# Iodine in British foods and diets

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**Levels of I were determined in selected foods and dietary supplements, and in samples of the British 'Total Diet'. The average concentration of I in British milk collected in thirteen areas on four occasions during 1990 and 1991 was 150 μg/kg (range 40–310 μg/kg), compared with 230 μg/kg in 1977–79. No difference was found between skimmed and whole milk. Winter milk contained 210 μg/kg while summer milk contained 90 μg/kg. Regional differences were less pronounced than seasonal differences. Levels in fish and fish products were between 110 and 3280 μg/kg. Edible seaweed contained I levels of between 4300 and 2660000 μg/kg. Kelp-based dietary supplements contained I at levels that would result in a median intake of 1000 μg if the manufacturers' recommended maximum daily dose of the supplement was taken, while other I-containing supplements contained a median level of 104 μg in the manufacturers' maximum recommended daily dose. Intake of I, as estimated from the Total Diet Study, was 173 μg/d in 1985 (277 μg if samples with very high I contents were included) and 166 μg/d in 1991. These levels are above the UK reference nutrient intake of 140 μg/d for adults but well below the Joint Expert Committee on Food Additives provisional maximum tolerable intake of 1000 μg/d.**

**Iodine: Milk: Dietary supplements**

Although I deficiency is still recognized as a major international public health problem (Valeix & Hercberg, 1992), levels of I in the British diet are generally plentiful and goitre is now rare. Previous estimates (Wenlock *et al.* 1982; Gregory *et al.* 1990) suggest that the I content of British diets is well above the reference nutrient intake (RNI) of 140 μg/d (Department of Health, 1991), although some groups, e.g. vegans, may still be at risk from low intakes (Draper *et al.* 1993).

During the 1980s there were concerns about potential adverse effects of high intakes of I in Britain, particularly in those sections of the population previously exposed to low intake. It has been suggested that geographical incidence of thyrotoxicosis is strongly correlated with previous prevalence of endemic goitre (Phillips *et al.* 1983; Barker & Phillips, 1984). The relatively high intake of I in Britain resulted largely from the high levels found in milk and dairy products. Nelson & Phillips (1985) speculated that a spring–summer peak in thyrotoxicosis incidence in Britain may be causally related to high milk I levels in winter, as a result of the addition of I to manufactured cattle feed. However, milk I levels in seven English towns did not correlate with incidence of thyrotoxicosis (Phillips *et al.* 1988), despite the correlation between milk I content and urinary I excretion (Nelson *et al.* 1987). In addition, the Ministry of Agriculture, Fisheries and Food (MAFF)/Department

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of Health (DH) Working Group on Dietary Supplements and Health Foods (MAFF & DH, 1991) expressed concern about the potential for high levels of I in the diet as a result of supplements such as kelp.

MAFF therefore commissioned a number of studies to update and extend previous work by determining the I content of milk, selected foods, and dietary supplements. To investigate present intake of I by the British population, the amount of I in the Total Diet was also estimated. In addition, results from a recent survey of the diets of over 2000 British adults, the Dietary and Nutritional Survey of British Adults (Gregory *et al.* 1990), were reanalysed in order to look at the contributions of different food groups to I intake. The results of these investigations are presented in this paper.

## METHODS

### *Collection and preparation of milk samples*

Samples of skimmed and whole milk were collected from thirteen dairies in England, Scotland and Wales on four occasions between November 1990 and July 1991, in order to investigate seasonal and regional differences. The choice of dairies was based on those used in a previous survey of milk (Scott *et al.* 1984). The dairies were located in Aberdeen, Glasgow, Newcastle, Liverpool, Leeds, Birmingham, Bridgend (Mid-Glamorgan), Wootton Bassett (Wiltshire), Totnes (Devon), Great Yarmouth (Norfolk), Bracknell (Berkshire), Morden (Surrey), and Southwick (West Sussex). Samples were frozen overnight and dispatched to the laboratory where I determinations were performed on the samples as received.

