zinc and vitamin A per serve. Initial and final non-fasting blood samples were taken for complete blood count, haemoglobinopathy assessment (baseline only) and biochemical analysis. Cognitive function was assessed after 31 weeks by a visual recall test where 15 objects were displayed for one minute, covered for one minute and then recalled by the child, and the digit span subtest from the Wechsler Intelligence Scale for Children (WISC) III.

There was a significant treatment effect on haemoglobin, serum zinc and urinary iodine. Children in the treatment group had significantly higher visual recall scores compared with placebo (10.01 vs. 9.45 items, 95% CI for difference 0.15, 0.99, P=0.008). This finding was independent of age, gender, estimated annual family income and haemoglobin type. There was no significant effect on the digit span test. Seasoning powder fortified with four micronutrients reduced the incidence of zinc and iodine deficiency and increased haemoglobin concentration over 31 weeks, while at the same time improving short term memory and attention, and thus may contribute to improved overall cognitive functioning over time.

Detrimental effect of high dose eicosapentaenoic acid supplementation on bone density in ovariectomised Sprague Dawley rats

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ABSTRACT

Estrogen deficiency results in disruption of the normal bone remodeling cycle leading to a loss of bone mineral and, in many cases, the development of osteoporosis. Various studies have demonstrated a beneficial effect of essential fatty acids (EFAs) in reducing g the loss of bone density as a consequence of estrogen deficiency (Kruger and Horrobin, 1997; Kruger *et al.,* 1998; 1997). The aim of the present study was to examine the specific effects of the n-3 EFA, eicosopentacnoic acid (EPA) on bone density and strength in ovariectomised female rats. Sixty Sprague-Dawley rats were randomized into four groups and either ovariectomised (n=45) or sham operated (n=15). Ovariectomised animals were fed calcium adequate diets containing either corn oil (OVX control, n=15), corn oil + 0.1 g/kg body weight EPA (low dose, n=15) or corn oil + 1.0 g/kg body weight EPA (high dose, n=15) for a period of nine weeks. Sham rats were fed the corn oil diet as per the OVX control group. Serum type I collagen c-telopeptide concentration, bone density, bone ash and bone breaking strength were measured. Plasma fatty acid composition was also determined. Femur bone density was significantly lower in the high dose group compared to sham, OVX control and low dose EPA groups ($P<0.001$, $P=0.0096$ and $P=0.0047$ respectively). No significant differences in serum concentrations of type-I collagen c-telopeptide or bone breaking strength were evident with either dose of EPA compared to unsupplemented, ovariectomised controls. EPA supplementation resulted in significant decreases in the levels of n-6 EFAs and increases in the levels of n-3 EFAs except docosiihexaenoic acid in plasma lipids. One g EPA/kg body weight had a detrimental effect on bone density in ovariectomised rats. It is proposed that high intake of the highly unsaturated EPA resulted in significant lipid peroxidation. This inhibited intestinal calcium absorption thereby stimulating PTH-mediated bone resorption.

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International perspectives on vitamin D and implications for bone health

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ABSTRACT

Vitamin D is a fat-soluble compound, synthesised in the skin as a result of sunlight exposure. It is found in fish oils, but an unsupplemented diet provides little vitamin D. There is evidence of significant reductions in nonvertebral fractures from replacement regimens particularly if vitamin D is combined with calcium therapy. Vitamin D deficiency is common among institutionalised elderly and recent data suggests that vitamin D status may also be inadequate among younger adults for optimal hone health. Objective was to assess the vitamin D status in a population of healthy postmenopausal women living in Malaysia, and identify influencing factors. A cross-sectional study of 276 randomly selected healthy Chinese and Malay women aged 50 between and 65 yr, and more than 5 yr postmenopausal participated in the study. Serum 25-hydroxyvitamin D (25 (OH) D), parathyroid hormone (PTH), diet, anthropometry and physical activity were assessed. Serum 25 (OH) D was significantly lower in Malay women (44.4 f 10.6 mmol/L) compared to Chinese women (68.8 + 15.7 nmol/L) ($P<0.05$). Hypovitaminosis D (serum 25 (OH) D between 50-100 nmol/L) was present in 27% of Malay and 87% of Chinese women. Vitamin D insufficiency (serum 25 (OH) D between 25-50 nmol/L) was present in 71% of Malay and 11% of Chinese women. Serum 25 (OH) D was significantly correlated to BMI, fat mass and PTI-I. A high prevalence of vitamin D inadequacy exists amongst healthy postmenopausal women living in Malaysia, which may have considerable implications for public health.

Folic acid fortified milk increases red blood cell folate concentration in women of childbearing age

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ABSTRACT

Folic acid (400 pg/day) taken around the time of conception significantly reduces the risk of bearing a child with a neural tube defect (NTD). Strategies to reduce NTDs with folic acid include supplement use and fortified foods. One fortification option is to add folic acid to milk powder formulated for use by women prior to and during pregnancy. It is uncertain whether folic acid fortified milk reduces NTD-risk. However, NTD risk has been inversely associated with red cell folate (RCF) concentrations. The objective of this experiment was to determine whether consuming folic acid (375 pg/day) fortified milk increases RCF and plasma folate concentrations in women of childbearing age compared to an equivalent amount of unfortified milk, over 12 weeks. A second aim was to determine the effect of fortified milk on plasma homocysteine concentration, a functional indicator of folate status. Seventy-three women (aged 18-47 years) were randomized for 12 weeks to receive either a fortified milk powder (Anmum, New Zealand Milk Ltd) or unfortified (control) milk powder. Participants were instructed to consume 75 g of milk powder as two servings per day. Both milks provided 38 pg of naturally occurring folate per day. The fortified milk provided an additional 375 pg of folic acid per day. The control milk powder was a blend of whole milk and a skim milk powder that was blended to match the fat level of the fortified milk. Blood samples were collected at baseline, 6 and 12 weeks.

Sixty-six women completed the trial. Consuming the fortified milk caused RCF concentrations to rise markedly so that by week 12 the mean (95% CI) concentration was 539 nmol/L (436, 641) higher in those consuming the fortified milk than those consuming the control milk ($P < 0.01$). The mean plasma folate concentration in participants consuming the fortified milk was 35 nmol/L (30, 41) higher at week 12 than in those taking the placebo ($P<0.01$). Women consuming the fortified milk had a 14% lower mean homocysteine concentration at week 12 than women consuming the control milk ($P<0.01$).

Milk fortified with folic acid (375 pg/day) substantially increases RCF and plasma folate and lowers plasma homocysteine concentration over 12 weeks in women of childbearing age. Milk powder fortified with folic acid can increase women's RCF concentrations and would be expected to reduce the risk of bearing a child with a NTD.

Dietary supplement use in people being treated for depression

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ABSTRACT

Dietary supplements use has increased over the last 10 years, but information about characteristics associated with their use and possible interactions with prescription drugs is lacking."2 Up to 50 % of adults have been reported to take dietary supplements, and while the taking of supplements has been found to be related to some physical morbiditics2, there is no information about supplement use in people being treated for depression. The objective of this experiment was to determine dietary supplement use in people being treated for depression. Participants were recruited for a clinical trial to determine the effect of fish oil on mood in the treatment of depression. Exclusion criteria included any co-existing psychiatric disorder (except anxiety disorders), blood clotting disorders, unstable medical conditions, and those already taking fish oil supplements. Demographic information, details about the participants' depression and current therapies, use of dietary and herbal supplements in the previous 12 months, and physical activity were collected at baseline. Characteristics of supplement users were compared to non-users using either chi-squared tests or Mann-Whitney U-tests.

Forty-five of 72 participants (63%) who provided dietary supplement information had taken at least one dietary supplement within the previous 12 months. On average, supplement users were found to have taken 2.8 ± 1.6 dietary supplements during the assessment period. Women were more likely to be taking supplements than men ($P<0.001$). Dietary supplements are used frequently in people being treated for depression. This has important implications for treatment as little is known about supplement-drug interactions.

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Serum 25-hydroxyvitamin D status of New Zealand adolescents and adults

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ABSTRACT

Suboptimal vitamin D status has been associated with lower bone mineral density and may increase the risk of osteoporosis later in life. New Zealand adolescents and adults may be at risk of suboptimal vitamin D status because of low vitamin D intakes, decreased sun exposure, and the country's location (35-46°S). The objective of this research was to determine 25-hydroxyvitamin vitamin D concentrations in New Zealand adolescents and adults 15 y or older who participated in the 1997 National Nutrition Survey. The nationally representative sample was recruited using an area based sampling frame with a three stage stratified design consisting of a selection of primary sampling units (PSU), households within a selected PSU, and a single randomly selected respondent within a household. Serum 25-hydroxyvitamin D concentrations were measured using a radioimmunoassay kit (DiaSorin, MN). Serum 25-hydroxyvitamin D concentration [geometric mean (95%CI)] of the population (n=3008) was 50 (48, 51) nmol/L. Serum 25-hydroxyvitamin D concentration in Maori (n=379) was 42 (39 to 45) nmol/L; in Pacific People (n=138) it was 37 (33 to 41); and in NZEO (n=2491) it was 51 (49 to 52) nmol/L. Overall, the prevalence of vitamin D deficiency (<17.5 nmol/L) and insufficiency (<37.5 nmol/L) was 3% (2 to 4) and 28% (25 to 30), respectively. The prevalence of vitamin D deficiency was 3% (1 to 5) amongst Maori, 5% (3 to 7) amongst Pacific People, and 3% (2 to 4) amongst NZEO. The prevalence of insufficiency was 41% (34 to 48) amongst Maori, 50% (40 to 60) amongst Pacific People, and 25% (23 to 28) amongst NZEO. Multiple regression analysis revealed that mean Vitamin D concentrations were lower in females [46 (45,48)] than males [51 (49,53) nmol/L], lower in the winter [45 (44, 47) nmol/L)] than summer [45 (50, 55) nmol/L)] and lower in Maori [41 (38, 44) nmol/L] and Pacific People [36 (33, 41) nmol/L] than NZEO [51 (49, 52) nmol/L]. Serum 25-hydroxyvitamin D concentrations are low in the New Zealand adolescent and adult population. The potential consequences of this lower vitamin D status, particularly amongst Maori and Pacific People, are not clear but should be investigated.