### *Other foods*

As part of MAFF's rolling programme of nutritional analyses to extend and, in some cases, update existing data, I was determined in a range of foods for which little information was available, including fish and fish products, edible seaweed, yeast and vegetable extracts, meat products, nuts, biscuits, and confectionery. Individual sub-samples were purchased from a range of retail outlets, prepared according to normal domestic practice where appropriate, and combined to form composite samples (mostly about ten sub-samples in each composite) of similar products for analysis. For some seaweeds and yeast and vegetable extracts, analyses were performed on individual samples.

### *Dietary supplements*

A total of sixty-seven I-containing supplements were purchased in the south-east of England in 1990. Most fell into one of two broad categories, kelp tablets or multinutrient supplements. For supplements in tablet form the mean weight of the tablets was determined and then a quantity of tablet sufficient for analysis was ground in a ball mill to produce a fine powder. For each supplement in capsule form the contents were separated from the shell and the separated contents mixed together for analysis.

A second study was carried out in 1993 in order to explore further the distribution of I between the shell and contents of capsules. I levels in both capsule shell and contents of ten types of supplement were determined. Shells and contents of capsules were carefully separated and prepared for analysis. I content of the entire capsule was then calculated.

### *Total Diet Study*

The Total Diet Study, which is carried out continuously, is a model of the national average domestic diet in the UK, details of which have been published elsewhere (Peattie *et al.* 1983). A total of 119 categories of food are specified for inclusion in the Total Diet; these are assigned to one of twenty food groups. The quantities of foods that make up the Total Diet and the relative proportion of each food are largely based on data from the National Food Survey and are updated annually.

Food samples are purchased at fortnightly intervals from different locations selected randomly to be representative of the UK as a whole. Samples are transported to one centre where they are prepared and cooked (where necessary) according to normal consumer practice. The constituents of each food group are then homogenized and frozen.

I was determined in samples from 1985 and 1991. For the 1985 study, samples from ten locations were analysed but the twenty food groups were bulked into twelve composite groups (these are shown in Table 5). For the 1991 study, all twenty food groups were analysed (for easy comparison between the two years these are combined into twelve groups in Table 5) but samples from twenty locations were bulked.

### *Iodine determination*

Prepared samples were dry-ashed at 550° in the presence of $K_2CO_3$ and $ZnSO_4$. The residue was dissolved in water for subsequent colorimetric measurement, based on the destruction of the intense orange-coloured iron thiocyanate complex by nitrite in the presence of iodide (Moxon & Dixon, 1980). The average recovery value was approximately 90%. The validity of results was confirmed using reference materials obtained from the National Institute of Standards and Technology. Analyses were performed at the Laboratory of the Government Chemist.

## RESULTS

### *Milk*

The average I content of milk during the sampling period was 150 $\mu$g/kg (Table 1), with individual levels varying from 40 to 310 $\mu$g/kg. Average levels in summer and winter milk were 90 $\mu$g/kg and 210 $\mu$g/kg respectively. No difference was observed between average values in skimmed and whole milk.

Some regional variation was observed, with average values for the year generally being slightly higher in Devon and Berkshire, and slightly lower in Liverpool, Leeds and Glasgow (Table 2). Regional variation was small when compared with seasonal variation.

### *Other foods*

I contents of other foods are given in Table 3. Highest I levels were found in edible seaweed (range 4300–2660000 $\mu$g/kg), with nori having the lowest levels and kelp or kombu the highest levels. Many fish and fish products were also rich in I, containing between 110 $\mu$g/kg (red mullet) and 3280 $\mu$g/kg (haddock). Yeast and vegetable extracts contained between 180 and 260 $\mu$g/kg, while two types of vegetable stock, as purchased, contained 2100 and 3000 $\mu$g/kg. Milk chocolate contained ten times as much I as plain chocolate. Fully-coated chocolate biscuits and chocolate-coated ice-cream bars contained 110 $\mu$g/kg and 160 $\mu$g/kg respectively. Nuts contained between 90 and 210 $\mu$g/kg; meat products contained between 50 and 180 $\mu$g/kg, with highest levels being found in frankfurters.

### *Dietary supplements*

Averages and ranges for the two broad categories of supplements and some specific types of supplement are shown in Table 4, together with comparisons of determined I contents with those declared by manufacturers. Levels of I found in kelp tablets varied considerably.

Table 1. *Iodine content of milk samples from thirteen dairies in England, Scotland and Wales, 1990–1991*

| Sample | Iodine content (μg/kg) | |
|---|---|---|
| | Mean | Range |
| All samples | 150 | 40–310 |
| All whole | 150 | 50–310 |
| All skimmed | 150 | 40–290 |
| Nov/Dec 1990 | 230 | 150–290 |
| March 1991 | 200 | 110–310 |
| May/June 1991 | 100 | 40–140 |
| July 1991 | 90 | 40–170 |
| Winter (Nov/Dec and March) | 210 | 110–310 |
| Summer (May/June and July) | 90 | 40–170 |

Table 2. *Regional variation in mean iodine content of British milk*

| Dairy location | Iodine content (μg/kg) | | | |
|---|---|---|---|---|
| | Winter Mean | Summer Mean | Year Mean | Annual range |
| Aberdeen | 220 | 50 | 140 | 40–260 |
| Glasgow | 180 | 70 | 130 | 70–230 |
| Newcastle | 180 | 130 | 150 | 120–250 |
| Liverpool | 170 | 80 | 120 | 60–200 |
| Leeds | 160 | 90 | 120 | 70–220 |
| Birmingham | 230 | 90 | 160 | 70–280 |
| Bridgend | 260 | 90 | 170 | 70–290 |
| Wootton Bassett | 240 | 90 | 170 | 60–280 |
| Totnes | 270 | 110 | 190 | 100–310 |
| Great Yarmouth | 200 | 80 | 140 | 50–290 |
| Bracknell | 250 | 100 | 180 | 60–270 |
| Morden | 210 | 110 | 160 | 90–250 |
| Southwick | 210 | 110 | 170 | 40–300 |

Some manufacturers made recommendations about the number of tablets to be taken, and if the highest dosages were taken, I intake could be as high as 1240 μg/d.

Of the thirteen kelp supplements for which the manufacturer declared an I content on the packaging, most (ten) contained more than the declared level, with one sample containing over five times, and another over nine times the stated level. Only one supplement contained less than 60% of the declared level.

For the other I-containing supplements (including multivitamins and minerals, multiminerals, children's supplements, and women's supplements) the mean I content was 94 μg/daily dose (median 104 μg). The dose was mostly one tablet or capsule/d. Two-thirds of the thirty-eight samples that stated an I content contained between 60 and 100% of the declared level. Only seven contained more than the declared level, and six less than 60% of the declared level.

The results in Table 4 do not take account of the I content of capsule shells. In those samples where shells and contents of the capsules were analysed, between 0·2 and 8·4% of

Table 3. *Iodine content of selected foods*

(Values for a composite sample of about ten sub-samples)

| Product | Iodine content (μg/kg) |
|---|---|
| Fish and fish products | |
| Cod fillets, fresh, raw | 1050 |
| Cockles, canned, bottled or purchased from stall | 1630 |
| Coley steaks, frozen, raw | 360 |
| Eels, jellied (eels+jelly) | 140 |
| Fish fingers, economy, raw | 780 |
| Haddock fillets, fresh, raw | 2500 |
| Haddock, fillets, fresh, coated in flour, shallow fried in oil | 3280 |
| Haddock, fillets, breaded, frozen, raw | 2050 |
| Haddock, fillets, breaded, frozen, shallow fried in oil | 2490 |
| Herring, raw | 290 |
| Herring, canned in tomato sauce | 180 |
| Kippers, fresh, raw | 550 |
| Mackerel, fresh, raw | 1380 |
| Mackerel, canned in brine, fish only | 490 |
| Mackerel, canned in tomato sauce, fish and sauce | 470 |
| Mussels, fresh and frozen, boiled | 1160 |
| Pilchards, canned in tomato sauce, whole contents | 640 |
| Plaice, fillets, frozen, raw | 280 |
| Plaice, fillets, breaded, frozen, shallow fried in oil | 310 |
| Prawns, frozen | 210 |
| Red mullet, raw | 110 |
| Red snapper, whole fish, shallow fried | 650 |
| Salmon, canned in brine, fish only | 590 |
| Salmon, canned in brine, backbones only | 540 |
| Sardines, raw | 290 |
| Sardines, canned in oil, fish only | 230 |
| Sardines, canned in brine, fish only | 230 |
| Scampi, breaded, frozen, deep fried in oil | 410 |
| Trout, rainbow, fresh, raw | 130 |
| Tuna, canned in oil, fish only | 140 |
| Whiting, fresh, raw | 670 |
| Edible seaweed | |
| Arame (*Eisenia bicyclis*), dried | 706000*, 721000* |
| Dulse (*Palmaria palmata*), dried | 44100* |
| Hijiki (sea grass), dried | 391000* |
| Kelp granules (salt substitute) | 67000* |
| Kelp/kombu, dried | 2650000 |
| Kombu (sea kelp), dried | 2660000* |
| Nori (*Porphyra tenera*), dried | 4300*, 25000 |
| Wakame, dried | 104000, 217000* |
| Yeast and vegetable extracts | |
| Vegetable stock (as purchased) | 2100*, 3000* |
| Yeast extract | 180*, 260* |
| Yeast and vegetable extract | 210* |
| Meat and meat products | |
| Beef sausage, fresh, grilled | 60 |
| Black pudding, fried | 50 |
| Breaded turkey steaks, grilled | 60 |
| Frankfurters | 180 |
| Pork sausage, fresh, grilled | 70 |
| Nuts | |
| Brazil nuts | 210 |
| Cashew nuts | 110 |
| Hazelnuts | 170 |
| Walnuts | 90 |