Effects on plasma lipids when plant sterol enriched fat spread or carbohydrate provide replacement energy for saturated fatty acids

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ABSTRACT

Clinical practitioners often inquire whether patients who need to lower plasma cholesterol are better served by consuming a plant sterol-enriched fat spread or reducing fat intake by consuming no spread. The objective was to determine the effects on plasma cholesterol of replacing a plant sterol enriched fat spread with carbohydrate. Twenty-nine healthy volunteers with raised low density lipoprotein cholesterol concentrations were assigned to follow in random order three diets; a typical New Zealand diet high in total (34%kJ) and saturated (15%kJ) fat, a cholesterol-lowering diet reduced in total (30%kJ) and saturated fat (8%kJ) but including a plant sterol spread, and the same cholesterol-lowering diet with the plant sterol spread ispcalorically replaced with carbohydrate (total fat, 26%kJ; saturated fat 7%kJ). All foods were provided and each diet was followed for four weeks. Mean (SD) plasma low density lipoprotein cholesterol concentration declined from 4.68 (0.92) mmol/L on the high saturated fat diet to 4.12 (0.83) mmol/L (P<0.001) on the carbohydrate diet and 3.76 (0.84) (P<0.001) on the plant sterol diet. The 20% decrease on the plant sterol diet was significantly greater (P<0.00I) than the 12% decrease on the carbohydrate diet. Relative to the high saturated fat diet, mean (95%CI) plasma high density lipoprotein cholesterol concentration declined by -0.11 (-0.16 to -0.06) mmol/L on the carbohydrate diet but changed little on the plant sterol diet, -0.03 (-0.09, 0.02). Including a plant sterol fat spread in a cholesterol-lowering diet produces a more favourable plasma lipid profile than replacement of the spread with carbohydrate.

Practical food-based dietary guidelines developed for 12-24 month old New Zealand toddlers

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ABSTRACT

Up to 33% of 12-24 month old urban New Zealand children have sub-optimal iron status related to inadequate dietary iron intakes. Dietary intakes of other essential micronutrients are also often low in this population. Objective - To develop practical food-based dietary guidelines (FBDGs) for 12-24 month old NZ toddlers that, if put into practice, will ensure adequate micronutrient intakes. Two sets of FBDGs were designed and tested using linear programming analysis and food consumption data (3-day weighed food records) recently collected from a representative sample of 12-24 month old urban South Island NZ toddlers (n=188). The FBDGs were distinguished on the basis of the inclusion or exclusion of fortified toddler foods. In this analysis, nutritional and palatability constraints were introduced, and deviations from observed food consumption patterns were minimised. This ensured nutritionally adequate FBDGs that were consistent with habitual food consumption patterns of NZ toddlers.

Practical FBDGs, which ensured nutritionally sound diets, were achievable only when fortified toddler foods were included in them. In these FBDGs, toddlers are encouraged to consume at least two toddler sized servings of foods from each of the cereal, dairy, fruit and vegetable food groups, as well as one toddler sized serving from each of the meat/fish/poultry/eggs/legumes and fortified toddler foods food groups per day. In addition, at least four toddler sized servings of carrots/pumpkin, and two of orange/kiwifruit/mandarin are recommended per week to ensure adequate intakes of vitamins A and C. FBDGs that exclude fortified toddler foods were designable. However, to ensure nutritional adequacy, they were necessarily prescriptive, which means adherence to them may prove difficult.

FBDGs that ensure nutritionally sound NZ toddler diets are only practical when they include a guideline for fortified toddler foods. The bioavailability of iron and zinc from these fortified toddler foods, however, is unknown.

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