Table 3. (*cont.*)

| Product | Iodine content (μg/kg) |
|---|---|
| Biscuits | |
| Cereal crunchy bars | 70 |
| Crunch biscuits with cream filling | 70 |
| Fruit biscuits | 60 |
| Fully coated chocolate biscuits with cream filling | 110 |
| Half-coated chocolate shortcake | 70 |
| Jam-filled biscuit | 60 |
| Oat-based digestives | 30 |
| Other foods | |
| Ice-cream-containing lollies | 80 |
| Luxury chocolate-coated ice-cream bars | 160 |
| Milk chocolate bar | 300 |
| Plain chocolate bar | 30 |
| Potato fritters (battered), frozen, baked | 40 |
| Soft-grain bread | 40 |

* Individual sample analysed.

the I was contained in the capsule shell (mean 3·9%), with levels in the shells being lower for products with powder content.

### *Total Diet Study*

The I content of Total Diet samples and the estimated average daily intakes for 1985 and 1991 are given in Table 5. In both 1985 and 1991, milk and dairy products together with meat products were major contributors to I intake. Certain samples (three meat products, one fruit product, one sugars and preserves) had very high I contents and were likely to contain the food colour erythrosine (E127, C.I. 45430), which contains 57·7% I. When these samples were excluded from the 1985 samples, the total I intake reduced from 277 μg to 173 μg/d.

## DISCUSSION

### *Milk*

The results shown in Tables 1 and 2 suggest that I levels in milk in Great Britain are not increasing, that skimmed and whole milk have the same I levels, and that seasonal differences in I levels are greater than regional differences.

*Trends in iodine content.* I levels in winter milk found in this study are lower than those found in 1982 (370 μg/kg; Wenlock *et al.* 1982) but still higher than those found in 1965 (100 μg/kg; Broadhead *et al.* 1965). Levels are similar to those found in seven English towns in 1988 (190 μg/kg in winter, 110 μg/kg in summer; Phillips *et al.* 1988).

*Low-fat milks.* That skimmed and whole milk were found to contain the same mean levels of I (Table 1) confirms the findings of a Finnish study (Varo *et al.* 1982). This finding is important as low-fat (skimmed and semi-skimmed) milks are becoming more widely consumed in Great Britain, replacing whole milk (MAFF, 1991).

*Seasonal differences.* The difference in I contents of summer and winter milk confirms the findings of several other groups both in the United Kingdom and in other countries (Wenlock *et al.* 1982; Nelson *et al.* 1987; Phillips *et al.* 1988; Pennington, 1990*a*; Lamand & Tressol, 1992).

Table 4. *Iodine content of dietary supplements*

| Supplement type | $n$ | Iodine content ($\mu$g/daily dose)* Range | Mean | Median | Declared content %† Range | Mean | Median |
|---|---|---|---|---|---|---|---|
| Kelp supplements | 22 | 210–3840 | 1244 | 1005 | 45–914 | 217 | 137 |
| Multinutrient supplements of which: | 42 | 11–171 | 94 | 104 | 8–197 | 82 | 79 |
| Children's supplements | 4 | 12–122 | 74 | 81 | — | — | — |
| Women's supplements | 3 | 11–124 | 47 | 16 | — | — | — |
| Multimineral supplements | 6 | 30–124 | 90 | 100 | — | — | — |
| Dolomite supplement | 1 | — | < 1 | — | — | — | — |
| Multivitamin supplement | 1 | — | < 1 | — | — | — | — |
| Iodine preparation | 1 | — | 185000 | — | — | — | — |

* Daily dose refers to manufacturers' maximum recommended daily dose of supplement.
† Where given.

Table 5. *Iodine content of UK Total Diet samples and estimated average daily intake, 1985 and 1991*

| Food group | Mean I content ($\mu$g/kg) 1985 | 1991 | Estimated intake of I ($\mu$g/d) 1985 | 1991 | Total intake (%) 1985 | 1991 |
|---|---|---|---|---|---|---|
| Bread | 40 | 30 | 5 | 3 | 2 | 2 |
| Other cereals | 180 | 90 | 21 | 9 | 8 | 5 |
| Meat products* | 1510 | 850 | 72 | 39 | 26 | 23 |
| Other meat and fish† | 330 | 300 | 25 | 19 | 9 | 12 |
| Canned vegetables | 30 | 20 | 1 | 1 | 0 | 0 |
| Other vegetables and nuts | 30 | 10 | 7 | 3 | 3 | 2 |
| Fresh fruit and products* | 90 | 50 | 8 | 5 | 3 | 3 |
| Milk | 150 | 170 | 52 | 50 | 19 | 30 |
| Dairy products and eggs | 370 | 340 | 33 | 26 | 12 | 16 |
| Beverages | 20 | 0 | 11 | 0 | 4 | 0 |
| Oils and fats | 130 | 280 | 4 | 1 | 1 | 1 |
| Sugars and preserves* | 410 | 150 | 37 | 10 | 13 | 6 |
| Total | — | — | 277 | 166 | 100 | 100 |

* In 1985, three meat products samples, one fresh fruit and products sample, and one sugars and preserves sample had very high I contents, probably due to the presence of erythrosine. If these samples were omitted, total I intake for 1985 would be 173 $\mu$g/d.
† Values for fish for 1985 and 1991 respectively are 1270 $\mu$g/kg, 1120 $\mu$g/kg; 22 $\mu$g/d, 16 $\mu$g/d; 8 %, 9 %.

While there are a number of potential sources of milk I arising from practices employed in dairy husbandry, it is generally accepted that dietary I is the major source (Alderman & Stranks, 1967). I may also occur in milk as a result of carry-over from the use of iodophors as teat sterilants and equipment sanitizers. Results from a number of studies demonstrate that, if they are used properly, the contribution to milk I from such sources is relatively small (Hemken, 1979).

I is an essential element in the diet of dairy cattle, with deficiency manifesting itself most noticeably in effects on reproductive function, and thus is often added to manufactured animal feeds. Supplementation is subject to the provisions in the UK Feeding Stuffs

(Amendment) Regulations 1993 (Statutory Instrument 1993, No: 1442), which enact EC Directive 70/524 (as amended). These stipulate the permitted sources of additional I and a maximum limit of 40 mg/kg in complete feed for dairy cattle, which takes account of any naturally occurring I. Both amounts and types of feed consumed by animals will vary within a herd, with farm, and with season. In general, the intake of manufactured feed is highest in winter, during the early stages of lactation, and lowest in summer. Thus, winter milk would be expected to have a higher I content than summer milk, as found in this and other studies. It has been suggested that the less extreme seasonal variation found in the United States may indicate a more consistent yearly proportion of supplemental feeding *v.* pasture feeding (Pennington, 1990*a*).

*Regional differences.* The regional variation in I content found in the present study confirms the findings of others (Fischer & Giroux, 1987*a*; Pennington, 1990*a*; Lamand & Tressol, 1992). The regional variation is less pronounced than seasonal variation, a finding also reported by Nelson *et al.* (1987).

The present results have been presented to the Department of Health's Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (COT), which had expressed concerns about the levels of I in milk. The Committee was reassured that the I content of milk appeared not to be increasing but recommended that monitoring of milk should continue (Department of Health, 1993).

### *Other foods*

*Fish and fish products.* The results are in the same order as those found previously in the UK (Wenlock *et al.* 1982). In that study, levels also varied between fish species, from 100 μg/kg (raw plaice) to 2100 μg/kg (grilled haddock). Values for cod, haddock, and plaice were higher in the present study, while levels for fish fingers, kippers, tuna and salmon were lower than before. These large variations in I content of fish have also been reported in other studies (Varo *et al.* 1982; Dellaville & Barbano, 1984).

*Seaweed and yeast and vegetable extracts.* Davies (1990) and Mabeau & Fleurence (1993) have also reported I levels in seaweed; levels found were generally in the same order as those in the present study. Wenlock *et al.* (1982) found I levels of 490 μg/kg in yeast extract.

*Other foods.* Many of these had not been analysed for I content previously. Where similar products have been analysed before (sausages, biscuits, bread, chocolate, nuts), levels found were generally in the same order (Varo *et al.* 1982; Wenlock *et al.* 1982).

### *Dietary supplements*

For kelp supplements in the present study (Table 4), the amount of I found means that, for some supplements, manufacturers' maximum recommended dosages would result in the World Health Organization (WHO)/Food and Agriculture Organization (FAO) Joint Expert Committee on Food Additives (JECFA) provisional maximum tolerable intake of 1000 μg/d (17 μg/kg body-weight) being exceeded (WHO/FAO JECFA, 1989). In a previous survey of fifteen kelp-containing dietary supplements on sale in the UK in 1986 (Norman *et al.* 1987), daily intakes, based on manufacturers' recommended maximum dose, ranged from 45–5000 μg/d, with a number of samples exceeding the JECFA limit.

It has been reported that the I content of kelp tablets can vary according to their age and position in the jar (Liewendahl & Turula, 1972). Further, kelp is subject to natural variability, which can make control of levels in supplements difficult. Since these analyses were undertaken, the Health Food Manufacturers' Association advised its members 'to check the iodine levels in products containing kelp and adjust the recommended intakes or add "on-pack" warnings if appropriate' (Health Food Manufacturers' Association, 1992).

Of the forty-two other I-containing supplements (Table 4), over half (twenty-three)

Table 6. *Average contribution of main food groups to iodine intakes of British adults**

| Food type | Iodine intake ($\mu$g/d)† | Iodine intake (%) |
|---|---|---|
| Cereal products | 30 | 14 |
| Milk and milk products | 77 | 35 |
| of which: full fat milk | 49 | 22 |
| Eggs and egg dishes | 11 | 5 |
| Fats | 6 | 3 |
| Meat and meat products | 13 | 6 |
| Fish and fish products | 17 | 8 |
| Vegetables | 9 | 4 |
| Fruit and nuts | 4 | 2 |
| Sugar, confectionery and preserves | 11 | 5 |
| Beverages | 35 | 16 |
| of which: beers | 20 | 9 |
| Miscellaneous | 5 | 2 |
| Total | 219 | 100 |
| Number of cases | 2197 | |

* Source: *Dietary and Nutritional Survey of British Adults, 1986–1987* (MAFF, 1994).
† Population average.

contained between 70 $\mu$g and 140 $\mu$g/dose, i.e. were above the lower reference nutrient intake and below the RNI (Department of Health, 1991).

*Iodine content of the Total Diet*

Intakes estimated from the 1985 and 1991 Total Diet Study were similar, if five samples with high I contents were excluded (Table 5), but lower than that estimated from the 1977–79 Total Diet Study (255 $\mu$g/d, or 323 $\mu$g/d when glacé cherries, which contain the food colour erythrosine, were included; Wenlock *et al.* 1982).

The mean I intake (excluding contribution from supplements) of over 2000 British adults was 219 $\mu$g/d (Gregory *et al.* 1990). Further analyses of data from the survey indicate that the 97·5th percentile I intake throughout the year was 434 $\mu$g/d. If the new analytical values for milk were to be applied to the food consumption data from this survey, estimated mean daily intake would fall but average intakes would still be above the RNI (Department of Health, 1991).

In all three Total Diet Studies and the Dietary and Nutritional Survey of British Adults (Table 6), milk and milk products contributed approximately one third of I intake. Although fish contains high levels of I, it accounts for less than 10% of I intake because consumption is low.

Because of different groupings of foods, direct comparisons between the studies are difficult but contributions of different foods to I intake appear to be broadly similar. Two main exceptions are beverages and meat products. The Total Diet Study excludes alcoholic beverages, and, in the adults' survey, beer alone provided, on average, 20 $\mu$g I/d (9% of the total; Table 6). If beer is excluded, the contribution from beverages in the two studies is similar.

Meat products made a significant contribution to I intake in both the 1985 and 1991 Total Diet Studies because of the high I levels found in this food group. This is likely to be the result of the presence of erythrosine in some meat products such as Danish salami and pork luncheon meat (Wenlock *et al.* 1982). When three samples containing very high levels of I were excluded from the 1985 study, I intake from the meat products group was only 9 $\mu$g/d, which is comparable with the adults' survey.

The metabolic fate of I contained in erythrosine is not clear but it is thought that availability in man is low (Parkinson & Brown, 1981; Katamine *et al.* 1987). The Food Advisory Committee (1989) has recommended that the use of erythrosine be restricted to glacé and cocktail cherries at levels not exceeding 200 mg/kg. This recommendation is likely to become a statutory requirement through European Community proposals on colours, which are currently being negotiated.

I content of diets in several countries has been summarized elsewhere (Pennington, 1990*b*). Valeix & Hercberg (1992) list I intakes in Europe. These range from 16 $\mu$g/d in parts of Germany to 250 $\mu$g/d in Finland. Intakes are also low in France, Belgium and Italy, where goitre is still a problem in some regions (Delange & Bürgi, 1989). In the Netherlands, mean I intake in the total diets of 18-year-old males was 402 $\mu$g/d (van Dokkum *et al.* 1989). Highest I levels were found in fish, sugars and sweets (possibly because of the use of erythrosine), and bread groups.

A representative Canadian diet was found to provide 1046 $\mu$g I/person per d, over six times the recommended nutrient intake for Canadians of 160 $\mu$g/d (Fischer & Giroux, 1987*b*). The main source, iodized salt, which provided 371 $\mu$g/d, is not commonly used in the UK. The second most important source was dairy products (239 $\mu$g/d). In the United States, I intakes estimated from their Total Diet Study (1982–89) were 410 $\mu$g/d and 260 $\mu$g/d respectively for men and women aged 25–30 years (Pennington & Young, 1991).

Thus, current I intakes for adults in the UK, as estimated by the Total Diet Study and other surveys, are not of concern, being above the RNI and well below the JECFA provisional maximum tolerable daily intake. However, there are certain sectors of the population that may have relatively high or low intakes. Infants are potentially 'at risk' of high intakes of I because they are high consumers of milk. However, a recent MAFF survey indicates that current intakes are well below the JECFA limit (Mills & Tyler, 1992). Vegans (i.e. individuals who avoid all animal products) are also a potentially 'at risk' group, because they do not consume milk, meat or fish, and thus may have low dietary intakes of I. A recent survey of vegetarians found that vegans consumed only 50–70% of the RNI (Draper *et al.* 1993). Vegans who use edible seaweed and/or dietary supplements will obtain I from these sources, but the amounts will be very variable.

## CONCLUSIONS

In summary, I levels in British milk appear not to be increasing, although the Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment has recommended that monitoring should continue (Department of Health, 1993). Thus the concerns expressed about high levels of I in British milk appear to be unfounded.

I content of British diets, as indicated by the Total Diet Study and other studies, is adequate but not excessive. However, it should be noted that certain sub-groups of the population (e.g. individuals taking certain dietary supplements, infants, and vegans) may be at risk from either high or low intakes of I.

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